

To Armored Mud Balls, with love. The true story, in four parts, of how armored mud balls formed, were discovered, and why Franklin County, Massachusetts is the lucky, rare location where the world's best and only lithified armored mud ball samples have ever been collected. You will also learn about **mud volcanoes**, including flaming ones!

By Richard D. Little, December 2020

Part One: In The Beginning....

I grew up along the NH coast happily hopping from granite to gneiss beach boulders and peeling a bit of mica along the way. At Clark University in Worcester, MA, I discovered geology. An epiphany during a Geo 101 field trip sealed my professional fate. Rocks and landscapes, so common and unappreciated, hold amazing and fantastic stories! Mysterious tales of great ice sheets and even dinosaurs (not at the same time) left their marks, underfoot and undervalued by most to the population. I was hooked.

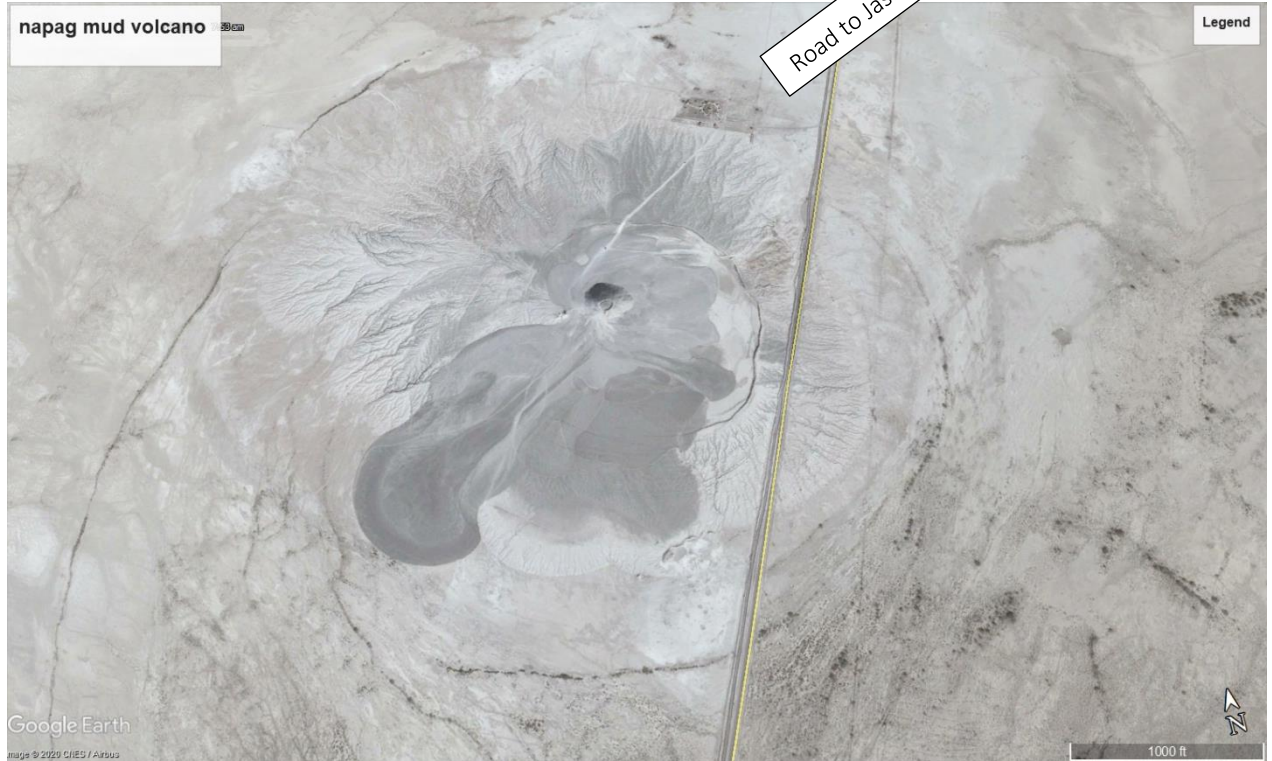
From Clark I went to the University of Southern California and discovered the desert. Stark and beautiful landscapes, so different from the East, held me spellbound with many opportunities to explore. My Masters thesis involved field work along the Makran Coast of Iran and Pakistan, a desert / coastal environment of great beauty and remoteness. [The Makran Coast is the east-west coastline between the Persian Gulf and India.] Its geology is very similar to California with coastal terraces prominent. One intriguing difference: **mud volcanoes!** The Makran Coast is famous for mud volcanoes and I climbed the Napag volcano pictured below. There is a lot of poorly consolidated "mud rock" underlying the Makran Coast. Faulting occurs and fluids, sometimes accompanied by methane, rise along the fault bringing mud to the surface. There are no igneous volcanic rocks here.



Napag Mud Volcano

about 100 feet high, with mud flows radiating from the cone. Picture below: mud flow front is several inches thick at edge, now dry. Note two people for scale. Napag Location:

25 ° 28' 01"
59° 55' 58".



Photos reference: **Mud Diapirism on the Makran, Iran: Case Study on the Napag Mud Volcano** Faranak Feizi, Mehran Arian, Artin Arian: **Open Journal of Geology**

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[10.4236/ojg.2015.55027](https://doi.org/10.4236/ojg.2015.55027)



Central mud vent. Bubbling.

OTHER LOCATIONS: (1) Man and boy walk down a mud volcano on the Pakistan Makran Coastal Plain (Indian Ocean in distance), 200 miles east of Napag volcano. See the smaller mud volcano with people climbing (look closely)?

The big volcano is Chandragup an active mud volcano located, 300 feet high, in Hingol National Park in Balochistan, Pakistan. Also known as Chandrakup, the volcano is considered holy by Hindus and is an important stop for pilgrims on their way to the shrine of Shri Hinglaj Mata temple.



(2) YouTube video of erupting mud volcano creating an island off the coast of Pakistan.
https://youtu.be/97D5_H05p2Y

(2) Baku (Caspian Sea coast) Mud Volcano, erupting and igniting!

Natural gas (methane) often bubbles through the mud and can ignite. This You Tube video captures this event!

Nijat Askerov, October 12, 2012, Baku, Azerbaijan (natural gas + mud volcano)

"Mud volcano in Baku - YouTube" In first frame, the volcano is erupting gaseous wet mud. Then, ignition.



Part Two: Greenfield Community College

After graduate school I was fortunate to be hired by Greenfield Community College. It was 1969 and the Massachusetts community college system was expanding. Lucky for me, I was in the right place at the right time. Let me share with you: I really *was* lucky! I was choice #2. I got a rejection letter. But #1 had to withdraw due to a Vietnam War draft situation. He had to take a public school science position to be draft deferred. I got a phone call in Los Angeles asking if I was still interested. Guess the answer!

In preparing for classes and exploring this new area, I went to Unity Park in Turners Falls, along the banks of the Connecticut River. Unity Park is the site of a suspension bridge, now dismantled, that connected Gill to Turners Falls (1878 – 1942). In the suspension cable anchors, a few feet from where I parked, were these intriguing round features (picture below)! I found armored mud balls! Below is the “genesis rock” of armored mud balls. It was right by the parking lot in the suspension cable anchor, adjacent to the Connecticut River. The ruler is 6 inches. The structure is now dismantled and the quarried stones with armored mud balls are at GCC or preserved at the site. A postcard view of this bridge is pictured below.

After several years of bringing students here as part of GCC field trips, further research revealed that no one had ever noted them in the geological (or any other) literature. I prepared a paper that was published in the

Journal of Geology (1982). Being the discoverer was quite a surprise since many 19th century geologists traveled over this bridge to nearby dinosaur footprint quarry sites in Gill. I am quite sure that they would have stopped to view these obvious and interesting sedimentary features, but nobody wrote about them. Maybe they were too busy thinking about dinosaur discoveries.

This postcard view is looking south from Gill toward Turners Falls.

The armored mud balls of



the suspension cable anchor pictured above were on the east face of the east anchor (near the arrow --the armored mud balls were in the suspension cable *anchor*, not the bridge abutment). They would not have been seen by people passing over the bridge. However, another anchor view is below and shows that some armored mud balls would have been visible to bridge users.

In order to protect these unique geological oddities, the Unity Park rocks of scientific interest were moved to Greenfield Community College in the 1980s where they became part of our outdoor geology collection.

The origin of Armored Mud Balls.

Occasionally streams would undercut hard mud banks and chunks of mud would roll downstream, become round, soft and sticky on the outside, picking up stream sand and pebbles along the way.

That coating is the “armor” to the mud ball. If these rolling balls were lucky, they got buried quickly in the stream gravel and eventually lithified (turned to stone) along with the surrounding rock.



*Lithified armored mud balls are rare features only found in about ten places in the world (such as Greenland, Austria, Montana, and Trinidad). Those examples are trapped in bedrock but documented in the geological literature. **In the whole world, the only source for samples of armored mud balls is Franklin County** and specimens have been donated to many local colleges and museums.*

The armored mud balls were first noted in quarried sandstone blocks (see below) and sometimes, rarely, they can be found in river eroded rock pieces along the Connecticut’s riverbank. It is fortunate that these rare geological oddities are preserved for display. Besides the GCC Geo Path and corridor display cases, you can see armored mud balls in Unity Park, Turners Falls and

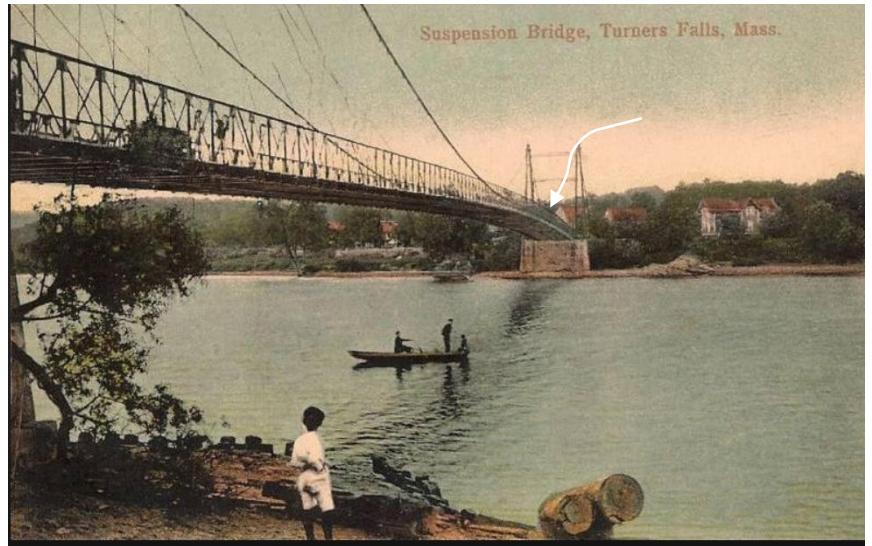
at the Beneski Museum, Amherst College.

Your author is the proud discoverer of the Franklin County armored mud balls, and wrote a paper describing them in the Journal of Geology (1982).

Part Three. TO BE OR NOT TO BE (LITHIFIED), THAT IS THE QUESTION.....

With apologies to Shakespeare, this indeed is a life or death situation. Lithification (turning to stone) is the key to geologic survival. Sediments easily get eroded, transported, and deposited, but they need to lithify, “petrify” in order to be a sedimentary rock. Lithification does not always involve great pressures and heat, as you might think. What is needed is fluids with minerals to precipitate and fill in the pore spaces between the grains. Calcium carbonate is a good example. Everyone has seen dripstone deposits in caves....caves are big pore spaces being filled. Imagine all the little ones between sand grains. Those would be easier to fill in. Ever make cement? Same general process.

It is rare to have armored mud balls form and then they must be quickly buried before drying and crumbling. And then, they must be lithified to become rock. Of course, after all this happens, that rock has to be uplifted and exposed by erosion so that some lucky person can make the discovery.



As far as I can tell, while armored mud balls have been noted in the geological literature from roughly 10 places on Earth, *pictures* only exist for two other locations. See below. Of these, the Franklin County Connecticut Valley examples are *by far the best*. And, even more important: they are in quarried blocks, not part of a mountainside. They can be broken or cut into smaller pieces for schools and museums.

How they formed. The Jurassic Connecticut Valley was a rift valley created as the Pangea supercontinent split. It looked like Death Valley (photo below). Streams flowed from mountains onto and across gently sloping



deposits of alluvial fans, which led downslope to ephemeral lakes. Lakes have mud deposits. Sometimes, during wet intervals, the lakes extended up and over alluvial fan edges, leaving mud deposits. Later the lakes shrank and when it rained, streams eroded the mud deposits. Pieces of mud rolled downstream becoming soft and sticky around their edges, and picked up pebbles from the stream bed. Then,

they were deposited. And then, and this is very important, a covering of sediment to buried them, protecting them from drying and cracking. Next, if these sediments remain buried, lithification will occur and the armored mud balls become “rock”! This all happened in the early Jurassic. Two hundred million years will elapse before they will next see the light of day. It was sometime before 1878 (when the “Old Red Bridge” was dedicated) that they were quarried from a local outcrop and the pieces became part of the suspension cable anchors. In 1969 I came along, and the rest is “history”.

Pictures are worth a thousand words. Below are lithified armored mud balls and that is followed by some excellent examples of unlithified ones. Enjoy.

LITHIFIED ARMORED MUD BALLS. First, Franklin County. Armored mud balls have only been found in three locations: Turners Falls, in the Jurassic Turners Falls Sandstone Formation. These are the ones from Unity Park – the “Old Red Suspension Bridge” cable anchors. There are armored mud balls in the upper Triassic Sugarloaf

Arkose, seen at Stop and Shop parking lot, High Street (Rte. 2 -A), Greenfield. Finally, the “Cheapside Quarry” in northeast Deerfield, River Road (private property). Armored mud balls have not been found in any other outcrops along the Connecticut River Valley in Massachusetts or Connecticut.

The rock below is in the GCC Geo Path and has the best grouping of armored mud balls. The large one to right is at this quarried block’s edge and therefore you can see two dimensions of this round basketball sized piece. Spectacular!





The rock below, now in the GCC Geo Path is the same one pictured previously (with the 6 inch ruler) in the suspension bridge anchor.





This rock from the Cheapside Quarry, River Road, NE Deerfield, has a dozen or more large armored mud balls with sand armor.

The Geology Path at Greenfield Community College. The armored mud ball specimens are in the first grouping on the left. The prominent “egg” is an esker-tumbled (glacier river) quartzite. There is a Geo Path Guide on site, and on a separate page on this web site. It is also posted on the GCC Science Department web site. **You** can find out more about Franklin County’s excellent geology in Richard Little’s new book: *Exploring Franklin County*. See the Publications Order Form page.



Other locations for LITHIFIED ARMORED MUD BALLS.

dynamic-earth.blogspot.com/.../armored-mudballs.html

Lithified armored mud balls from the Eocene Cathedral Bluffs Member in SW Wyoming/NW Colorado, a pretty thick succession of fluvial/alluvial sediments that form some fairly picturesque vistas in that area.



Certainly, these are interesting but not too exciting when you compare to the competition.



Left and below: Going To The Sun Road, Glacier National Park. These late Precambrian sediments show a beautiful combo of AMBs. Grinnell Formation.

Armored mud balls in Grinnell Formation, Glacier Park. Photo by Richard Gibson



On no, a missing armored mud ball! Where did it go?



Friday Field Foto #41 (FEBRUARY 8, 2008): Armored mudball (eroded out) Eocene Grès d'Annot Formation of southeastern France, "[Clastic Detritus](#)" web site, Prof. Brian Romans, Virginia Tech.

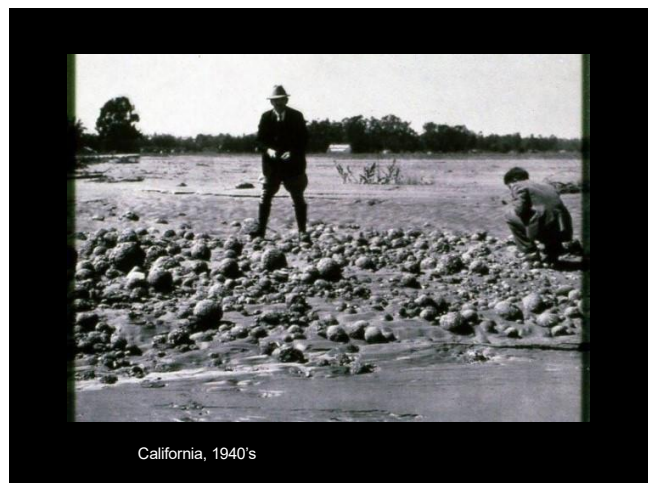
Attention Web Surfers: If you find other images of lithified armored mud balls, please let me know and I will add to this collection.

UNLITHIFIED ARMORED MUD BALLS

ARMORED MUD BALLS'
THEIR ORIGIN, PROPERTIES, AND ROLE
IN SEDIMENTATION'

HUGH STEVENS BELL
Soil Conservation Service Cooperative Laboratory
California Institute of Technology

Journal of Geology, January – February 1940. In this issue, Hugh Bell first used the term "armored mud ball".



California, 1940's

Now, this is amazing: I FOUND AN ARMORED MUD BALL! Just south of Carlsbad Caverns is a little known national park: Guadalupe Mountains. Along the visitor center nature trail was this stream-bank armored mud

ball from a flood 8 months before. I could not locate any others, although there were some suspicious sediment piles which may have been another one or two that had disintegrated. The white rocks are limestone.



Guadalupe Mts. Nat. Park, W. Texas, March 2015 (from flood of September, 2014)



Will Sillin, 2015, Factory Butte, Utah

Sunderland, MA, artist Will Sillin often takes photo trips out west to capture images for future painting ideas and inspiration. Look what he found on this hike in Utah. These armored mud balls are about one foot in diameter.

Prof. Callan Bentley, No. Virginia Comm. College, captured this armored mud ball in the clay-rich badlands at “Devils Coulee”, Warner, Alberta, Canada

Callan says “At [Devil’s Coulee](#) in Alberta, there are dinosaur bones and Western Interior Seaway clamshell fossils — *yawn*. What really got me excited, though, were the armored mud balls!” 8 AUGUST 2012 [Armored mud balls - Mountain Beltway - AGU Blogosphere](#)



FIG. 3.—Large armored mud boulder on the surface of 1982 Mount St. Helens mudflows approximately 2.5 km downstream from Kid Valley on the North Fork of the Toutle River. Shovel is 80 cm long. Note smaller root-bound mud ball resting on the top of the armored mud boulder.

W.J. Fritz, S. Harrison “**Giant armored mud boulder from the 1982 Mount St. Helens mudflows**”

Journal of Sedimentary Geology, 53 (1983), pp. 131-133



This photo was taken during shore zone mapping in Alaska's arctic.

Read more: <http://www.groundtruthtrekking.org/photo/armored-mud-ball/#ixzz6fuWmkEig>

The black armor is coal.

Armored mud balls collected in Monroe County, Indiana. Photo by John M. Day and Barbara T. Hill, 2008 They formed after a torrential rainstorm.



Roosevelt National Park, North Dakota. Erosion of clay-rich badlands.

Nat. Park Photo.

A 'swarm' of mudballs – and a sure indication of high erosion activity [10 June 2012]



EAST YORKSHIRE, UK,
COASTAL EROSION -
MUDBALLS
(urbanrim.org.uk)

Part Four: More Information. [This will not be on the test.] The following is a section copied from Exploring Franklin County (2020). It gives more information about our local specimens and where to find them. See the Publications page for order information.

Did you know that Armored Mud Balls (AMBs) led to the discovery of the only dinosaur bone in the Mesozoic Deerfield Basin? This is a commentary by the author.

In the late 1980's I was showing the AMBs in quarried blocks at the dismantled bridge site in Turners Falls' Unity Park to geologists Phil Huber and Nick McDonald. Phil said, "forget the armored mud balls, look at this dino bone." Near the edge of the several ton arkose stone was an odd colored "pebble" which I had given no thought or study. That "pebble" was just part of the conglomerate deposit to me. But, as you will see, it was a significant find! It was, indeed, a dinosaur bone.

If it weren't for the armored mud balls, this bone would have probably never been discovered! Who knows where a rolling ball of Mesozoic mud will next advance the study and understanding of our magnificent Franklin County geology? After its discovery, this bone, luckily near the edge of the quarried block, was sawed out and further studied. Where it currently rests is a bit of a mystery. The sawed rock with bone was sent to a vertebrate paleontologist in Canada, and seems to not be labeled, catalogued, or displayed (Ed Gregory research, email, 5.16.2019).

However, it has been referenced in the geological literature: "Stratigraphy and Paleocology of the Deerfield Rift Basin (Triassic-Jurassic, Newark Supergroup), Massachusetts, by Paul E. Olsen, Lamont-Doherty Geological Observatory of Columbia University, Palisades, NY 10964, Nicholas G. McDonald, Dept. of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06459, plus Phillip Huber and Bruce Cornet, *in* Guidebook for Field Trips in the Connecticut Valley Region of Mass. and Adjacent States (vol. 2), 84th Annual Meeting, New England Intercollegiate Geological Conference, Amherst, MA October 9 – 11, 1992, p 488 – 535. (The bold print below is my edit.)

*"The osseous remains of probable tetrapods in the Deerfield basin are represented by two bone fragments: one from the Sugarloaf Arkose; the other from the Turners Falls Sandstone. The Sugarloaf specimen was discovered by Solon Wiley in Greenfield in ?1875 and presented to Professor O.C. Marsh of Yale, where it was catalogued as YPM 6281. Lull (1953) and Galton (1976) regarded this bone fragment as presumably dinosaurian without additional comment or description. We regard its identification as dinosaurian as very suspect. **The second specimen was discovered (by PH and NGM) in a large, transported block of pebbly sandstone in Turners Falls. The specimen is a blue-weathered, hollow bone fragment about 2.5 cm in diameter, exposed in oblique section. It extends into the matrix an unknown distance. The bone is quite thin ~0.5 cm. Thin, hollow bones are a shared derived character of theropod dinosaurs. We conclude that this fragment may be a portion of the distal end of a long bone of a medium sized theropod, and as such it is the first record of a theropod bone from the Deerfield basin. (my emphasis) The block of pebbly sandstone contains clasts up to 10 cm in diameter and excellent armored mud balls (see Little, 1982). The block came from the abutments of the "Red Suspension Bridge", which formerly spanned the Connecticut River upstream of the Turners Falls-Gill dam (observed by Richard Little, pers. comm., 1992). According to Ms. Therrisa Rice (of Turners Falls) the original stratigraphic origin of the block is from an abandoned quarry (presently occupied by buildings) on the west side of Main St. in the Village of Turners Falls."** (p. 498)*

I always chuckle how armored mud balls have become such a fun way to interest people in geological history. I am a lucky guy, being the first person to discover them in the Connecticut Valley in the fall of 1969 after moving here from Southern California to begin my teaching career at Greenfield Community College. Several years later I discovered how rare these specimens were and wrote a paper that was published by the Journal of Geology (1982). Connecticut Valley armored mud balls have only been found in Turners Falls, northeast Deerfield, and Greenfield. A small geographic area. They are separated by about 1000 feet of rock, with the Deerfield Basalt lava in between. **So, some rolled into the valley before the lava and some after, over a period of perhaps half a million years.**



The author (mid 1970's) at the old Red Bridge's west suspension cable anchor, pointing to armored mud balls. This anchor along with its neighbor to the east, was dismantled in the 1970's and the armored mud ball specimen blocks were transported to Greenfield Community College or placed nearby at Unity Park.

Even though there are massive amounts of Jurassic red sandstones exposed in Connecticut and in similar rift valleys of this era, no armored mud balls have ever been found although there are many mud pieces, a few of which are round, but not armored.

Why are armored mud balls only here in the Mesozoic Deerfield Basin? The Deerfield Basin must have had just the right conditions that were hard to duplicate. There had to be mud deposits (old lake beds) just the right distance upstream, up on the alluvial fans. Then, just the right amount of stream erosion and transport for lake bottom mud chunks to become round and armored with pebbles. Burial had to occur quickly before drying crumbled them to dust. This part of

Franklin County for hundreds of thousands of early Mesozoic years was the "sweet spot" for armored mud ball

formation and preservation! Is it possible that dinosaurs came from far and wide to smile at these rolling balls of mud and leave their footprints impressed along the old riverbanks?

Where can you go to see armored mud balls? Greenfield Community College has a Geology Path (S. side of Main Building, by parking lot F) which displays specimens from Turners Falls and Deerfield. Stop and Shop in Greenfield. Unity Park in Turners Falls has several of the old quarried blocks right by the river (picture below). There are a few harder-to-see AMBs in the old bridge foundations across the river in Gill and along the at least one outcrop on a side street in Turners Fall.



Photos by Ed Gregory. You can see the cut where the rock saw has removed the dinosaur bone. While many of the armored mud ball specimens were removed to Greenfield Community College, several rocks from the dismantled suspension cable anchor remain at Unity Park, with the Connecticut River in the background.

Saturday,
June 23, 1980:
The day when
Armored Mud
Balls made a
banner headline!
(It must have
been a slow
news day.)
And another
long-forgotten
event from

shortly after: Northampton Station WHMP's disc jockeys made a humorous song from a Beach Boys hit, substituting "Turners Falls Mud Balls" for "California Girls". Groovy.

This is the end.