A Geologist′s Harvard

By David B. Williams

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Photographs by Adam Shyevitch were shot specifically for this PDF document.

The best geology exhibits at Harvard aren′t in a gallery or museum. The University buildings themselves are the display cases. The university features a range of rocks as diverse as any assembled by plate tectonics. One building reveals a world of marine fossils. Another incorporates gray and black granite that solidified hundreds of millions of years ago. A third is made from a red sediment deposited in a land teeming with dinosaurs. A careful examination of these structures offers insights into cultural as well as natural history.

Harvard′s earliest builders used locally abundant rock. Harvard Hall (1766, with additions in 1842 and 1870), by the main gate to the Yard, exemplifies this practice with a course of sandstone at its base and sandstone steps quarried from the Connecticut River valley. Although the red sandstone′s official geologic name is the Portland Formation, more people probably know it as brownstone—a dominant building material during the last half of the 19th century in Boston, New York and Philadelphia. Boston Brahmin, Oliver Wendell Holmes, celebrated this material in his poem ″Contentment″:


Close up of Portland Formation brownstone shows weathering caused by freeze/thaw cycle.

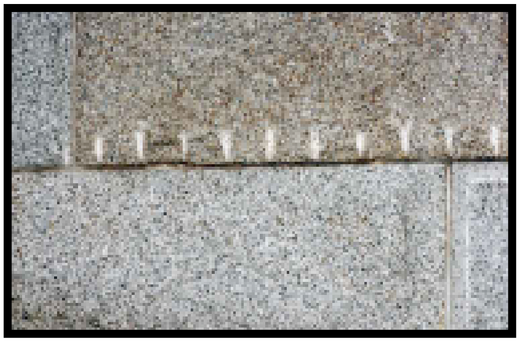
> Little I ask; my wants are few;
> I only wish a hut of stone
> (A *very plain* brown stone will do).
> That I may call my own;
> And close at hand is such a one,
> In yonder street that fronts the sun.

Quarries in the Connecticut River valley started shipping brownstone in the middle 1600s. The peak of quarrying in East Longmeadow, Massachusetts, the state′s principal brownstone region, occurred after rail service reached the town in 1876. Three or four trains per day would leave carrying as many as 17 cars of rock. Labor strikes in the 1890s forced the quarry industry into decline. By 1915 the major sandstone producers had shut down, and minimal amounts of building blocks have trickled out over the last 80 years.

Deposition of the Portland Formation sediments began 200 million years ago when Massachusetts sat about 15 degrees north of the equator. Streams washing westward out of a now eroded mountain chain deposited mostly red sands and silts more than 6,000 feet deep onto a vast valley floor, created as North America and Africa wrenched apart from each other. The climate fluctuated between humid and semi-arid periods lasting hundreds of thousands of years. Conifers, horsetails (scouring rushes), and ferns grew near the water. Three- to nine-foot-long carnivorous and herbivorous dinosaurs roamed about with lizard-like and crocodile-like reptiles. Unfortunately, these plants and animals did not leave their traces in the rock used at Harvard Hall. Neither did the numerous species of fish that swam in the streams and perennial lakes, in which sediments slowly accumulated in layers called bedding planes.

The orientation of these beds in the Harvard Hall sandstone has left some blocks unscathed, while others crumble when touched. In winter, when the temperature rises above 32 degrees Fahrenheit, water infiltrates the porous sandstone of the hall′s steps. When temperatures fall below freezing again, the water turns to ice and expand nine percent. If a builder places a sandstone block with its beds vertical and parallel to the building's surface, the freeze/thaw cycle will force the layers to separate like cards off a deck. But if the beds lie horizontally, water cannot penetrate the layers and the rock does not deteriorate.

In contrast to this crumbling structure, Charles Bulfinch's University Hall (1815) rises solidly across the Yard in massive blocks of Chelmsford Granite. Magma cooling deep within the Earth formed this rock roughly 400 million years ago. The granite's light color indicates that it is rich in aluminum and silica; a darker rock would have more iron and manganese. Small dark red garnets are embedded in the matrix of light brown feldspar and whitish quartz. On a clear day, shiny sheets of mica wink in the sunlight.



An example of the Tarbox cutting method.

Bulfinch is often credited with helping to start Boston's early 19th century granite building boom. His desire in 1802 to use granite for a new prison in Charlestown inadvertently led to the introduction of an improved method for cutting stone. Until then, stone cutters rarely quarried rock; instead they worked with loose boulders, using heat to crack the stone. They built a fire on top of a large stone and then dropped a heavy iron ball to split it. Stonemasons would further break the heated rock with sledges. To create square pieces, they cut a groove into the surface with a sharp-edged tool called an axhammer and then struck the rock with a heavy hammer until it fractured.

Bulfinch wanted granite for the prison, but local stone prices were too high. Lieutenant governor Edward H. Robbins, one of the prison's commissioners, set out to locate cheaper materials. While passing through Salem, he noticed a building made of rock that had been cut in a manner new to him. After several inquiries he found a Mr. Tarbox of Danvers, who explained his method of drilling a row of holes into the rock and then pounding small wedges into the openings to split the rock open, creating a smooth face.

Robbins was so impressed that he hired Mr. Tarbox to instruct the local stone cutters, who were so elated with this new method "they adjourned to Newcomb's Hotel, where they partook of a sumptuous repast," according to William Sullivan Pattee in *A History of Old Braintree and Quincy*. This new technique dropped the price of cut stone 60 percent.

Many of the Charlestown prisoners eventually had the opportunity to practice the Tarbox method; three, certainly, of Bulfinch's post-1802 buildings used rock trimmed to size at the prison. The chances are that the stones of University Hall also were cut by prison inmates.

Brownstone, granite, and slate were the triumvirate of common Boston building stones of the 1800s. Harvard's premier slate-roofed structure, Memorial Hall (1878), displays rock from the two most important slate-producing regions of New England. The red shingles came from quarries near Granville, NY, the green shingles from nearby Fair Haven, Vermont, and the black from Monson, Maine. They are also some of the oldest rocks on campus ranging in age from the pea-soup green, 550-million-year-old Mettawee Slate through the red Indian River Slate to the black Monson rocks, a 400-million year old unit, known to geologists as the Carrabassett Formation.

The amount of oxygen and the type of sediment in the depositional environment determined the colors of the Memorial Hall roofing slate. The red in the Granville slate resulted from the erosion of iron-rich soils that were exposed to an oxygen-rich environment. Granville has the only red slate quarries in the United States. If the iron oxides were deposited in an anaerobic environment they yield a green- to purple- colored sediment. The black slate also formed in an oxygen-starved environment but contains abundant organic matter that imparted its black coloration.

The formation of Memorial Hall's slates started with clay and silt washing off the North American continent into a vast sea, the Iapetus Ocean (Iapetus fathered Atlas for whom the Atlantic is named). For 150 million years, the Iapetus served as a dumping ground for sediments that sank slowly into the deep waters of the ocean, building up several thousand feet of extremely fine-grained layers of shale.

During the entire depositional history of these sediments, the Iapetus was slowly closing. As the ocean shrank, it transported a volcanic island arc (similar to Japan) that had risen in the middle of the ocean towards a collision with North America. When the arc slammed into the continent, it pushed the marine-deposited Vermont and New York sediments up onto the land, simultaneously burying and folding them. The weight of this mass of land compressed the sedimentary beds, metamorphosing the shale into a slate. The stress of the collision also caused the grains of clay, which is a flat, sheet-like mineral, to align themselves into a rigidly parallel arrangement, like organizing a collapsed house of cards into a tight deck. The Monson slate metamorphosed in a similar process 50 million years later.

Memorial Hall displays red New York, green Vermont, and black Maine slate.

This alignment of clay minerals, which facilitates the even and clean splitting of slate into distinct layers, has made slate an important roofing material for hundreds of years. The same qualities make it useful for floor tile, billiard tables, and blackboards. Immigrants from Wales played a critical role in establishing the slate industry in America. They were the first to recognize the high quality Monson slate deposits in the early 1800s and also helped to expand the quarries in Vermont and New York in the 1850s.

Not all of the original Memorial Hall roofing slate is intact. In two restoration projects during the last 12 years, workers replaced shingles that had broken because people walked on them, especially at the base of the roof, and other shingles that had cracked because of deterioration of the iron fasteners. Overall, though, the slate has proven its durability.

As the University became more wealthier, it no longer had to rely on local rock. From 1913 through 1915, architect Horace Trumbauer and his chief designer, Julian Francis Abele, oversaw construction of Harvard's great sanctuary of books, Widener Library, using a buff limestone from Indiana quarries for the foundation and columns. Packed with bits and pieces of information Widener's building blocks house the University's most accessible fossil collection of marine shells.

These fossils occur in blocks of the 330-million-year-old Salem Limestone, a rock unit that formed in a warm tropical sea. These fossils occur in blocks of the 330-million-year old Salem Limestone, a rock unit that formed in a warm, tropical sea. At that time most of the land mass now known as North America lay south of the equator. Shallow, clear water covered the area that stretches from present-day Nebraska to Pennsylvania. A myriad of organisms swam and crawled about this placid sea. When they died their bodies settled to the sea floor, over time solidifying into a 90-foot-thick stone menagerie. This homogeneous matrix of corpses formed a rock that cuts cleanly and evenly in all directions.

Wave action from long gone tides shattered most of the shells, but many organisms persist and stand out. A unicellular animal, known as a foraminifer, which lived in the ooze and muck on the bottom of the sea, is common in this limestone but hard to see, even with magnification. Dotted throughout the walls, and easily discernible, are the poker chip-shaped stems of crinoids, an extinct relative of starfish, and half-inch long bryozoans, a sedentary animal that formed colonies of Lilliputian-scaled apartment complexes patterned like Rice Chex cereal. Many shell fragments come from pelecypods, the group that includes oysters, clams, and scallops. A rare find is a perfectly formed half-inch-long snail shell, which resembles a tiny swirled dunce cap.

Salem Limestone is one of the most commonly used building stones in the world. Over the past century, quarries in Indiana have sent this stone to the Metropolitan Museum of Art, Empire State Building, Grand Central Station, Dallas Museum of Fine Arts, San Francisco City Hall, and innumerable buildings in cities and towns from coast to coast. Other Harvard buildings that use Salem Limestone include the Gunzburg Center for European Studies (formerly the Busch-Reisinger Museum), Lowell Lecture Hall, and Langdell Hall.

330-million-year-old Salem Limestone includes crinoid, brachiopod, coral, and bryozoan fossils.

William James Hall (1964) on Kirkland Street also incorporates a type of limestone at its base, but one that lacks fossils. Instead of forming at the bottom of a sea, the oatmeal-colored material, known as travertine, precipitates from calcite-rich water, often associated with caves or springs. (Mammoth Hot Springs in Yellowstone National Park is a well-known modern travertine deposit.)

The William James panels were quarried from 30-million-year old deposits near Rome, where travertine has been used since the 2nd century BC in buildings such as the Colosseum and Quirinal Palace. Travertine had only a short period of popularity in Boston, though. As in Harvard Hall's crumbling sandstone, water can permeate the stone's Swiss-cheese-like texture and freeze, expand and break apart the travertine.

In 1994 Harvard furthered its use of imported rocks with the construction of Hauser Hall. The Law School building's yellow-gray limestone was quarried in Germany. Chosen for its color, the 175-million-year-old limestone contains numerous striking fossil ammonites, an extinct marine relative of the octopus and chambered nautilus including one speciment that is one foot in diameter.

This modern building tells the story of ancient seas, but also of the changing tastes and fortunes of Harvard. The plain facade and local rock of Harvard Hall has given way to the elaborate patterns and exotic rock of Hauser. Like all good stories, the buildings of the main campus can be read for both text and subtext. Natural history and cultural history are linked, reminding us that living in an urban environment need not separate us from the natural world.