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Faunal Comparison and Analysis of the Blufftown Formation-Cusseta Sand Contact at Hannahatchee Creek, Georgia

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by

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ABSTRACT

The origin of fossil material in the highly fossiliferous bed above the Upper Cretaceous (Campanian) Blufftown Formation-Cusseta Sand contact at Hannahatchee Creek, Georgia, has long been a subject of scientific curiosity; however, no research has yet been conducted to specifically investigate discrepancies between the fossil assemblages of the upper Blufftown Formation and the basal Cusseta Sand, which overlies it unconformably. In the most recent published hypothesis, Case and Schwimmer (1988) propose that the basal Cusseta Sand contains a mixture of original fauna as well as material reworked and redeposited from the underlying Blufftown Formation, resulting in a lag deposit above the contact. Analysis of fossils discovered in 294 g of concentrate samples collected from the upper Blufftown Formation and basal Cusseta Sand reveals distinct incongruities between the fossil assemblages. Fossils from the Cusseta Sand range in quality from well preserved or angularly fractured to heavily fragmented and rounded, whereas fossils from the Blufftown Formation are consistently and extremely weathered, with highly fragmentary and pitted specimens and invertebrate internal molds devoid of original shell material. The degree of weathering observed on the Blufftown Formation specimens is inconsistent with a majority of specimens from the Cusseta Sand sample. The Cusseta Sand sample also contains a more diverse fossil assemblage compared to the Blufftown Formation. The higher diversity characteristics of the Cusseta may be related to the presence of a Crassostrea cusseta oyster bioherm found in the same horizon as the Cusseta Sand assemblage at the locality, as contemporary oyster reefs provide a habitat for a diverse array of fauna. It is likely that some specimens original to the Blufftown

Formation were reworked and deposited into the Cusseta Sand, but a majority of the fossil material present in the basal Cusseta assemblage is likely original to the Cusseta Sand.

Keywords: Blufftown Formation, Cusseta Sand, Hannahatchee Creek, Late Cretaceous, vertebrate paleontology, Georgia

DEDICATION

I would like to dedicate this thesis to my childhood dog, Dot, who passed away shortly before the completion of this project. She was a good girl and will be forever missed.

ACKNOWLEDGMENTS

This research would not have been possible without the aid of several others, primarily Dr. Alyson Brink from The University of Southern Mississippi (USM), who advised and mentored me throughout the thesis process, provided matrix for this research, and allowed me to sieve concentrate in her backyard. The foundation for this project was laid by Dr. David Schwimmer from Columbus State University, who provided literature, figures, and proprietary information and allowed Dr. Brink access to the Hannahatchee Creek locality. Fossil photography would have been impossible without the aid of Dr. Jeremy Deans (USM), who lent me laboratory space and microscope/photography equipment to image specimens; Dr. Deans also allowed me to sieve concentrate in his backyard. Dr. Mark Puckett (USM), George Phillips (Mississippi Museum of Natural Sciences/Mississippi State Paleontologist), and Dr. David Dockery (Mississippi Department of Environmental Quality Office of Geology/Mississippi State Geologist) provided me with literature and aided in fossil identification.

This research could not have been accomplished without the aid of the University of Southern Mississippi Honors College, who provided me with the opportunity to pursue this research as well as monetary assistance. The Drapeau Center for Undergraduate Research provided a grant and travel stipend to conduct this research and present at the Mississippi Academy of Sciences 86th Annual Meeting and the University of Southern Mississippi's 2022 Undergraduate Research Symposium. The School of Biological, Environmental, and Earth Sciences also contributed to the travel stipend to disseminate preliminary results at the Mississippi Academy of Sciences 86th Annual Meeting.

Special recognition goes out to fellow Honors Scholar, Ginger Trochesset, who shared the pain and provided moral support throughout the entire thesis process. I would also like to recognize Wu Tang Clan, Motorhead, Nuclear Assault, Death, Metallica, and countless other artists for providing me with musical entertainment while tediously picking fossils for countless hours under the microscope in the laboratory.

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LIST OF ABBREVIATIONS

Fm.	Formation
pers. comm.	Personal Communication
USM	The University of Southern Mississippi

CHAPTER I: INTRODUCTION

Along Hannahatchee Creek in westernmost central Georgia, the contact between the Blufftown Formation and overlying Cusseta Sand is prominent, separated by an unconformity directly underlying and associated with a prolific vertebrate fossil bed in the basal-most Cusseta Sand. The nature of this contact, along with implications for the fossil bed, have been the subject of study and debate since the 1980s (Case and Schwimmer, 1988). The outcrop displays mid Campanian to earliest Maastrichtian strata, deposited during a period of high eustatic sea level when much of the Coastal Plain was inundated by a shallow sea. The bone and shell bed at the locality has served as a resource for paleontological study and paleoenvironmental analyses of the Late Cretaceous Gulf Coastal Plain. The Hannahatchee Creek locality is located in Stewart County, Georgia, east of the Chattahoochee River near the town of Omaha (Figure 1). The contact is exposed along the creek bank and is clearly visible due to shell material in the fossil bed (Schwimmer, pers. comm.).

In the 1980s, the Blufftown-Cusseta contact at Hannahatchee Creek was placed higher in the section at a different erosional surface underlying a lithologic change (Schwimmer, 1981). However, in subsequent years, the contact has been informally reassigned lower in the section at the unconformity directly underlying the fossil deposit, based on the occurrence of a *Crassostrea cusseta* oyster bioherm, an index fossil for the Cusseta Sand, on the same stratigraphic horizon as the unconformity and fossil bone and shell bed (Figure 2). This distinction has been mentioned but not specifically addressed in published literature concerning the fossil deposit at Hannahatchee Creek (Schwimmer, pers. comm.).

The current interpretation described by Case and Schwimmer (1988) suggests that the fossils within the bone and shell bed originate from the Blufftown Formation and were reworked and redeposited into the Cusseta Sand after a brief regressive-transgressive sequence (Figure 3). This resulted in a fossiliferous phosphatic lag deposit overlying the erosional surface containing a mixture of reworked Blufftown fossils and original Cusseta material (Schwimmer, 1986; Case and Schwimmer, 1988). Proposed evidence supporting this hypothesis includes the appearance of Blufftown Formation index fossils such as *Exogyra erraticostata* above the unconformity and observed weathering on shark teeth, indicating reworking (Schwimmer, pers. comm.). East of the Flint River in Georgia, the Blufftown and Cusseta intertongue at outcrops, with the contact represented as a cross-bedded gradation from the Blufftown Formation into the Cusseta Sand; therefore, evidence of these strata mixing is represented in the rock record, but is implied at the Hannahatchee Creek locality (Eargle, 1955).

This research serves to specifically address the nature of the Blufftown Formation-Cusseta Sand contact at the Hannahatchee Creek locality based on the content of the fossil bed and physical weathering characteristics of observed specimens in each bed, relative to the unconformable contact. There is currently no published literature with the prime objective of investigating these characteristics relative to the erosional surface. This research will investigate fossil content within the uppermost Blufftown Formation and basal Cusseta Sand, focusing on variance in diversity and degrees of weathering between the two sections.

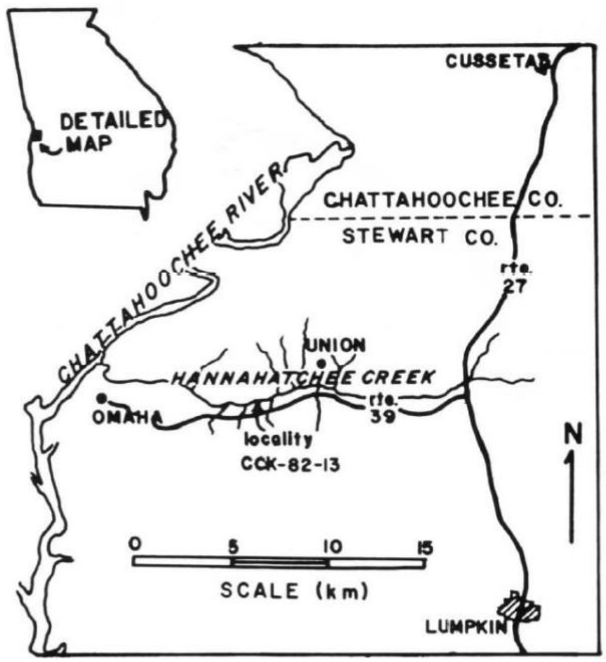

Figure 1. *Inset map displaying the Hannahatchee Creek locality in Stewart County, Georgia. Adapted from Case and Schwimmer (1988) with Schwimmer's permission.*

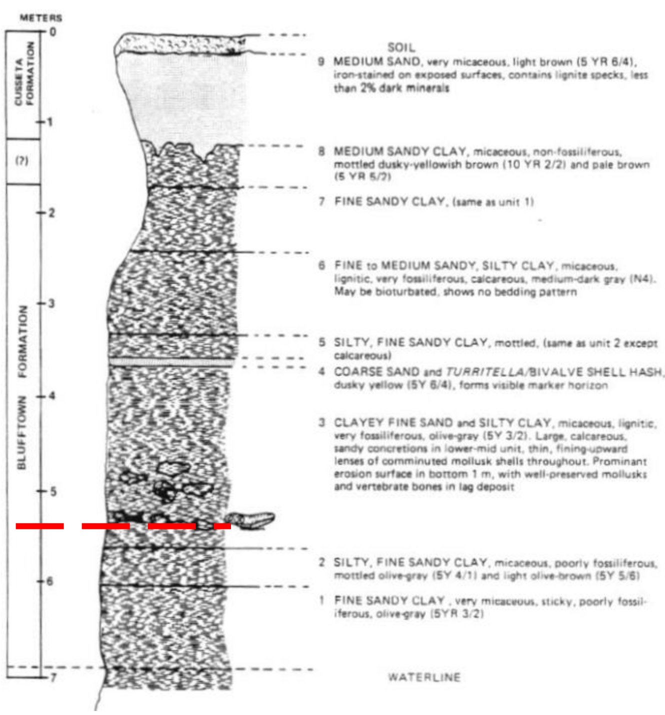

Figure 2. *Measured section showing a profile view of the Hannahatchee Creek outcrop of the Blufftown Formation and Cusseta Sand with the original contact definition. The line marked in red indicates the redefinition of the contacts and extent of the Blufftown Fm. and Cusseta Sand at the unconformity underlying the fossil bed. Adapted from Schwimmer with author's permission (in Reinhardt and Gibson, 1981) based on personal communication with Dr. David Schwimmer.*

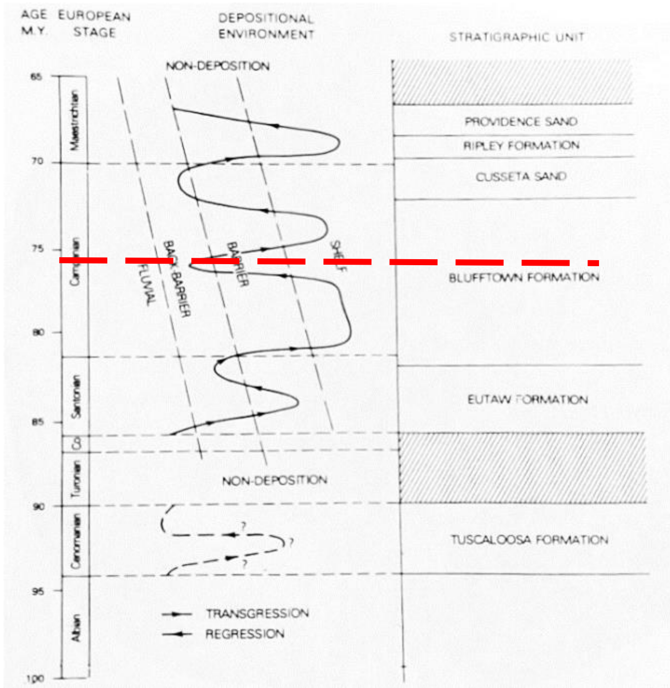

Figure 3. *Depositional environments associated with transgressive and regressive sequences in the Upper Cretaceous in Alabama and Georgia. The line marked in red indicates the redefinition of the Blufftown Formation-Cusseta Sand contact and the transgressive-regressive sequence thought to create the contact unconformity (Schwimmer, pers. comm.). Edited from Reinhardt (in Reinhardt and Gibson, 1980).*

CHAPTER II: GEOLOGIC SETTING AND STRATIGRAPHY

During the latest stages of the Cretaceous Period, North America was divided into two landmasses by the Western Interior Seaway, with Laramidia to the west and Appalachia to the east. The seaway lasted through the latest stages of the Cretaceous Period, caused by elevated global (eustatic) sea level (Sampson et al., 2010). The offshore deposits of Appalachia comprised part of the Gulf Coastal Plain, which is an extensive basin extending from modern Texas to New Jersey (Figure 4). The Hannahatchee Creek locality in Georgia contains some of these Coastal Plain marine sediments.

The two strata outcropping at Hannahatchee Creek are composed of sediments deposited in the Gulf Coastal Plain during a period of high sea level. Based on foraminiferal biostratigraphy, the lower stratum, the Blufftown Formation, is early to middle Campanian in age (Rosen, 1985), and the overlying Cusseta Sand is middle Campanian to earliest Maastrichtian in age (Puckett, 2005; Reinhardt, 1980). Sedimentary textures and structures, lignite, fresh and brackish water invertebrates, and terrestrial vertebrates present in this layer suggest it was deposited in a nearshore estuarine environment (Hall, 2005).

The Blufftown Formation is a marginal marine deposit that overlies the Eutaw Formation and underlies the Cusseta Sand (Eargle, 1955). It is comprised of crossbedded medium to coarse quartz sands with laminated sandy, micaceous, carbonaceous, fossiliferous, gray silts and clays (Eargle, 1955; Schwimmer, 1986). The Blufftown Formation crops out roughly parallel to its strike along Hannahatchee Creek. The formation is interpreted as deposited in a subaerial, nearshore marine environment, containing upward-fining storm deposits in the uppermost section (Schwimmer, 1986). This context, based on the presence of the serpulid worm *Hamulus* sp. and the brachiopod *Lingula* sp. (Schwimmer, pers. comm.) indicates the Blufftown was a very shallow environment of deposition, with probable occasional aerial exposure and indications of freshwater input.

The Cusseta Sand is comprised of coarse, glauconitic quartz sands and micaceous, gray silts and clays with shell material, lignite, and phosphatic fragments (Eargle, 1955; Schwimmer, 1981). At Hannahatchee Creek, the basal Cusseta Sand is interpreted as a marginal to nearshore marine deposit or shallow back barrier tidal marsh (Schwimmer, 1986; Case and Schwimmer, 1988). The Cusseta sits unconformably above the Blufftown Formation, with a fossil bed occurring in the lowest Cusseta associated with a stratigraphically equivalent bed containing an intact assemblage of the index fossil *Crassostrea cusseta* (Schwimmer, pers. comm.). East of the Flint River in Georgia, the Blufftown Formation and Cusseta Sand cross bed and grade into one another with an indistinguishable contact (Eargle, 1955).

Stratigraphy of the Hannahatchee Creek locality is explained in depth by Schwimmer's contribution to Reinhardt and Gibson's guidebook for a Georgia Geological Society field trip (1981). However, it must be noted that since the publishing of the guidebook, the contact between the Blufftown and Cusseta has been redefined at the erosional contact underlying the fossil bed at Hannahatchee Creek. Figures 2 and 3 display correlative units of the Blufftown and Cusseta across the Gulf Coastal Plain and a stratigraphic column of Stewart County, Georgia, respectively.

Figure 4. *Map displaying the Atlantic/Gulf Coastal Plain sediment deposits in the modern United States (U.S. Geological Survey, 2016).*

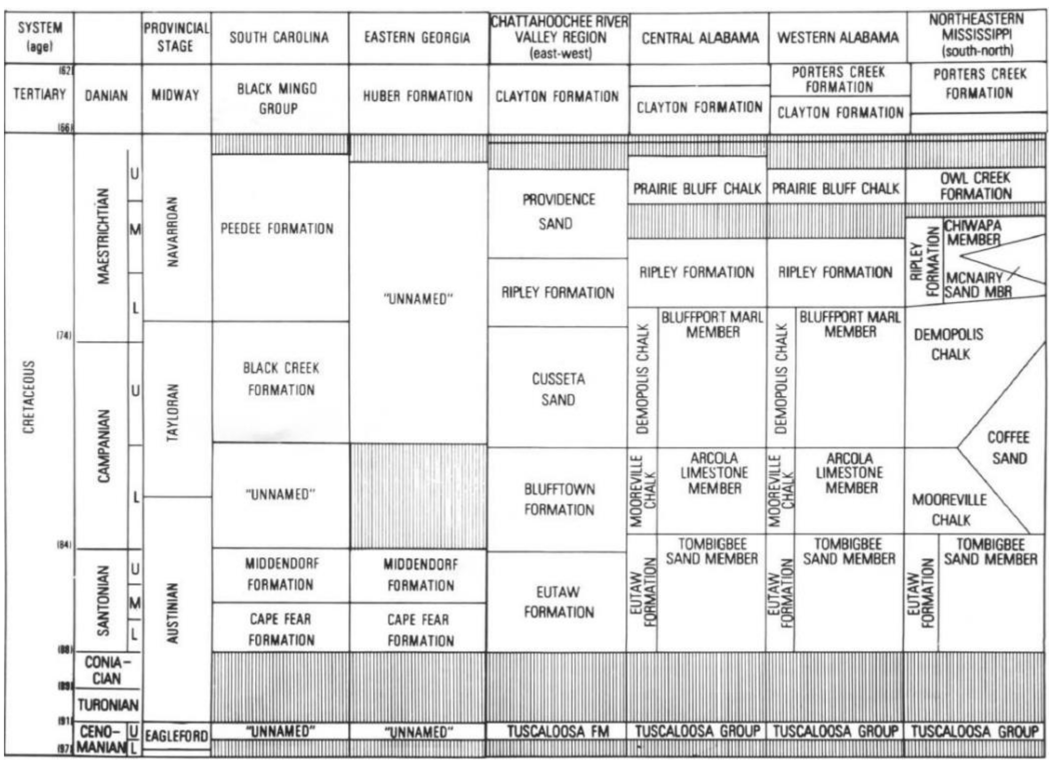

Figure 5. *Correlations of Late Cretaceous units in the Atlantic and Gulf Coastal Plains in relation to the Blufftown Formation and Cusseta Sand in Stewart County, Georgia. Adapted from Case and Schwimmer (1988) with Schwimmer's permission.*

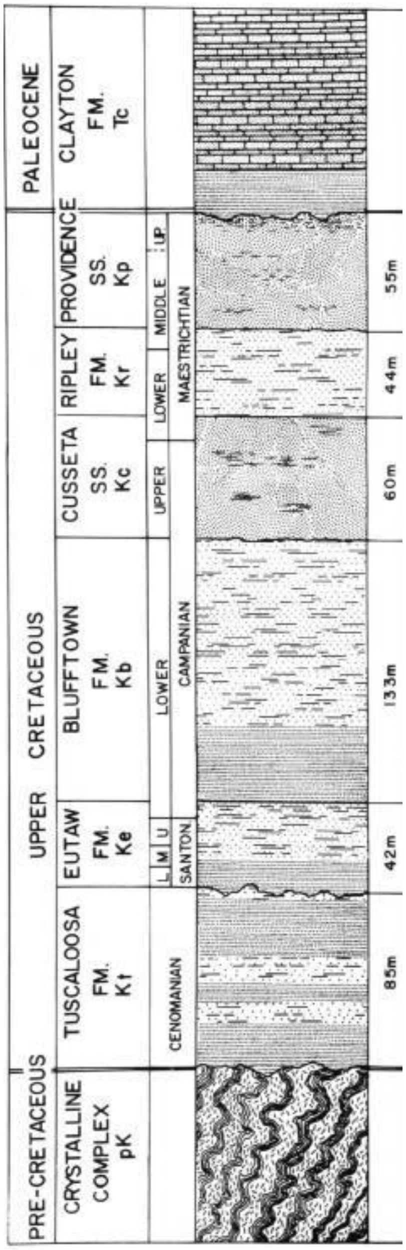

Figure 6. *Stratigraphic column displaying Cretaceous units present in Stewart County, Georgia. Adapted from Case and Schwimmer (1988) with Schwimmer's permission.*

CHAPTER III: METHODS AND MATERIALS

In the summer of 2019, Dr. Alyson Brink from The University of Southern Mississippi collected several buckets of bulk matrix during a field trip with Dr. David Schwimmer from Columbus State University (Fig. 7, 8). Matrix was excavated from the upper Blufftown Formation and the basal Cusseta Sand on Hannahatchee Creek in Stewart County, Georgia. Schwimmer (1986), who originally identified the strata and contact on Hannahatchee Creek, reports that locally the Blufftown Formation is a fine, micaceous sand with distinct upward fining storm deposits, and that the Cusseta contains coarser, organic-rich, poorly laminated sands. Schwimmer also indicates that at this locality, the oyster *Crassostrea cusseta* serves as an index fossil for the Cusseta, and the unconformity underlying the Cusseta Sand defines the contact between the two units (Schwimmer, pers. comm.).

The bulk matrix was processed by wet sieving, utilizing water and vigorous agitation with 1 mm and 425 μm wire sieves to separate the matrix into three size fractions: particles greater than 1 mm in diameter, particles between 1 mm and 425 μm in diameter, and particles smaller than 425 μm in diameter (Fig. 10). This study only considers particles of the concentrate that have a diameter greater than 425 μm. Fossils large enough to be seen without the aid of a microscope were collected and are analyzed in this study, but are not included in the total weight mentioned below.

The concentrate was placed on aluminum foil sheets and was heated in several batches in a 200º F oven until it was dry. Then it was weighed using an OHAUS Scout II digital scale with accuracy up to 0.028 g. The larger sieve sample from the Blufftown Formation only produced 147 g, restricting sample sizes from both strata to 147 g to maintain comparable equivalence. 147 g of concentrate was measured for both sieve sizes in both samples, resulting in 294 g of concentrate from each formation to process (588 g total). The dried concentrate was picked under a Nikon SMZ-1B microscope with a fine-tip brush in increments of approximately one teaspoon, and fossils were separated from all other material and stored in gel capsules or plastic bags (Fig. 10). Equal proportions of both formations were picked, determined by weighing an equal mass of bulk concentrate to process. Fossil material greater than 1 mm is referred to as the "macrofossil" portion, whereas material between 425 μm to 1 mm is referred to as the "microfossil" portion.

Specimens were imaged using a Nikon SMZ T385 microscope, Nikon DS-Fi3 camera, and NIS-Element AR software. Fossil plates were edited using GIMP 2.10.24 image manipulation software and are located in Appendix A. Fossil specimens from the Blufftown Formation and Cusseta Sand were compared based on size, angularity/rounding, fragmentation, pitting, and preservation of shell material to interpret variance in degrees of weathering. Variance in weathering is assumed to reflect the amount of erosion or transport the specimens underwent before diagenesis, which reflects original depositional conditions. If the Cusseta Sand includes fossils reworked from the underlying Blufftown Formation, then many specimens from the Cusseta sample are expected to exhibit a greater degree of weathering. Fossil identification and taxonomy were determined by referencing peer- reviewed literature, such as local faunal composition lists (Hall, 2005; Case and Schwimmer, 1988, etc.).

Specimens were quantified by comparing the ratio of all identified specimens between both units. Fossils from vertebrate material, internal molds of scaphopods, gastropods, and bivalves were counted and quantified. The relative abundance of shell material from each stratum was compared; a direct quantity comparison of shell hash is inappropriate, given the fragility of shell material and inability to discern whether fragmented specimens came from the same shell or many different shells.

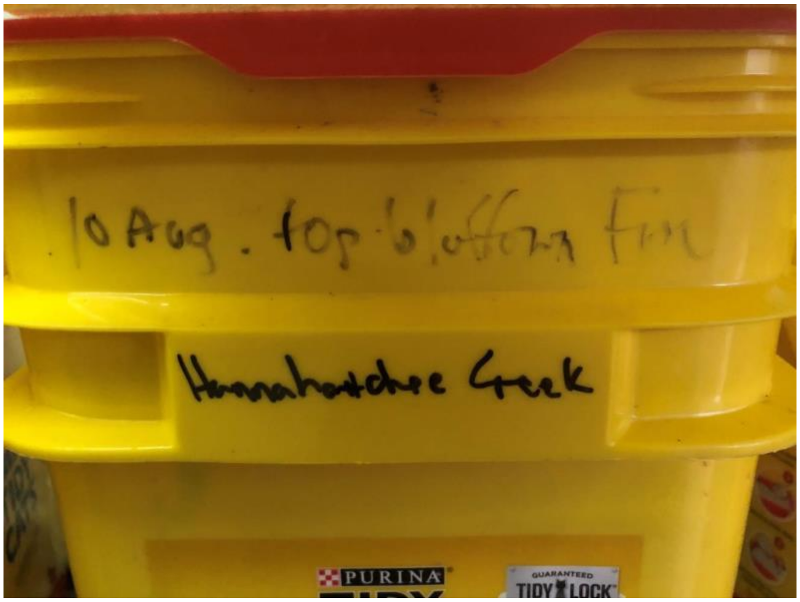

Figure 7. *Bulk matrix sample collected from the upper Blufftown Formation at Hannahatchee Creek, Georgia.*

Figure 8. *Bulk matrix sample collected from the basal Cusseta Sand at Hannahatchee Creek, Georgia.*

Figure 9. *Wet sieving concentrate from the basal Cusseta Sand from Hannahatchee Creek, Georgia.*

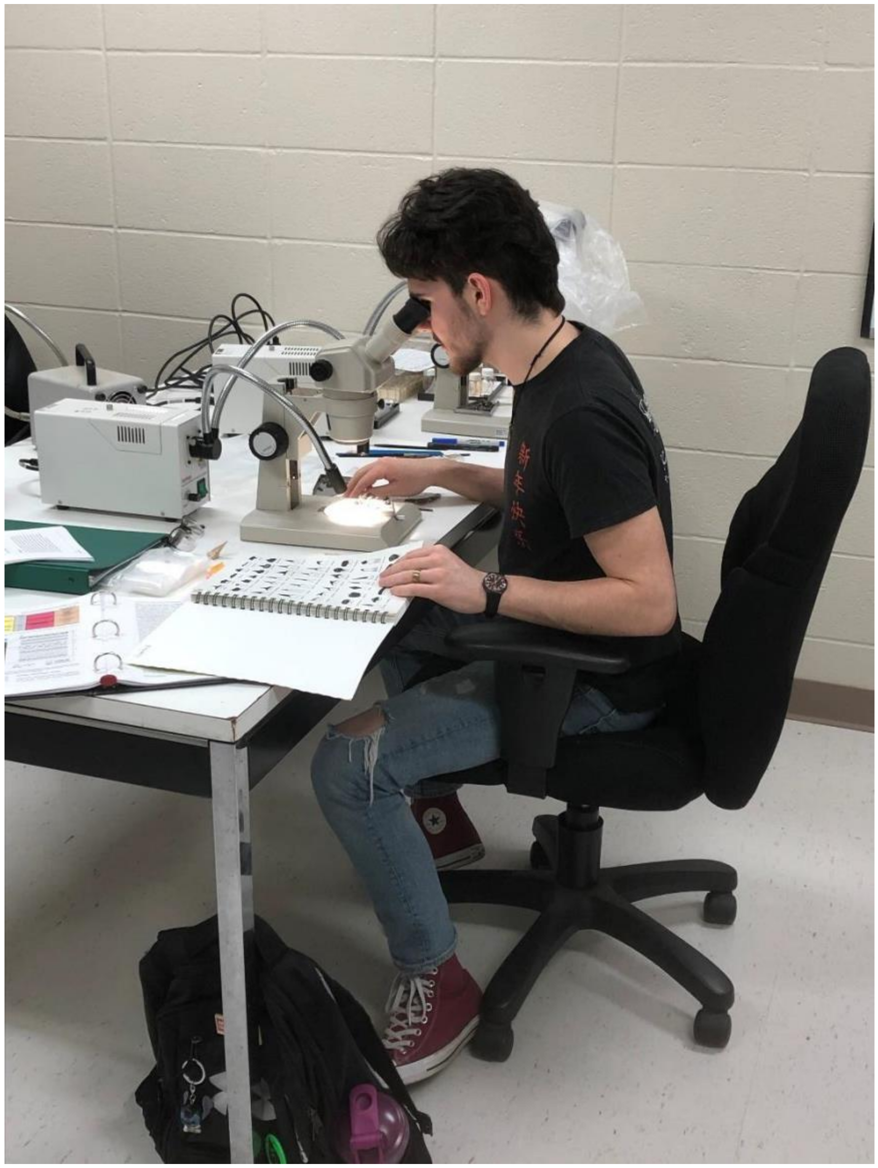

Figure 10. *Picking fossil material from detritus in Dr. Brink's laboratory.*

CHAPTER IV: SYSTEMATIC PALEONTOLOGY

Blufftown Formation: Invertebrates

Phylum ANNELIDA Lamarck, 1809
Class POLYCHAETA Grube, 1850
Order SERPULIMORPHA Sepkoski, 2002
Family SERPULIDAE Rafinesque, 1835
Genus HAMULUS Regenhardt, 1961

?*Hamulus* sp.
Plate 1: A, B

Material: Two siliceous internal molds. [Specimens A, B]

Description: Two fragmentary internal molds, cylindrical in shape, but slightly flattened, with variation in tube thickness near the base. No original shell material remains.

Discussion: These internal molds resemble scaphopods or serpulid worm tubes. They are unlike scaphopods because of the variation in thickness at the base of the specimens, which resembles variation seen in some serpulid worm shells such as Hamulus (Howell, 1943, p. 167, Plate 20: Fig. 1-2). *Hamulus* is reported in Cretaceous deposits near the Chattahoochee River (Veatch and Stephenson, 1911).

Phylum BRACHIOPODA Cuvier, 1805
Class LINGULATA Gorjansky and Popov, 1985
Order LINGULIDA Waagen, 1885
Family LINGULIDAE Gray, 184

Gen. et sp. indet.
Plate 2: A, B

Material: Two large shell fragments and 19 fragments of shell hash. [Specimens A, B]

Description: Fragmentary but well-preserved shell material, brown to beige in color, exhibiting concentric, oblate growth lines.

Discussion: Although no complete specimens were recovered, these shell fragments are attributed to Family Lingulidae based on coloration and growth line shape and pattern. No other shell material observed in the Blufftown sample exhibit such well-preserved surfaces, and the ovular growth lines preserved on these shell fragments closely resemble a lingulid brachiopod (Emig and Bitner, 2005, p. 183, Fig. 2). The presence of *Lingula* in the Blufftown Formation has been reported by Schwimmer (1986; pers. comm.), but a genus cannot be assigned based on shell morphology alone (Emig, 2008), especially given the incomplete nature of these specimens.

Phylum MOLLUSCA Linnaeus, 1758
Class BIVALVIA Linnaeus, 1758

Order, Family, Gen. et sp. indet.
Plate 3: A-D

Material: Eighty siliceous internal molds of bivalve shells. [Specimens A, B, C, D]

Description: No shell material remains. Most specimens range from 1 to 5 mm in diameter and exist as partially fragmentary to nearly complete internal molds.

Discussion: Although general shapes remain on several specimens, no defining characteristics are preserved to identify succinctly to the family level, so all similar bivalve internal molds are attributed to Class Bivalvia due to the domed surface and rounded commissure opposite to a defined beak protrusion, as seen in Dockery (2020, p. 6, all specimens).

Order NUCULIDA Dall, 1889
Family NUCULIDAE Gray, 1824

Gen. et sp. indet.
Plate 4: A, B

Material: Two bivalve internal molds. [Specimens A, B]

Description: One specimen contains one patch of preserved shell material. The specimens largely exist as internal molds. Molds of the beaks and comb teeth are preserved, and the shell shape is laterally elongate.

Discussion: These specimens are assigned to Family Nuculidae based on the position of the beak and general elongate shape. The umbo is off-center and recurved slightly to one side, resembling the genus *Nuculana*, which also has a laterally elongate shell morphology (Dockery, 2020, p. 48, Specimen 2570); however, these specimens lack diagnostic characteristics to assign a genus.

Class GASTROPODA Cuvier, 1795

Order, Family, Gen. et sp. indet.
Plate 5: A-F

Material: Ten siliceous internal molds of gastropod shells. [Specimens A, B, C, D, E, F]

Description: No shell material remains. These specimens are internal molds resembling internal structures of gastropod shells.

Discussion: These specimens are assigned to Class Gastropoda as they lack diagnostic features to designate an order or family classification. Several specimens resemble the columella or central support within a gastropod shell.

Class Gastropoda "Morph A"
Plate 5: G-J

Material: Five siliceous internal molds of gastropod shells. [Specimens G, H, I, J]

Description: No shell material remains. These specimens are fragmentary to sub-intact internal molds with relatively flat body whorls, low apexes, and prominent apertures.

Discussion: These specimens lack diagnostic features to classify into an order. The body whorl appears flat with a low apex and spire, resembling *Gyrodes* in general shape

(Dockery, 1993, p. 135, Plate 20: Fig. 11-14) but lacking any diagnostic characteristics to assign to that genus definitively.

Class Gastropoda "Morph B"
Plate 6: A-E

Material: Twenty-one siliceous internal molds of gastropod shells. [Specimens A, B, C, D, E]

Description: No shell material remains. The upper whorl is missing on several specimens, with a prominent spire preserved on others. The parietal wall is rounded and nearly atop the aperture, with the body whorl rounding at a shoulder below the spire.

Discussion: These specimens lack shell material and diagnostic features required to assign an order classification. The morphology of the aperture extending below the main body whorl and the rounded shoulder preserved in the internal molds below the spire is most similar to shell morphology of *Anchura* (Dockery, 1993, p. 123, Plate 14: Fig. 2-7) but lack any diagnostic characteristics to identify succinctly.

Class Gastropoda "Morph C"
Plate 6: F-I

Material: Eleven siliceous internal molds of gastropod shells. [Specimens F, G, H, I]

Description: No shell material remains. The spire is visible and extends shortly above the body whorl. The aperture is elongate and closely conforms to the palatal wall of the body whorl. The apex does not extend far above the body whorl.

Discussion: These specimens lack shell material and any diagnostic features required to assign an order classification. The elongate aperture and low apex distinguish these specimens from Morphs A and B.

Class SCAPHOPODA Bronn, 1862
Order GADILIDA Starobogatov, 1974

Family GADILIDAE Stoliczka, 1868
Genus CADULUS Philippi, 1844

Cadulus sp.
Plate 7: A-E

Material: One hundred seventy-three internal molds of scaphopod shells with some shell material. [Specimens A, B, C, D, E]

Description: These specimens are predominantly tubular siliceous internal molds. Some original shell material is present, but it is heavily weathered and fragmentary. Tube morphology is straight to recurved and varies between either consistent thickness along the length of the tube fragments or conical variation from one thin end to one thick end.

Discussion: These specimens resemble the internal molds found in the Blufftown Formation assemblage attributed to *Hamulus* shells; however, there is a distinct lack of surficial undulation or any artifacts resembling Hamulus. These specimens are comparable to scaphopod shell material in the Cusseta Sand sample and are tubular in shape. Any shell material is heavily fragmented or worn if present. However, the intact shell pieces are white to pale beige and resemble that of *Cadulus*, lacking the smooth surficial texture often observed in *Cadulus* (Ozturk, 2011, p. 209, Fig. 10). *Cadulus obnutus* is present in the Chattahoochee region of Georgia (Veatch and Stephenson, 1911).

Blufftown Formation Vertebrates

Phylum CHORDATA Haeckel, 1874
Class ACTINOPTERI Cope, 1871

Order, Family, Gen. et sp. indet.
Plate 8: A-G

Material: Thirty-five fish vertebral fragments and one originally intact vertebra.

[Specimens A, B, C, D, E, F, G (1-3)]

Description: Most specimens are highly fragmented but exhibit typical fish vertebral characteristics such as defined longitudinal ridges and ringed centra. The centrum is hollow and extends the length of the vertebra. Several longitudinal ridges extend between the centra. The centra are marked with circular concentric rings. The complete specimen is circular and lacks neural or hemal arches.

Discussion: These specimens resemble an *Enchodus* vertebra published by Dockery (1992, Plate 10: Fig. 6). The fragmentary and incomplete nature of these vertebrae is not conducive to assigning a family or genus name. Specimen G was intact upon discovery, but it was fragmented and ultimately lost during imaging.

Cusseta Sand Invertebrates

Phylum FORAMINIFERA d'Orbigny, 1826
Class NODOSARITIA Mikhalevich, 1992
Order VAGINULINIDA Mikhalevich, 1993
Family VAGINULINIDAE Reuss, 1860
Genus ROBULUS Montfort, 1808

Robulus sp.
Plate 9: A-C

Material: One hundred seventy-two pristine to angularly fractured foraminifera. [Specimens A, B, C]

Description: The tests are closely coiled with triangular chambers and overlapping convexly shaped suture marks and aperture. The tests are translucent beige to tan in color. Fractured specimens appear angular and jagged along broken surfaces

Discussion: This is the only foraminifera genus occurring within the sample. Most specimens exhibit excellent preservational quality. These specimens are attributed to the genus *Robulus* based on the tightly coiled test, convex suture marks, and triangular chambers and aperture (Butler, 1962, p. 1366, Fig. 3).

Phylum MOLLUSCA Linnaeus, 1758
Class BIVALVIA Linnaeus, 1758
Order ARCIDA Stoliczka, 1871
Family GLYCYMERIDIDAE Dall, 1847

Gen. et sp. indet.
Plate 10: A-C

Material: Three shell fragments. [Specimens A, B, C]

Description: These specimens are fragmented to nearly complete valves. The umbo is nearly intact on two specimens. The shells are beige to tan and lack distinct growth rings. The shells are striated from the dorsal to ventral ends, with a distinctly raised arch on the dorsal side near the umbo.

Discussion: These specimens exhibit shell material, unlike previous samples from the Blufftown Formation. The arching dorsal side and longitudinal striations resemble the genus *Glycymeris* (Dockery, 2020, p. 61-62: Specimens B050, 2599, 2600, and 2601), but these specimens cannot be assigned below the family level due to fragmentation, resulting in the absence of any diagnostic shell features.

Order PHOLADIDA Lamarck, 1809
Family CORBULIDAE Lamarck, 1818
Genus CORBULA Bruguière, 1797

Corbula sp.
Plate 11: A-D

Material: Four intact to fractured shells. [Specimens A, B, C, D]

Description: These specimens all have intact umboes and dorsal portions of the valves. The shells are white with subtle growth lines radiating concentrically from the umbo. The shells are relatively symmetrical with the umbo tapering slightly to one side.

Discussion: The growth line and umbo morphology resemble *Corbula* specimens in Richards et al. (1958, Plate 43: Fig. 6-9). *Corbula* is present in Upper Cretaceous strata of the Chattahoochee region of Georgia (Veatch and Stephenson, 1911).

Order PECTINIDA Gray, 1854
Family ANOMIIDAE Rafinesque, 1815
Genus ANOMIA Linnaeus, 1758

Anomia argentaria Morton, 1833
Plate 12: A, B

Material: Two fractured shells. [Specimens A, B]

Description: These specimens are fragmented, but the umbo of one is preserved. The shells have a waxy to subvitreous luster and concentric growth lines radiating from the umbo. The shells progressively flatten toward the ventral ends.

Discussion: These shells are fractured with angular edges and have retained a glossy luster after fossilization. It is uncertain whether these specimens were fractured during excavation or diagenesis. The luster, growth lines, and rounded umbo morphology are comparable to *Anomia argentaria* specimens from the Coffee Sand of Mississippi (Dockery, 2020, p. 87: Specimens 2648 and 2649). This species is present in Upper Cretaceous strata of the Chattahoochee region of Georgia (Veatch and Stephenson, 1911).

Order TRIGONIIDA Lamarck, 1819
Family TRIGONIIDAE Lamarck, 1819
Genus TRIGONIA Bruguière, 1789

Trigonia sp.
Plate 13: A-C

Material: Five fractured shells broken near the umbo. [Specimens A, B, C]

Description: These specimens have a dull luster and are white to beige in color. The shells are fractured with subrounded to subangular edges. The umbo is intact on two specimens. The shells exhibit pronounced growth lines progressing away from the umbo.

Discussion: These shells are fractured but not extremely weathered. The lateral teeth near the umbo, the color, luster, and growth lines resemble *Trigonia* from the Coffee Sand of Mississippi (Dockery, 2020, p. 46: Specimens 2566 and 2567). These specimens also resemble *Pterotrigonia*; however, the *Trigonia* is recorded in Upper Cretaceous strata of the Chattahoochee region of Georgia by Veatch and Stephenson (1911), whereas *Pterotrigonia* is not.

Order OSTREIDA Férussac, 1822

Family, Gen. et sp. indet.
Plate 14: A-C

Material: Ten disarticulated oyster valves. [Specimens A, B, C]

Description: These specimens vary in color from gray to white with a dull luster. Growth lines are visible radiating concentrically from the umbo area. The edges are moderately worn, but the shells are overall intact.

Discussion: These are attributed to valves of unidentified oyster genera in Order Ostreida, lacking an articulated matching valve. Comparable oyster valves are found in Dockery (2020, p. 73-74: Specimens 2622 and 2623).

Family OSTREIDAE Rafinesque, 1815
Genus FLEMINGOSTREA Vredenburg, 1916

Flemingostrea sp.
Plate 15: A-E

Material: Five shell fragments. [Specimens A, B, C, D, E]

Description: These specimens are gray to beige in color, heavily fragmented, and subrounded to rounded on fractured surfaces. The overlapping growth lines seen on *Flemingostrea* (Sohl and Smith in Reinhardt and Gibson, 1980) are present, but heavily worn, on Specimen A on Plate 15.

Discussion: These shell fragments are assigned to *Flemingostrea* due to the overlapping step-like growth lines as seen on Specimen A. These lines are reduced to faint slits in the total shell due to weathering. The underside of Specimen A is comparable to the hinge seen on *Flemingostrea* in Sohl and Smith (in Reinhardt and Gibson, 1980, p. 393, Plate 1). The growth lines on Specimen C resemble the ventral side of a *Flemingostrea* shell. Specimens B-E are attributed to *Flemingostrea* based on uncanny similarity in color, composition, and degree of weathering to Specimen A.

Family GRYPHAEIDAE Vialov, 1936
Genus EXOGYRA Say, 1820
Exogyra ponderosa Roemer, 1852
E. ponderosa var. *erraticostata* Stephenson, 1914

Exogyra ponderosa var. *erraticostata*
Plate 16: A-C

Material: Five shell fragments. [Specimens A, B, C]

Description: These shells are heavily fragmented left valves preserving the beaks and umbos. Lateral growth lines are present with longitudinal ridges/undulations extending dorsoventrally. Shell material has a dull luster and is blue gray in color with delicate sheets of shell extending beyond some of the undulating growth lines.

Discussion: The coloration and growth lines of these shell fragments closely resemble that of *Exogyra*, notably *E. ponderosa* var. *erraticostata* (Dockery, 2020, p. 67: Specimen 2610a) due to the ornate growth lines with dorsoventral ridges. The presence of *E.*

ponderosa var. *erraticostata* has been reported in Cretaceous strata in the Chattahoochee region of Georgia (Veatch and Stephenson, 1911). These specimens are fragmented but exhibit excellent preservational quality of the shell material.

Class GASTROPODA Cuvier, 1795
Order LITTORINOMORPHA Golikov and Starobogatov, 1975
Family NATICIDAE Guilding, 1834
Genus GYRODES Conrad, 1860

Gyrodes sp.
Plate 17: A, B

Material: Three fragmented shell spires. [Specimens A, B]

Description: These specimens are fragmentary and vary from fair to poor preservational quality. Shell material is white with relatively flat body whorls and low apexes.

Discussion: Although fragmented, these specimens resemble the basic body format of *Gyrodes*, lacking a prominent spire and conforming to a generally flattened shell shape, comparable to specimens of *Gyrodes* found in the Coffee Sand (Dockery, 1993, p. 135, Plate 20: Fig. 11-12). These shells vary in completion, with Specimen A retaining some spire and whorl detail and Specimen B existing only in the general shape of a shell. Th *Gyrodes* is present in Coastal Plain deposits near the Chattahoochee River (Veatch and Stephenson, 1911).

Order SORBEOCONCHA Ponder and Lindberg, 1997
Family TURRITELLIDAE Lovén, 1847
Genus TURRITELLA Lamarck, 1799
Turritella quadrilira Johnson, 1898

Turritella quadrilira
Plate 17: C, D

Material: Two shell spire fragments. [Specimens C, D]

Description: These specimens are fragmentary portions of the shell spires. The whorls are lined with four spiral lirae along the length of the whorl. Shell material of Specimen C is relatively smooth with a glossy luster, but in Specimen D it is slightly dull and pitted. The aperture and apex are absent, but the spire fragments are conical and narrow.

Discussion: These specimens are attributed to the species *Turritella quadrilira* based on the slender, conical shell morphology with four prominent lirae along the whorl (Dockery, 1993, p. 111, Plate 8: Fig. 6-13). *Turritella quadrilira* is present in Cretaceous deposits near the Chattahoochee River (Veatch and Stephenson, 1911).

Order HETEROBRANCHIA Burmeister, 1837
Family AMPHITOMARIIDAE Bandel, 1994
Genus NEAMPHITOMARIA Bandel in Dockery, 1993

Neamphitomaria sp.
Plate 17: E

Material: One gastropod shell fragment. [Specimen E]

Description: This specimen is a fragment of a gastropod shell, displaying a depressed whorl. The shell is white with a glossy luster and minimal surficial pitting. The aperture is absent.

Discussion: The apex and spire visible on this specimen are depressed below the surface of the outermost whorl. The shell appears to be relatively flat and devoid of visible growth lines. Based on the flattened spiral surface, this specimen is attributed to the genus *Neamphitomaria* based on the descriptions from by Dockery from the Coffee Sand (1993, p. 165, Plate 35: Fig. 2, 5, 7).

Order, Family, Gen. et sp. indet.
Plate 18: A-E

Material: Five gastropod internal molds and one gastropod shell fragment. [Specimens A,B, C, D, E]

Description: Specimens A, B, C, E, and F are gastropod siliceous internal molds, bearing little to no original shell material. Specimens A-C are macrofossils up to 1.5 cm in length, whereas Specimens D-F are microfossils 1-2 mm in length. The shape of the shells are visible, but preservational quality is poor with the exception of Specimen D, which preserves the spire and apex, exhibiting excellent preservational quality. The shell width of Specimen D is equivalent in thickness to a strand of hair, and fine detail such as concave growth lines are present along the whorl. Specimens A, B, C, E, and F have little to no shell material and poorly preserved internal molds.

Discussion: These specimens vary greatly in preservational quality. The shell material of Specimen D is fragmented but extremely thin and delicate with well preserved surficial shell material, whereas Specimens A, B, C, E, and F retain little, if any, shell material. The internal molds are filled with a coarser and darker material than that of the Blufftown Formation gastropod internal molds.

Class SCAPHOPODA Bronn, 1862
Order GADILIDA Starobogatov, 1974
Family GADILIDAE Stoliczka, 1868
Genus CADULUS Philippi, 1844

Cadulus sp.
Plate 19: A-D

Material: Eight hundred thirty-nine shell fragments. [Specimens A, B, C, D]

Description: These specimens are all fragmentary shell material, often tubular and cylindrical in cross section. Shell material is white with a glossy to sub-glossy luster and minimal pitting present on some specimens. No intact shells were recovered, but some fragments exhibit nearly conical changes in thickness, tapering at one end. Most specimens are tubular fragments less than 1 mm in diameter.

Discussion: These shells are attributed to *Cadulus* based on the smooth shell texture, tubular morphology, and conical to bulbous variance in morphology (Ozturk, 2011, p. 209, Figure 10). *Cadulus obnutus* is present in the Chattahoochee region of Georgia (Veatch and Stephenson, 1911), and this shell material is comparable to the internal molds and shell fragments recovered from the Blufftown sample that are attributed to *Cadulus*. The *Cadulus* shells in the Blufftown Formation have undergone a more extreme degree of weathering than this Cusseta Sand sample, based on the smoothness and retention of shell material in the Cusseta.

Order DENTALIIDA Starobogatov, 1974
Family DENTALIIDAE Children, 1834
Genus DENTALIUM Linnaeus, 1758

Dentalium sp.
Plate 19: E-G

Material: Three shell fragments. [Specimens E, F, G]

Description: These specimens are fragmentary and tubular with preserved white shell material. The interior of the shells appear smooth and hollow, whereas the exteriors are faceted with longitudinal ridges. Specimens E and F are notably weathered and rounded, having lost most surficial features. Specimen G is of higher preservational quality and exhibits concentric growth lines propagating toward the aperture. The fractured edges of all three specimens are rounded.

Discussion: These specimens are identified as *Dentalium* based on the tubular interior and ridged facets along the length of the shells, described and illustrated by Boissevain

(1906, p. 79, Plate 1). *Dentalium* is present in the Upper Cretaceous deposits near the Chattahoochee River (Veatch and Stephenson, 1911).

Phylum ARTHROPODA von Siebold, 1848
Order PODOCOPIDA Sars, 1866
Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948
Genus BRACHYCYTHERE Alexander, 1933

Brachycythere rhomboidalis (Berry, 1925)
Plate 20: A-C

Material: Eighty-five articulated and disarticulated ostracod carapaces. [Specimens A, B, C]

Description: These specimens are predominantly articulated, with some disarticulated carapaces. The anterior and posterior ends of the carapace are flattened, with a bulbous ventrolateral keel. Shell material varies from beige to brown with a sub-glossy luster. Aside from the disarticulation of some specimens, these ostracods are largely devoid of weathering artifacts, extensive fracturing, or rounding.

Discussion: These ostracods are assigned to *Brachycythere rhomboidalis* based on the sub-oblate, bulbous protrusion located centrally on the carapace juxtaposed by flattened ends (Puckett et al., 2016, p. 118, Plate 5: Fig. 1-3).

Family CYTHERIDEIDAE Sars, 1925
Genus HAPLOCYTHERIDEA Stephenson, 1936

Haplocytheridea renfroensis Crane, 1965
Plate 20: D-F

Material: Twelve articulated and disarticulated ostracod carapaces. [Specimens D, E, F]

Description: These specimens are predominantly articulated, with some disarticulated carapaces. The posterior of the carapace is rounded and blunt. The carapace is pitted with fine pores, resulting in a dull luster. The carapace lacks any protruding morphological features on the face of the carapace.

Discussion: These ostracods are assigned to *Haplocytheridea renfroensis* based on the rounded posterior end, rather flat carapace surface, and pitted surface texture (Puckett, 1994, p. 1324, Figure 4: 2-6). These specimens are mostly intact; however, some specimens exhibit fracturing and rounding (Plate 20, D).

Cusseta Sand Vertebrates

Phylum CHORDATA Haeckel, 1874
Sub-Phylum VERTEBRATA Lamarck, 1801

Class, Order, Family, Gen. et sp. indet.
Plate 21: A-C

Material: Forty fragmented and unidentifiable vertebrate tooth fragments. [Specimens A, B, C]

Description: These specimens are fragments of phosphatic material likely originating from teeth. They are fragmented and weathered beyond identification. Most of these specimens have at least one smooth surface resembling tooth material. Most of these specimens have angular surfaces, such as Specimen B, whereas Specimens A and C exhibit fractured yet subangular to subrounded edges.

Discussion: The degree of weathering of these specimens is highly variable. Images of pristine vertebrate teeth specimens can be found in Case et al. (2001, p. 105, Plate 3).

Plate 22: A1, A2

Material: One phosphatic bone fragment. [Specimen A (1, 2)]

Description: This specimen is roughly 4 cm in length and well-rounded on all surfaces. The bone exhibits a porous texture that approximately follows the length of the specimen. The specimen lacks distinctly identifiable characteristics.

Discussion: The origin of this bone fragment is unknown, and the specimen is unidentifiable due to its state of preservation.

Class CHONDRICHTHYES Huxley, 1880

Order, Family, Gen. et sp. indet.
Plate 23: A-B

Material: Two shark vertebrae. [Specimens A (1-3), B (1-3)]

Description: These vertebrae exhibit a wide, shallow centrum and short ventral length. Some thick ventral ridges are present connecting the centra. These specimens exhibit fair preservational quality.

Discussion: They are assigned to Class Chondrichthyes based on the wide centrum in comparison to the shortened ventral length with thick supporting ridges, comparable to those of lamniform sharks from Texas in Frederickson et al. (2015, p. 6, Fig 4).

Superorder SELACHIMORPHA Nelson, 1984

Order, Family, Gen. et sp. indet.
Plate 24: 1a-2b, A-D

Material: Six tooth cusps. [Specimens 1 (a-b), 2 (a-b), A, B, C, D]

Description: These teeth lack intact roots. The crowns are present, but no cusplets are visible. The tip of the crown is slightly rounded, and all teeth recurve slightly in the distal plane.

Discussion: These specimens are shark teeth. Specimens 1 and 2 specifically resemble *Squatina* in morphology but lack the labial flange associated with the genus (Case and Schwimmer, 1988, p. 293, Fig. 4: 7-8, and see Plate 29, this report). The absence of an intact root prohibits a more detailed assignment.

Order ORECTOLOBIFORMES Applegate, 1972
Family GINGLYMOSTOMATIDAE Gill, 1862
Genus HYBODUS Agassiz, 1837

Hybodus sp.
Plate 25: 1a-3

Material: Two oral teeth and one cephalic spine fragment. [Specimens 1 (a-b), 2, (a-b), 3]

Description: Specimens 1 and 2 are deeply striated at the base of the crown, which tapers toward a rounded cusp. The teeth are wide in lateral view and recurve to the lingual side. Both teeth flange outward near the fractured roots. Specimen 3 is a fragmented cephalic spine/hook that is deeply striated toward the tip. The striations of the cephalic spine appear to rotate around the spine. The root structure is fractured but appears to have three lobes.

Discussion: These specimens are assigned to *Hybodus* due to the absence of cusplets, flanged basal crown, thick in lateral view, and lingual curvature (Case and Schwimmer, 1988, p. 293, Fig. 4: 1-2). The cephalic spine is comparable in morphology to those in Case (1987, p. 29, Fig. 4f) and Case and Cappetta (2004, p. 18, Plate 2: 1a), exhibiting a twisting striated pattern. Case and Schwimmer also note that *Hybodus* cephalic spines have a three-lobed root (1988).

Order LAMNIFORMES Berg, 1958
Family ANACORACIDAE Casier, 1947
Genus SQUALICORAX Whitley, 1939

Squalicorax ?*kaupi* (Agassiz, 1843)

Plate 26: A-D

Material: Thirty teeth and tooth fragments. [Specimens A, B, C, D]

Description: These teeth are prominently serrated along the edge of the crown and lack cusplets. The root is wide with prominent, rounded mesial and distal lobes. Transverse ridges are apparent at the base of the crown below the basal ledge. The teeth distinctly recurve distally, forming a serrated blade on the distal edge of the crown. In some specimens, the cusp extends beyond the mesial end of the root. Many of these specimens are intact and exhibit fair preservational quality.

Discussion: These teeth are assigned to *Squalicorax* ?*kaupi* based on the semicircular morphology of the mesial cusp edge (Case and Schwimmer, 1988, p. 293, Fig. 4: 17-20). These specimens are provisionally assigned to this species because the mesial cusp edge is not identifiable or present in many fragmentary specimens. Fractured specimens were identified based on the evenly serrated edge (Case and Schwimmer, 1988). The fractured specimens are angular on the broken edges.

Family MITSUKURINIDAE Jordan, 1898
Genus SCAPANORHYNCHUS Woodward, 1889

Scapanorhynchus texanus (Roemer, 1852)
Plate 27: A-F

Material: Eighty-seven teeth and tooth fragments. [Specimens A, B, C, D, E, F]

Description: These teeth exhibit steep, elongate root lobes, with a nutrient groove on a prominent central root protuberance. Most specimens have elongated, sharp crowns with some minor transverse ridges. Many teeth exhibit a slight recurve in the lateral plane. Some specimens have cusplets or exhibit a distal recurve. Specimens in this sample range from 2 mm to 3 cm in length. Approximately half of the specimens are intact. Most of the fragmented specimens are angular to subangular on the fractured surfaces.

Discussion: Teeth from this species are common in Late Cretaceous strata and widely variable in morphology depending on mouth position (Case and Schwimmer, 1988). These specimens are identified based on the elongate root structures and bladelike crown morphology (Case and Schwimmer, 1988, p. 293, Fig. 4: 21-26).

Family OTODONTIDAE Gluckman, 1964
Genus CRETALAMNA Glikman, 1958

Cretalamna appendiculata Agassiz, 1843
Plate 28: 1a-4b

Material: Six shark teeth. [Specimens 1 (a-b), 2 (a-b), 3 (a-b), 4 (a-b)]

Description: These specimens are generally short with rounded to sharp tips. The teeth recurve distally, accompanied by small, generally rounded cusplets. The root is short and broad, with widely shouldered root lobes and a small nutrient groove. These teeth are predominantly intact with some wear on the roots.

Discussion: These specimens are assigned to *Cretalamna appendiculata* based on the distal recurve, triangular tooth shape, cusplets, and short yet broad root (Case and Schwimmer, 1988). Comparable specimens can be found in Case et al. (2001, p. 105, Plate 3: 57-58).

Order SQUATINIFORMES Buen, 1926
Family SQUATINIDAE Bonaparte, 1838
Genus SQUATINA Duméril, 1806

Squatina sp.
Plate 29

Material: One tooth. [Specimen 1]

Description: This specimen lacks any root structure. The crown is symmetrical, flanging laterally from the root and tapering toward the cusp. The tooth exhibits a labial flange that extends below the base of the root. The tooth is surficially smooth and lacks serrations. The root has been fragmented from the specimen, but the crown exhibits fair preservational quality.

Discussion: This tooth is assigned to *Squatina* based on the symmetrical morphology, the low crown profile above the root, and the labial flange (Case and Schwimmer, 1988; Case et al., 2001). This specimen was lost during photography before the labial view could be recorded. Comparable specimens can be found in Case et al. (2001, p. 103, Plate 1: 13-16).

Order RAJIFORMES Berg, 1940
Family SCLERORHYNCHIDAE Cappetta, 1974
Genus ISCHYRHIZA Leidy, 1856

Ischyrhiza mira Leidy, 1856
Plate 30: 1a-4c

Material: Three oral teeth and three rostral tooth fragments. [Specimens 1 (a-b), 2 (a-b), 3 (a-b), 4 (a-c)]

Description: The oral teeth exhibit exceptional preservational quality and range in size from 0.5 to 3 mm across. The root is comprised of two flat, triangular lobes. The crown is pyramidal in shape and recurves distally. The cusp is sharp and tapers from a wide base. The labial flange is prominent. The rostral teeth are fragmentary and subrounded on the edges, but portions of the crown and root are present on all specimens. The crown and basal root are relatively smooth, with a distinct saddle.

Discussion: The oral teeth are assigned to *Ischyrhiza mira* based on the pyramidal morphology, recurve, and root structure (Case and Schwimmer, 1988). The rostral teeth are assigned to *I. mira* due to the smoothness of the crown base, defined saddle, and smooth, tapered root (Case et al., 2001, Plate 6: 126-132).

Genus BORODINOPRISTIS Case, 1987

?*Borodinopristis* sp.
Plate 30: 5

<u>Material</u>: One rostral tooth root. [Specimen 5]

<u>Description</u>: This specimen lacks most of the rostral tooth crown. The root structure is conical and smooth with four distinct lobes extending symmetrically from the root base. The crown is weathered but not distinctly fractured.

<u>Discussion</u>: This tooth is assigned to the genus Borodinopristis based on the four basal lobes on a conical root, resembling a heavily weathered *B. schwimmeri* root (Case, 1987, p. 27, Fig. 2d-f).

Genus PTYCHOTRYGON Jaekel, 1894

Ptychotrygon vermiculata Cappetta, 1975
Plate 31: A-C

<u>Material</u>: Three tooth fragments. [Specimens A, B, C]

<u>Description</u>: These specimens are fragmentary. Specimens A and B are occlusal surfaces with prominent undulations in the tooth crown. The roots and basal portions of the teeth are absent in specimens A and B. Specimen C is a lingual fragment broken cleanly before the crest of the crown with two distinct root lobes.

<u>Discussion</u>: These teeth are assigned to *Ptychotrygon vermiculata* based on the undulations on the crown of the teeth, lingual protrusion, and two distinct root lobe structures (Case and Schwimmer, 1988, p. 296, Fig. 5: 21-24).

Order MYLIOBATIFORMES Compagno, 1973
Family MYLIOBATIDAE Bonaparte, 1838

Genus PSEUDOHYPOLOPHUS Cappetta and Case, 1975

Pseudohypolophus sp.
Plate 32: 1a-3c

Material: Three oral teeth. [Specimens 1 (a-c), 2 (a-c), 3 (a-c)]

Description: These teeth are nearly intact but lacking some root structure. The teeth are hexagonal and rounded, with variable degrees of crown wear between the specimens. Specimen 2 exhibits the greatest degree of crown wear. Specimen 3 has the lowest degree of crown wear. The surficial enamel on the crown is smooth and lacks prominent features. Two roots appear to have been present. The teeth exhibit variance in thickness of the crown.

Discussion: These teeth are assigned to *Pseudohypolophus* based on the rounded hexagonal morphology, smooth crown surface, and bilobed root structure (Case and Schwimmer, 1988, p. 298, Fig. 6: 1-5).

Family RHOMBODONTIDAE
Genus RHOMBODUS Dames, 1881

Rhombodus laevis Cappetta and Case, 1975
Plate 33: 1a-2c

Material: Two oral teeth. [Specimen 1 (a-c), 2 (a-c)]

Description: These teeth exhibit rhomboidal morphology in occlusal or basal view, with a slightly raised peak on the lingual edge. The teeth are thick and taper slightly from the crest of the crown to the root. The root structures are fragmented, but two root lobes are visible. The crown surfaces of both teeth are heavily pitted, much more than the sides of the enamel, which exhibit some abrasion.

Discussion: These teeth are assigned to *Rhombodus laevis* based on the rhomboidal shape, thick enamel, bilobed root, and lingual edge (Case and Schwimmer, 1988, p. 298, Fig. 6: 6-9).

Class ACTINOPTERI Cope, 1871

Order, Family, Gen. et sp. indet.
Plate 34: A-F, 1-3; Plate 35

Material: Fifty-five vertebral fragments and one quadrate bone fragment. [Specimens A, B, C, D, E, F, 1 (a-b), 2 (a-b), 3 (a-b)]

Description: The degree of fragmentation is highly variable across the vertebrae. A majority of the microfossils in this sample resemble Specimens A-F in size and degree of abrasion. Few specimens retain intact, identifiable features. Some longitudinal ridges are visible, as well as growth rings on the centra. Specimen 1 is the most complete of this sample, exhibiting a distinct centrum with growth lines and some preserved longitudinal ridges. The quadrate bone is fragmented and lightly abraded but overall maintains a fair preservational quality. The prominent edges of this specimen are subrounded. Most of these fragments, especially the microfossils, are angular on the broken surfaces.

Discussion: These specimens resemble vertebrae of osteichthyes, such as the *Enchodus* vertebra presented by Dockery (1992, p. 39, Plate 2: Fig. 6). The elongate structure of the vertebral fragments does not resemble the compressed nature of Chondrichthyes vertebrae (Frederickson et al., 2015). The quadrate bone is most similar to an articulated icthyodectiform skull in Berrell et al. (2014, p. 907, Fig. 3).

Order LEPISOSTEIFORMES Hay, 1929
Family LEPISOSTEIDAE Bonaparte, 1838
Genus LEPISOSTEUS Lacepede, 1803

Lepisosteus sp.

Plate 36: 1-3b, A, B

Material: Two oral teeth and two ganoine scales. [Specimens 1 (a-c), A, B]

Description: Specimens 1 and 2 are enameled, smooth tooth crown fragments with some remaining root structure. Specimen 1 terminates at a subrounded tip, whereas 2 terminates at a broadly rounded tip. Specimen 2 exhibits a hollow root structure. Specimens A and B are ganoine scales, ranging from 0.5 to 1 cm in length. The scales are rhomboidally shaped and adorned with a wood-like surficial texture containing small, undulating growth lines.

Discussion: These teeth are attributed to *Lepisosteus* based on the crown morphologies described by Case and Schwimmer (1988, p. 298, Fig. 6: 10-11). Specimen 3 is most comparable to Case and Schwimmer's Specimen 11 on Figure 6 (1988). The surficial texture and rhomboidal shape of the scales are diagnostic features (Dockery, 1992).

Order PYCNODONTIFORMES Berg, 1937

Family, Gen. et sp. indet.
Plate 37: 1-3

Material: Three oral teeth. [Specimens 1 (a-b), 2 (a-c), 3 (a-c)]

Description: Specimen 1 has a distinct hollow root structure and flat, smooth crown pavement separated from the root. Specimen 2 is fractured and well rounded, with a presumed socketed root with pitted texture on the base of the tooth. The crown surface is porous enamel, lacks distinguishable characteristics, and is noticeably rounded on the broken edge. Specimen 3 has a defined rounded, triangular, enamel tooth crown with a shouldered, socketed base but lacks identifiable characteristics.

Discussion: These teeth are most similar to Order Pycnodontiformes due to the socketed root area, as seen in *Anomoeodus* (Case and Schwimmer, 1988, p. 298, Fig. 6: 12-16).

Specimens 1 and 3 are more easily recognized as teeth than Specimen 2, which is very poorly preserved and rounded.

Family PYCNODONTIDAE Agassiz, 1835
Genus ANOMOEODUS Forir, 1888

Anomoeodus phaseolus (Hay, 1899)
Plate 38: A

Material: One oral tooth. [Specimens A (1-3)]

Description: This specimen has a socketed root and enamel crown. The tooth morphology is trapezoidal in occlusal and basal views with a rounded crown. The center of the crown contains a depresses divot that conforms to the outline of the crown. The tooth is of fair preservational quality, exhibiting some surficial pitting on the crown enamel.

Discussion: This tooth resembles a tooth cap from a pycnodontid fish, most comparable to *Anomoeodus* (Case and Schwimmer, 1988, p. 298, Fig. 6: 12-16). The elongate, flattened shape, central depression, and concave socketed root area closely resemble the spelinal tooth cap of *Anomoeodus phaseolus* in Case and Schwimmer (1988).

Order ALBULIFORMES Greenwood et al., 1966
Family ALBULIDAE Cope, 1871
Genus ALBULA Bloch and Schneider, 1801

Albula sp.
Plate 39: A

Material: One oral tooth. [Specimen A (1-3)]

Description: This specimen is a circular, solitary tooth cap with a socketed root area. The tooth exhibits a circular ridge halfway between the root and tip of the crown that shoulders below the domed upper crown. The crown of the tooth is fragmented and rounded, and the surface of the crown is smooth.

Discussion: This specimen is assigned to *Albula* based on the circular ornamentation around the crown, smooth crown surface, and missing root structure (Case and Schwimmer, 1988, p. 298, Fig. 6: 19-20).

Order AMIIFORMES Hay, 1929
Family DORYPTERIDAE Cope, 1877
Genus ENCHODUS Boulenger, 1898

*Enchodus s*p.
Plate 40: 1, A-F

Material: Two vertebrae and six teeth. [Specimens 1 (a-b), A, B, C, D, E, F]

Description: The vertebrae are roughly 1 mm in diameter with a distinct centrum and longitudinal ridges. Specimen 1 exhibits some artifacts resembling neural arch attachments. Concentric growth lines are visible in the centra. The teeth are elongate and medially flattened, some with a distinct edge. The teeth are generally straight, recurving distally at the base of the crown (Plate 40, Specimen E). The teeth taper toward the apex.

Discussion: The vertebrae are assigned to the genus *Enchodus* based on a similar morphology in Dockery (1992, p. 39, Plate 2: Fig. 6), notably the presence of a fractured neural arch attachment. The teeth are comparable to specimens in Case and Schwimmer (1988, p. 298, Fig. 6:23-26), especially in the straight basal area that recurves and tapers distally.

Order TETRAODONTIFORMES Berg, 1940
Family TRIGONODONTIDAE Weiler, 1929
Genus STEPHANODUS Zittel, 1883

?*Stephanodus* sp.
Plate 41

Material: One pharyngeal tooth. [Specimen 1]

Description: This specimen has a translucent, flattened, recurved, triangular crown that terminates before the distal-most section of the tooth. The root structure is fragmented and unrecognizable. Several edges of the tooth are rounded.

Discussion: This tooth is of comparable morphology to a tooth in Case and Schwimmer (1988, p. 298, Fig. 6: 28). The provisional designation to *Stephanodus* is based on Case and Schwimmer's classification, although similar teeth have been attributed to pycnodontid and sclerodontid fish (1988).

Class REPTILIA Laurenti, 1768
Order TESTUDINES Batsch, 1788
Family TRIONYCHIDAE Gray, 1825
Genus TRIONYX Geoffroy Saint-Hilaire, 1809

Trionyx sp.
Plate 42: 1-2

Material: Nine bony turtle shell fragments. [Specimen 1 (a-b), 2 (a-b)]

Description: These specimens exhibit one smooth, platy interior face and a speckle-textured outer face. Most fragments conform to a polyhedral shape. Fractured surfaces are subangular to subrounded.

Discussion: The ornamented exterior surfaces of these specimens is indicative of a trionychid turtle (Dockery, 1992) These specimens are most comparable to a specimen in Dockery (1992, p. 39, Plate 10, Fig. 7). The presence of *Trionyx* is recorded at Hannahatchee Creek (Schwimmer, 1986).

Order CROCODILIA
Superfamily ALLIGATOROIDEA Gray, 1844
Genus DEINOSUCHUS Holland, 1909

Deinosuchus sp.
Plate 43: 1

Material: One tooth. [Specimen 1 (a-b)]

Description: This specimen is approximately 8 mm wide by 12 mm long, with a circular, socketed root encircled by the crown enamel at the base. The enamel is faintly striated from base to tip and is subrounded on fractured surfaces. The morphology is circular in basal view and lacks a defined edge with an overall conical shape and ablated tip.

Discussion: This tooth is comparable to those in Schwimmer (in Milan et al., 2010, p. 184, Fig. 2) in the Blufftown Formation based on the conical profile, shallow taper, and socketed root.

Superfamily GAVIALOIDEA Brochu, 1997
Genus ?THORACOSAURUS Leidy, 1852

?*Thoracosaurus* sp.
Plate 43: 2

Material: One tooth. [Specimen 2 (a-c)]

Description: This specimen is circular in basal view and cross section. The tooth is conical, recurved on the lingual side, and tapers toward the occlusal surface, although the tip is broken. The tooth is likely socketed as all root structure is absent. The cusp is surficially striated/faceted along the length of the crown but lacks any distinct edge.

Discussion: This tooth is provisionally designated as *Thoracosaurus* sp. based on the sharp, conical morphology and circular cross section. The socketed root resembles a crocodilian (Dockery, 1992, p. 43, Plate 12, Fig. 5). The specimen is striated/faceted much like mosasaur teeth (Dockery, 1992, p. 41, Plate 11, Fig. 1-4); however, there is no defined edge. Dockery (1992) indicates that *Thoracosaurus* teeth are not recurved; however, others (Erickson, 1998, p. 203, Fig. 3) figure specimens that do exhibit curvature.

Order SQUAMATA Oppel, 1811
Family MOSASAURIDAE Gervais, 1852

Gen. et sp. indet.
Plate 44

Material: One tooth fragment. [Specimen 1]

Description: This specimen is a single tooth fragment preserving a portion of the enamel crown. No root structure is preserved, and the fractured surfaces are subangular. The tooth is faceted on the surface and is roughly 1 cm in length.

Discussion: This specimen is assigned to Family Mosasauridae primarily based on the faceted crown surface indicative of mosasaurs (Dockery, 1992, p. 41, Plate 11, Fig. 1-4). The fragment is comparable in size to several other enamel tooth fragments in this sample (Plate 21).

CHAPTER V: RESULTS

Although the same amount of concentrate (294 g) was sorted from each bed, the fossil composition varied significantly in quantity (Fig. 11, Tables 1-3), diversity (Fig. 12, Tables 1-3), and quality of preservation. Including fragmentary samples, the Cusseta Sand yielded 1,389 specimens, and the Blufftown Formation yielded 362 specimens from the 294 g of total concentrate processed from each unit. The Cusseta Sand produced 383% more fossils than the Blufftown Formation from weight-equivalent samples. The Cusseta Sand produced 1,157 invertebrate specimens and 232 vertebrate specimens, and the Blufftown Formation produced 326 invertebrate specimens and 36 vertebrate specimens (Fig. 11). The majority of specimens in both samples were invertebrates. Eighty-three percent of the Cusseta specimens were invertebrates, compared to 90% from the Blufftown Formation.

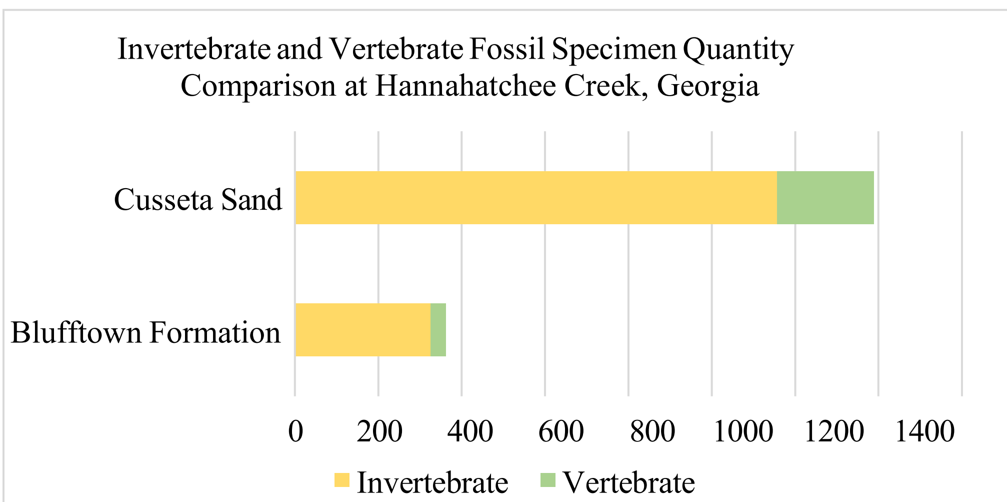

Figure 11. *Histograms showing the total fossil specimens and ratio of invertebrate to vertebrate specimens recovered from 294 g samples of the Cusseta Sand and Blufftown Formation at Hannahatchee Creek, Georgia.*

Scaphopod shell fragments inflated the sample quantities, constituting approximately 61% of the specimens from the Cusseta sample and 48% from the Blufftown sample (Figure 12).

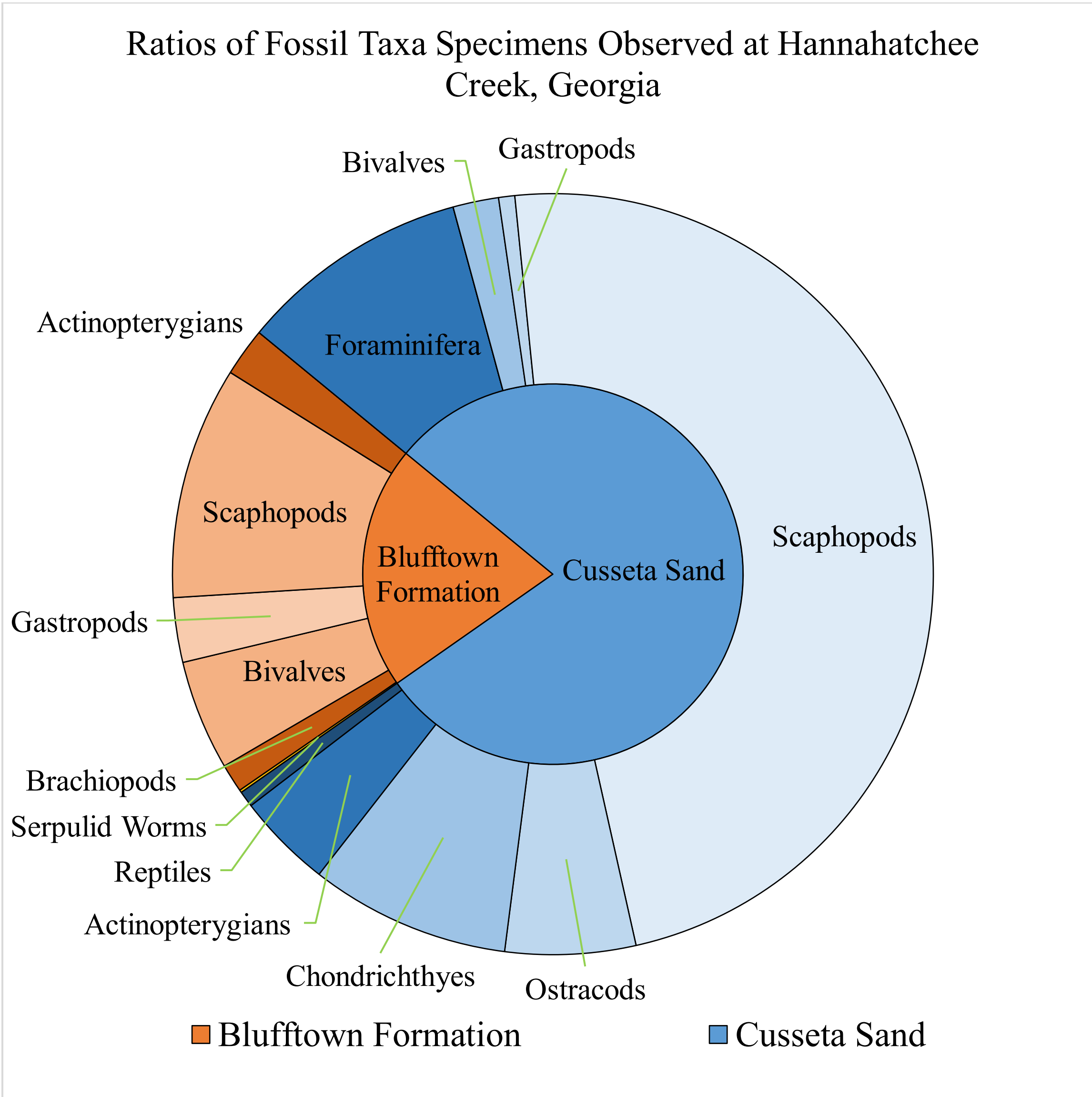

Figure 12. *Pie diagram showing the total fossil specimens recovered from 294 g concentrate samples from the Cusseta Sand and Blufftown Formation (inner circle) and ratios of each fossil taxa comprising each sample (outer circle). The Cusseta Sand is presented in blue, and the Blufftown Formation is presented in orange.*

Shell material in the Cusseta Sand varied from fair (Plate 16) to poor (Plate 15) quality on bivalve specimens. Three macrofossil gastropods recovered from the Cusseta (Plate 18: A-C) were internal molds lacking most or all shell material; these specimens were outliers when considering shell preservation quality in the Cusseta Sand. All shells in the Cusseta exhibited some degree of weathering, evidenced by shell fragmentation and pitting. Little to no shell material was preserved in the upper Blufftown Formation, and most specimens existed only as internal molds (Plates 1, 3, 4, 5 and 6). Shell material present in the Blufftown Formation was heavily fragmented and pitted (Plates 4 and 7). Lingulid brachiopod shell fragments from the Blufftown were the only specimens from this sample to retain identifiable surficial details and luster (Plate 2). Unidentifiable bulk shell hash was not quantified due to the brittle nature of fossil shells and because several fragments could result from the same source shell. However, shell hash was generally more intact, larger, and more abundant in the Cusseta Sand than in the Blufftown Formation. The serpulid worm *Hamulus* and lingulid brachiopods were found only in the Blufftown Formation.

Vertebrate material was more abundant and better preserved in the Cusseta Sand than in the Blufftown Formation. From the Blufftown sample, only vertebral fragments of unidentifiable osteichthyan fishes and one intact osteichthyan vertebra were recovered (Plate 8). Vertebrae from the Cusseta sample generally exhibited better preservational quality (Plate 34; Plate 40: 1a, 1b). Vertebrate teeth were abundant in the Cusseta sample, ranging in preservational quality from heavily worn (Plate 30: 4a-5; Plate 40: A-F) to fair (Plate 26: A, B; Plate 28). Fragmented teeth ranged in degree of rounding from rounded (Plate 37: 2a-2c; Plate 43: 1a, 1b) to angular (Plate 26: C, D).

The Cusseta Sand (Tables 1 and 2) exhibited much higher taxonomic diversity than the Blufftown Formation (Table 3). Fourteen invertebrate families and 22 vertebrate families were identified from the Cusseta sample. Eight invertebrate families and one vertebrate family were identified from the Blufftown sample. The only direct overlap of identified taxa observed between the two samples was the presence of the scaphopod *Cadulus*.

Table 1. *Invertebrate Faunal Composition and Quantification from a 294 g Concentrate Sample of the Basal Cusseta Sand at Hannahatchee Creek, Georgia.*

Cusseta Sand: Invertebrates				
Class	Family	Genus	Species	Quantity
Nodosariata	Vaginulinidae	*Robulus*	sp.	172
Bivalvia	Glycymerididae			3
Bivalvia	Corbulidae	*Corbula*	sp.	4
Bivalvia	Anomiidae	*Anomia*	*argentaria*	2
Bivalvia	Trigoniidae	*Trigonia*	sp.	5
Bivalvia				10
Bivalvia	Ostreidae	*Flemingostrea*	sp.	5
Bivalvia	Gryphaeidae	*Exogyra*	*?ponderosa erraticostata*	5
Gastropoda				6
Gastropoda	Naticidae	*Gyrodes*	sp.	3
Gastropoda	Turritellidae	*Turritella*	*quadrilira*	2
Gastropoda	Amphitomariidae	*?Neamphitomaria*	sp.	1
Scaphopoda	Gadilidae	*Cadulus*	sp.	839
Scaphopoda	Dentaliidae	*Dentalium*	*ripleyanum*	3
Ostracoda	Trachyleberididae	*Brachycythere*	*rhomboidalis*	85
Ostracoda	Cytherideidae	*Haplocytheridea*	*renfroensis*	12

Table 2. *Vertebrate Faunal Composition and Quantification from a 294 g Concentrate Sample of the Basal Cusseta Sand at Hannahatchee Creek, Georgia.*

Cusseta Sand: Vertebrates				
Class	Family	Genus	Species	Quantity
			(teeth fragments)	40
			bone fragment	1
Chondrichthyes			(vertebrae)	2
Chondrichthyes				6
Chondrichthyes	Ginglymostomatidae	*Hybodus*	sp. (teeth)	2
Chondrichthyes	Anacoracidae	*Squalicorax*	*?kaupi*	30
Chondrichthyes	Mitsukurinidae	*Scapanorhynchus*	*texanus*	87
Chondrichthyes	Otodontidae	*Cretalamna*	*appendiculata*	6
Chondrichthyes	Squatinidae	*Squatina*	sp.	1
Chondrichthyes	Sclerorhynchidae	*Ischyrhiza*	*mira (oral)*	3
Chondrichthyes	Sclerorhynchidae	*Ischyrhiza*	*mira (rostral)*	3
Chondrichthyes	Sclerorhynchidae	*?Borodinopristis*	sp.	1
Chondrichthyes	Sclerorhynchidae	*Ptychotrygon*	*vermiculata*	3
Chondrichthyes	Myliobatidae	*Pseudohypolophus*	sp.	3
Chondrichthyes	Rhombodontidae	*Rhombodus*	*laevis*	2
Actinopteri			(vertebrae)	55
Actinopteri			(quadrate)	1
Actinopteri	Lepisosteidae	*Lepisosteus*	sp. (teeth)	2
Actinopteri	Lepisosteidae	*Lepisosteus*	sp. (scales)	2
Actinopteri	Pycnodontidae	*Anomoeodus*	*phaseolus*	1
Actinopteri	Albulidae	*Albula*	sp.	1
Actinopteri	Dorypteridae	*Enchodus*	sp. (vertebrae)	2
Actinopteri	Dorypteridae	*Enchodus*	sp. (teeth)	6
Actinopteri	Trigonodontidae	*?Stephanodus*	sp.	1
Reptilia	Trionychidae	*Trionyx*	sp.	9
Reptilia	Alligatoroidea (super)	*Deinosuchus*	sp.	1
Reptilia	Gavialoidea (super)	*?Thoracosaurus*	sp.	1
Reptilia	Mosasauridae			1

Table 3. *Faunal Composition and Quantification from a 294 g Concentrate Sample of the Upper Blufftown Formation at Hannahatchee Creek, Georgia.*

Blufftown Formation: Invertebrates				
Class	Family	Genus	Species	Quantity
Polychaeta	Serpulidae	*Hamulus*	sp.	2
Lingulata	Lingulidae	*Lingula*	sp.	21
Bivalvia			(internal molds)	80
Bivalvia	Nuculidae			2
Gastropoda				10
Gastropoda			"Morph A"	5
Gastropoda			"Morph B"	21
Gastropoda			"Morph C"	1
Gastropoda	Conidae			11
Scaphopoda	Gadilidae	*Cadulus*	sp.	173
Blufftown Formation: Vertebrates				
Actinopteri			(vertebral fragments)	36

CHAPTER VI: DISCUSSION

The degree of weathering on the Blufftown Formation specimens is much more extensive than on most of the Cusseta Sand specimens. Fossils in the Blufftown sample are consistently heavily abraded and weathered, and one intact specimen, an osteichthyan vertebra, was recovered from the upper Blufftown Formation. On the few specimens preserving at least some shell material, nearly all of it is heavily abraded and fractured, and most of the fossil assemblage is represented by siliceous internal molds of bivalve and gastropod shells.

The Cusseta Sand fossil assemblage is variable in preservation quality. The sample contains a mix of intact to fragmented and angular to rounded specimens, indicating variable degrees of weathering. Shell material of bivalves and gastropods is often fractured but preserved in the Cusseta, unlike the specimens from the Blufftown assemblage which are almost exclusively comprised of internal molds. Some gastropods from the Cusseta Sand resemble the internal molds that lack shell material found in the Blufftown; however, the sediment comprising the Blufftown internal molds is a fine, gray, siliceous clay, whereas the Cusseta gastropod internal molds are coarser grained and darker in color. Fragile and fragmented gastropod shell material was also found in the Cusseta sample in addition to the internal molds, unlike in the Blufftown assemblage. This indicates that material in the basal Cusseta Sand is generally better preserved and typically exhibits lower degrees of weathering compared to the Blufftown fossil assemblage, but there is substantial variability in the degree of weathering on some Cusseta specimens.

Case and Schwimmer (1988) proposed that the fossil bed overlying the unconformity at Hannahatchee Creek is a mixture of fossil material original to the Cusseta Sand plus material from the underlying Blufftown Formation that has been reworked and incorporated into the Cusseta Sand. While the degree of weathering of Cusseta specimens is highly variable, this alone does not necessarily indicate reworking. A large, heavily weathered bone fragment (Plate 22) observed in the Cusseta Sand is an outlier in the sample; it is apparent this fragment originated from a larger section of bone. A fragment of such a large bone is not expected to be found in a nearshore depositional environment like the Cusseta Sand. The presence of this specimen in the Cusseta could be explained by (1) long-distance transport from a terrestrial source, (2) transport from another marine location, or (3) by reworking from the underlying Blufftown Formation. No comparable specimens were observed in the Blufftown sample, and the only direct overlap of taxa common to both the Cusseta and Blufftown assemblages is the scaphopod *Cadulus*. Therefore, it is more likely that the bone fragment originates from terrestrial or marine transport and was heavily weathered upon deposition in the Cusseta Sand, rather than being reworked from the Blufftown Formation.

If fossils were reworked from the Blufftown and deposited in the Cusseta, some congruency between the two fossil assemblages is expected. However, the basal Cusseta Sand contains a much more diverse fossil assemblage than the Blufftown Formation, and the only overlap of genera observed is the presence of *Cadulus*. Both layers include gastropods (Plates 6, 18) and actinopterygians (Plates 8, 34-35) that might be common to both, but because diagnostic characters were not preserved, they could not be identified to the generic level. The preservational quality of Blufftown specimens is consistently poor. If this material were reworked, the preservational quality would be significantly worse, or perhaps it would not be preserved at all. No comparable specimens were observed between the two units, except for a minor component of unidentifiable molluscs and fish vertebrae and *Cadulus* shell material. Furthermore, *Cadulus* shells in the Cusseta (Plate 19: A-D) are less weathered and better preserved than those found in the Blufftown assemblage (Plate 7), which is not indicative of reworking. It should be noted that the sample size of this study is extremely limited (294 g of concentrate per stratum as well as any visible macrofossils recovered from the bulk matrix), so these interpretations are preliminary and reflect only a small component of both units observed.

The presence of reef building oysters in the basal Cusseta Sand at Hannahatchee Creek may contribute to the higher diversity of the Cusseta sample. Modern oyster reefs provide the basis for diverse marine habitats in shallow water environments (Harding and Mann, 2001; Luckenbach et al., 2005). The notably higher diversity found in the basal Cusseta Sand may relate to the reported abundance of shell material (Eargle, 1955) and the occurrence of a *Crassostrea cusseta* oyster bioherm in the same stratigraphic horizon at Hannahatchee Creek (Schwimmer, 1986). The reef building oysters may have provided a habitat for other molluscs and small fish (Harding and Mann, 2001; Luckenbach et al., 2005), which would in turn likely attract larger predatory animals such as sharks or crocodilians.

Given the discrepancy in quality of preservation and trends of weathering observed between the Cusseta Sand and Blufftown Formation, it is possible that fossils in the bed occurring above the Blufftown-Cusseta contact originate from the oyster assemblages providing a habitat for a diverse array of fauna. If fossil material in the

Cusseta is attributed to a lag deposit of reworked Blufftown Formation fauna (Schwimmer, 1986; Case and Schwimmer, 1988), then fossils comparable to and more heavily weathered than those of the Blufftown assemblage could be expected in the Cusseta fossil bed. The Cusseta Sand was deposited during a period of regression (Schwimmer, 1986), indicating a shallower facies than the underlying Blufftown Formation. Fauna associated with shallower water environments than those found in the Blufftown would also be expected in the Cusseta Sand. However, most specimens in the Cusseta sample are better preserved, exhibit lesser degrees of weathering, and are comparably larger than those in the Blufftown Formation. Based on these observations, it is more likely that most of the fossil material in the basal Cusseta Sand fossil bed is original to the Cusseta and does not include reworked material from the Blufftown Formation.

CHAPTER VII: CONCLUSIONS

At the Hannahatchee Creek locality, fossil material in the basal Cusseta Sand consistently exhibits better preservational quality and lower degrees of weathering than fossils recovered from the Blufftown Formation, and the Cusseta Sand assemblage is much more diverse than that of the Blufftown. Thirty-six taxonomic families are identified from the Cusseta Sand compared to nine families from the Blufftown Formation, and the scaphopod *Cadulus* is the only genus observed in both units.

The Cusseta Sand sample exhibits variability in weathering, containing complete specimens with little abrasion, intact shell material, fractured and rounded specimens, and heavily weathered gastropod internal molds lacking shell material. A large, heavily rounded and weathered bone fragment was found in the Cusseta sample. This specimen likely did not originate from the Blufftown Formation due to discrepancies in size and degree of weathering compared to the Blufftown vertebrate fossil assemblage. The fragment is more heavily weathered and larger than any vertebrate specimens in the Cusseta or Blufftown samples, and it is suggested that the bone underwent a significant degree of weathering from wave action or transport before deposition in the Cusseta Sand. There is little evidence to suggest this specimen results from reworking of the Blufftown Formation at Hannahatchee Creek. *Cadulus* shell fragments were observed in both units, but the specimens in the Blufftown sample are much more heavily weathered than specimens recovered from the Cusseta, which does not support the reworking hypothesis.

The oyster reef noted by Schwimmer (1986; pers. comm.) at the Hannahatchee Creek outcrop in the same stratigraphic horizon as the fossil bed under investigation likely provided a habitat for a variety of fauna. This could explain the abundance of vertebrate material observed at the Blufftown-Cusseta contact. Although the degree of weathering on some Cusseta specimens could be explained by reworking, no direct overlap of fossil taxa was observed between the Cusseta and Blufftown samples. The higher diversity and consistently better preservational quality observed in the basal Cusseta assemblage is incomparable to the specimens observed in the upper Blufftown Formation, indicating most observed fauna could be original to the Cusseta, inhabiting the oyster reefs or transported from other locations like the large bone fragment (Plate 22).

APPENDIX A: FOSSIL PLATES

Plate 1
A, B: ?*Hamulus* sp. internal molds.
Scale bar represents 5 mm.

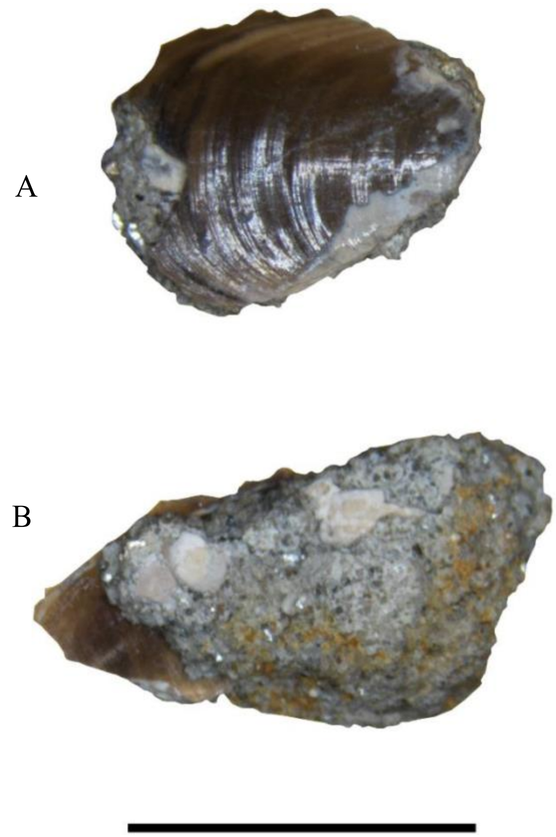

Plate 2
A, B: Brachiopod shell material from the Family Lingulidae in lateral view.
Scale bar represents 5 mm.

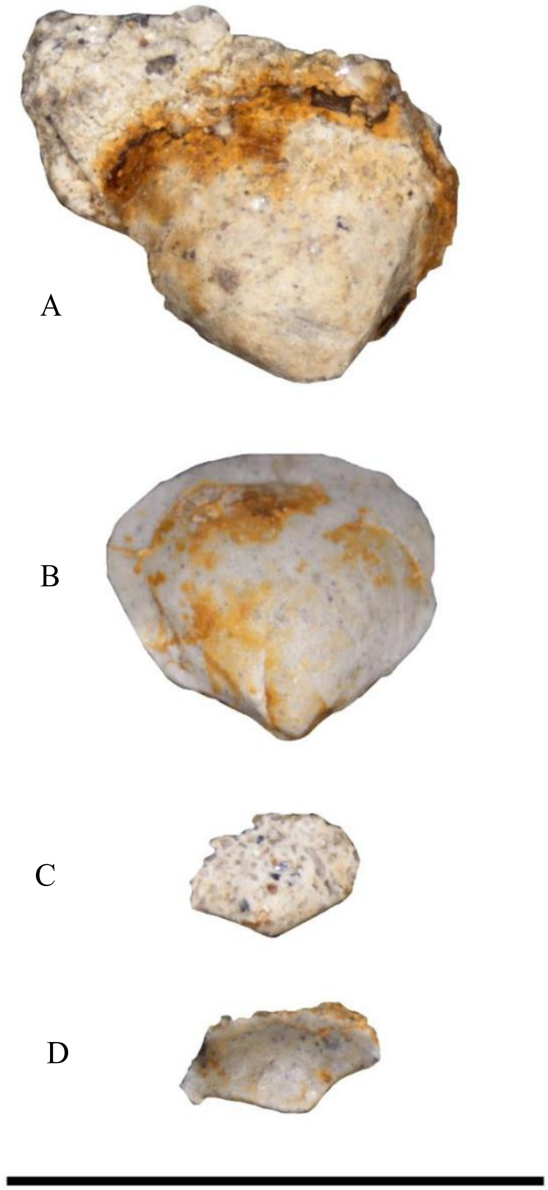

Plate 3
A - D: Unidentified bivalve internal molds.
Scale bar represents 5 mm.

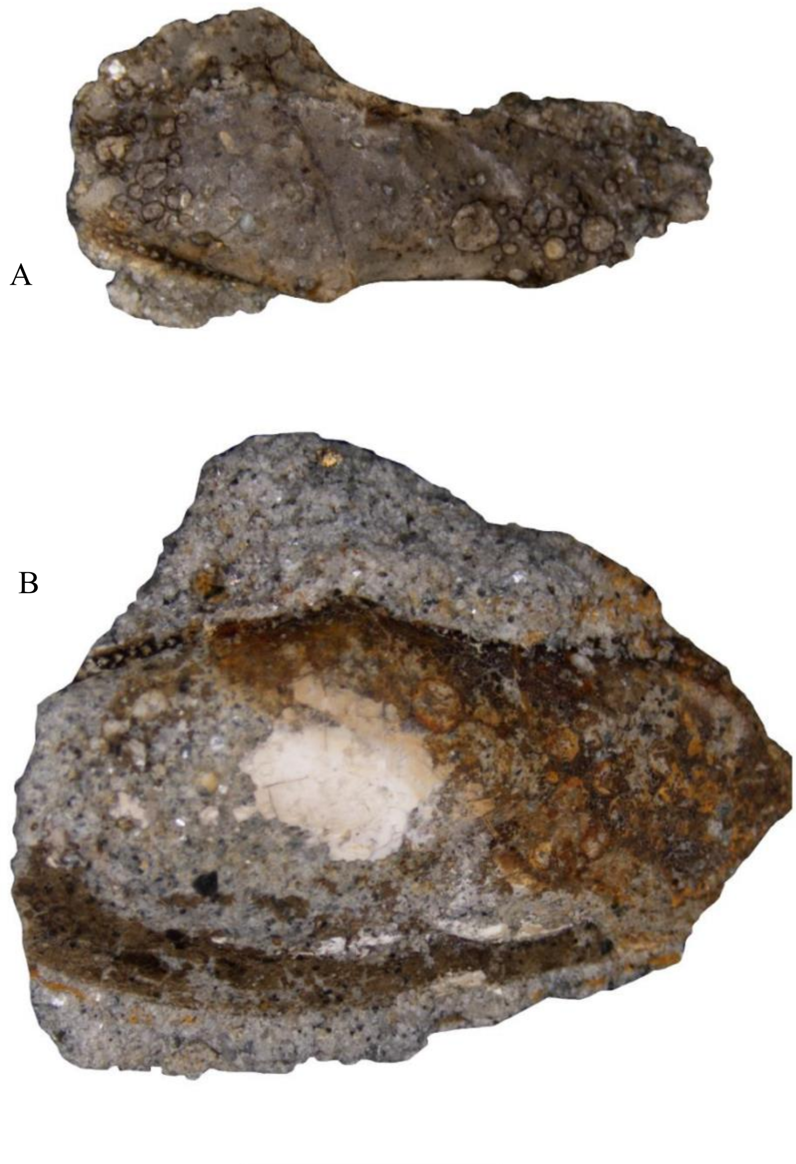

Plate 4
A, B: Unidentified nuculid internal molds with shell material.
Scale bar represents 5 mm.

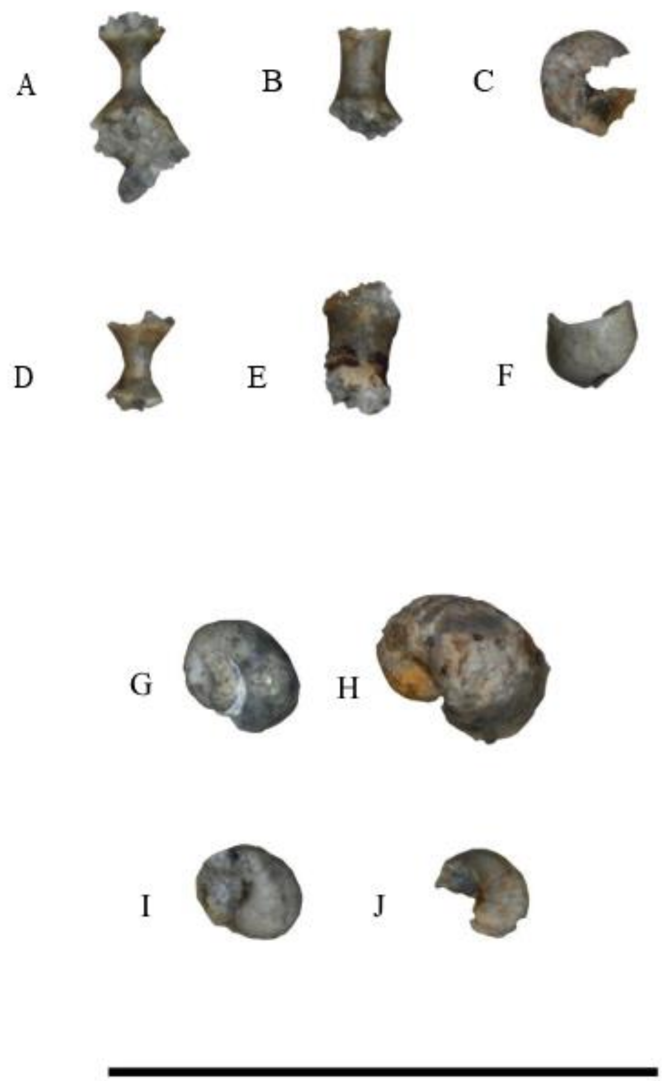

Plate 5
A-F: Unknown gastropod internal mold fragments.
G-J: Unknown gastropod Morph A internal molds.
Scale bar represents 5 mm.

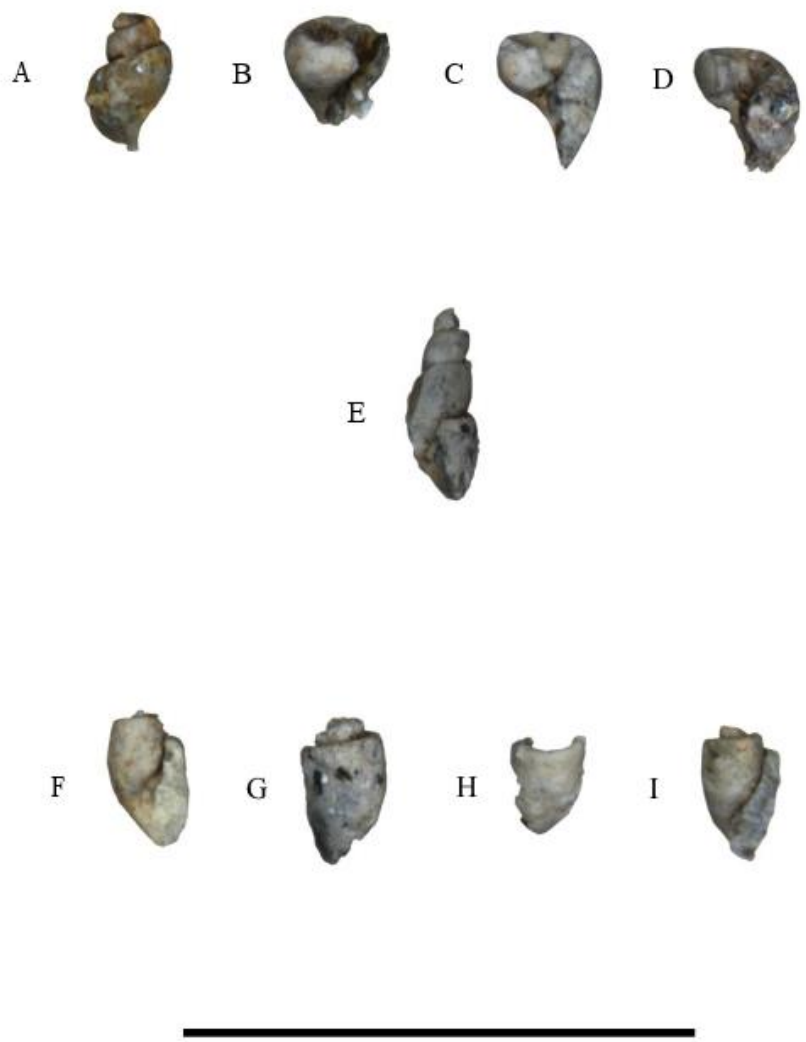

Plate 6
A-E: Unknown gastropod Morph B internal molds.
F-I: Unknown gastropod Morph C internal molds.
Scale bar represents 5 mm.

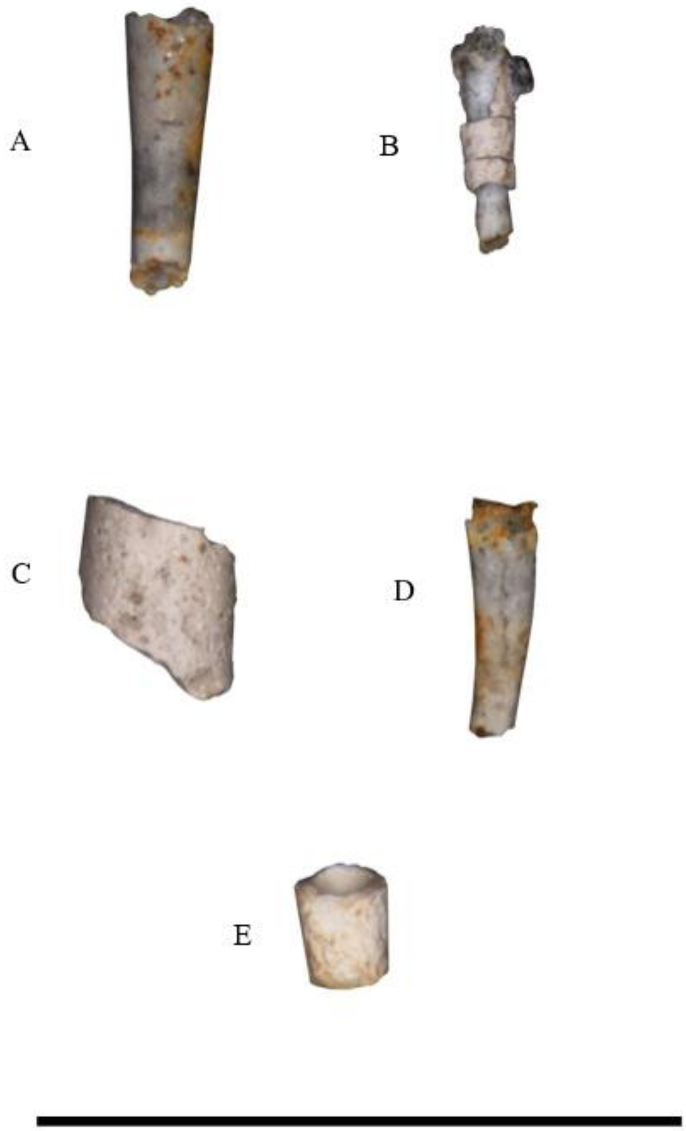

Plate 7
Cadulus sp. shell fragments.
Scale bar represents 5 mm.

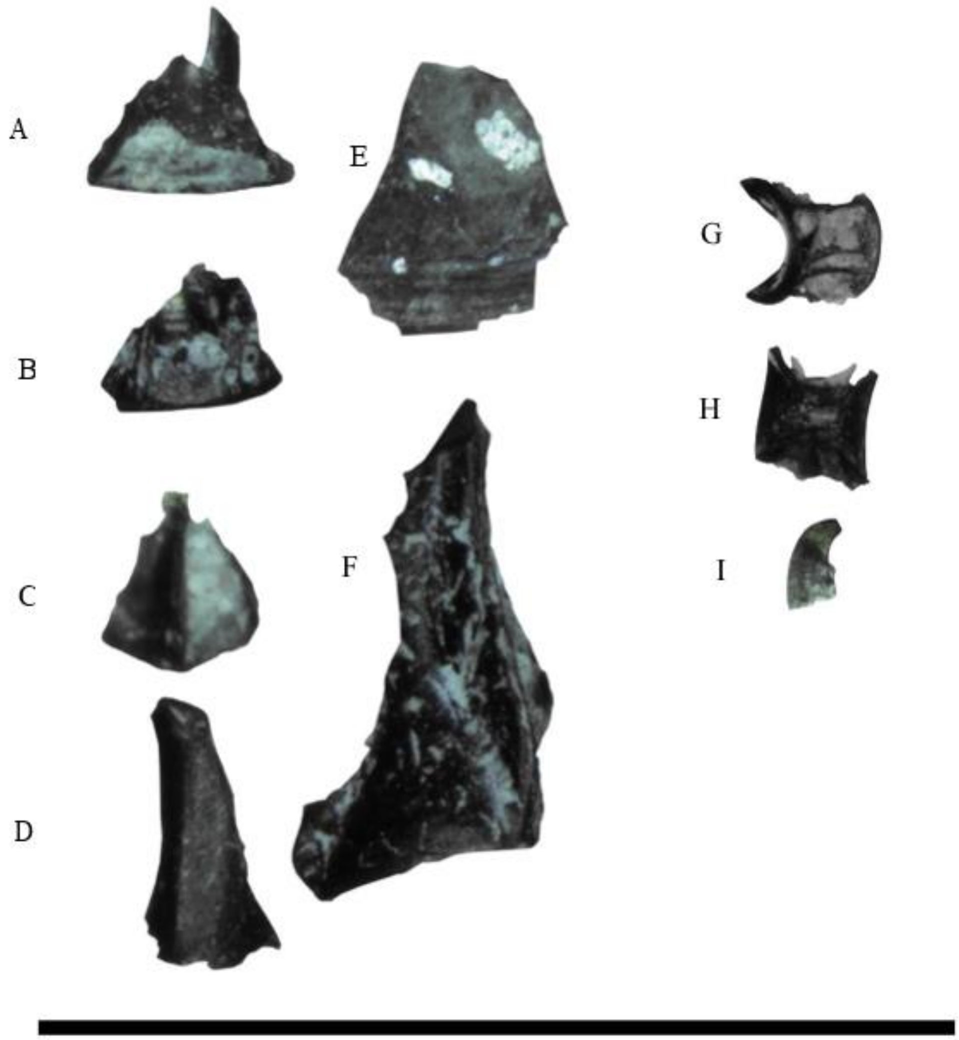

Plate 8
A-F: Unknown actinopterygian vertebral fragments.
G-I: Unknown actinopterygian vertebra.
Scale bar represents 5 mm.

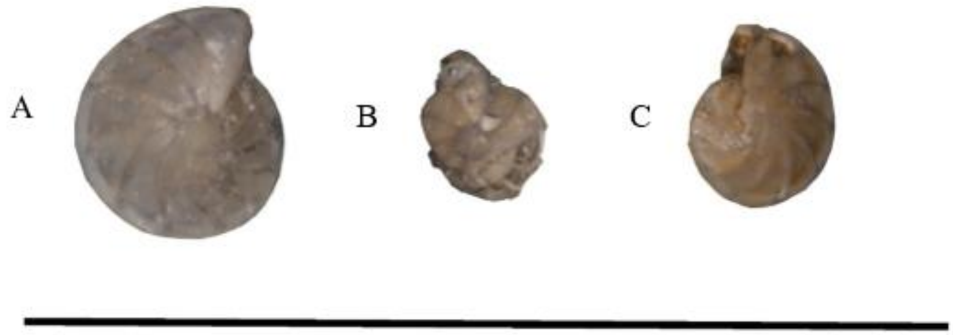

Plate 9
A-C: *Robulus* sp. foraminifera.
Scale bar represents 5 mm.

Plate 10
A-C: Unidentified shell fragments of bivalves in the Family Glycymerididae in posterior view.
Scale bar represents 5 mm.

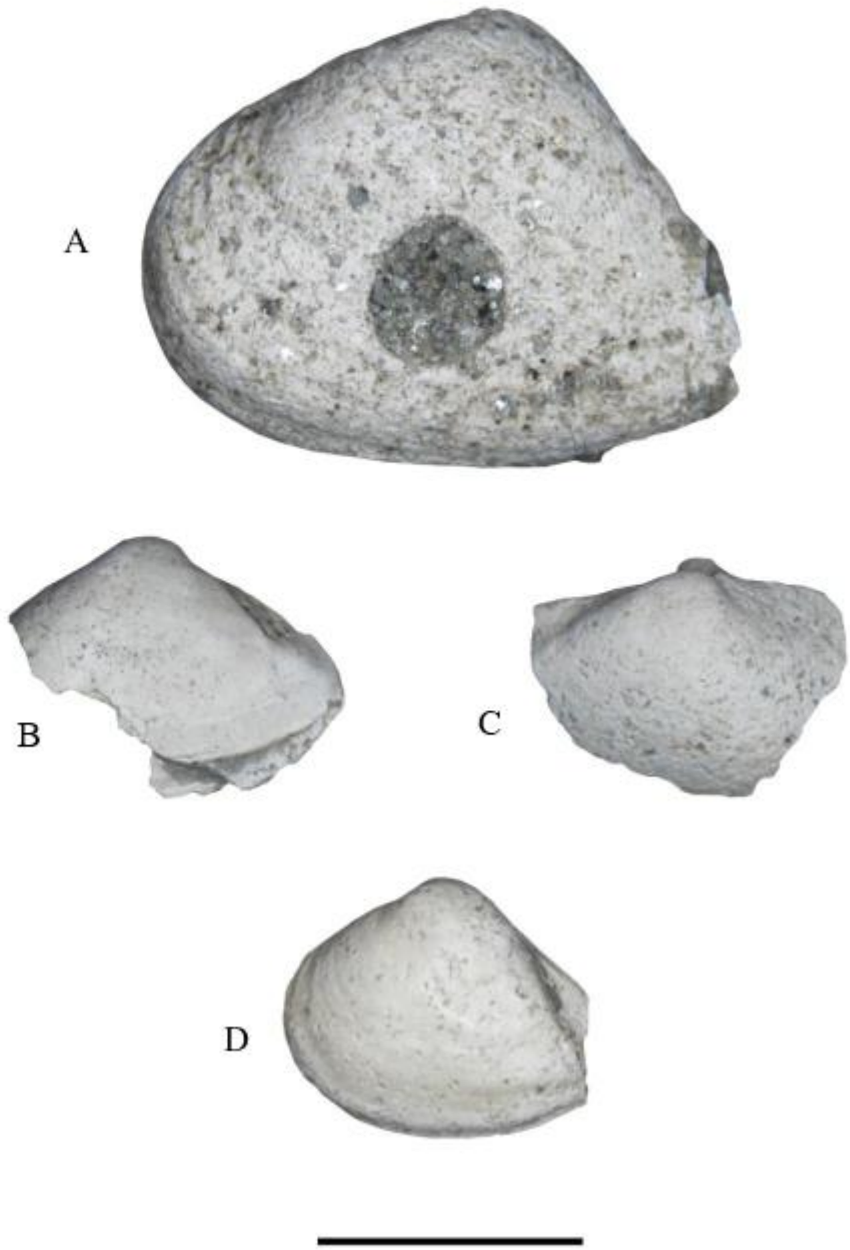

Plate 11
A-D: *Corbula* sp. shells in posterior view.
Scale bar represents 5 mm.

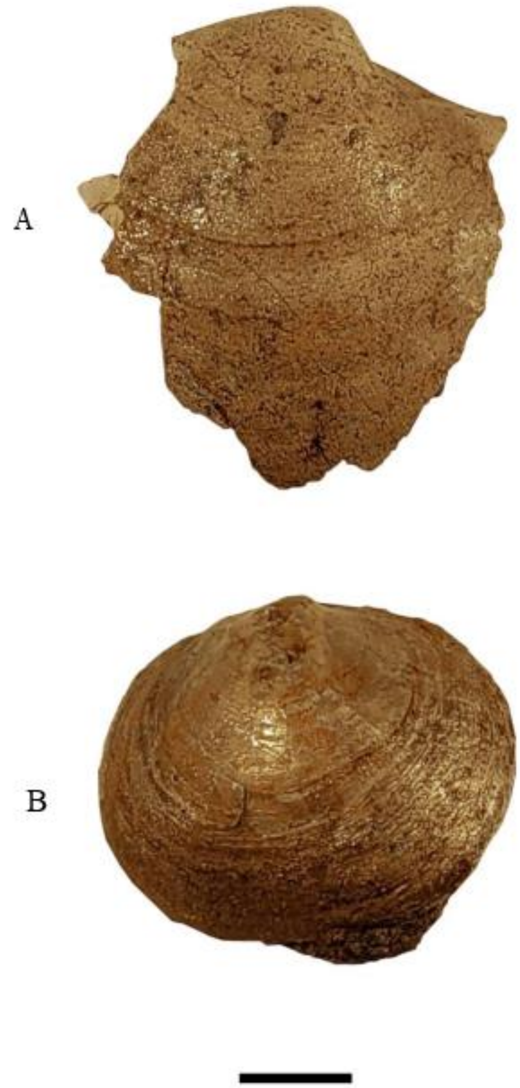

Plate 12
A-B: *Anomia argentaria* shell fragments in posterior view.
Scale bar represents 5 mm.

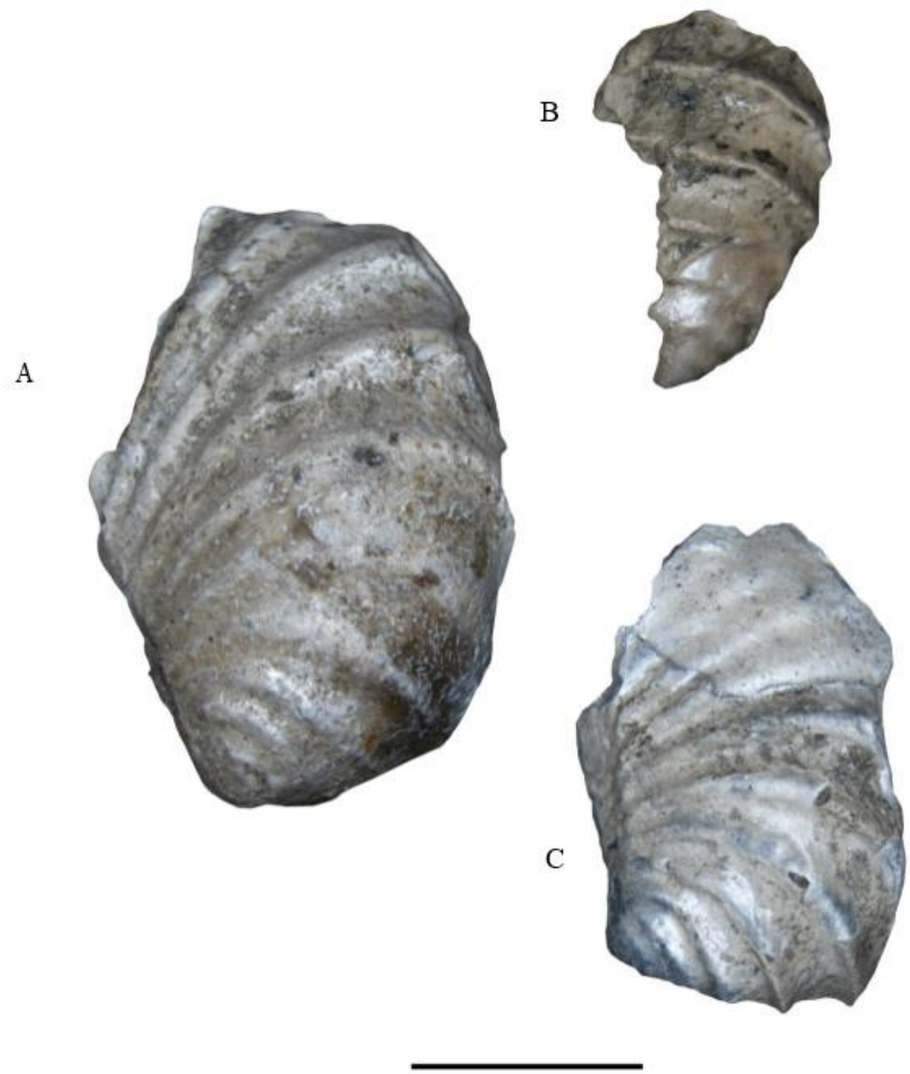

Plate 13
A-C: *Trigonia* sp. shell fragments in posterior view.
Scale bar represents 5 mm.

Plate 14
A-C: Right valves of bivalves belonging to Order Ostreida in anterior view. Scale bar represents 5 mm.

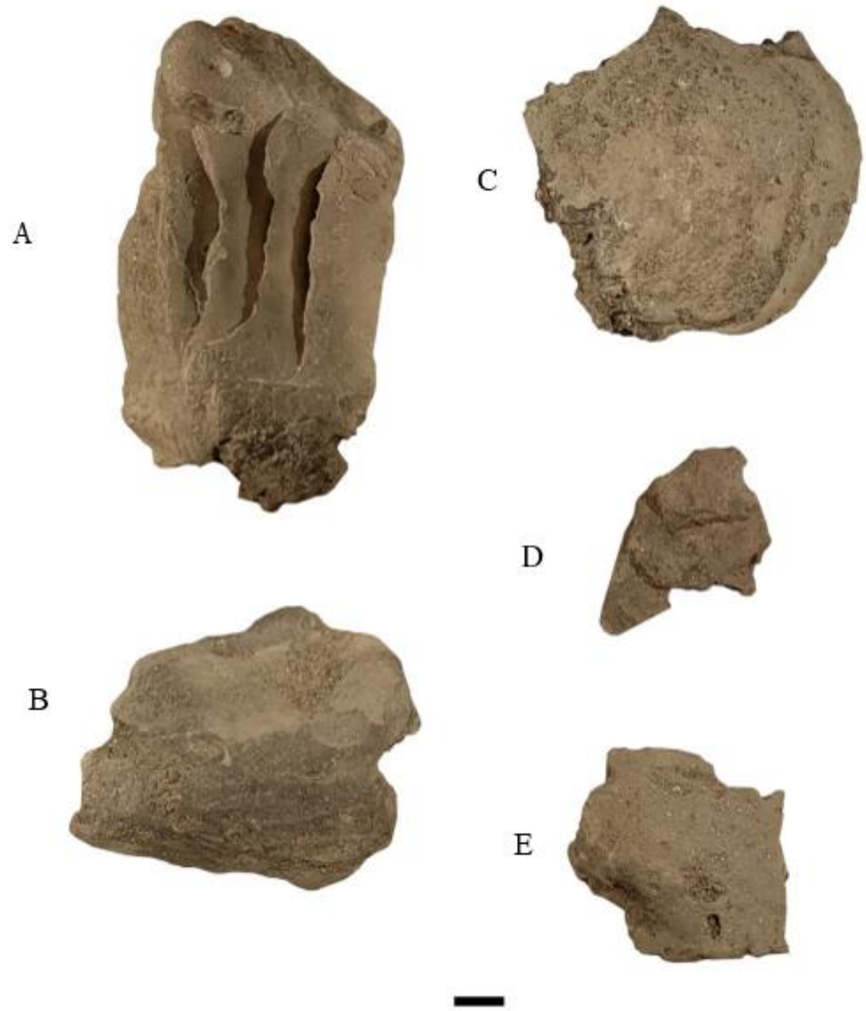

Plate 15
A-E: Shell fragments of the oyster *Flemingostrea* sp. in posterior view.
Scale bar represents 5 mm.

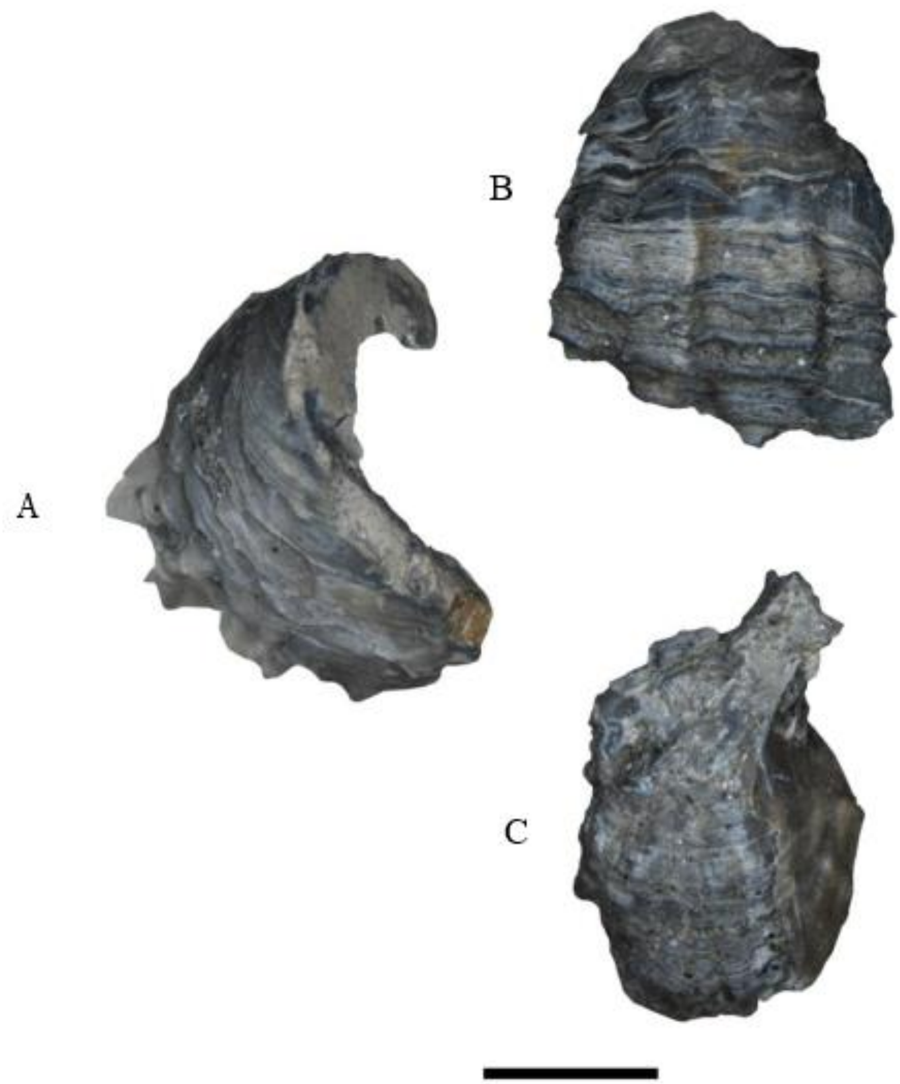

Plate 16
A-C: Shell fragments of the oyster *Exogyra ?ponderosa* var. *erraticostata* in posterior view.
Scale bar represents 5 mm.

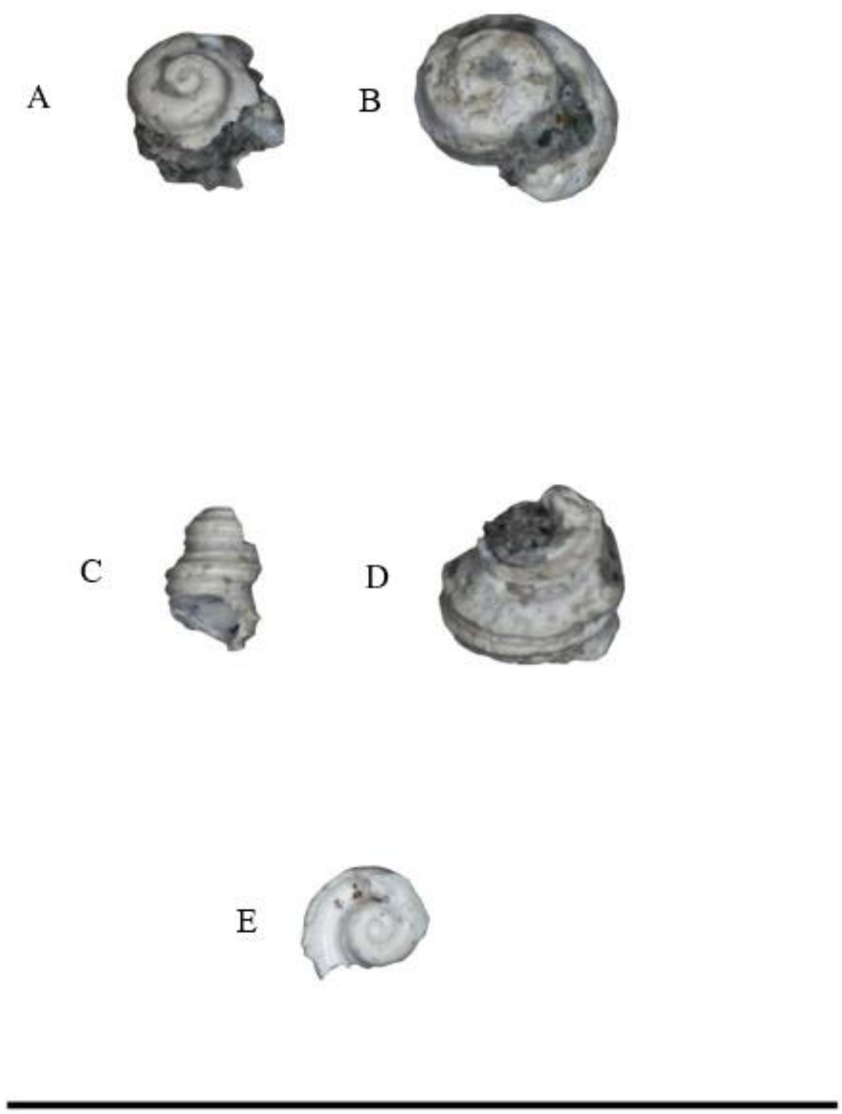

Plate 17
A-B: Shell material from *Gyrodes* sp.
C-D: Shell material from *Turritella quadrilira*.
E: Shell material from ?*Neamphitomaria* sp.
Scale bar represents 5 mm.

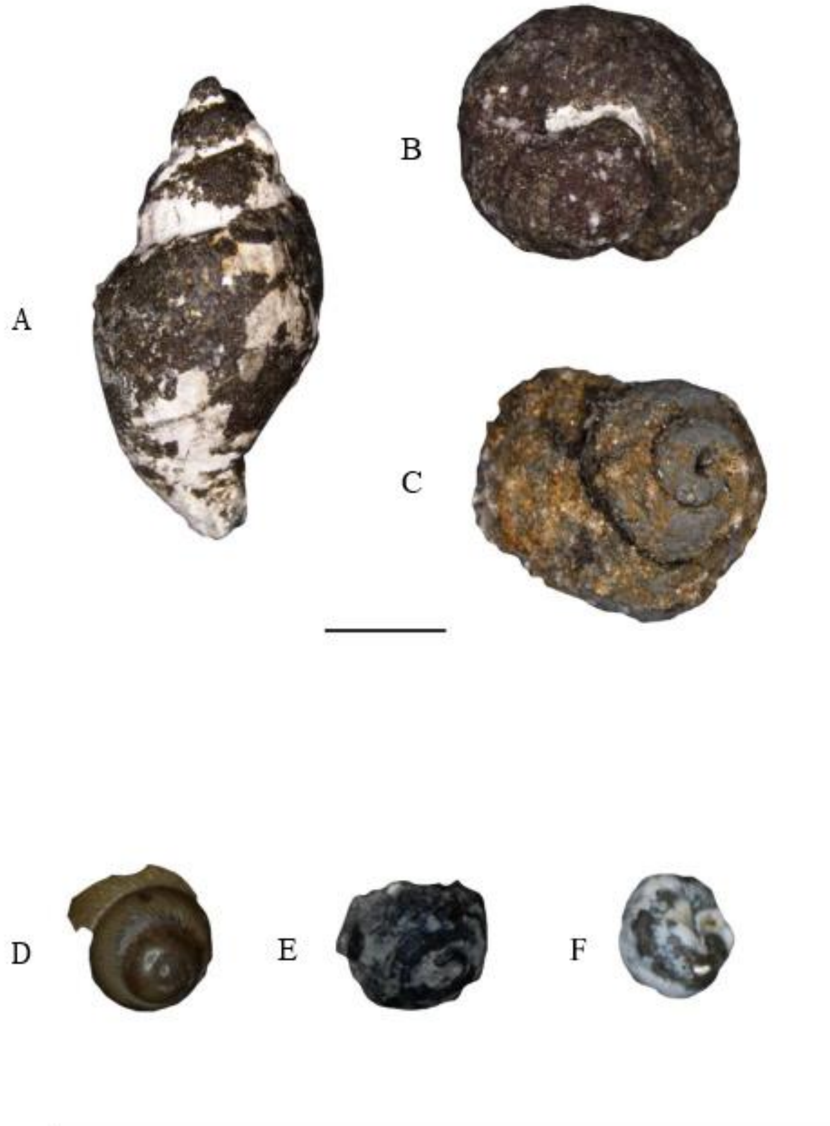

Plate 18
A-C: Unknown gastropod macrofossils.
D-F: Unknown gastropod microfossils.
Scale bar represents 5 mm.

Plate 19
A-D: Shell material from *Cadulus* sp.
E-G: Shell material from *Dentalium* sp.
Scale bar represents 5 mm.

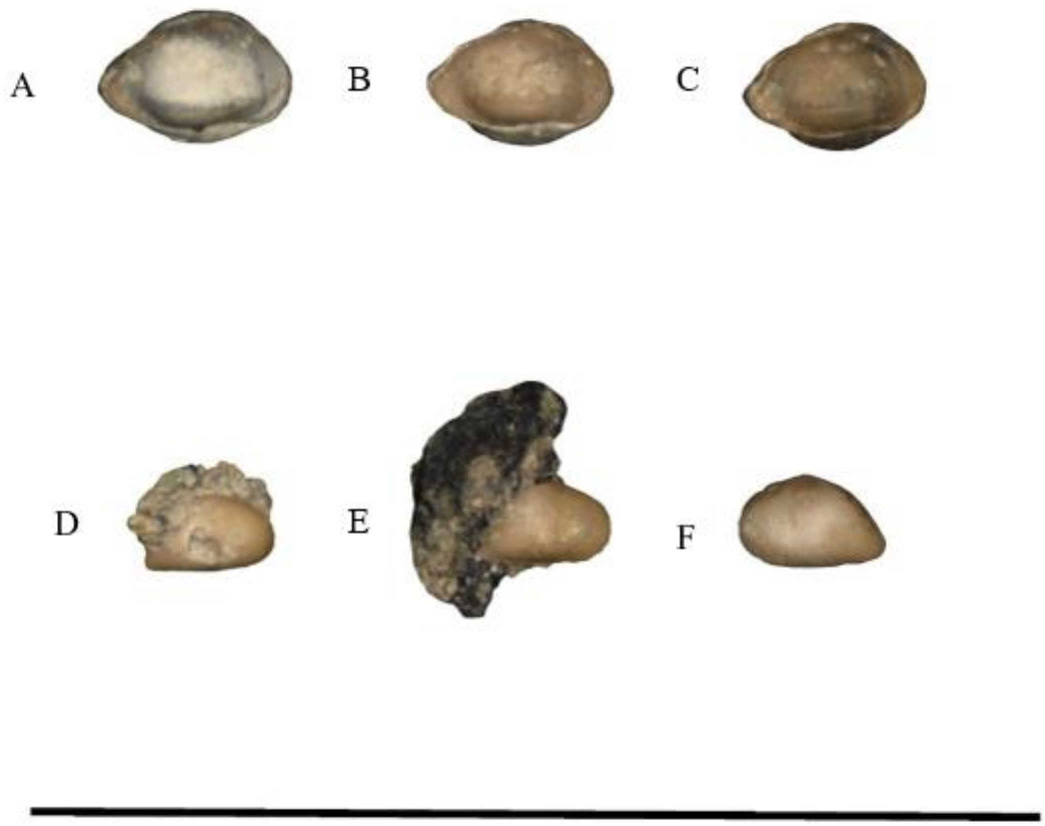

Plate 20
A-C: Ostracods *Brachycythere rhomboidalis.*
D-F: Ostracods *Haplocytheridea renfroensis*.
Scale bar represents 5 mm.

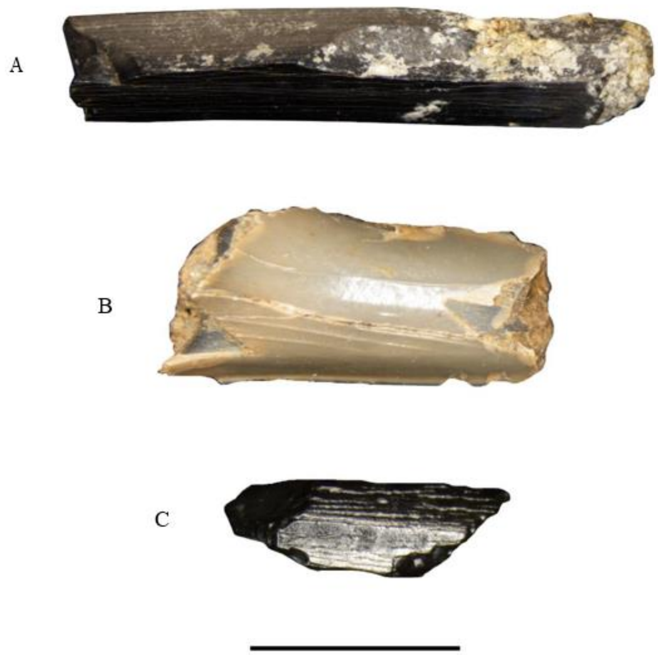

Plate 21
A-C: Unidentifiable tooth fragments.
Scale bar represents 5 mm.

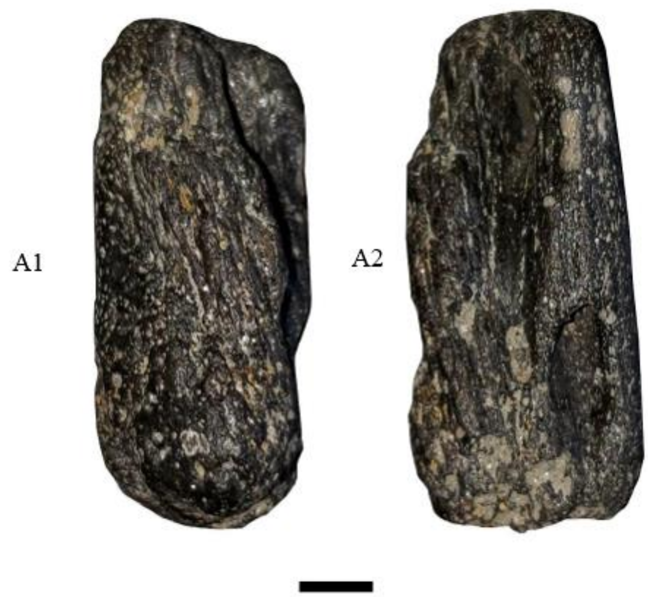

Plate 22
A1, 2: Unidentified phosphatic bone fragment.
Scale bar represents 5 mm.

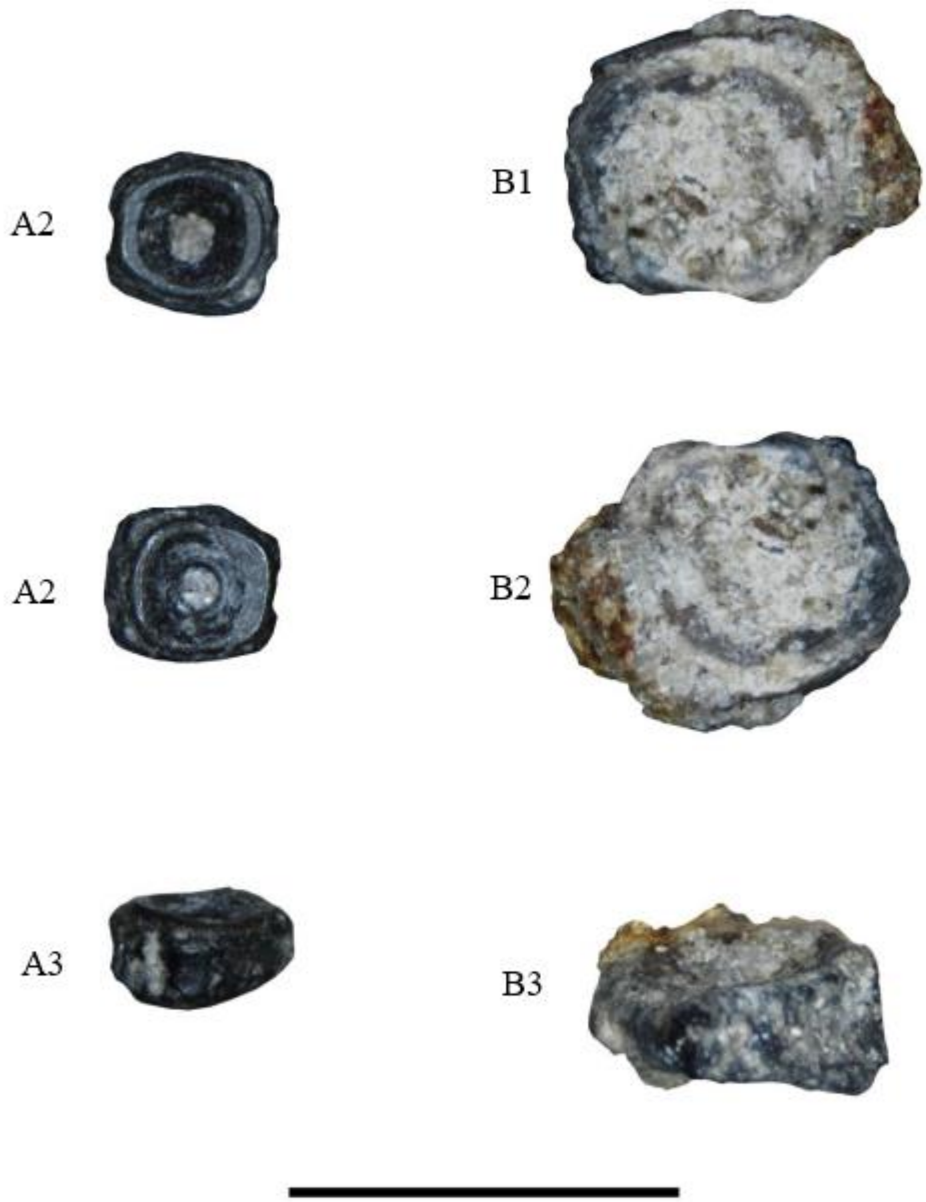

Plate 23
A, B: Unidentified chondrichthyan vertebrae.
Scale bar represents 5 mm.

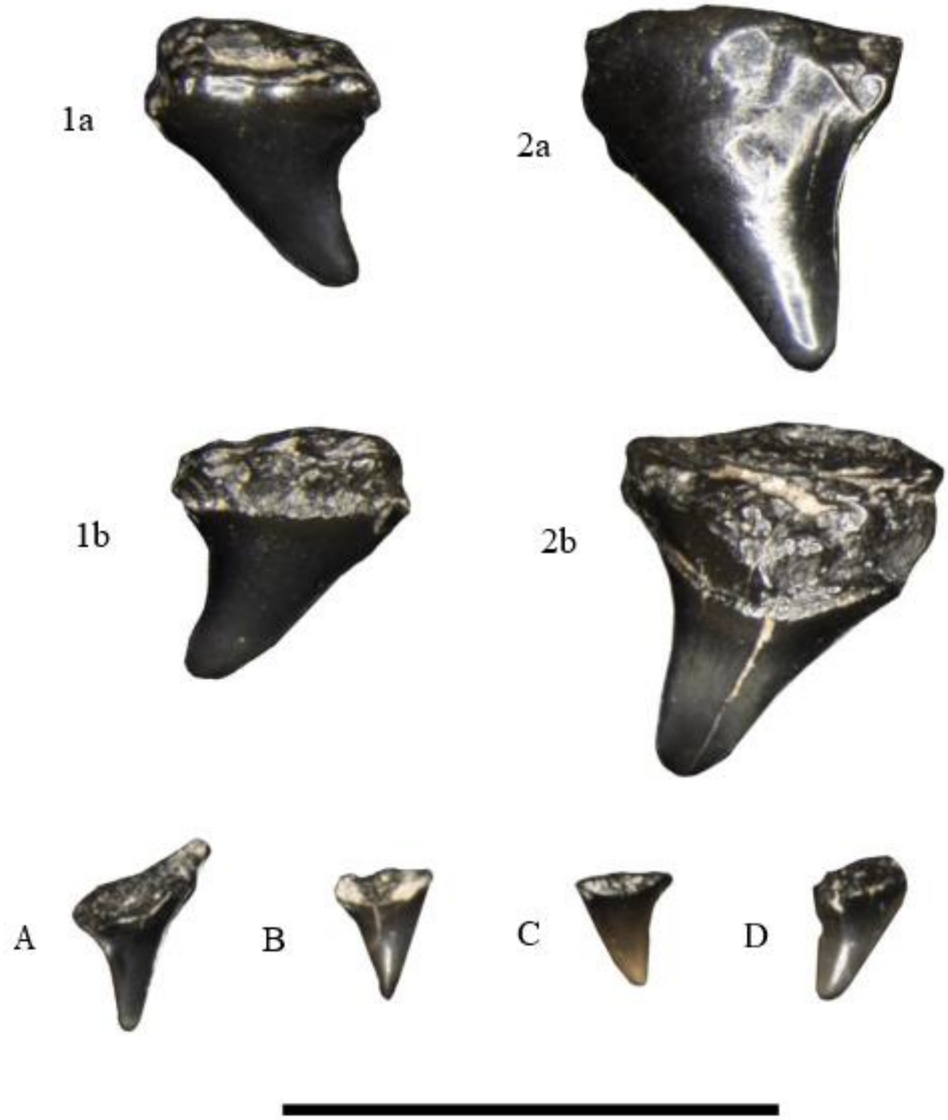

Plate 24
Unidentified selachian teeth.
1a, 1b: labial and lingual views of selachian tooth 1
2a, 2b: labial and lingual views of selachian tooth 2.
A-D: Selachian teeth.
Scale bar represents 5 mm.

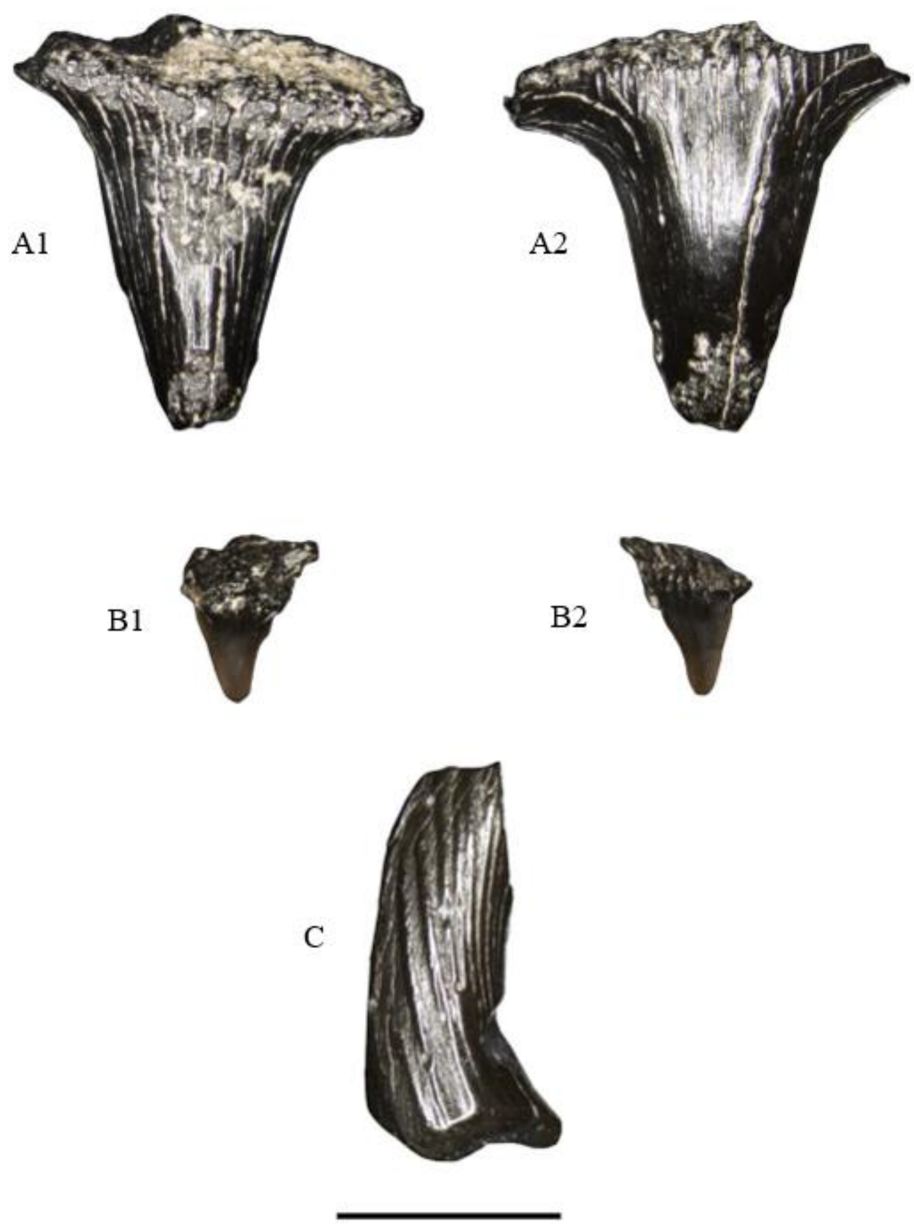

Plate 25
Hybodus sp. teeth and cephalic spine fragment.
A: labial and lingual views of *Hybodus* sp. tooth 1
B: labial and lingual views of *Hybodus* sp. tooth 2.
C: *Hybodus* sp. cephalic spine fragment.
Scale bar represents 5 mm.

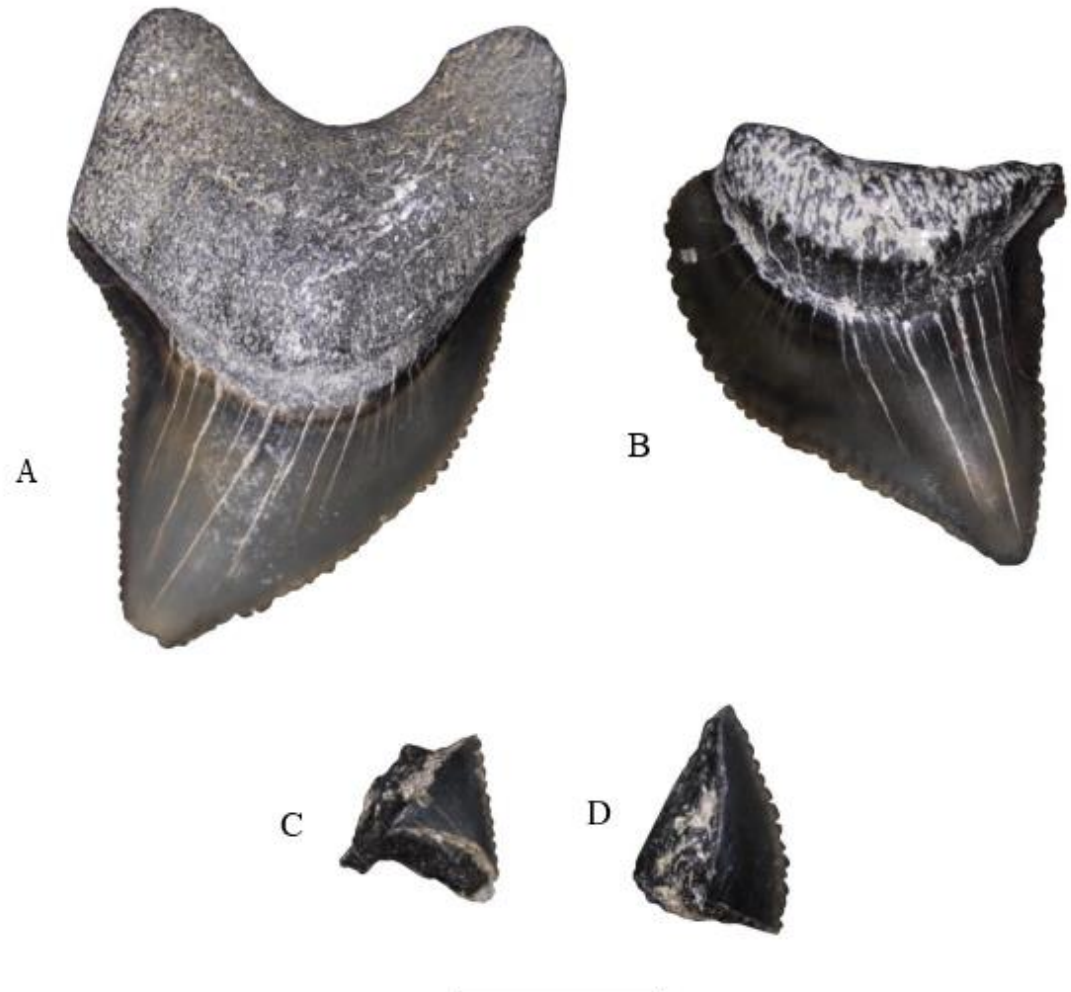

Plate 26
A, B: *Squalicorax ?kaupi* teeth in lingual view.
C, D: *Squalicorax* sp. tooth fragments.
Scale bar represents 5 mm.

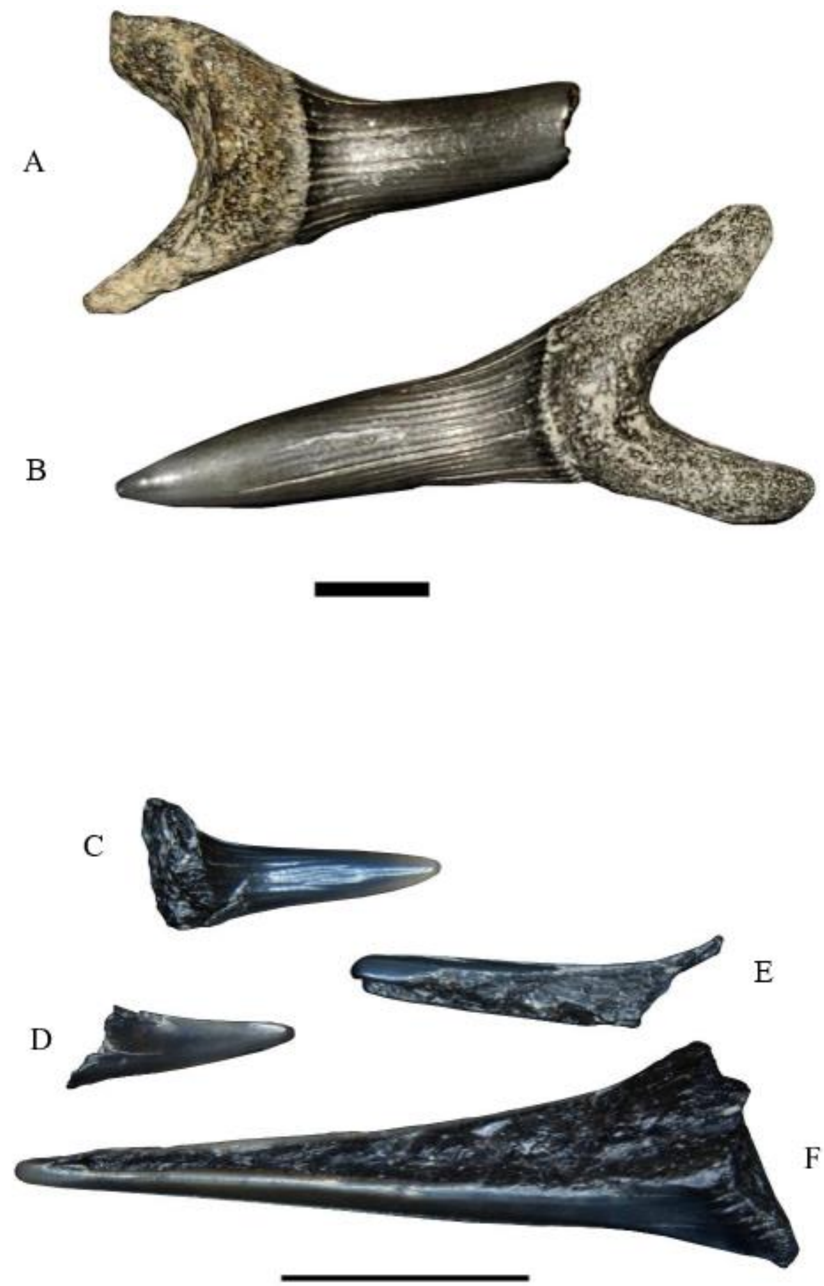

Plate 27
A: Nearly complete *Scapanorhynchus texanus* tooth in lingual view.
B: Complete *Scapanorhynchus texanus* tooth in lingual view.
C-F: Fragmented *Scapanorhynchus texanus* teeth.
Scale bar represents 5 mm.

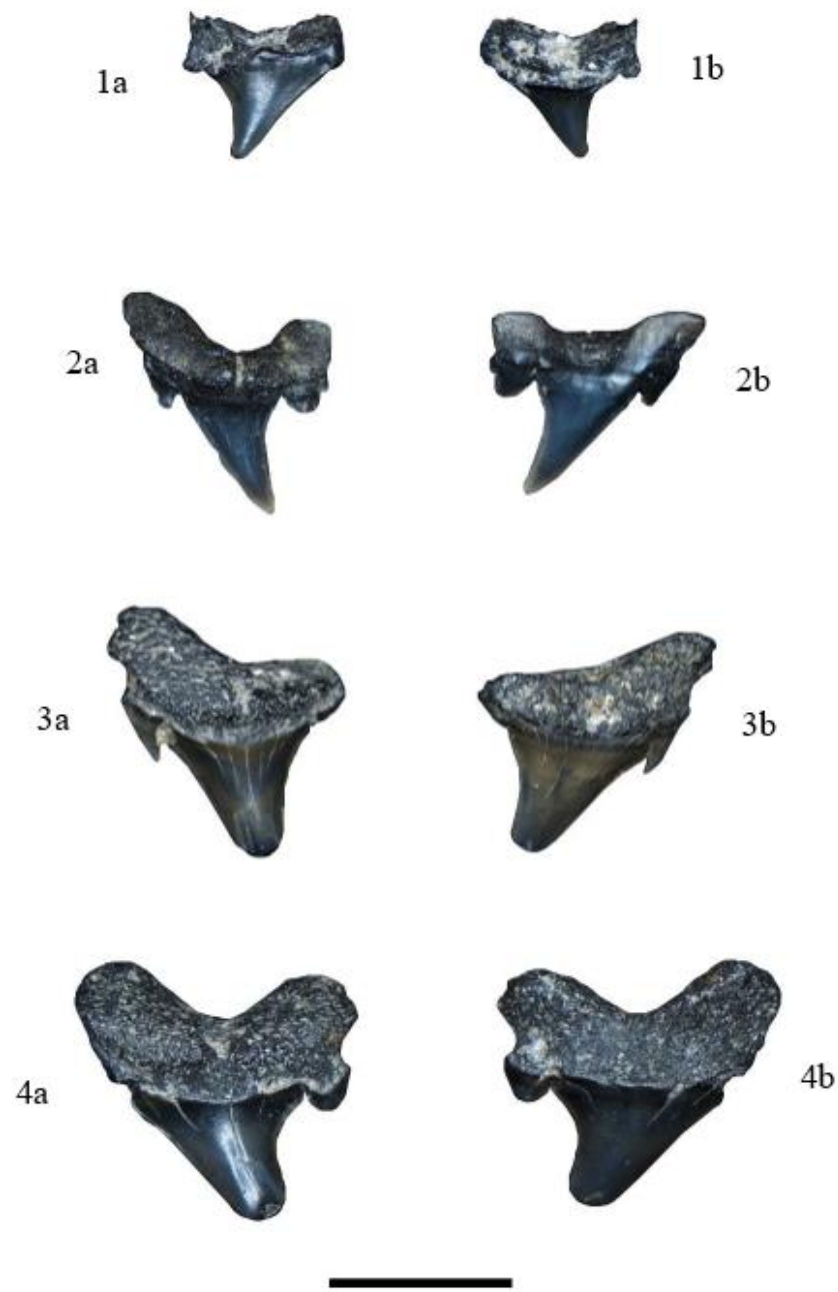

Plate 28
1a, 1b: *Cretalamna appendiculata* tooth 1 in labial and lingual views.
2a, 2b: *Cretalamna appendiculata* tooth 2 in lingual and labial views.
3a, 3b: *Cretalamna appendiculata* tooth 3 in lingual and labial views.
4a, 4b: *Cretalamna appendiculata* tooth 4 in lingual and labial views.
Scale bar represents 5 mm.

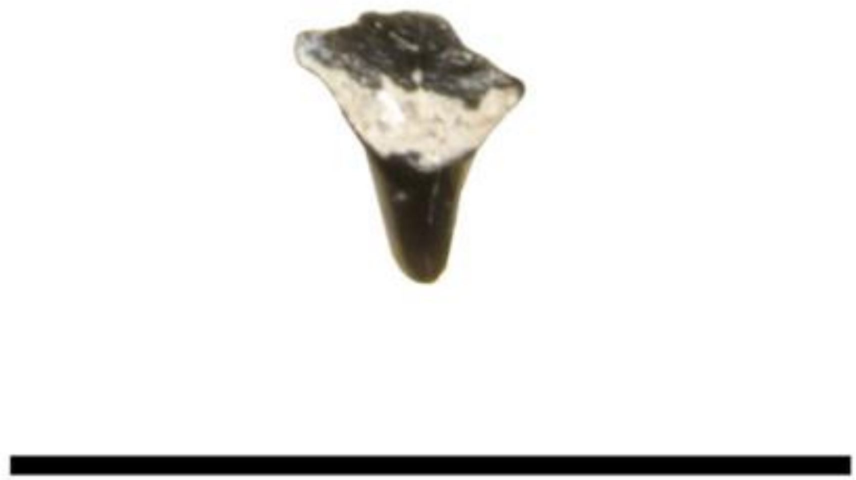

Plate 29
Squatina sp. tooth in lingual view.
Scale bar represents 5 mm.

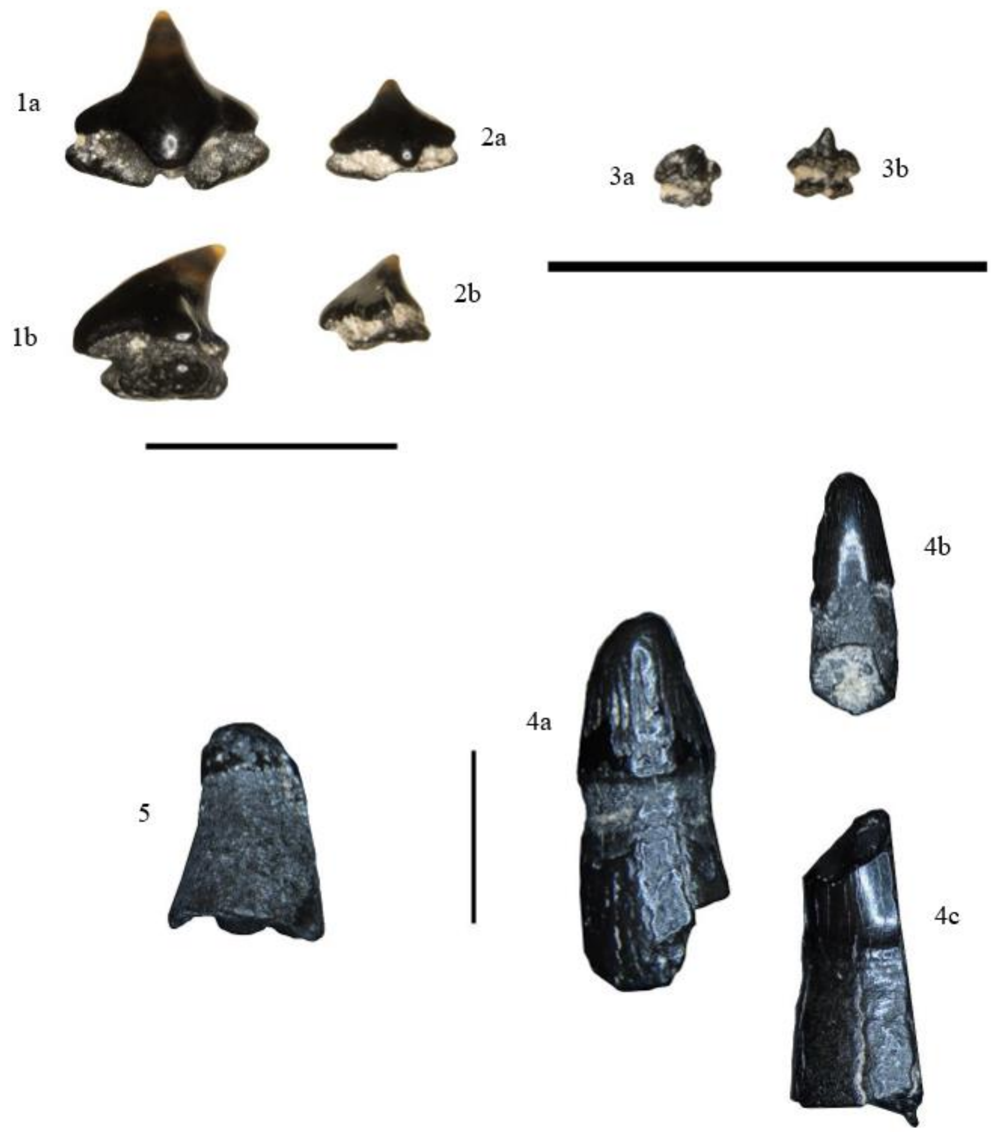

Plate 30
1a, 1b: *Ischyrhiza mira* oral tooth 1 in labial and lateral views.
2a, 2b: *Ischyrhiza mira* oral tooth 2 in labial and lateral views.
3a, 3b: *Ischyrhiza mira* oral tooth in lingual view.
4a-c: *Ischyrhiza mira* rostral tooth fragments.
5: ?*Borodinopristis* sp. rostral tooth root fragment.
Scale bar represents 5 mm.

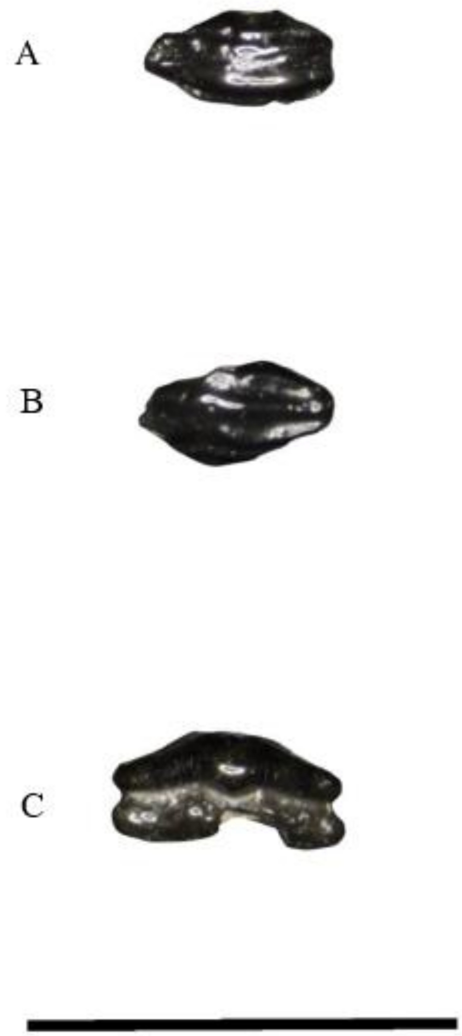

Plate 31
A: *Ptychotrygon vermiculata* tooth 1 in occlusal view.
B: *Ptychotrygon vermiculata* tooth 2 in occlusal view.
C: *Ptychotrygon vermiculata* tooth 3 in lingual view.
Scale bar represents 5 mm.

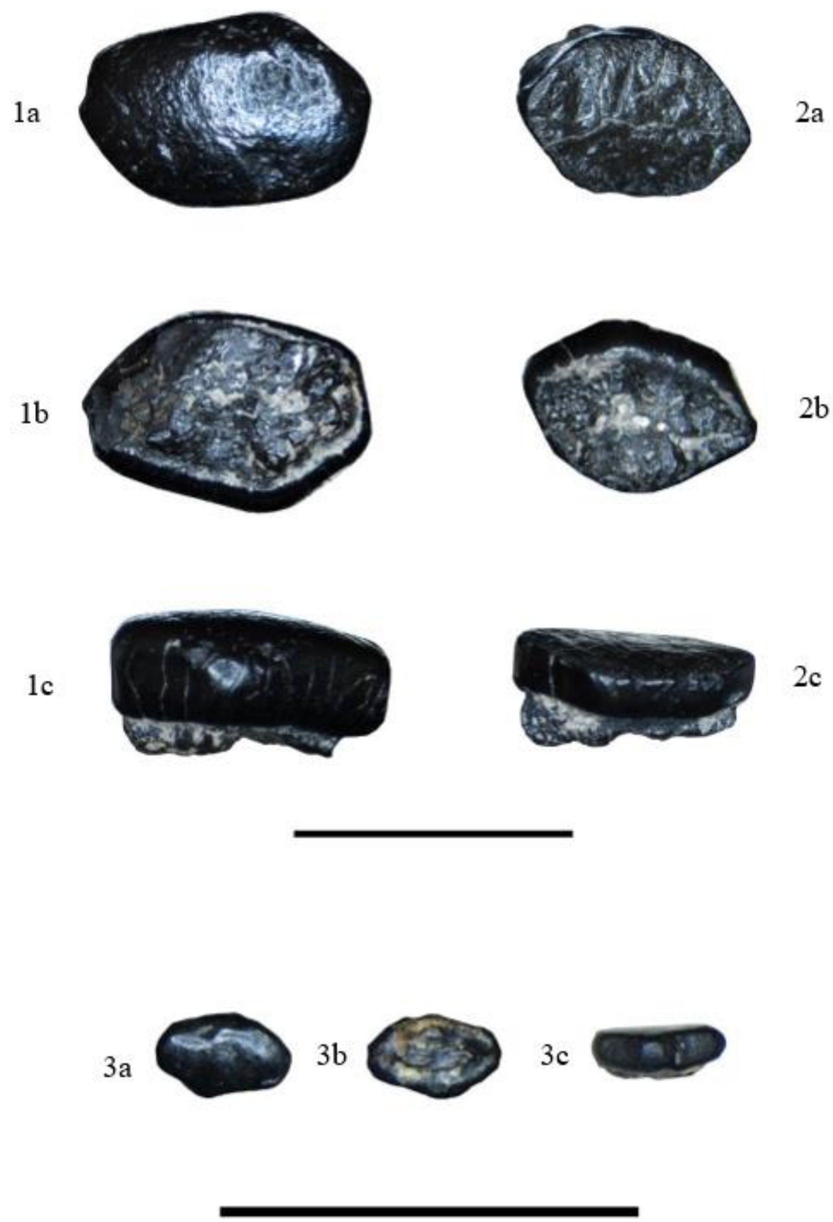

Plate 32
1a, 1b, 1c: *Pseudohypolophus* sp. tooth 1 in occlusal, basal, and lateral views.
2a, 2b, 3c: *Pseudohypolophus* sp. tooth 2 in occlusal, basal, and lateral views.
3a, 3b, 3c: *Pseudohypolophus* sp. tooth 3 in occlusal, basal, and lateral views.
Scale bar represents 5 mm.

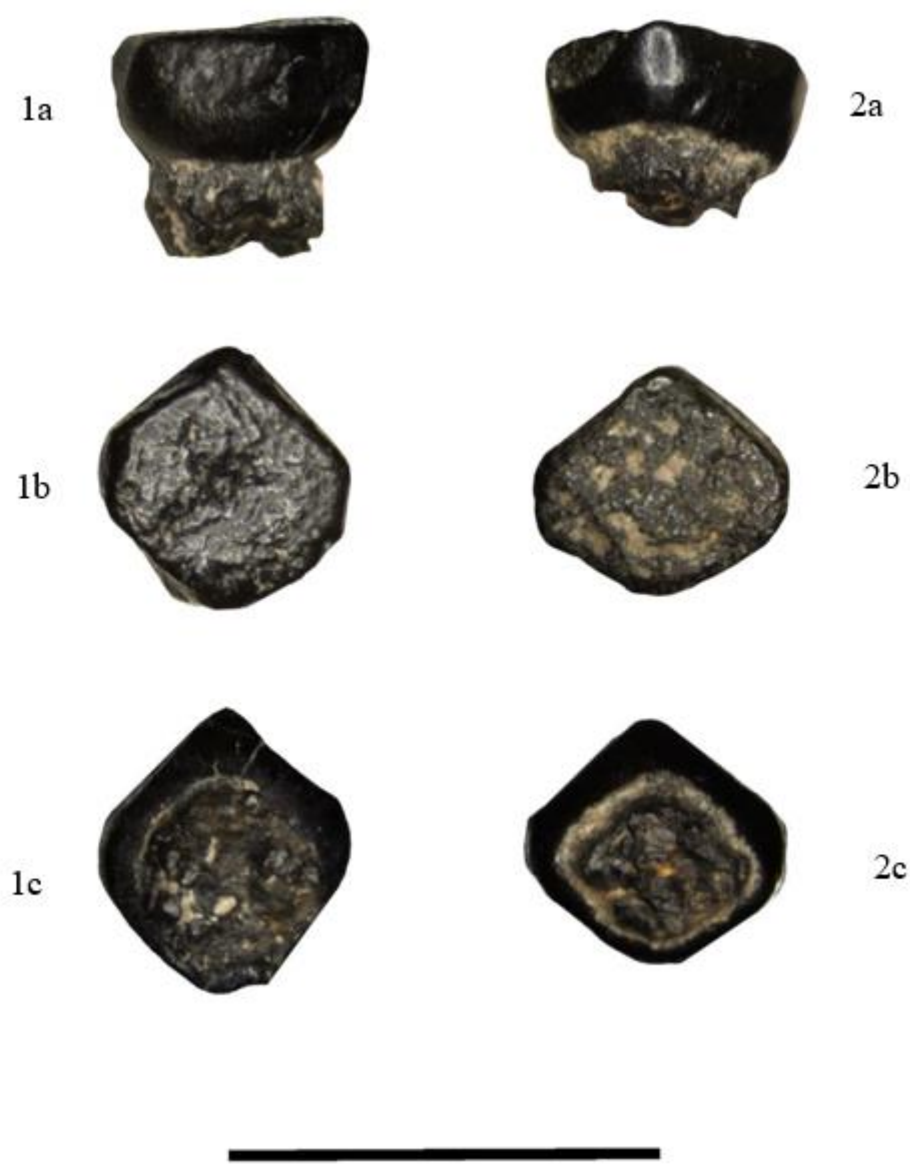

Plate 33
1a, 1b, 1c: *Rhombodus laevis* tooth 1 in lateral, occlusal, and basal views.
2a, 2b, 3c: *Rhombodus laevis* tooth 2 in lateral, occlusal, and basal views.
Scale bar represents 5 mm.

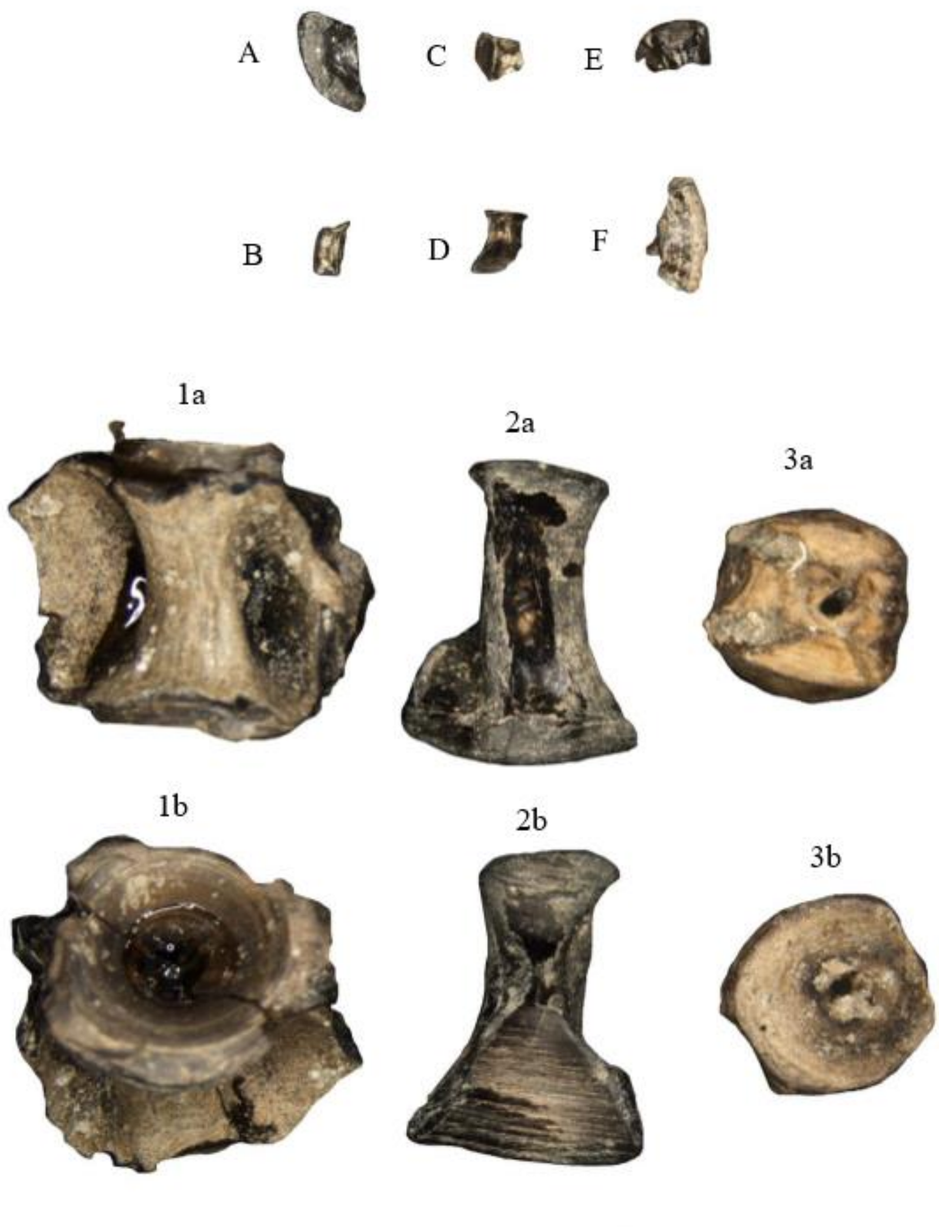

Plate 34
A-F: Microfossil osteichthyes vertebral fragments.
1a-3b: Macrofossil osteichthyes vertebral fragments.
Scale bar represents 5 mm.

Plate 35
Unknown osteichthyan quadrate bone fragment.
Scale bar represents 5 mm.

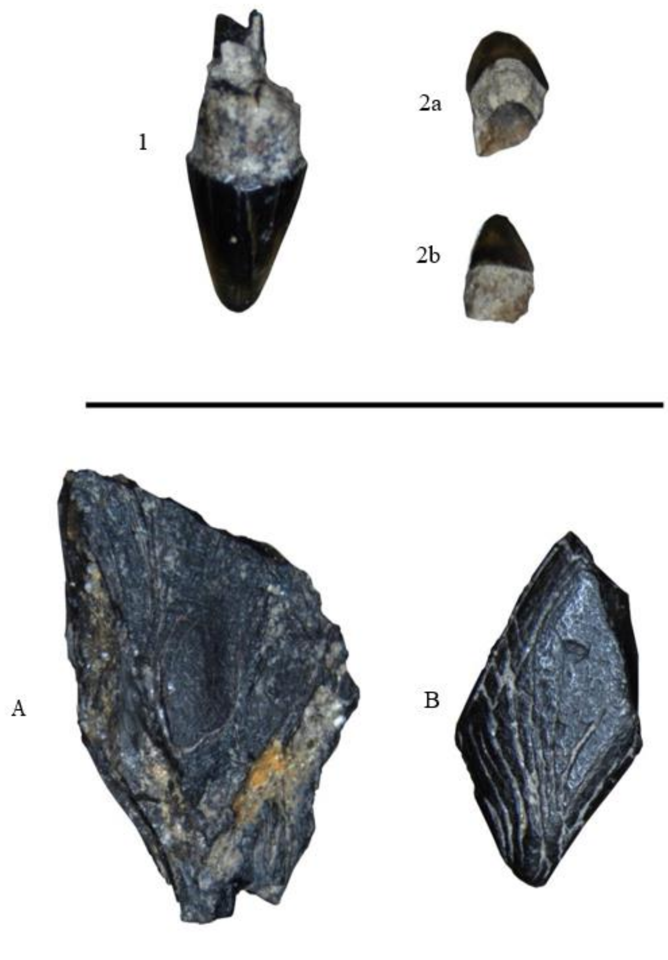

Plate 36
1: Fragmented *Lepisosteus* sp. dentary tooth crown 1.
2a, 2b: *Lepisosteus* sp. tooth 2 in lateral views.
3a, 3b: Fragmented *Lepisosteus* sp. dentary tooth crown 3.
A, B: *Lepisosteus* sp. scales in internal and external view.
Scale bar represents 5 mm.

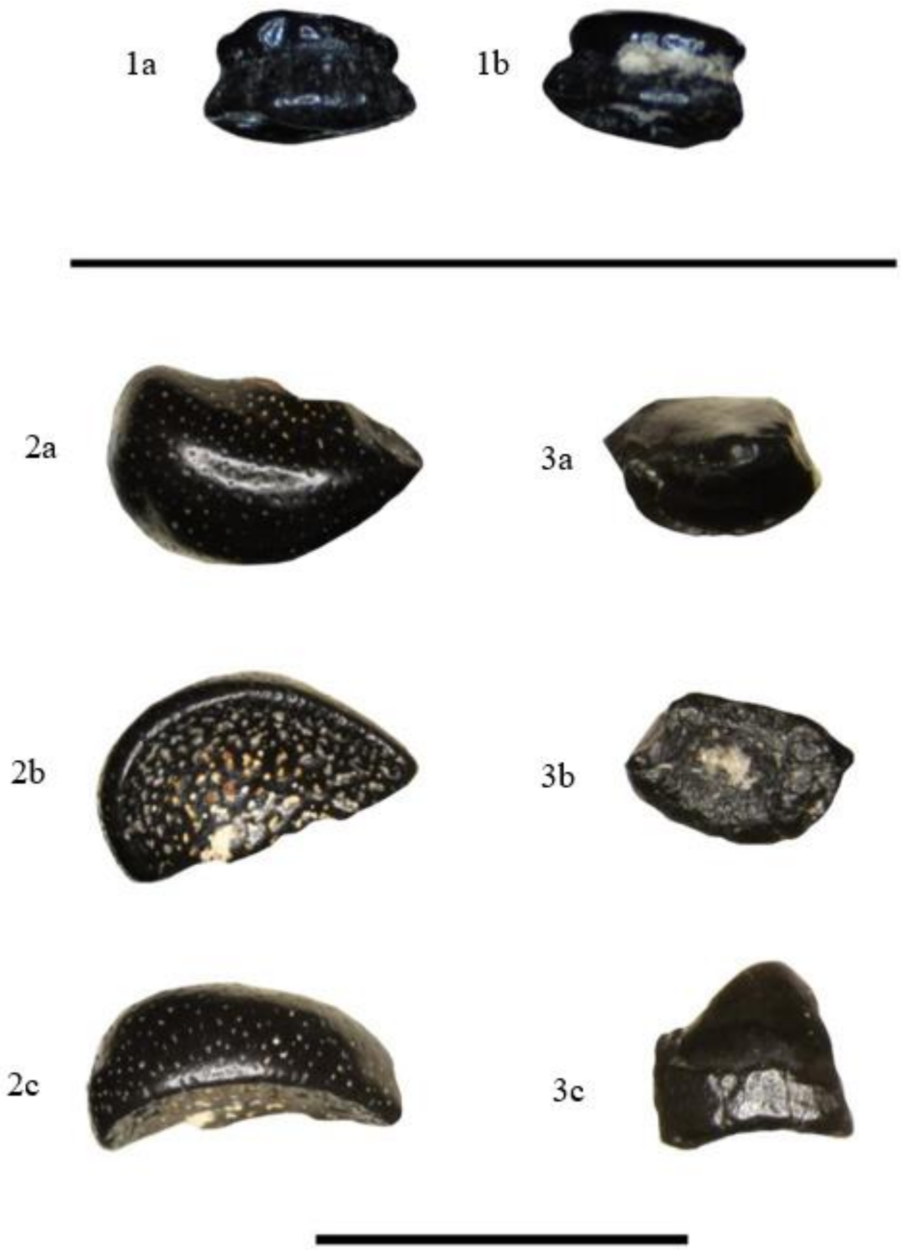

Plate 37
1a, 1b: Unidentified pycnodontiform tooth 1 in lateral views.
2a, 2b, 2c: Unidentified pycnodontiform tooth 2 in occlusal, basal, and lateral views.
3a, 3b, 3c: Unidentified pycnodontiform tooth 2 in occlusal, basal, and lateral views.
Scale bar represents 5 mm.

A1

A2

A3

Plate 38
A 1-3: *Anomoeodus phaseolus* tooth in occlusal, basal, and lateral views.. Scale bar represents 5 mm.

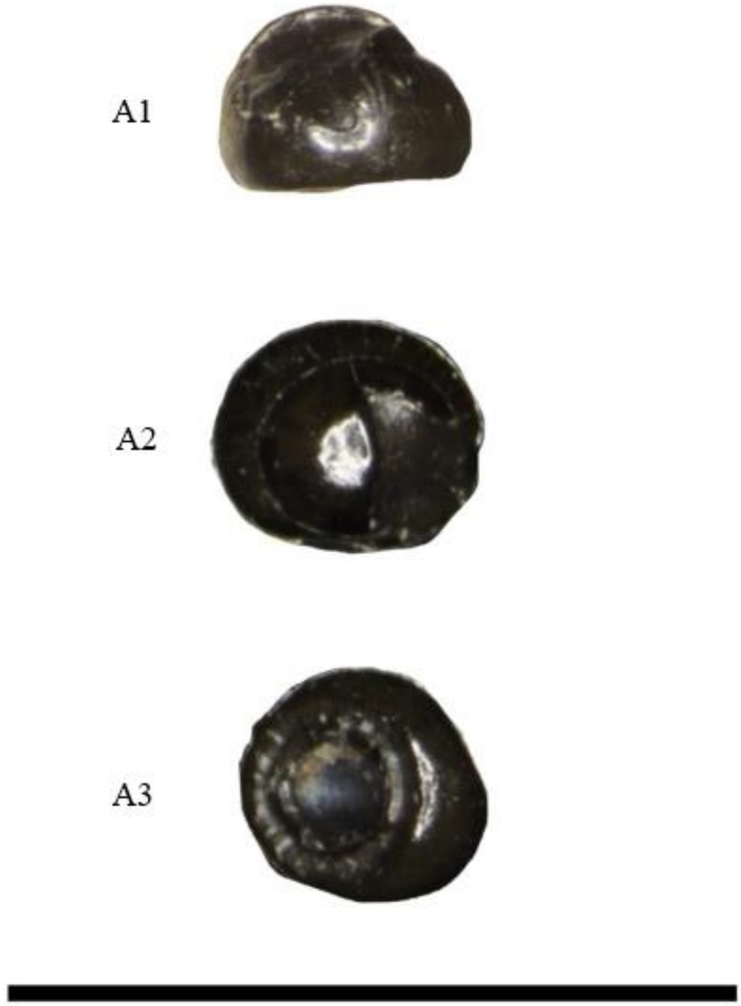

Plate 39
A 1-3: *Albu*la sp. tooth in lateral, occlusal, and basal views.
Scale bar represents 5 mm.

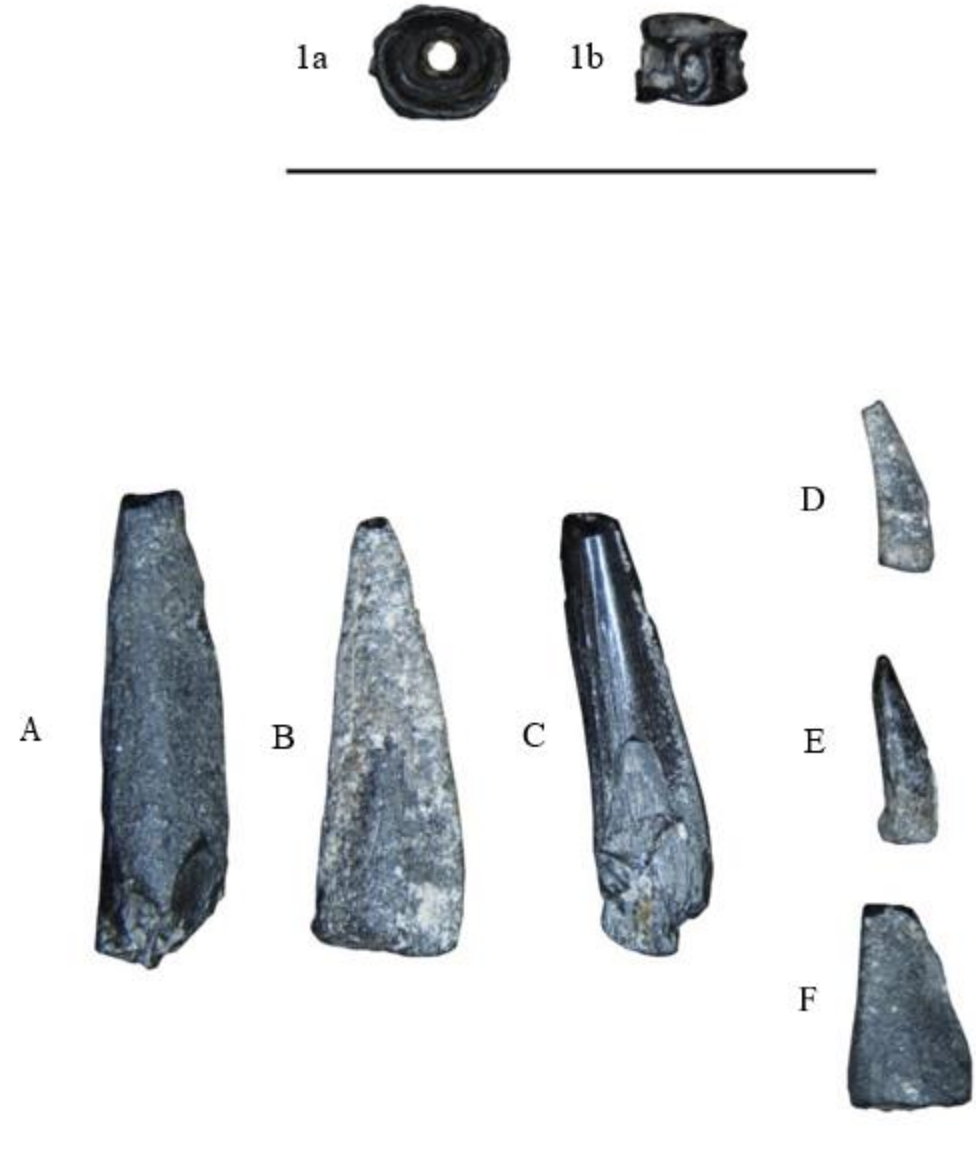

Plate 40
1a, 1b: ?*Enchodus* sp. vertebrae.
A-F: ?*Enchodus* sp. teeth in lateral view.
Scale bar represents 5 mm.

Plate 41
?*Stephanodus* sp. pharyngeal tooth in lateral view.
Scale bar represents 5 mm.

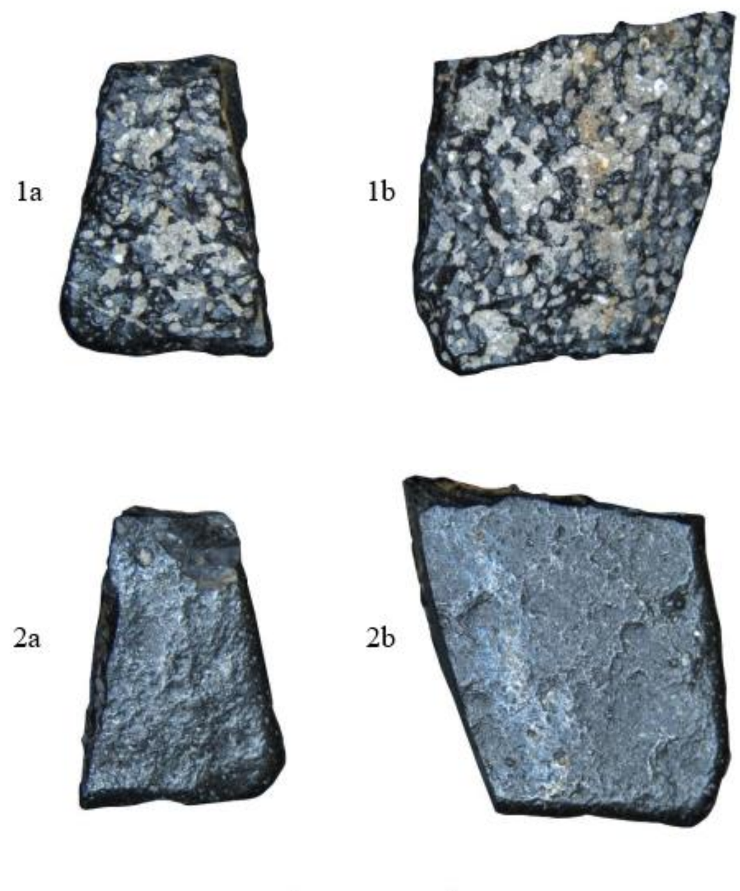

Plate 42
1a, 1b: *Trionyx* sp. shell fragments in exterior view.
2a, 2b: *Trionyx* sp. shell fragments in interior view.
Scale bar represents 5 mm.

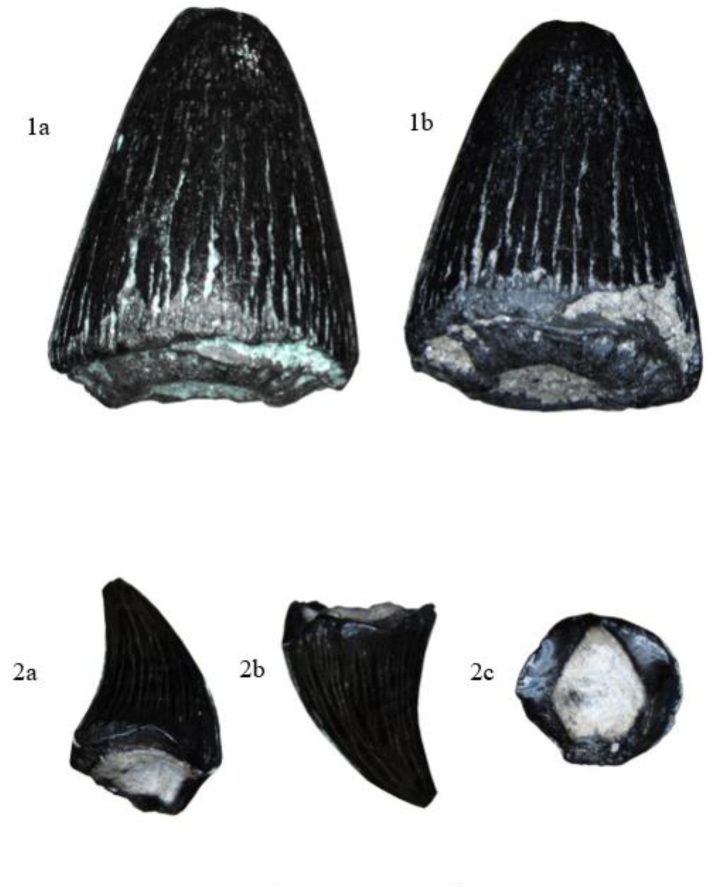

Plate 43
1a, 1b: *Deinosuchus* sp. tooth in labial and lingual views.
2a, 2b, 2c: ?*Thoracosaurus* sp. tooth in lateral and basal views.
Scale bar represents 5 mm.

Plate 44
Unidentified mosasaur tooth fragment.
Scale bar represents 5 mm.

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