Geological Principles Illustrated in the Art along the Antelope Valley Hiker/Biker Trail – The BIG X (Salt Creek Roadway/Antelope Valley Parkway) South to Q Street

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Introduction

When the weather is good (and even sometimes when it isn’t) I occasionally walk around the periphery of the UNL city campus, often over the lunch hour, now that the trails and the sidewalks allow one to walk a complete circuit. The walk along Antelope Creek from the Big X to Q Street is beautiful. The designers of the project made nice art works on the floor of the creek and on the retaining walls on the valley sides that add to the beauty of nature.

I am a geologist and wondered about some of the art and its meaning because it looks in many respects to have been derived from things that can be seen in road-cuts and natural exposures in parts of eastern Nebraska. Curious about the meaning, I went for help to people who had worked on the project. Mary Anne Wells, Senior Project Landscape Architect, was very helpful and explained that the design team wanted to add some interest to the wall and used a “wave” pattern to look like the rolling hills of eastern Nebraska or like a soil profile close up. Three different textures and earth-tone colors were used on the panels to give them rock- or soil-like appearances. Construction on the Big T (now Big X) was started in 2005. The mechanically stabilized earth (MSE) walls at the center of the ”X” are about 35 feet tall and the cladding is made of concrete panels about four-feet eight inches wide by four-feet ten inches high (Fig. 2).
Mary Anne further explained that leaf patterns from native trees (maple, cottonwood, and oak) were used in the central group of panels and that Nebraska invertebrate fossils were used in the lower group. These fossil invertebrate forms (brachiopod, bivalve, and cephalopod shells) were selected by Dr. R. Matthew Joeckel of UNL. No organisms are depicted on the upper group of panels (Figs. 3 and 4).

Fig. 1. Aerial image of the Big X area to Q St. Q St. is first site to visit. North toward the top of the image. Q St. is the east-west street at the bottom of the image.
Fig. 2 (above). Installation of MSE walls at Big T (later Big X). Image by Mary Anne Wells.

Fig. 3 (below). Completed MSE wall, southwest side of Big X east of 16th St.
My thought when first looking at the arrangement of three layers with fossils, leaves, and invertebrate shells was that these images were illustrating the local geology exposed in the area in road cuts and natural exposures. The upper layer might represent Quaternary deposits that generally cover the bedrock; the middle layer Cretaceous bedrock, which in eastern Nebraska contains fossil leaf imprints at some sites; and the lower layer Pennsylvanian bedrock ocean deposits that contain shells of fossils including brachiopods, bivalves and cephalopods (Figs. 3 and 4). Mary Anne’s explanation above disabused me of these ideas, but the depicted layers and artistic depictions of parts of organisms in a natural geologic arrangement started me thinking of how a thought experiment using the art might allow me to get those who read this work and then looked at the art to learn some basic geological principles and some basic local geology. That way readers might be able to apply those principles in the future to interpret the geological past, at least in a general way when they see exposed strata (layers of rock) at other places.

Fig. 4, Top row, left to right: maple leaf; cottonwood leaf; burr oak leaf. Bottom row: brachiopod shell; bivalve shell; coiled cephalopod shell.
Some Geologic Principles

Geologists teach basic geological principles used for working out geological history to every student so that each has a starting point for use in interpreting what he or she sees at any geologic site. The first three of these (now called original horizontality, lateral continuity, and superposition) were discovered and explained by Nicolas Steno in 1669. These three principles all have exceptions that geologists have learned to recognize. All can be demonstrated when we examine layers of sediments deposited in relatively still bodies of water.

I have drawn four cartoons (Fig. 5) to illustrate Steno’s principles and two other principles as well. Figure 5, A-C shows three cross sections through a body of water that I labeled a lake. This body could be any size from a mud puddle up to an ocean. In all such waters sediment is carried off the land primarily by water and wind erosion and transport and then settles to the floor of the lake (Fig. 5 A). If sediment is not deposited continuously, layering is developed. The layers are nearly horizontal (original horizontality) and continuous across the floor of the lake (lateral continuity; Figures 5 B and C). The first deposited layer is at the bottom of the lake deposits and the layers above are each geologically younger than those below (superposition).

I have tried to illustrate two other geologic principles in Figure 5. The first of these, floral and faunal succession, was originally observed by William Smith, an English geologist in the early 1800s. Smith found that fossils of plants and animals occurred only in either a single layer of sediment or sedimentary rock or in multiple layers, but that no one kind of fossil occurred throughout the complete geologic section that he studied. This principle was applied by geologists in other places in England and in other parts of the globe. These changes reflect organic evolution through time.
The final principle that I have tried to illustrate in Figure 5 D is of cross-cutting relationships as it has come to be called. James Hutton, a Scottish geologist, is credited with discovering this principle, which he described and explained in a two-volume book in 1795. Hutton found that any geologic feature the cuts across others must be geologically younger than those it cuts. In Figure 5 D an earthquake fault has cracked and offset superposed layers.

Fig. 5. Left; A-D – Model of sediment deposition in a standing body of water (in this case a lake) demonstrating the principles of original horizontality, lateral continuity, superposition, floral and faunal succession, and cross-cutting relationships. Top center, sediments and sedimentary rock strata exposed in a limestone quarry in Omaha, NE; Note buried darker topsoil (paleosol) about one-third of the way from the top of the cut. Top right, Holocene and Pleistocene sediments exposed in Elba Cut, 3 mi east of Elba, NE – Note that uppermost tan sediments were deposited in valleys cut into geologically older sediments. Lower center, Sedimentary formations offset along an earthquake fault, Harlan County Lake, NE. Lower right, Sedimentary formations bent into a U-shape, Sidling Hill road cut, Interstate 68, Washington, County, MD.
Figure 5 also includes four images of man-made or natural exposures of sedimentary deposits which illustrate one or more of the five principles just explained. The top center image is of the working face of a limestone quarry in the Omaha, NE, area. The layers of marine limestone are overlain by two thick glacial till layers deposited after the ice from two ice-sheets advanced over the area and then melted away during parts of the Ice Ages. Original horizontality, lateral continuity and superposition can be observed in the image. You can see a darker layer about one-third of the way down from the top of the exposure, which is an ancient buried topsoil (paleosol) similar to the topsoil visible at the top of the exposure. This paleosol formed when deposition ceased and plants covered the exposed surface of the older glacial till for a long time.

The top right image is of another man-made cut through a succession of wind deposits called loess and stream deposits called alluvium. Here again you can see nearly horizontal layers that continue laterally and are superposed with the geologically oldest layer at the bottom of the cut. Notice that the uppermost layers have a base that is not horizontal. The sediments below the base were eroded by small ancient streams to form a landscape of small hills and valleys. These valleys were subsequently filled with the light tan sediment.

The bottom center image is of a natural cut-bank on the south side of Harlan County Lake in south-central Nebraska. An earthquake fault runs from near the center of the image downward to the left. Notice that fault plain does not extend across the sediment at the top of the image. Using what you now know about cross-cutting relationships you should be able to say with confidence that the fault is geologically younger than the rocks it cuts, but is older than the un-cut sediments above it.

Finally, the bottom right image is of rocks deformed into a U-shape by mountain formation in the Appalachian Valley and Ridge Province of western Maryland. The rocks were originally
deposited as nearly horizontal layers with lateral continuity and were deposited with the oldest layer at the bottom of the mass exposed in the road cut. The layers were subsequently deformed into the U-shaped fold (called a syncline by geologists).

**Imaginary Geology Tour of the Public Art**

Now that you know some of the basic geological principles that I and other geologists use to work out the geologic history of exposed rock sequences use your imagination as you follow me from the Big X south toward Q Street on the hiker-biker trail. You should by now have some general knowledge about the construction of the walls and fills supporting the roadway and bridges. Put that aside and imagine as I did that what you see in Figure 6 is not a wall, but instead an excavated cut down through the sediments and rocks beneath the surface of Lincoln.

Fig. 6. Hypothetical exposed geologic section
In the Lincoln area the land surface is generally underlain by complex surficial Quaternary (the last 2.58 million years of geologic history) deposits of interlayered stream alluvium, wind-deposited loess, and glacial till except in some topographically low spots on the landscape where older bedrock is exposed by the erosive actions of Antelope and Salt creeks. The lighter-colored upper part of the scene in Figure 6 could be those deposits in this imaginary scenario. If so fossils not depicted, but possibly buried just out of sight behind the supporting walls, would include fossil plants, fossil invertebrate shells (such as snail shells) and bones of land animals.

There is a big time gap in geologic age between these Quaternary sediments and the ancient bedrock beneath them. This gap is represented by an erosion plane at the top of the ancient rock that geologists call an unconformity. Think back to the top center image of Figure 5. There are at least two major unconformities in the scene, one at the top of the buried paleosol or ancient soil and one at the top of the limestone layers.

Cretaceous sandstones and shales of the Dakota Group directly underlie the Quaternary sediments beneath the Lincoln area. These sedimentary rocks were deposited more than 100 million years ago on an ancient coastal plain marginal to a vast seaway. Fossils found in these rocks in eastern Nebraska include leaf impressions of trees that look like maple, cottonwood, oak (Figure 4, top row) and other trees similar to those that grow in the area today. They are not attached to woody plant parts and generally do not have fossil flowers and seeds attached to them. Paleobotanists have given them scientific names like *Acerites, Populites,* and *Quercites* because they look like (= *ites*) maple, cottonwood and oak leaves. These names reflect the scientists’ uncertainty about whether or not the leaves are from ancient species of those kinds of trees. In any event the “layer” with the leaves fits the reality of the geologic sequence beneath Lincoln and the sand-like texture in the panels of the MSE walls does as well (Figure 4, top row).
There is another even greater age gap in the geological sequence between the base of the Dakota Group and the underlying Upper Pennsylvanian rocks, which are more than 300 million years old. These rocks are of marine limestone and shale which contain fossils of invertebrate animals with shells like brachiopods, bivalves and cephalopods (see Figure 4, bottom row) and a host of fossil microscopic marine animal shells and plant parts.

One thing that does not fit this imaginary geologic scenario is the sediment depicted as surrounding the fossils in the panels illustrated in the bottom row of Figure 4. The material that the shells are in looks like pebbles. Rock pebbles indicate rapid water movement. The shells of the three aforementioned marine animals are composed of calcium carbonate (CaCO₃) and are not hard and durable when moved with gravel. It is highly unlikely that these shells would all have been preserved unbroken when moved any distance as part of gravel transport in water.

The three layers just described fit the principles of superposition and lateral continuity, but do not fit the idea of original horizontality because the layers are not horizontal as depicted.

Walking or biking south toward Q Street you can see a scene like that shown in Figure 7. Mary Anne Wells, you may recall, said the some of the panel art represented the rolling hills of Lincoln in the designer’s mind. If we imagine that the walls were cut into geologic materials, then an alternate explanation might be that what you are seeing is a somewhat more complicated example of the cut-and-fill of ancient valleys in Figure 5, top right.

If these were real geologic strata you could verify what you see in the side views either by test drilling through them to see if the formation tops or the paleosols occurred in the cuttings or cores taken from the test holes or by using geophysical methods to determine changes in the strata with depth.
Fig. 7. Hypothetical paleovalley cuts and fills with paleosols or stylized hills and valleys?

**Other Artistic Features**

As you approach Q Street you can see three small stylized waterfalls or cascades with a pond between each of them (Figures 8 and 9). The concrete at each has been shaped to look like tilted layers of natural rock that water has partially eroded through to form the falls or cascades. The “rock” resembles Dakota Group sandstone, which may be cross-stratified. The tilted and cross-stratified layers have some natural tilting due to deposition or the channel floor of some fast flowing stream or river. Another possible explanation for the tilting could be that an earthquake uplifted and tilted the rock layers after they were deposited.
Fig. 8. Aerial view of ponds and water features at Q and N. 22\textsuperscript{nd} streets.

Fig. 9. Water fall/cascade over concrete resembling Dakota sandstone layers
A Distant Connection to the South along Antelope Creek

You might well ask if such features could occur naturally along Antelope Creek and you, like I, might answer that they might have at one time or another. For years I have driven southeastward along Capitol Parkway from 27th Street to A Street and glanced down into the creek bed just east of the Children’s Zoo. The rusty yellowish-red hue of the Dakota Group sandstone is visible on both sides of the creek. I thought that I also saw two natural cascades or falls on that reach. I asked about these apparent falls and was directed to Ed Zimmer, Historical Preservation Planner in the City of Lincoln Planning Department, and to Glenn Johnson, General Manager of the Lower Platte South NRD. I asked Ed about the history of the creek through that area and he supplied a copy of a map in the department’s files dated 1914 (Figure 10).

Fig. 10. Map of Antelope Creek (1914) courtesy of Ed Zimmer. Modified by D. Ebbeka.
From 27th Street southeastward to A Street the creek meandered considerably east of its present location (Fig. 10). Ed wrote that the creek was about in its current alignment by 1941 as shown from a historical aerial photograph from that year. The creek originally flowed around a Dakota sandstone hill and was clearly straightened after 1914 and before 1941. That straightening required excavation down through the sandstone to grade with no cascades or falls along the straightened reach. That’s seems to have been the way things stayed until probably the mid-1980s when limestone rocks from Weeping Water were added “…in the bottom and across the channel to create the small water drops.” After reading this remark I went to the Billy Wolff Trail and saw the truth of the matter. Figures 11 and 12 show the locations of the two artificial cascades.

Fig. 11. Dakota Group sandstone along Antelope Creek east of Children’s Zoo.
OTHER GEOLOGICAL FEATURES

As you walk or bike the trail you should also look for natural decay features of the rocks, concrete and sediments; for water erosional and depositional features; and for evidence of ground water recharge to the creek.

Decay features are called weathering by geologists. Physical weathering is natural breakage of the rock or concrete. You can observe this in some places along the trail. Chemical weathering is a chemical change in the minerals and concrete. The rust-colored streaks that are on a few of the concrete walls and panels (see Fig. 4, top right image) are produced by oxidation of pieces of the mineral marcasite, an unstable form of iron disulfide (FeS₂), into limonite, a hydrated iron oxide with the liberation of sulfuric acid. The cream colored streaks on the walls
are from dissolution of lime in concrete and precipitation of the lime on the surface of the walls when water evaporates.

An erosional feature of the creek is the development of meanders of the creek channel north of the concrete-lined part of the channel north of Q Street. Depositional features include the debris marked flood line(s) after the water levels have risen and fallen during flood events after high rainfalls in the drainage basin of the creek. Other depositional features at low water include ripple marks and sand bars in the bed of the channel just north of the Vine Street Bridge across the creek.

You can observe two ground-water related features from Q Street to just north of Vine Street. The channel along that reach of the creek from north of the northernmost falls to just north of the Vine Street bridge is concrete lined. There are circular openings in the concrete floor of the channel spaced fairly regularly along the length of that reach. Especially at low water stage, fountains of water issue from the openings. This water may be flowing because groundwater is under pressure beneath this part of the creek. Groundwater also issues from the bases of some concrete slabs and flows into the creek.

FINISHING UP

All of this has been fun to consider. I hope that you walk or bike the trails along Antelope Creek, particularly from The Big X south to Q Street, and look at the public art and the geologic features. If you have never seen bedrock in Lincoln the site at the Children’s Zoo is instructive and shows how the city has changed things over the years.
ACKNOWLEDGMENTS

I thank Mary Anne Wells, Ed Zimmer and Glenn Johnson for their help supplying information images and a map for me to use for this project. Figure 2 courtesy of Mary Anne Wells. Figures 1, 8, 11 and 12 are Google Earth Pro images modified by Dee Ebbeka. All others images are by the author. Any errors of fact are entirely my own.

SOME USEFUL REFERENCES

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Reed, E, C, and V.H. Dreeszen, 1965, Revision of the Classification of the Pleistocene Deposits of Nebraska: Conservation and Survey Division, University of Nebraska, Nebraska Geological Survey Bulletin 23, 65 p. Outlines the stratigraphy of the Pleistocene deposits covering much of Nebraska including the Lincoln area.

Note: Many other works on aspects of the geology of Nebraska are either in print or on-line from the Conservation and Survey Division, School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE 68583-0961; telephone (402) 472-3471.