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Tennessee “Marble”: a potential “Global Heritage Stone Resource”

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The Holston Formation aka Tennessee “marble”, though not steeped in antiquity as many European stones, has been quarried continuously in Tennessee for lime and dimension stone since colonial times in North America. The white to red, massive, coarse-grained limestone occurs as a conspicuous stratigraphic unit within the Middle Ordovician Chickamauga Group in the Valley and Ridge province of East Tennessee. The formation is a reef mass consisting mainly of bryozoan colonies, pelmatazoa and lime mudstone deposited along the hinge of a tectonically subsiding basin southeast of the reef. The mass is 100 m thick and extends along northeast-southwest trending strike belts for nearly 100 km. Though not marble in the geological sense, it is crystalline, takes a high polish, and possesses physical properties that typically surpasses those of metamorphic marble. Its chemical purity and physical properties have made it a popular choice among architects, sculptors, and chemists for over 200 years. Tennessee, along with Vermont and Georgia has always been ranked among the top three marble producers in the U.S. – in 1956 Tennessee led the United States in marble production. Tennessee “marble” has been used in sculptural work, and for major building interiors and exteriors in at least 35 USA states and Canada and continues to be used today.

Introduction

The first published mention of “marble” in Tennessee was in the late 1810’s as natural scientists, itinerant ministers, and various travelers noted this attractive rock unit. Their accounts appeared in publications such as the American Journal of Science (Kain, 1818). The first noted use of the native stone was in construction of Francis Alexander Ramsey’s home, Swan Pond in 1797. It was designed by architect Thomas Hope and built of hewn pink “marble” quarried nearby. In 1814 U.S. Congressman John Sevier, first governor of Tennessee, extended the potential market for the stone when he took a sample to Giovanni Andrei, one of two Italian artisans at work on sculptural decoration at the U.S. Capitol. Andrei declared Sevier’s stone to be fine and valuable. Subsequently, after considerable national debate over appropriate construction material for federal buildings, Tennessee “marble”

appeared in three significant architectural interiors in the 1850s: in the form of two memorial stones mounted on the inside walls of the Washington National Monument, in the main staircase and balustrade of the Tennessee State Capitol, and in three of the four staircases and balustrades, as well as the Senate Retiring Room of the U.S. Capitol Extensions. Tennessee “marble” is a rock unit within the Middle Ordovician Chickamauga Group in the folded and faulted Paleozoic strata comprising the Valley and Ridge province of the southern Appalachian Highlands of Tennessee, USA. The Holston Formation is dominantly a coarsely crystalline (essentially unmetamorphosed), 100 m-thick limestone unit that extends for over 100 km from Blount County, Tennessee to Hawkins County Tennessee along NE-SW trending strike-belts bound by thrust faults (see Figs. 1 and 2). The crystalline Holston Formation is apparently the product of a unique sedimentary paleoenvironment. It is bounded above and below by siliciclastic and other carbonate rocks with no evidence of metamorphism. The nearest metamorphic rocks lie 20+ kilometers to the East in the Blue Ridge physiographic province. The physical and chemical properties of the stone and its decorative and architectural use for over 200 years make it a viable candidate for recognition as a Global Heritage Stone Resource (GHSR).

Tennessee “Marble”: A Potential Global Heritage Stone Resource

Hughes et al. (2013) and Cooper et al. (2013) defined the essential characteristics of a Global Heritage Stone Resource (GHSR); and the Heritage Stone Task Group (HSTG) “Terms of Reference” were approved by the International Union of Geological Sciences (IUGS) in February 2012. The HSTG criteria for recognition as a GHSR include the following: 1) must have a cultural history spanning a significant time; 2) needs to have been utilized in noteworthy works – either buildings, sculpture, or in a utilitarian application; 3) should have relatively wide use – preferably international; and 4) should be recognized as a cultural icon such as having a national identity. Tennessee “marble” possesses all the above attributes and continues to be selected by architects and builders for both its structural and decorative qualities, and by sculptors for artistic inspiration. Many natural stones have already been proposed as candidates for GHSR recognition (e.g., Pereira et al., 2015; Pereira and Marker, 2016). The purpose of this paper is to introduce another excellent stone resource for

Figure 1. The approximate location of Tennessee “marble” in the United States of America (from Powell, 2005).

Figure 2. A portion of the Tennessee State geologic map showing folded and faulted rock units comprising the valley and ridge physiographic province of East Tennessee, USA (Hardeman et al., 1966). The region between the red arrows is where the Middle Ordovician Holston Formation (dark pink) has been quarried. North is the top of the map.

recognition as a GHSR.

(Cooper et al., 2013), as follows:

Required GHSR Nomination/Citation Criteria

To be considered for GHSR nomination, the HSTG Terms of Reference state that citations shall contain certain specific information

Formal Name

GHSR Name: Tennessee “Marble”

Stratigraphic Name: Holston Formation

Other Names: Holston Marble, Farragut Formation, Red Knobs

Formation, Holston-Tellico Formation, and Holston-Chapman Ridge Formation

Various Commercial names include: Light Pink, Cedar, Rose, Dolly Varden, and Quaker Grey

Place of Origin

The Valley and Ridge physiographic province of East Tennessee, USA.

Resource Location

Tennessee “marble” has been extracted from quarries located where the Holston Formation is exposed along a NE-SW trending strike belt in eastern Tennessee. The trend extends nearly 100 km through Blount and Hawkins Counties, Tennessee, but due to folding and faulting the formation does not crop out continuously along the trend. There are four major districts that have produced the bulk of the stone: Friendsville in Blount County; Knoxville in Knox County; Luttrell in Union County; and the vicinity of Rogersville in Hawkins County.

Quarrying

The earliest record of quarrying Tennessee “marble” can be correlated to the construction of the Francis Alexander Ramsey home in Knox County, Tennessee, USA in 1797. However, the first national recognition of the stone is likely linked to Tennessee Congressman, John Sevier, formerly the first Governor of Tennessee, who took a sample of the rock to Giovanni Andrei, one of the Italian master carvers engaged in decorative carving at the U.S. Capitol in 1814. Ever since 1850, after a slab of dark pink Hawkins County marble was sent to Washington, D.C. for use as a “memorial stone” representing Tennessee in the construction of the Washington National Monument, Tennessee “marble” has been a popular dimension stone. Historically the stone has been quarried from at least one of four districts, Knoxville, Friendsville, Luttrell, or Rogersville.

Heritage Issues

The Holston Formation aka Tennessee “marble”, though not steeped in antiquity as many European stones, has been quarried continuously in Tennessee for dimension stone, sculpture, and lime for over 200 years. Many federal, state and county government buildings, as well as banks, hotels, office buildings, museums, and railroad terminals, many of which are listed in the National Register of Historic Places (National Park Service, United States Department of the Interior) in the United States of America (USA) and Canada are constructed from Tennessee “marble”.

Petrographic Name

It is a coarsely crystalline limestone consisting of two basic lithologies: first, a white to pink to red ectoproct (bryozoan) boundstone (Dunham, 1962) composed of abundant ectoprocts that bind micrite and fossil debris into mound-like structures to form a reef core, and secondly a white to pink, cross-bedded, pelmatozoan calcarenite that fills the spaces between the boundstone cores and forms the reef

flanks. According to Folk (1959) the reef cores could be classified as biolithite and the reef flanks classified as biosparite.

Mineralogic Composition

The following minerals, listed in alphabetical order, have been identified in samples of the Holston Formation: Calcite (CaCO_3); an earthy chloritic mineral; Collophanite (a complex hydrous carbonate and phosphate of lime); Dolomite (MgCaCO_3); Feldspar (plagioclase); Hematite (Fe_2O_3); Limonite ($\text{Fe}_4\text{O}_5\text{H}_6$); Pyrite (FeS_2); Rhodocrosite (MnCO_3); Quartz (SiO_2); and Siderite (FeCO_3). Calcite is the dominant mineral comprising the fossil bryozoa and pelmatozoa. Hematite and Rhodocrosite to some extent add the pink tint to the stone with the darker chocolate-like tints coming from hematite and limonite. Sparse grains of feldspar and quartz are associated mainly with the calcarenite and the other minor minerals are mainly associated with the coatings on stylolites (Dale, 1924).

Color

Gordon (1924) described the main colors and shades of the stone as follows: gray (light and medium); faintly pinkish-gray; pink (light, medium, deep); dark reddish-purplish (chocolate color); mixed gray and reddish or pinkish. Others have described the colors of the stone as variegated. Some of the commercial designations of color include: light gray, mottled rose, mottled pink, dark pink, cedar red, and light pink. The presence of macro fossils often lends blotches of white.

Natural Variability

The paleoenvironmental setting of the Holston Formation deposition as a reef resulted in subenvironments manifested by variations in color and texture. Stylolitic sutures also add to the variability of the unit.

Suitability

The appearance and physicochemical properties of the Holston has made it an excellent stone for interior and exterior construction as well as for sculpture. The chemical purity and crystalline texture of the Holston provides high compressive strength, low absorption, and high durability.

Stratigraphy

Walker and Ferrigno (1973) described the Holston as a major reef tract at the edge of a large carbonate bank being deposited along the hinge of a foredeep basin to the East (see Fig. 3; Walker et al., 1980). The reef mass is divided into two sub-environments, a reef-core, and an intervening reef-flank. The flanking debris deposits compose about 75 to 80 percent of the entire mass and the cores about 20 to 25 percent. The entire reef forms a mass about 100 m thick.

Geological Age and Setting

Based upon the bryozoan assemblage, Walker and Ferrigno (1973) suggested an age of upper Wilderness (middle Champlainian = mid-

Figure 3. Cross-section (NW-SE) across a portion of the Tennessee Valley showing facies of the Middle Ordovician Chickamauga Group. The vertical lines RV, FC, NK, SK, BC, and WQ represent locations of measured sections of strata. The numbered dashed lines represent inferred time-stratigraphic markers across the region based upon biostratigraphy, bentonite deposits, and paleobathymetric mapping (Walker et al., 1980).

dle Caradocian) for the Holston Formation.

Commercial Designation

Some of more recent commercial designations for “Tennessee marble” include: Tennessee Cedar, Tennessee Pink-Light Rose, Tennessee Pink-Dark Rose, and Quaker Gray.

Physical/Chemical Properties

ASTM C-568 “Standard Specification for Limestone Dimension Stone” classifies dimensional limestone into three categories: Type I (Low Density), Type II (Medium Density) and Type III (High Density). Tennessee “marble”, based upon tests by the U.S. Bureau of Standards (Dale, 1924) and the Tennessee Marble Company (2016), aligns Tennessee “marble” with Type III Dimensional Limestone (ASTM C-568).

Table 1 compares the properties of Tennessee “marble” with ASTM C-568 standards.

Chemically Tennessee “marble” is considered a high calcium limestone (> 95% CaCO_3). According to Dale (1924) an average composition for Tennessee “marble” is:

$\text{CaCO}_3 = 97.5\%$ average

$\text{SiO}_2 \leq 0.2\%$

$\text{MgCO}_3 \leq 0.2\%$

$\text{Fe}_2\text{O}_3 = 0.17\%$ in light-gray stone to 0.4% in dark stone

Vulnerability and Maintenance of Supply

The known occurrence of the Holston is limited geographically to East Tennessee where it is quarried from surface exposures. Currently not all surface exposures have been exploited but, if the future ever posed increased demand, the stone could possibly be mined underground for dimension stone. The Holston Formation is cur-

Table 1. Physical properties of Tennessee “Marble”

	Density Kg/m^3 (Min.)	Compressive Strength MPa (Min.)	Water Absorption wt% (Max.)
Tennessee “marble”; Dale; US Bur. Standards (1924)	NA	103–126	0.035–0.09 (Av. 0.06)
Tennessee “marble”; Tenn. Marble Co. (2016)	2691.1	Av. 99.165	0.066
Type III; ASTM C-568	2560	55	3.00
Type II; ASTM C-568	2160	28	7.50
Type I; ASTM C-568	1760	12	12.00

Data adapted from Dale (1924), Tennessee Marble Company (2016) and C 568-08a Standard Specifications for Limestone Dimension Stone, ASTM International (2015).

rently being mined underground in the Luttrell, Tennessee area for aggregate and lime. The availability of certain varieties of stone is impacted by the geometry of the Holston's reef structure.

Historic Use and Geographic Area of Utilization

Tennessee "marble" has been quarried for dimension stone, lime and sculpture for over 200 years. The "marble" has been used in interiors for cladding, wainscoting, balustrades, flooring, staircases and stair treads, columns, pilasters, shelves, mantelpieces, door and window surrounds, and decorative and utilitarian purposes as well as for dimensional stone, sculptural elements, exterior window and door frames and surrounds, and decorative and utilitarian purposes on the exteriors of buildings in over 35 United States, Puerto Rico, and Canada. Many of these buildings are recognized as heritage sites nationally, internationally, or by a State.

Buildings (Selected)

Historical

Exterior:

U.S. Custom House, Post Office, Federal Building, Knoxville, Tenn. (1874)

The J.P. Morgan Library, New York, N.Y. (1906)

James J. Hill Research Library and St. Paul Public Library, St. Paul, Minn. (1917)

Richard C. Lee U.S. Courthouse, New Haven, Conn. (1919)

Candoro Marble Company Office/Showroom, Knoxville, Tenn. (1923)

U.S. Post Office and Courthouse, Knoxville, Tenn. (1934)

Tennessee Supreme Court Building, Nashville, Tenn. (1937)

National Gallery of Art, Washington, D.C. (1941, 1978)

Interior:

Tennessee State Capitol, Nashville, Tenn. (grand staircase, columns) (1850s)

U.S. Capitol, Washington, D.C. (Senate Retiring Room, also known as "Marble Room" cladding, window surrounds; House and Senate gal-

Figure 4. U.S. Custom House, Post Office, Federal Building, Knoxville, Tennessee – 1874 Image: Library of Congress.

Figure 5. Knoxville Museum of Art under construction, Knoxville, Tennessee – 1990 Image: KMA.

Figure 6. Senate Retiring Room ("Marble Room"), The U.S. Capitol, Washington, D.C. – 1850s Image: Architect of the Capitol, Curator's Office.

lery staircases) (1850s)

South Carolina State Capitol, Columbia, S.C. (door frames, cladding) (1850s)

Baltimore City Hall (rotunda columns) (1877)

Boston Public Library (vestibule floors, walls, vaulted ceiling) (1895)

Montana State Capitol, Helena, Mont. (1899)

Hermitage Hotel, Nashville, Tenn. (lobby floors) (1910)

Kentucky State Capitol, Frankfort, Ky. (1910)

Grand Central Terminal, New York, N.Y. (main concourse floor) (1913)

San Francisco City Hall (stairs, floors) (1915)

Wisconsin State Capitol, Madison, Wisc. (stairs, balustrades, floors, walls) (1917)

Manitoba Legislative Building, Winnipeg, Canada (main rotunda floor) (1920)

Figure 7. *The Hermitage Hotel, Nashville, Tennessee – 1910 Image: Hermitage Hotel.*

Figure 8. *Tennessee Supreme Court Building, Nashville, Tennessee – 1937 Image: Tennessee Judiciary Museum, Courtesy Rock City Construction Company.*

Union Station, Toronto, Canada (grand hall floor) (1920)

Tennessee Supreme Court Building, Nashville, Tenn. (atrium walls, floors) (1937)

U.S. Post Office and Federal Building, Chattanooga, Tenn. (courtroom) (1934)

Contemporary

Exterior:

Knoxville Museum of Art, Knoxville, Tenn. (1990)

East Tennessee History Center, Knoxville, Tenn. (2005)

Howard Baker Center for Public Policy, University of Tennessee, Knoxville, Tenn. (2008)

Newseum, Washington, D.C. (2008)

Interior:

Nashville Public Library (lobby counters) (2003)

U.S. Capitol Visitor Center, Washington, D.C. (first-story floor) (2008)

Sculpture

– Daniel Chester French, neoclassical exterior sculptural groups for Minnesota State Capitol (1903–1906) and United States Customs House, New York City (1900–1907)

– Adolph Weinman, Carved Relief Panels, J.P. Morgan Library

Figure 9. *Albert Milani, Sculptor, Candoro Marble Company, Knoxville, Tennessee – 1934, Thompson Commercial Photographers, Knoxville, Tennessee Image: Tennessee Department of Environment & Conservation (published in Tennessee Division of Geology Bulletin 28, 1924).*

(1905–1906)

– Edward Clark Potter, “Assyrian” lions, J.P. Morgan Library (1905–1906) and “Patience and Fortitude” lions, New York Public Library (1911)

– Albert Milani, Eagles, Federal Post Office and Courthouse, Knoxville (1934)

Conclusions

Tennessee “marble” possesses all the essential characteristics of a Global Heritage Stone Resource (GHSR) as defined by Hughes et al. (2013) and Cooper et al. (2013); and the Heritage Stone Task Group (HSTG) “Terms of Reference” approved by the International Union of Geological Sciences (IUGS) in 2012.

Due to the exceptionally fine chemical and physical properties of the stone it has been quarried for more than two centuries – from the Colonial Period of the United States of America to the present – for many purposes, including: fine sculpture; building exteriors and interiors; and as a source for lime. Perhaps the most important properties of the stone are its high compressive strength and its very low absorption values making it highly resistant to decomposition and disintegration – its low permeability makes it an excellent choice for building exteriors and water features such as fountains and basins.

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