PROCEEDINGS OF THE TWENTY-SIXTH ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY

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TYLER SCHUETZ, Carleton College
Research Advisor: Clint Cowan

INTRODUCTION

The Chickaloon Formation is located in the Matanuska Valley Region of Alaska, approximately 70 miles northeast of Anchorage. The Chickaloon is a >1500m thick terrestrial sedimentary unit and is composed of a complex succession of sandstones, laminated siltstones, mudstones, carbonaceous shales, coal beds and conglomerates (Neff et al., 2011; Sunderlin et al., 2011). The purpose of this research was to determine more about higher latitude continental settings preserved in this unit during and near the Paleocene-Eocene thermal maximum. The formation has been dated using ash layers that approximately straddle the Paleocene-Eocene boundary and previous research has determined that the formation represents sedimentation in a high-latitude (~60°) temperate environment (Sunderlin et al., 2011). In addition to abundant plant remains, the Chickaloon Formation contains a variety of gastropod and bivalve fossils, which further constrain the paleoenvironment of the formation to be a meandering floodplain setting (Neff et al., 2011). This claim is supported by the modern analogues of *Campeloma* snails and Unionoida bivalves collected and analyzed in this project

METHODS

In my examination of the invertebrate fauna of the Chickaloon Formation I mapped a horizontally continuous exposure of the unit at the Evan Jones Mine and collected samples of both gastropod and bivalve fossils. Fossiliferous beds were located using previous knowledge of the area and stratigraphic sections were measured surrounding the beds for approximately half a meter. This project focused on one primary mollusk fossil bed.

All specimens were brought back to Carleton College and were labeled and measured, with particular attention given to the spacing and orientation of visible growth lines on the fossil surface. The specimens were identified through a review of the literature and the observed associations between certain gastropod and bivalve species.

I then studied modern analogues of the identified fossils and the mapped stratigraphic sections of the formation to constrain the depositional environment of the Chickaloon Formation at the Evan Jones Mine.

RESULTS

Approximately 50 samples were catalogued and identified, and were tied to three distinct locations along the sedimentological/environmental gradient. These samples were identified using morphological measurements and comparison with paleoecological literature and with modern analogues. Particular attention was paid to observed modern associations between gastropods and bivalves. The gastropods were identified as members of the Viviparidae family, and the genus *Campeloma*. The bivalves were identified as members of the *Unionoida* family and the Unionoidae family. This identification, as well as the stratigraphic analysis of the stratigraphic columns supports the claim that the paleoenvironment of the Chickaloon Formation is represented by a floodplain, fluvial setting with periodic crevasse splays resulting from episodic flood events.

DISCUSSION

Facies Associations

Two main facies were observed in the stratigraphic columns taken at the Evan Jones Mine location. The first layer is dominated by organic material, with heavily fractured clay interbeds and carbonaceous shale and mudstone; the top of the section is marked by grey to tan sandstone beds. In general the sections coarsen upward, which is indicative of crevasse splays in a fluvial environment. Figures 1, 2, and 3 show the observed stratigraphy at each location.

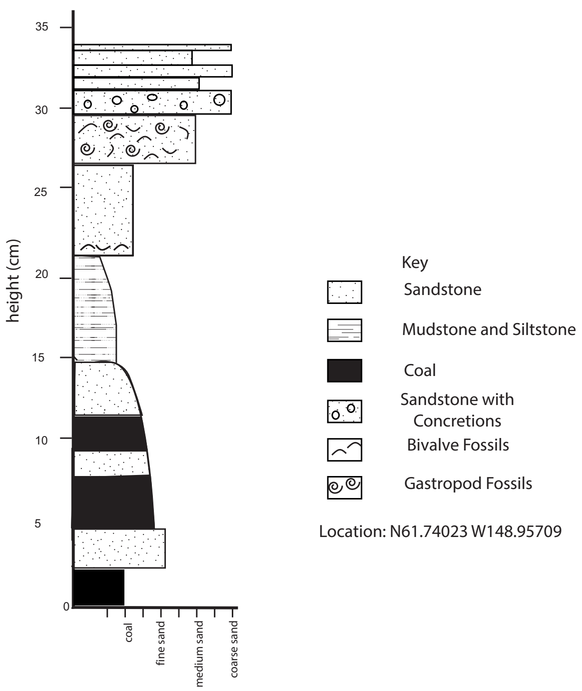

Figure 1. Stratigraphic column of West vertical section. This column is comprised of interbedded coal and clay layers coarsening upward to poorly consolidated sandstones.

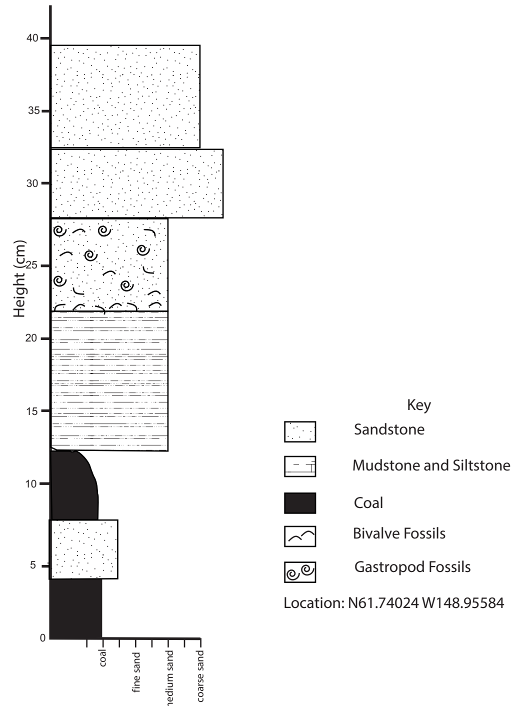

Figure 2. Stratigraphic column of center vertical section. This column contains an ash layer, which was not visible at other locations. The sand layers are much more lithified than in other columns.

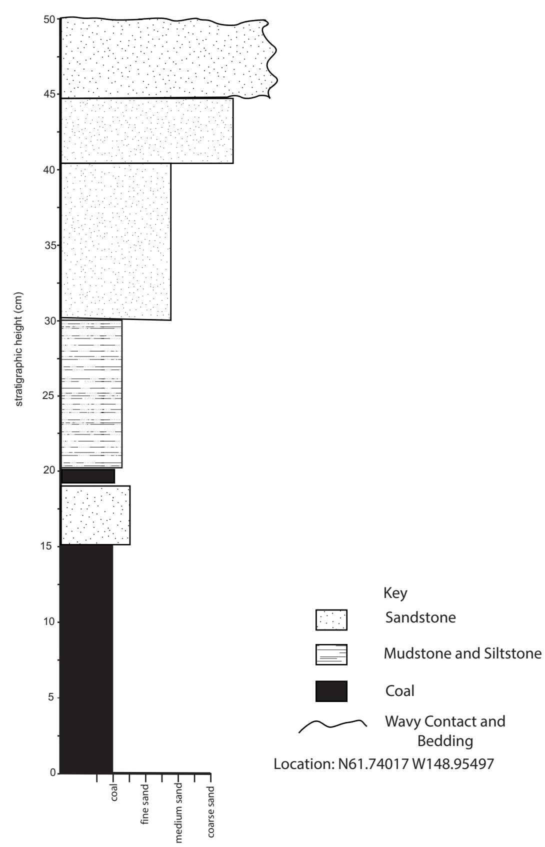

Figure 3. Stratigraphic column of East vertical section. This section shows much larger organic layers and thinner sandstone layers.

Facies Association I – organic layers
Description

3.5cm of coal, in contact with 2 cm of a fine grained, heavily fractured clay. The coal layer continues above the clay for 9 cm, and becomes less consolidated and siltier toward the top of the layer. Occasional presence of an ash layer, but this is not continuous across all measured columns. As the beds move eastward, they become much less lithified.

Interpretation

The presence of interbedded layers of coal and shale is indicative of a mire environment, where organic material is preserved under anoxic conditions. The variations of shale beds to coal beds occur when the mire floods, which causes an influx of material into the system, forming shale beds.

Facies Association II – coarsening upward sandstone
Description

Grey, carbonaceous shale and mudstone continue for 11 cm and are in contact with grey sandstone. The sandstone is very fine grained, with bivalve and gastropod fossils found in the contact between carbonaceous shale and sand layers. Above the grey sandstone lies 4 cm of tan sandstone that contains iron rich concretions. This sandstone is less fine grained and the interactions between the two continue upward out of the study section. The exposure in general coarsens upward, however the sandstone beds fine upward. Moving to the east along the exposure, the sandstones begin to form grey and orange sandstone ribbons. All specimens collected were found in the contact between facies I and II.

Interpretations

This succession was deposited in slow moving waters in a lacustrine or fluvial environment. Crevasse splays are represented by the sandstone beds that laterally pinch and swell, and were caused by sand deposited in overbank deposits during flood conditions. The increasing grain size represents the increase in carrying capacity of the fluvial environment the stratigraphic column continued I would expect to see an abrupt termination of increasing grain size indicating when the flood conditions concluded.

Taxonomy/Modern Analogs

Modern Genus *Viviparus*

Modern *Viviparus,* as described in Richardson and Brown (1989) are detritivores who populate shallow waters with pH ranges of 6.3-8.5 (Duch, 1976; Vincent, 1979; Jokinen and Pondick, 1981). *Viviparus* typically lives for 18-48 months (Eckblad and Shealy, 1972; Richardson and Brown, 1989). *Viviparus* is often common in areas that experience non-energetic flow and not much current but have sufficient water movement to maintain adequate oxygen concentration for the gastropods to survive (Richardson and Brown, 1989). Often found in eutrophic lakes, ponds, and slow-moving streams, *Viviparus* prefers to silt-mud areas (Duch, 1979). Hanley and Flores (1984) found that *Viviparus* prefers large, shallow, low energy environment with low clastic influx .

Fossil Genus *Campeloma*

Twenty-five *Campeloma* fossil remains were identified by their low to moderate spire, impressed sutures, and dextral nature (Jokinen, 1992; Thorp, 2001). The shell is thick, with a rounded or convex center spiral and a simple, continuous peristome. The surface of the shell is smooth, and the only striae are growth lines (Ellsworth, 1886). The species *Campeloma* is generally found in fluvial environments and is common in lowland river courses, often with bivalves like *Unio, Anodonta, Margaritifera,* and *Coricula* (Yen, 1951).

Campeloma are most often found at the muddy bottoms of ponds, rivers, and creeks, are intolerant of temperatures higher than 90 degrees, and are sensitive to changes in mineral character of the water (Ellsworth, 1886).

Campeloma is a genus of the Viviparidae family, whose taxonomy has been discussed more than *Campeloma.* Therefore, to constrain my inferred paleoenvironment, I will assume *Campeloma* is analogous to modern day *Viviparus* and that their environmental preferences are similar.

Campeloma specimens were found exclusively in Facies Association II – the coarsening upward sandstone at the study area. This facies is comprised of different sandstone layers that pinch and swell laterally, indicative of a crevasse splay deposition. *Campeloma* favors large, shallow, low energy environments and could have been entrapped when the crevasse splay spilled out onto the low energy flood plain. Crevasse-splay deposits occur when large quantities of floodwater and sediment are diverted into adjacent flood basins by following distinct channels cut across the banks through natural levee deposits (Reineck and Singh, 1973). These channels are called crevasses, and when water overtops the levees of the main channel crevasse splay systems can develop their own distributary channel pattern (Reineck and Singh, 1973).

Ellsworth (1887) reports finding frost-killed specimens, indicating that *Campeloma* responds drastically to changes in environment. *Campeloma* is used as a bioremediation indicator because it reacts to changes sediment composition, implying it must live in relatively stable environments. This conclusion is supported by the observed disappearance of *Campeloma* communities in areas that receive sewage from cities or manufactories. The paleoenvironment of the *Campeloma* fossils must have been stable during the life span of the gastropod; temperatures must not have exceeded 90° and the pH range must have been constrained to 6.3-8.5.

Order *Unionoida*

I interpret the Chickaloon bivalve specimens to be members of the Order Unionoida based on a comparison of the literature (Vaughn and Hakenkamp, 2001, Thorp and Covich, 2001, and Vaughn and Spooner, 2006). Unionids typically inhabit stable, freshwater habitats (Thorp and Covich, 2001). Mussel beds tend to be prominent in areas that are stable during periods of high water inundation, or flooding (Vaughn and Spooner, 2006). *Unionoida* are found in patchy distributions, caused by patchily distributed resources (Vaughn and Spooner, 2006). Vaughn and Hakenkamp (2001) observed the impact Unionoida have on their environments and found that the bivalves are integral to maintaining certain environmental conditions.

At my study area, unionids are found in the contact between the organic layers and sandstones. This indicates Unionoida survives in a variety of stable, freshwater environments. Unionoidae specimens were found in the crevasse splay deposition, along with *Campeloma*. This association has been recognized in the literature before, and is supported by the observation that mussel beds are more common in areas of flooding or inundation.

Growth Line Analysis

The abundance and pattern of growth lines can help constrain seasonality and variation in paleoenvionment. Growth lines are used to determine the age of a specimen at death. However, the thickness of growth lines depends on the climatic factors during the period of growth (Imbrie and Newell, 1964). In many skeletonized organisms, growth lines grow by accretion over one or more years. Seasonal environment variations influence this growth, so we can cautiously interpret growth lines as annual in nature (Ivany, 2012). Butler et al. (2010) argue that growth lines in mollusk and gastropod fossil are annual and can be used to construct chronology for marine environments that are analogous to those produced from tree rings in the terrestrial environment. Growth line variations potentially record paleoclimate indicators such as temperature, salinity, nutrients and dissolved oxygen (Carter, 1980). Therefore, examining growth lines of molluscan and gastropod specimens are a potential way to constrain the paleoclimate of an area.

Growth line patterns of the observed specimens (both *Campeloma* and Unionoids) show periodicity in groupings. The lines are arranged into two distinct sets, one with many closely spaced thin lines, and one with cm scale spacing between lines. These patterns indicate seasonality in the paleoenvironment, with closely spaced line indicating shorter growing seasons with less available water and greater spacing showing longer seasons with more available water (possibly flood like conditions). These patterns indicate the differences in seasons were consistent. The lack of growth lines on some areas of the specimens and the raised varices indicate halts in growth, which could be due to changes in seasonality and climate. More research should be done into the possibility of further constraining seasonality with growth line analysis. Unfortunately, the specimens collected in this project did not have original preserved material, so the analysis could not be completed.

CONCLUSIONS

By studying the distributions, tolerances, and environments of modern day *Campeloma* and *Unionoidae* we can start to recreate the paleoenvironment of the specimens found at Evan Jones Mine. Both *Campeloma* and *Unionoidae* are found in stable, fresh-water, fluvial environments. *Campeloma* prefer large, shallow low energy environments and *Unionoidae* are most prominent in areas with stable conditions analogous to flood plains. These preferences along with observed stratigraphy indicate the Chickaloon Formation experienced periodic episodes of crevasse splay deposition. By looking at the modern and fossilized examples of *Campeloma* and *Unionoidae* I sought to determine if the fossil assemblages I observed in the field matched the previous paleoclimate research on the Chickaloon Formation. I found that the Chickaloon was deposited in a fluvial, crevasse plain with evidence for the presence of mires and floodplains. These observations correlated well with previous research on the area, supporting the view of the Chickaloon as a high-latitude continental fluvial setting. This research contributes to the available knowledge of the paleoclimate during the Paleocene-Eocene thermal maximum by lending more credibility to already published theories. Further research in this area should focus on the observed periodicity of growth intervals to further constrain patterns of temperature and seasonality.

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