History of the Connecticut River Valley in Relation to the Break-Up of Pangaea

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ABSTRACT

The processes of continental rifting in relation to the break-up of the supercontinent Pangaea during the Mesozoic and early Cenozoic eras involves part of Connecticut, more specifically the Central Valley area also known as the Hartford Basin. Its copious amounts of basaltic lava flows and dolerite fillings represent the significant part of rifting in which new oceanic crust formed and continents divided. This information has allowed us to better understand the cause of Pangaea's break-up, which began as a mantle upwelling due to warming effect the supercontinent imposed on the magma beneath its lithosphere.

INTRODUCTION

A geographic swath that is composed of basalt, diabase dikes and sills, and clastic sediments is spread in separated segments as far down the eastern coast as North Carolina and as far north as Nova Scotia. Part of this section passes through the very center of Connecticut, known as the Connecticut River Valley, and is over 100 miles long and roughly 17 miles wide (Keck, 1999). It initially formed during the Mesozoic era as the supercontinent Pangaea began to rift apart, which began roughly 200 million years ago (Tarbuck et al., 2002). A continental rifting process divided this collection of landmass, spreading apart the continents to their current position.

RIFTING OF PANGAEA

Four major stages have been identified in the break-up of Pangaea beginning around 250Ma with the initial separation of the two major landmasses known as Laurasia and Gondwana during the Triassic period, and ending roughly 175Ma (Stiles and Gierlowski-Kordesch, 2006). During this first stage the Tethys Sea expanded into the developing basin between these two new separate masses, now the North American and African continents, to form what is presently the Atlantic Ocean. This was followed by the rifting of North America from South America during the Late Triassic.

The second stage revolved around the further rifting of various Gondwana continents throughout the Late Triassic and Jurassic periods. Then in the Late Jurassic period South America and Africa began separating, forming the third stage. Finally in the fourth stage which is entering into the Cenozoic era, Australia proceeded to northward, meanwhile Greenland became completely detached from Europe and rifted apart from North America (Wicander and Monroe, 2000).

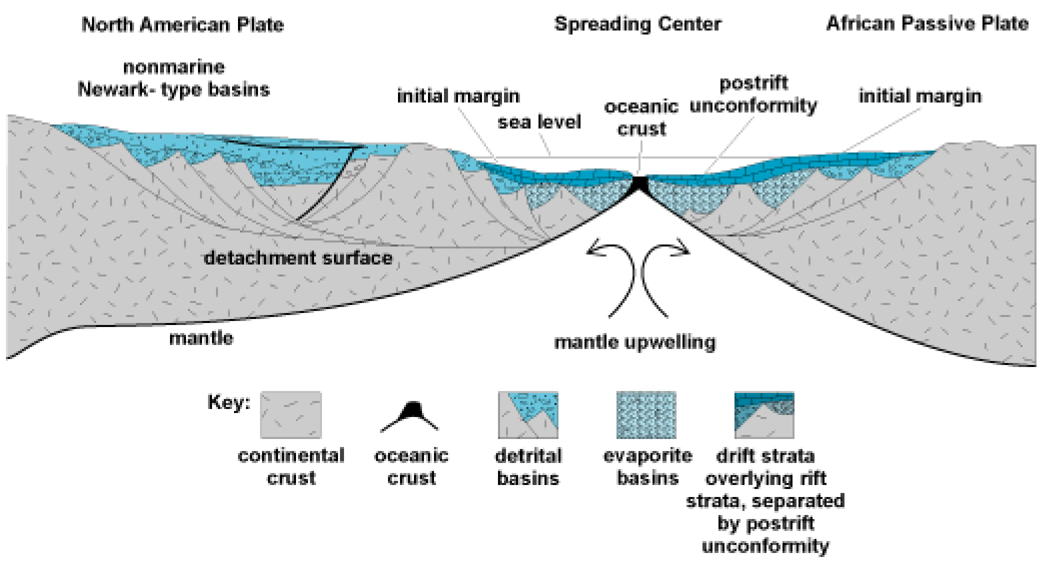


Figure 1. A visual representation of mantle upwelling beneath the supercontinent of Pangaea along the boundary between the North American plate and the African plate (Fazeli, 2008).

Pangaea had an insulating effect on the mantle plume beneath the lithosphere, which lead to mantle upwelling and convection. The building of pressure beneath the supercontinent forced the landmass to compensate for this uplifting by breaking in brittle fractures as magma pushed upward, causing rifts in the extending continental crust (Figure 1). This process of continental rifting by which new oceanic crust forms and continents separate is influenced by mantle upwelling and convection.

Continental rifts form in areas of diverging landmasses where crust is thinning, and often involving igneous related activity. These rifts form ocean basins and passive margins (found along edges of inactive continents), aulacogens (failed section of a triple junction rift), and interior rift basins (located within the interior of a continent) (Marshak, 2009).

When Pangaea began to expand, a triple junction rift formed between the continental masses of North America, Europe, and the South American-African continent which were still connected at the time (Figure 2). As these areas diverged, the formation of each rift valley progressed as the continental crust extended further apart. This is where the crust began to

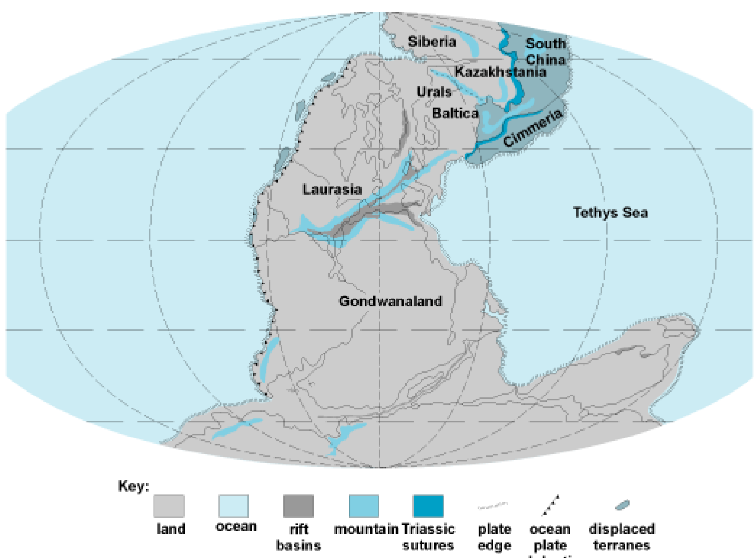


Figure 2b. Representation of Pangaea during the Late Triassic to Early Jurassic. Located between Laurasia and Gondwanaland is a dark grey section that appears to split as it moves towards the right (Fazeli, 2008).

fracture in a brittle manner, which allowed basaltic magma (now lava as it reaches the surface) to flow upwards. Then the rift valley formed when large slabs of this faulting crust fell loosely off the sides of these cracks. This pattern continued and the valley deepened over time to eventually sink lower than sea level, allowing the Tethys Sea to flow between the separating masses to form what is now the Atlantic Ocean. At the center axis of these rift valleys magma is pushed upward until it breaches the thinning crust, forming basaltic and submarine lava flows which aid to the spreading of new ocean floor (Blanchard, 1998).

The Connecticut River Valley

The formation of the Connecticut Valley is estimated to have taken place over a period of 245Ma. There are two basins that make up the Connecticut Rift Valley, which reach as far as northern Massachusetts. These basins are also known as grabens, which are surrounded by elevated rocks known as horsts, and typically form from normal faulting events. The Connecticut Valley is specifically known as a half-graben, which is triangular in shape (Mortensen and Scollan, 2002).

Connecticut's position within the supercontinent at the time of Pangaea's break up was located directly on top of the new spreading center that began the rifting. As the continents of North America and Africa stretched and pulled apart, lava erupted from the deep crustal rifts to flood the valley. As the valley floor dropped, the rocks positioned along the east and west borders were thrust upwards along the fault lines. Over time they eventually formed a range of hills, which today we call the Holyoke Range (Keck, 1999).

There are three known synclines found in the Hartford sub-basin, which is local to the Connecticut River Valley, that can be used to identify where the fault segments might have been, as they typically represent the center of fault segments. Transverse folds are also present within the northeastern part of the Newark basin. The anticlines positioned between these synclines represent overlapping segments, which provides evidence to us that the folds we find in the Connecticut River Valley were the results of faults (Schlische, 1993).

Eventually erosion took a toll on these hills, creating alluvial fans along the cliffs as the rock fragments continued to accumulate. Some of this debris carried further to form layers of fine silt and clay along the bottoms of rivers and lakes. These fine grained layers are what made the claystone that we see in Connecticut today. Exposure to oxygen of the iron content found within the rock resulted in the red coloring of the claystone (Keck, 1999). In figure 4, the drawing of a stratigraphic section from the Connecticut River Valley, there are several layers of red claystone which begin at 172cm from the bottom.

Various types of other sediment have accumulated here in the valley, but the majority is primarily clastic sedimentary rocks, basaltic lava, granite, gneiss, schist, and diabase formations. There are abundant red beds of arkosic sandstone, as previously discussed, conglomerates, and

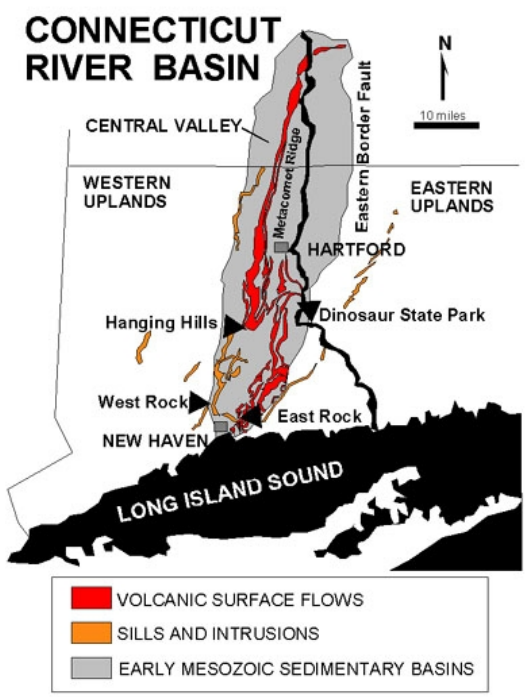


Figure 3. Colored diagram showing the locations of dikes, sills, and lava flows throughout the Hartford Basin of Connecticut (Stoffer and Messina, 2003).

shale that date back to Early Jurassic to Late Triassic in age. The basalt and diabase fillings formed from past lava flows and the formation of dikes and sills, respectively, during the early Jurassic (Figure 3). Additional layers of black shales ranging from a foot to three feet thick are abundant along the bottom of the stratigraphic section shown in Figure 4. Formed in a subtropical, lacustrine environment, these layers spanned throughout most of the basin and reached several meters deep (Kruge et al, 1990).

Scientists suspect that the climate at the time of Pangaea's rifting initially involved frequent rainfall and flash flooding, much like today's tropical monsoon climate, during the beginning of the Mesozoic (Mortensen and Scollan, 2002). They believe this because of the varying thicknesses, from merely inches up to several feet, of the claystone and siltstone layers found in piles along the alluvial fans surrounding the valley (Keck, 1999). Deep, dense mudcrack formations found here separate the sequence boundaries of wetting and drying cycles, and also represent periods of extreme exposure. Evidence for braided streams can also be found here (Drzewiecki, 2006).

Within the sedimentary layers in the valley and other rifting areas along the triple junction, alternating sequences of plant fossils and evaporates have been found. Some examples of fossils found here include conifers, horsetails, giant club mosses, and cycads. This supports the understanding that Pangaea was centered along the equator, providing a humid climate for the Connecticut Rift Valley during the Mesozoic. In addition, it also provides evidence for periods in which lakes developed (Prothero and Dott, 2002).

The five following dinosaur footprints are examples of the most common trace fossil found in the valley: *anchisaurus*, *yaleosaurus*, *coelophysis*, *ammosaurus*, and a relative of *dilophosaurus* called eubrontes. There are two additional tracks that have yet to be identified with any dinosaur genera, called *grallator* and *otozoum* (Mortensen and Scollan, 2002).

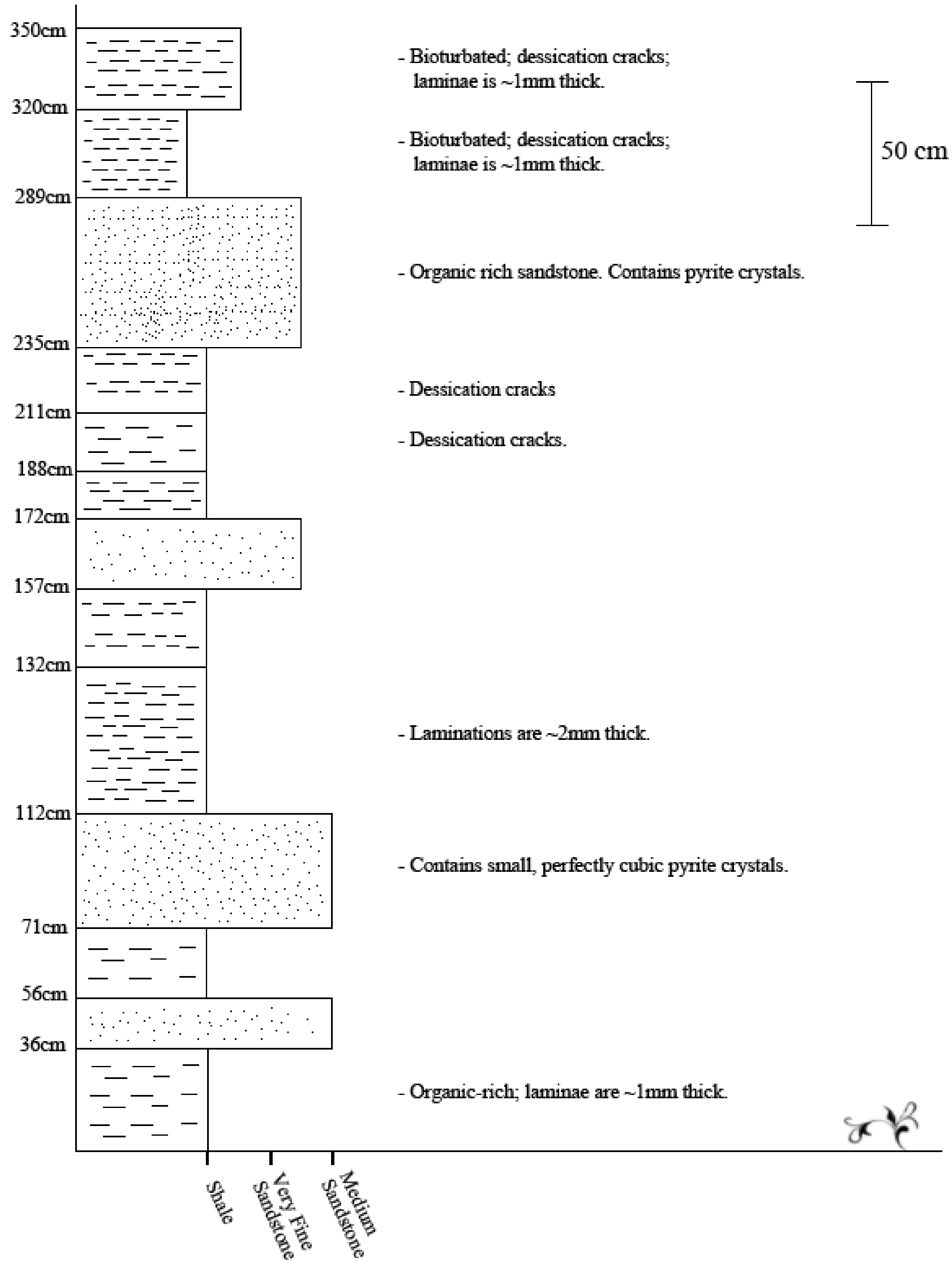
Volcanism in the Connecticut River Valley

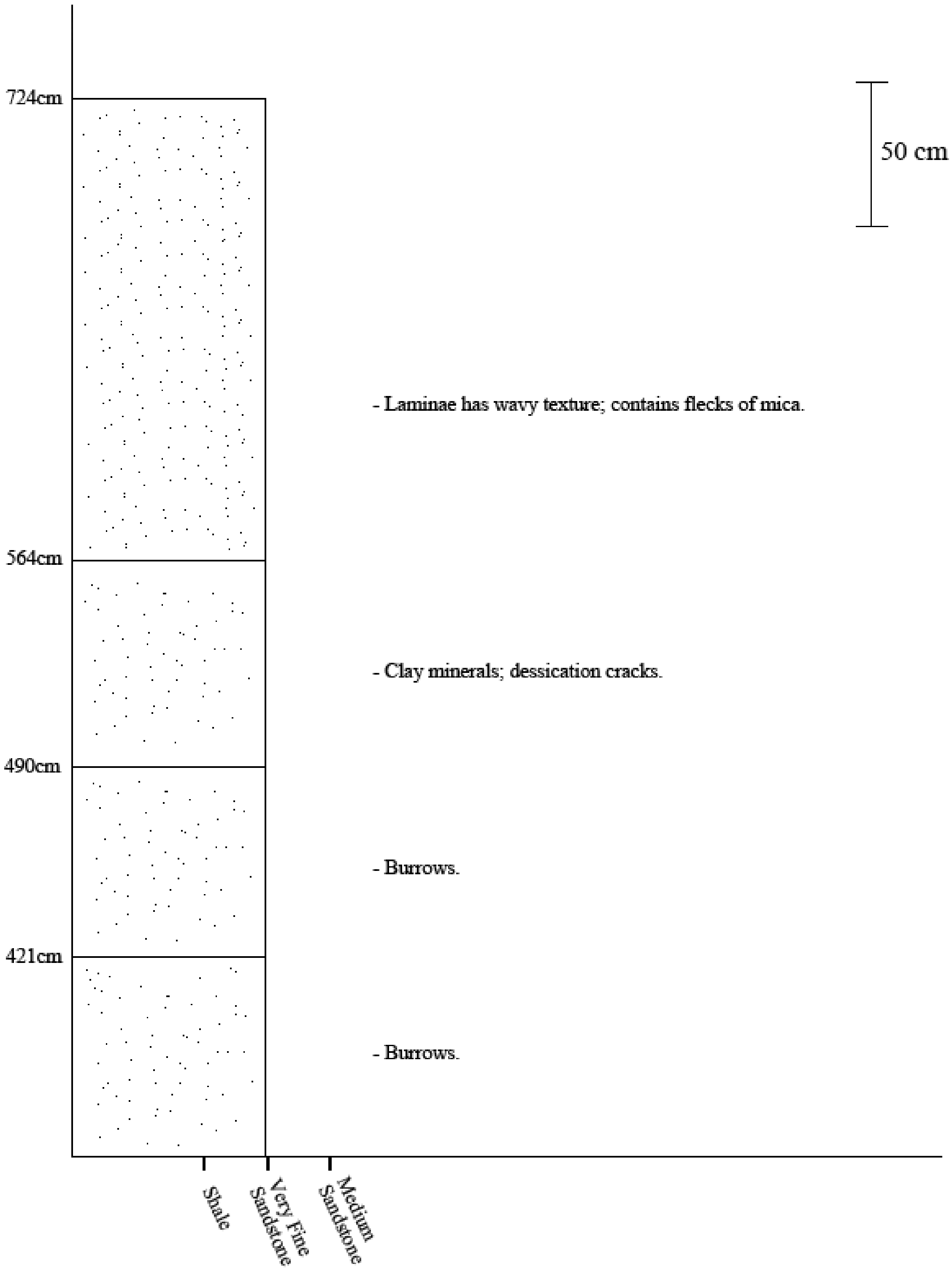
Four separate periods of volcanic activity during the Late Triassic to Early Jurassic have been identified and they are named, in order from oldest to youngest, the Talcott, Holyoke, Hampden, and Higganum volcanic events (De Boer, 2009). Volcanism in the Connecticut River Valley during the time of Pangaea's break-up was not of the explosive, stratovolcano type. Instead, as a result of the brittle crust frequently releasing flows of basaltic lava, the majority of the igneous processes here revolved around the formation of dikes and sills, as well as the formation of new oceanic crust. This lava was mafic and lacked viscosity making it basaltic lava and more prone to flowing rather than erupting as a result from a build-up of volatile-related pressures (Marshak, 2009). Then when pouring onto ocean floor of the Connecticut River Valley, it would form pillow basalt.

CONCLUSION

Continental rifting processes are complex and may take up to hundreds of millions of years to separate large landmasses such as Pangaea, and although the continents continue their separation today, the initial rifting apart of Pangaea has been completed. All tectonic activity has since ceased, but has produced a sufficient amount of resources for the study of continental rifting. There are several rock outcrops in remarkable condition that allow for opportunities of clear documentation of stratigraphic sequences, one example of which is displayed in Figure 4, located in the Appendix. This small stratigraphic section does however succeed in representing part of the elaborate history of Connecticut's bedrock.

Appendix


350cm
320cm
289cm
235cm
211cm
188cm
172cm
157cm
132cm
112cm
71cm
56cm
36cm
- Bioturbated; dessication cracks; laminae is ~1mm thick.
- Bioturbated; dessication cracks; laminae is ~1mm thick.
- Organic rich sandstone. Contains pyrite crystals.
- Dessication cracks
- Dessication cracks.
- Laminations are ~2mm thick.
- Contains small, perfectly cubic pyrite crystals.
- Organic-rich; laminae are ~1mm thick.
50 cm
Shale
Very Fine Sandstone
Medium Sandstone


724cm
564cm
490cm
421cm
50 cm
- Laminae has wavy texture; contains flecks of mica.
- Clay minerals; dessication cracks.
- Burrows.
- Burrows.
Shale
Very Fine Sandstone
Medium Sandstone

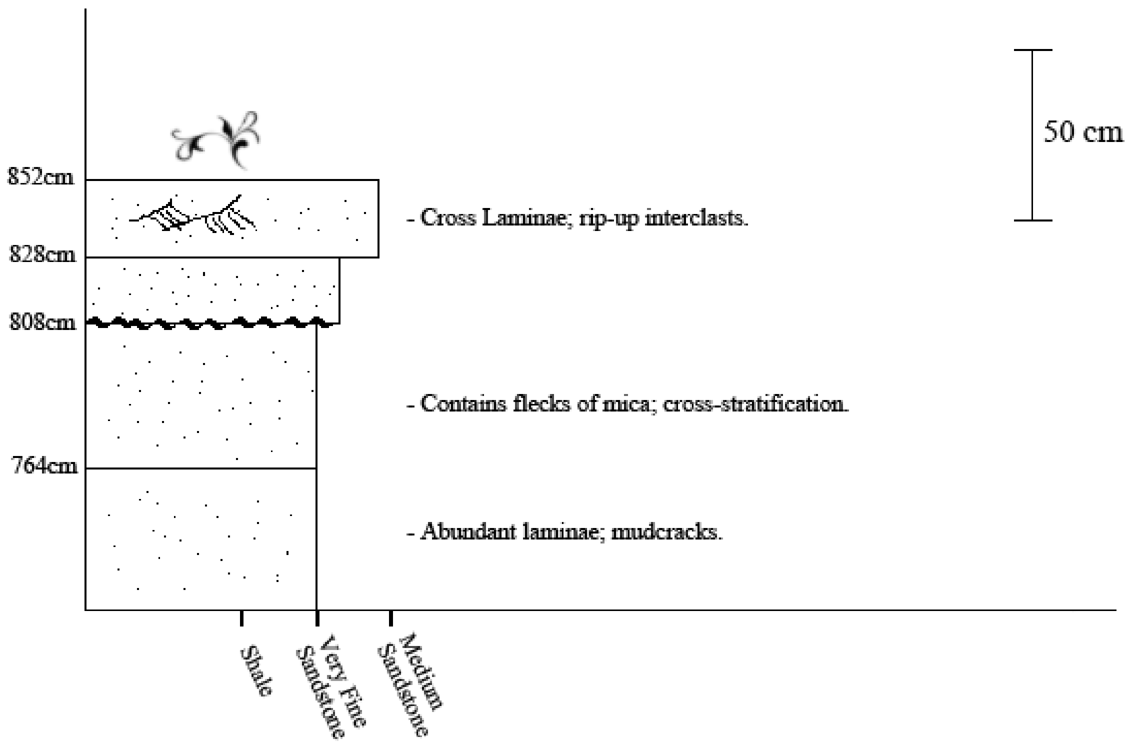


Figure 4. This is a stratigraphic section taken from the center valley of Connecticut. It shows the varying layers of sand and shale, and provides evidence for past life by containing burrows. It also guides us in understanding the paleoenvironment which had humid and arid cycles.

References Cited

Blanchard, Donald L., 1998, The ABCs of Plate Tectonics: Sedimentation and Continental Growth, <http://webspinners.com/dlblanc/tectonic/sediment.php>.

De Boer, Jelle; 1968, Paleomagnetic Differentiation and Correlation of the Late Triassic Volcanic Rocks in the Central Appalachians (with Special Reference to the Connecticut Valley), Geological Society of America Bulletin, 79, pp.609-626.

Drzewiecki, Peter A.; Zuidema, Shantar; Dwyer, Allen R. III, 2006, Paleoenvironmental and Sequence Stratigraphic Interpretations of Paleosols in Continental Strata of the Hartford Rift Basin (Triassic/Jurassic), Connecticut, Geological Society of America, Vol. 38, No. 2, p. 30.

Fazeli, Ali, 2008, eGeology, Geology Articles, <http://egeology.blogfa.com/post-84.aspx>.

Keck, E. B.; 1999, The Connecticut River Valley, <http://homepage.mac.com/ebandpck/cityrocks/connecticut.html>.

Kruge, Michael A.; Hubert, John F.; Akes, R. Jay; Meriney, Paul E.; 1990, Biological markers in Lower Jurassic synrift lacustrine black shales, Hartford Basin, Connecticut, U.S.A., Elsevier ltd., Organic Geochemistry, Vol. 15, Issue 3, pp. 281-289.

Marshak, Stephen, 2009, Essentials of Geology, 3rd Ed, W.W. Norton & Company, Inc., pp. 171.

Mortensen, Katherine; Scollan, Daniel, 2002, Dinosaurs and the Connecticut Valley, The Traprock, Vol. 1, pp. 23-28.

Prothero, Donald R.; Dott, Robert H., 2002, Evolution of the Earth, 6th ed., McGraw Hill, New York, NY, pp. 384.

Schlische, Roy. W.; 1993, Anatomy and Evolution of the Triassic-Jurassic Continental Rift System, Eastern North America, Tectonics, Vol. 12, No. 4, pp. 1026-1042.

Stiles, Cynthia; Gierlowski-Kordesch, Elizabeth H.; Interpreting Sedimentation Patterns and Paleoclimate from Paleosol Sequences of the Triassic-Jurassic Hartford Basin Rift Valley, Connecticut, USA, International Union of Soil Sciences, <http://a-c-s.confex.com/crops/wc2006/techprogram/P16850.HTM>

Stoffer, Phil; Messina, Paula; 2003, Geology of the New York City Region: The Connecticut River Basin, U.S. Geological Survey, U.S. Department of the Interior, <http://3dparks.wr.usgs.gov/nyc/mesozoic/connecticut.htm>.

Tarbuck, Edward D.; Frederick, Lutgens K.;Tasa, Dennis, 2002, Earth: An Introduction to Physical Geology, 7th ed, Upper Saddle River, NJ: Prentice Hall.

Wicander, Reed; Monroe, James S., 2000, Historical Geology: Evolution of Earth and Life Through Time, 3rd Ed., Brooks/Cole, pp.248-254.