A Different View of Stone Monuments, Memorials and Buildings of Washington, D.C.

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Field Trip Guidebook T235

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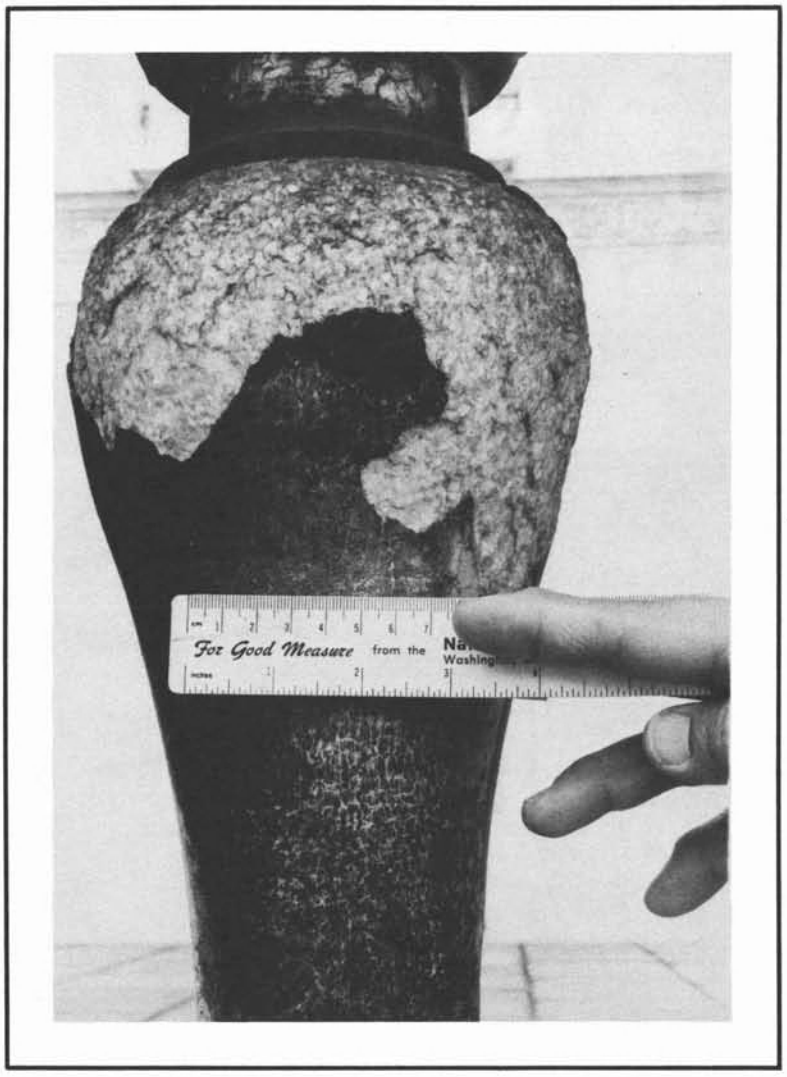

COVER Marble baluster in balustrade of the west patio, Pan American Union Building (completed 1910), Washington, District of Columbia. The black coating contains fine-grained gypsum and is scaling off. Photograph by Deborah Dwornik, U.S. Geological Survey, 1984.

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IGC FIELD TRIP T235:
A DIFFERENT VIEW OF STONE MONUMENTS, MEMORIALS, AND BUILDINGS OF WASHINGTON, DISTRICT OF COLUMBIA

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Abstract. This afternoon trip in downtown Washington, D. C., will permit study of pollution, structural, and other kinds of damage to structures with emphasis on those constructed of fine- to coarse-grained marble but with representatives of limestone and red sandstone. The tour will include in order of examination [date of work initiated (i) and/or occupied (o.) and stone type]: the Renwick Museum (1859o., red sandstone trim replaced 1987), Corcoran Museum (1879c. enlarged 1927, coarse-grained marble), two Red Cross buildings (1915i.-1917o., 1927i., fine-grained marble), Memorial Continental Hall of the Daughters of the American Revolution, DAR (1904i.-1909o., fine-grained marble), Pan American Union Building (1908i.-1910o., coarse-grained marble), Constitution Hall (DAR)(1929o., limestone), Washington Monument (1885o., marble), Jefferson Memorial (1943o., exterior of fine-grained marble), and Lincoln Memorial (1922o., very fine-grained marble). Coarse-grained marble is normally more resistant to pollution damage than fine-grained marble. Direct exposure to the elements hastens degradation. The most severe pollution damage occurs to balustrades and columns: runoff from bronze onto fine-grained marble can also cause serious degradation. Any sort of overhang tends to protect the underlying stone, but exceptions will be seen at the Jefferson Memorial. In general, vertical walls have less pollution damage than horizontal surfaces which can begin to show roughening within two years of installation. Limestone in common use is surprisingly resistant to degradation owing, at least in part, to the porous nature of the stone that inhibits runoff. If one of the trips is made to the Powell Building of the U. S. Geological Survey in Reston, Virginia (1974o., concrete), it will be seen that concrete behaves much like limestone and marble.

INTRODUCTION

Normally when we visit a monument or memorial as a tourist, we concentrate on the whole picture of the structure and the setting and on the statues or quotations inside. When we visit a stone building on business, we are usually preoccupied with the business at hand upon entering and on the next destination when leaving. In either case, most of us are unlikely to notice the state of the structure and the various kinds of structural or pollution damage it may have undergone. The author was no exception. While helping the National Park Service set up stone test sites as a part of the contribution to the National Acid Precipitation Assessment Program [Sherwood and Doe, 1985], the author began examinations of stone buildings in the Washington, D. C., area on April 17, 1984, at the Jefferson Memorial at the request of and in the company of Heather Huyck of the National Park Service with Malcolm Ross of the U. S. Geological Survey. The study gradually expanded to other buildings during the course of 1984 and 1985. This tour (Fig. 1) represents a selection of the more famous buildings and structures available for coverage in an afternoon of visits. The tour illustrates the state of these structures, concentrating on characteristic types of damage. The major stone type featured is marble of both fine- and coarse- grain size (eight buildings) with one representative of the red sandstone and one of limestone. The fine-grained marble structures visited are: Jefferson Memorial exterior, Lincoln Memorial, Memorial Continental Hall of the Daughters of The American Revolution (DAR), two Red Cross buildings. The coarse-grained marble representatives are: Corcoran Museum, Pan American Union building (Organization of American States) and Washington Monument. The limestone building is Constitution Hall (DAR), and the red sandstone representative is the trim of the Renwick Museum. A supplement to the field trip will be given at the end

of the guide to furnish the interested observer with contrasting examples to the features observed. Stone degradation can result in several ways, and a listing follows that is more complete than I have seen elsewhere:

A. Inherent vice

1. Mineral content (pyrite, clay)
2. Locked-in stresses(tectonic)

B. Pollution (anthropogenic)

1. Acidity (carbonic, sulfuric and nitric acids)
2. Others (sulfur dioxide, nitrogen compounds, etc.)

C. Pollution (natural) and weather

1. Biologic (algal growth, organic acids)
2. Volcanogenic and coal combustion
3. Freeze-thaw
4. Hail, wind driven particulates
5. Natural carbon dioxide, water

D. Processing

1. Fabrication (turning, carving)
2. Cleaning (sandblasting, etc.)

E. Construction and Treatment

1. Subsidence
2. Coatings

F. Vandalism and carelessness

Although the exact causes of degradation cannot always be identified, examples will be seen of nearly all the above classes of damage.

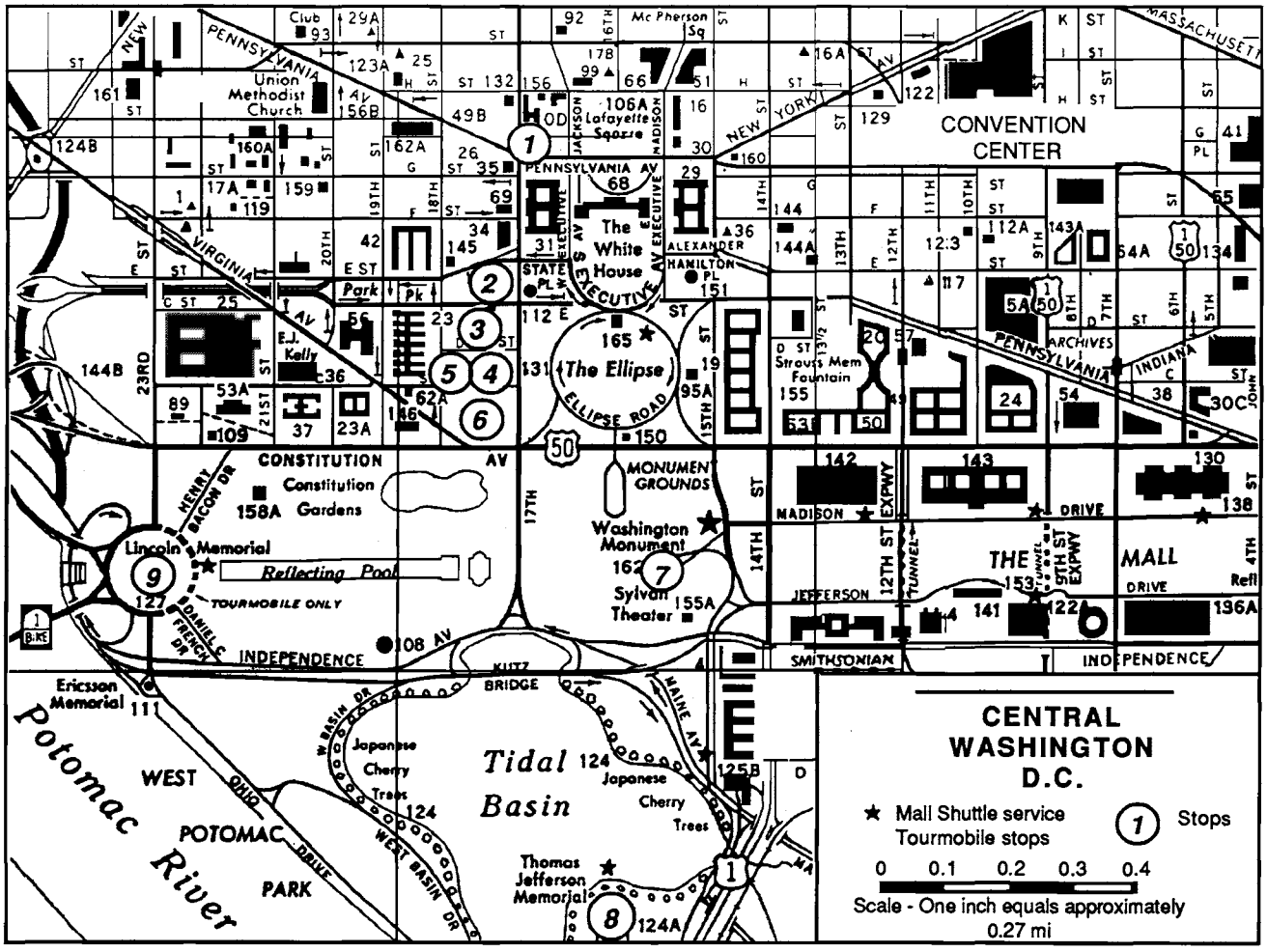

FIGURE 1 Location of stops in downtown Washington

TOUR

Stop 1 Renwick Museum

A brief look will be taken at the Renwick Museum, named after the architect James Renwick, located at the corner of Pennsylvania Avenue and 17th Street. The building was completed in 1859 with an original trim of red Triassic Belleville Sandstone from New Jersey that was replaced with a reddish cast stone in 1987. A previous attempt to repair the stone by patching it with a plastic impregnated with crushed stone failed as the patching began to discolor within two years of the replacement. The patching then began to spall off making a covered walkway around the building necessary to prevent pedestrians from being hit by falling pieces.

Across the street can be seen the Old Executive Office Building of gray granite, completed in 1888. This building constructed so as to be fireproof is not visited on this trip, but tours of the building are held regularly by appointment on Saturday mornings (telephone 395-5894).

Stop 2 Corcoran Gallery

The Corcoran Gallery is on 17th Street at New York Avenue. The original building was completed in 1879 but was enlarged in 1927 and furnishes some opportunity to compare 50 years separation in exposure. The building is of coarse-grained Cambrian Murphy Marble Formation (more usually called Cherokee Marble from near Tate, Georgia, on a foundation of pink granite from near Milford Massachusetts. Unfortunately the building can be examined close-up in only a few places. Ornamentation at the original entrance is deeply degraded; yet, flat, vertical areas are pretty smooth down to a meter or so from the landing, perhaps because of protection furnished by a slight overhang above the entrance. Old stone in rails leading to the door are deeply degraded, so much so that they again have a rather smooth but very granular feel. Some mineral is seen to stand in positive relief, probably magnesian calcite or dolomite. Much stone has been replaced in the railings. Vertical walls are still in good condition, however. Among the features of note are that runoff from the bronze lions stains the coarse-grained marble, but the staining does not seem to have any cracking or sugaring effect on the marble, a situation essentially unchanged since it was noted in the report of Kessler and Anderson [1953]

Stop 3 Red Cross buildings

But a short walk across E Street to the building facing north on E Street is the more recent of two Red Cross buildings to be studied. Construction of this building started in 1928 with completion in 1931. Following examination of this building, we will proceed to 17th Street to the original Red Cross building facing East that was started in 1915 and completed in 1917. For convenience, these two buildings will be discussed together. The main stone of these buildings is fine-grained Shelburne Marble of Ordovician age from near Danby, Vermont. A feature of particular note is the rougher feel of the portions of the columns directly exposed to the elements compared to the more protected interior parts. As one feels outward, exposed faces and inward, more protected faces of flutes on the columns, one gets to a point in rotating under the portico where outward flute faces feel abrasive and inward facing flutes relatively smooth. Qualitatively, directly exposed flutes on the older 17th Street building seem to feel more abrasive than the E Street building that is 13 years younger.

A second feature of note is the famous cracking as well as staining of the fine-grained marble from the drainage off the bronze lamps. Greenish and purplish staining is occurring on the marble with removal of much carbonate matrix (sugaring). The area was cleaned by hydraulic sandblasting in 1985, but extensive staining had reappeared by 1987. Kessler and Anderson (1953) describe cracking in an advanced stage in only one block on the north check wall of the steps. We now not only see extensive cracking within the stained area of this wall, but cracking is beginning on the south check wall as well.

Balustrades line either side of the driveway in front of the 17th Street entrance. Although the posts have only minor splits and the rails only a few, many balusters are split and spalled exposing some granular surfaces. Many balusters are cracked all the way through in a narrow location near their bases, most commonly on the 17th Street side of the drive. These breaks probably continue to occur as, although most are

patched with cement, a few unpatched and fresh-looking breaks are observed as well. On the building side, the balustrade recedes well away from the drive and breaking due to careless parking of vehicles seems unlikely. Such consistent breaking of balusters has not been observed elsewhere so it may not be the result of pollution. The base of the balustrade is granite rather than marble so the breaking may be the result of differential thermal expansion and contraction between granite and marble, or, perhaps, damage during snow removal.

Stop 4 Memorial Continental Hall

The tour will then cross D Street to examine Memorial Continental Hall, the original building of the Daughters of the American Revolution (DAR). This structure, which was started in 1904 and completed in 1909, is again comprised of Shelburne Marble. The building was sandblasted in 1959 and hydraulically cleaned in 1982. The balustrades on both the north and south sides were in such a state of deterioration that much stone was replaced by Cherokee Marble in 1982. Examination will concentrate on the South portico area. By feeling the tops and bottoms of new stone on the balustrade railings, the tops of the new stone are felt to be already roughening. Such roughening was already detected at the time of the first examinations in 1984. This roughening shows that pollution damage from acid rain continues since institution of the Clean Air Act that has done much to improve metropolitan air. The only other possible factor would seem to be hail. Much original stone remains which dramatizes the differential response of stone to pollution damage. The monolith columns are most unusual in the Washington, D. C., area. Examinations of these fluted columns give results similar to what was observed on the Red Cross buildings. Notice that columns well under the portico have smoother outward facing surfaces and better preserved bases than the more freely exposed columns. The vertical walls of the building are generally in good condition, although many silicate swirls have begun to weather out. As you depart from this area, note the cracked condition of many blocks of stone that were not replaced. Although such stone should be more susceptible to weathering action, deterioration of such marble is seen to progress slowly as observed at the original Red Cross building.

Stop 5 Constitution Hall

A walk along C Street towards 18th Street enables an examination of Constitution Hall of the DAR. This building was constructed when Memorial Continental Hall was condemned and was completed in 1929. It is constructed of limestone from Alabama (Unfluted columns on the east and north sides of Memorial Continental Hall also appear to be of this stone.). In general the stone is in remarkably good shape; however, some restoration of the limestone on the south (and north) podia, steps and landing was made in the spring of 1985 to correct damage possibly related to salting of the steps and landing in the winter. Some limestone has been replaced in the steps on 18th Street also. The area of a sill will be examined to see how even minor overhangs protect stone from precipitation runoff damage. Columns along 18th Street show a predominant precipitation direction from the south as evidenced by clean-looking and roughened surfaces to the south and smoother but polluted surfaces on the north (Fig. 2).

FIGURE 2 Acid rain effect on column of Constitution Hall. Southward facing surface is abrasive feeling and clean looking. Northward facing surface is smoother feeling with accumulation of pollution.

This condition is well observed by crossing 18th street and looking east, back at Constitution Hall. The relationship is common, and I have observed it on a variety of construction materials in diverse locations of the world, e. g. sandstone (City Police Station near the Rat Haus Bruche, Switzerland) and concrete (Powell Building, Reston, Virginia).

When you have crossed 18th Street to look back at Constitution Hall, you will be standing next to the Interior Department that was occupied in 1937. It is constructed of Salem Limestone from near Bedford, Indiana. This stone comprises more than 50 percent of the limestone used in limestone buildings in the U. S. This stone is remarkably resistant to degradation, aided by its coarse pore size and will not be examined on this tour.

Stop 6 Pan American Union building (Organization of American States)

The tour will then backtrack slightly across C Street to the Aztec Garden area of the Pan American Union (Organization of American States) building, where construction was started in 1908 and completed in 1910. Much of the exterior of this building is of Cherokee Marble from Georgia with steps and foundation of two kinds of Tennessee Marble [Withington, 1981]. Although coarse-grained marble normally shows much resistance to decay, balustrades are in a remarkable state of decay in both the garden and patio areas. Black coatings of gypsum-containing alteration (Fig. 3) are seen on the balusters bordering the west patio which have granular exposures where the coating has exfoliated. Staining and cracking of a fine-grained marble are observed beneath bronze lamps similar to that observed at the original Red Cross building. The degradation is so extreme and in such contrast to other examples of coarse-grained marble of similar construction age that some added cause for degradation is suspected other than ambient pollution. Mr. Terrance Woods who looks after this building thinks it has been cleaned by sandblasting more than once. It is his feeling that sandblasting removes a protected surface formed in polishing of marble (i. e. an analogy of glazing on bricks). This removal opens pores in the rocks subjecting it to saturation with water during storms followed by deleterious processes such as freeze-thaw action in winters. In addition to his hypothesis, consideration must be given to the idea that sandblasting creating microcracks in the surface. Limestones with only small pores (less than 5 microns) are known to degrade rapidly [Robertson, 1982]. Sandblasting may convert relatively impervious marble into a micropored limestone analogue with similar results. Although such hypotheses can be proposed to explain the areas of greatest damage, it should be remembered that much of the stone is holding up very well, the vertical walls in particular.

Some cracking of rails around the garden appears to go all the way through. Surfaces of the rails are extremely rough with some mineral accumulations--probably magnesian calcite or dolomite as in the Corcoran Gallery -- standing in positive relief. Accumulations of white material under the broad rails contain

FIGURE 3 Gypsum alteration and spalling at the Pan American Union Building.

gypsum. In 1985, it could be seen that vines had been recently removed from the east-facing podium of the garden and the south side of the adjacent building. The Aztec Garden is the most vegetated location studied with numerous trees nearby so that organic acids from the

trees or other exudates perhaps contributed to the accelerated decay of this stone.

If time permits, smooth surfaces, even retaining some polish, under a canopy on the north side of the building can be traced to exposed areas where the characteristic roughening has occurred as we have seen on columns of Shelburne Marble and limestone from Alabama in earlier stops. In the front of the building facing 17th Street, balusters have also suffered degradation, five are even missing. Statues affixed to the east side of the building offer study of complex geometrical shapes. They are in generally good condition, except the fingers have suffered with a part of the hand on the statue to the south of the entrance having the appearance of being replaced. The front steps display an unusual amount of cracking compared to marble steps elsewhere.

Stop 7 Washington Monument

The bus will be reboarded for a trip to the Washington Monument completed in 1885. The monument will not be entered. The purpose of the stop is to note the structural damage occurring to the initial 47 meters of Proterozoic marble from Texas, Maryland, constructed between 1845 and 1854. Whereas most monuments and memorials use more than one kind of building stone, this one has had a particularly complex history. Funds ran out in 1854 and work did not resume until 1879 (Shoring up of the foundation was required already in 1876.). Four layers of white Ordovician marble from Lee, Massachusetts, were laid, but this marble was found to be too expensive so the monument was completed with less-expensive Proterozoic marble from Cockeysville, Maryland. The changes in marble types can be easily seen from a distance.

Stop 8 Jefferson Memorial

The bus will then proceed to the Jefferson Memorial. It is said that three features are components of a great monument -- columns, a dome, and balustrades. Even though the Jefferson Memorial has no balustrade, many consider it to be the most beautiful of U. S. monuments, perhaps because of the extraordinary setting near the Tidal Basin and the numerous columns. The exterior is of Shelburne Marble and an interior of Cherokee Marble. It is a pity the locations of the two kinds of marble were not reversed because much less pollution damage might be visible if they had been reversed in view of the greater resistance of coarse-grained marble to pollution damage. This observation, arrived at from examination of stone buildings, is also in accord with studies of tombstones by Baer and Berman [1983]. Although the Jefferson Memorial was only completed in 1943, a rare civil structure completed during World War II, a surprising amount of damage is noted. The polish is already gone from exterior vertical surfaces. This loss of polish probably is not related to prior cleaning because it is still present on more protected parts of the Shelburne Marble. Grooving (Fig. 4), as much as six millimeters deep, is noted where silicate-rich swirls in the Shelburne Marble are eroding preferentially to the main white calcitic marble, even on the interiors of columns. As the carbonate matrix is dissolved away, silicate minerals (e. g. chlorite) fall out providing a greater rate of erosion in the swirl areas. To what extent this grooving is related to inherent vice of pyrite observable in the swirls is not known, but the damage is greater than for either of the older Red Cross buildings or the Memorial Continental Hall. Pyrite normally looks fresh so that the

FIGURE 4 Grooving of column at the Jefferson Memorial.

alteration rind seems to be continuously removed furnishing surfaces for further reaction. Once the grooves begin, excellent locations for freeze-thaw action are formed to create spalling.

This is the structure showing the most extensive flaking and spalling of material on vertical walls (Especially on the retaining walls for the garden.).

The unusual amount of damage may be related in some fashion to its location near the bottom of the area known as "foggy bottom", brackish water nearby, its proximity to a coal fired power plant in the days before the Clean Air Act, hydraulic cleaning, and/or its location on the flight path to National Airport. Grooving is observed near the tops of the columns that would seem to be well above the horizon of normal hydraulic cleaning. Perhaps the lower mean annual temperature somehow accounts for the significant damage observed in short-lived marble structures of the Washington, D. C. area relative to centuries older structures in Rome or Greece; however, Skoulikidis [1982] has estimated from studies of photographs and molds that damage to the Acropolis accelerated 20-25 years before his report along with the development of industrialization in Greece where fuels high in sulfur content were used.

Although not to be visited, the sloping surface of the roof of the portico has some mineral accumulation in positive relief like at many other locations, presumably of magnesian calcite or dolomite. The relief here, however, is extreme giving a minimum rate of erosion of a millimeter per 10 years, assuming there has been no dissolution of the resistant mineral accumulations at all, a rate that greatly exceeds those observed at stone test sites [Reddy et al., 1986, Youngdahl et al., 1985]!

Also although not to be observed, stalactites and stalagmites are growing in the basement of this memorial along cracks in the concrete floor. The calcium in these features are more likely to have been derived from the concrete in the floor than from the marble surfacing of the floor (see Stop 8 Lincoln Memorial).

The bronze letters in the interior are staining the Cherokee Marble but with no other discernible effect. The unusual locations of damage probably are the result of the aerodynamics of the building where rains swirl through the structure and acid fog has free access (In the Los Angeles Basin, fogs have achieved a pH of 1.2, similar to battery acid, but the pH of Washington, D. C., fogs is unknown.). Structural damage is noted here in cracks through interior blocks of marble and particularly at the northwest corner of the memorial that has been built on fill of part of the Tidal Basin. Rather than being the result of locked-in stresses in the rocks, the structural damage is more likely to be the result of subsidence. Some marble has been replaced such as at the base of columns at the front of the memorial and at the entrance to the restrooms on the ground level at either side of the steps on the north side.

The effect of tourists seems to be to polish the surfaces frequently touched through sliding shoe soles or hand rubbing. The steps of the memorial look to be in good shape, and it could be that continuous polishing seals pores and results in less degradation than continuous exposure to the elements would seem to suggest, although marble steps on some other older buildings are not so well preserved (e.g. Pan American Union building).

Stop 9 Lincoln Memorial

The bus will then be reboarded for the final stop at the Lincoln Memorial, completed in 1922, to examine the exterior of the very fine-grained Mississippian Leadville Formation or Yule Marble from near Marble, Colorado. The foundation is a granite from Massachusetts and the interior floor is of pink marble from Tennessee. The statue of Lincoln is of Cherokee Marble from Georgia, a fitting tribute to his preservation of the nation. Although an unusual amount of pollution damage is observed in the Yule Marble at the Lincoln Memorial that must be related in some fashion to its location at "foggy bottom", as at the Jefferson Memorial, the main feature of note here is from "inherent vice", a term originally used (for self destruction of paper) to express the observation that an object may carry the seeds of its own destruction. In this case, locked-in stresses are spontaneously resulting in cracking, spalling and chipping that continues down to today as some defects are seen to be filled in with cement patches and others look fresh. Fossil cracks filled with calcite are also seen to show that the process started while the rock was still in the ground. Modern cracking is primarily horizontal with subordinate cracks at about 45 degrees.

This monument is also famous for its stalactites and stalagmites in the basement forming along cracks in the

concrete under the front steps which will be visited if time permits. These features are not only observed under the marble part of the steps but under the granite part as well. Although water saturated with calcium carbonate from marble flowing down the marble-concrete interface and under the granite steps cannot be completely ruled out, Holly Huyck (now at the University of Cinncinatti and sister of the earlier cited Heather Huyck) concludes in a report made to the National Park Service that the carbonate is more likely dissolved mainly from concrete.

The granite features near the street display unusual damage for this stone. The lower levels of the granite next to the walkway are spalled. The top of the spall zone is linear so as to suggest the damage is related in some fashion to snow and snow removal.

Not to be visited on this trip is the roof; however, as elsewhere, magnesian calcite or dolomite is observed to stand in positive relief on top of ornamentation on the cornice by about a millimeter, a minimum weathering rate of horizontal surfaces therefore exceeds 1 mm/60 yrs.

Comparative structures (not visited)

For Cherokee Marble, Georgia: Mount Vernon Place United Methodist Church (900 Massachusetts Ave., N.W.), construction began 1917, completed 1919, abundant pyrite in silicate swirls but with little preferential weathering, has columns, exceptionally well preserved except for minor roughening of surfaces; Rayburn Building (First St. and Independence Ave., S.E.), completed 1965, exceptionally well preserved with little roughening noticeable on exposed parts of columns, horizontal surfaces are rough.

Shelburne Marble, Vermont: Russell Building (Constitution Ave. west of First St., S.E.), considerable signs of degradation on the south side marble balustrade (granite of the west side is well preserved, however) and second floor flutes on columns, stalactites observed from mortar at the east side underpass in 1985; Dirkson Building (Constitution Ave. east of First St., S.E.) , construction initiated in 1956, vertical surfaces are definitely rougher than adjacent New Senate Office Building; the Hart or New Senate Office Building, construction begun 1975, no obvious signs of degradation, slightly rougher feel observed on openly exposed surfaces compared to more protected surface near doorways.

Salem Limestone, Indiana: numerous examples were built during the Great Depression of the 1930's, especially extending eastward along Constitution Avenue from 15th Street, stone is generally in excellent condition but with some blackening of balusters where present that suggests some gypsum accumulation(usually on floors above ground level such as at the Interstate Commerce Commission). The balustrades at ground level of the Department of Justice are in an advanced state of decay.

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Not to be visited on this trip is the roof; however, as elsewhere, magnesian calcite or dolomite is observed to stand in positive relief on top of ornamentation on the cornice by about a millimeter, a minimum weathering rate of horizontal surfaces therefore exceeds 1 mm/60 yrs.

Comparative structures (not visited)

For Cherokee Marble, Georgia: Mount Vernon Place United Methodist Church (900 Massachusetts Ave., N.W.), construction began 1917, completed 1919, abundant pyrite in silicate swirls but with little preferential weathering, has columns, exceptionally well preserved except for minor roughening of surfaces; Rayburn Building (First St. and Independence Ave., S.E.), completed 1965, exceptionally well preserved with little roughening noticeable on exposed parts of columns, horizontal surfaces are rough.

Shelburne Marble, Vermont: Russell Building (Constitution Ave. west of First St., S.E.), considerable signs of degradation on the south side marble balustrade (granite of the west side is well preserved, however) and second floor flutes on columns, stalactites observed from mortar at the east side underpass in 1985; Dirkson Building (Constitution Ave. east of First St., S.E.) , construction initiated in 1956, vertical surfaces are definitely rougher than adjacent New Senate Office Building; the Hart or New Senate Office Building, construction begun 1975, no obvious signs of degradation, slightly rougher feel observed on openly exposed surfaces compared to more protected surface near doorways.

Salem Limestone, Indiana: numerous examples were built during the Great Depression of the 1930's, especially extending eastward along Constitution Avenue from 15th Street, stone is generally in excellent condition but with some blackening of balusters where present that suggests some gypsum accumulation(usually on floors above ground level such as at the Interstate Commerce Commission). The balustrades at ground level of the Department of Justice are in an advanced state of decay.

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