

DEPARTMENT OF THE INTERIOR

U. S. GEOLOGICAL SURVEY

Deterioration of Building Stones in Washington, DC
A Field Trip Guide

by

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Introduction

Many of our important historic buildings and monuments in Washington, DC are made of stone and bronze. We tend to think that our monuments will last forever, but stone deteriorates when it is exposed to rain, wind, and freeze-thaw cycles; in Europe scientists and conservators have become concerned that increases in urban pollution are greatly accelerating the natural deterioration of buildings and monuments. Although we have few industrial sources of pollution in the Washington DC area, we do have automobiles that contribute significantly to air pollution and smog. Also, air pollution can be transported by winds to areas beyond where the pollutants are first generated. Acid precipitation, caused by the atmospheric reactions of sulfur and nitrogen oxides with oxygen and water to form acids, has lately received increased attention in the United States. Acid precipitation has been blamed for damage to lakes, trees, and aquatic life, and it can contribute to the deterioration of materials, particularly some limestones and marbles that are more susceptible to the effects of acidity.

This guide is intended as a reference for those who would like to examine some buildings and monuments in Washington, DC for various types of deterioration including some that may be due to acid precipitation. First, we will address three questions: What is acid precipitation? What types of stone are susceptible to deterioration from acid precipitation? What does stone deterioration look like? In order to find out, we will be visiting a number of buildings and monuments in Washington. We will also get an idea of the variety of stone materials used in our buildings. One important point to keep in mind while examining these buildings and monuments is-- stone deterioration is not entirely due to acid precipitation. Although we can observe deterioration of the stone, we do not yet know how much of the deterioration is from acid precipitation and how much is from other causes.

Acid Precipitation

"Acid rain" is the popular term for atmospheric deposition of acidic particles that includes rain, snow, fog, dew, or dry particulates. The more general term, that is preferred is "acid precipitation". Distilled water has a neutral pH of 7; liquids with a pH less than 7 are acid, those with a pH greater than 7 are basic. "Clean" or unpolluted rain has a pH of 5.6, which is slightly acidic, because carbon dioxide and water in the air react to form carbonic acid (a weak acid). In the Washington, DC area the average rain pH is between 4.2 and 4.4.

The additional acidity in our rain comes from the reaction of air pollutants, primarily oxides of sulfur and nitrogen, with water to form strong acids (sulfuric and nitric). Principal manmade sources of these pollutants are industrial and power-generating plants and transportation vehicles. Transportation vehicles are the predominant source of pollutants in the Washington DC area.

In the media today, when you hear about the effects of acid rain, you hear about lakes, fish, and trees in New England and Canada. However, in Europe there has been concern over the last few years that pollution and acid rain may be accelerating the deterioration of buildings and monuments. Stone weathers (deteriorates) as part of the normal geologic cycle through natural chemical, physical, and biological processes when it is exposed to the environment. Our concern is that air pollution, particularly in urban areas, may be accelerating the normal, natural rate of stone deterioration, so that we may lose buildings and sculptures of historic or cultural value.

Stone Types

Granite, limestone, sandstone, and marble have been used for many of the buildings in Washington, DC. However, because of their composition, some stones are more susceptible to deterioration from acidic deposition than others. Granite is primarily composed of silicate minerals which are resistant to acid attack. Sandstone is also primarily composed of silica and thus resistant, but a few sandstones are less resistant because they have a carbonate cement that dissolves readily in weak acid. Limestone and marble are primarily composed of the mineral calcite (calcium carbonate) which dissolves readily in weak acid; a characteristic that we use to identify the mineral calcite. Because of their relative susceptibility to acid attack, we will focus on buildings and monuments made of limestone and marble.

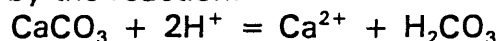
The main difference between limestone and marble is that limestone is a sedimentary rock, composed of calcium carbonate fossils, and marble is a metamorphic rock. Marble is formed when a sedimentary rock (limestone) is heated and squeezed so that the minerals recrystallize. If you look closely at a limestone you can usually see fossil fragments (eg. bits of shell) held together by a calcite matrix. Limestone is more porous than marble as there are small openings between the fossil fragments. Marble appears crystalline and may contain colored streaks that are inclusions of non-calcite minerals.

Many of our buildings and monuments in Washington are made of limestone and marble. Marble has often been used for buildings of historical or cultural value; hence, we have a large concentration of such buildings in Washington. Limestone is the second most widely used building stone (after granite). It was widely used prior to the appearance of portland cement because of its homogeneous color and texture, and because it can be easily carved and it shows little tendency for preferential splitting.

Limestone and Marble Deterioration

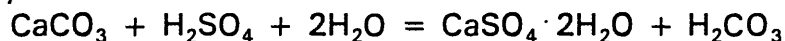
As mentioned above, because of their composition both marble and limestone are susceptible to acid attack. Thus, you would expect to see these stones showing the effects of dissolution when they are exposed in an environment with acid precipitation. In exposed areas of buildings and statues we see roughened surfaces and loss of carved details because acidic rain has washed and removed some of the stone surfaces. One would expect then, that sheltered areas of stone buildings and monuments would not be at risk from the effects of acid precipitation. However, examination of sheltered areas on limestone and marble buildings and monuments reveals blackened crusts that have spalled off in some places, revealing disaggregated stone beneath. This blackened crust is primarily composed of gypsum, a calcium sulfate mineral that forms from the reaction between calcite, water, and sulfuric acid. Thus, two types of deterioration related to acid deposition are typically found on limestone and marble: dissolution and alteration. We will examine examples of dissolution and alteration on marble and limestone throughout this tour, but first a brief explanation of the two processes involved.

Dissolution. Sulfurous, sulfuric and nitric acids in polluted air dissolves calcite in the stone by the reaction:



Calcite reacts with acid to form calcium and carbonic acid. Stone surface material may be lost generally or preferentially (in spots that are more reactive). You will observe a graininess compared to the original surface, eroded grooves, or loss of crisp edges and details of carved features.

Alteration. Sulfuric acid and water react with the calcite to form the mineral gypsum, a hydrated calcium sulfate:



Gypsum is soluble in water, so although it may form anywhere on carbonate stone surfaces that are exposed to SO_2 , it usually remains on those surfaces that are protected from direct washing by the rain. Typically gypsum alteration crusts can be recognized on marble or limestone surfaces by a blackened accumulation in sheltered areas. Eventually the black crusts blister and spall off, revealing crumbling stone that readily reacts with the pollutants. Scanning electron microscopic examination of the gypsum alteration crusts shows that bladed gypsum crystals form networks that trap various dirt and pollution particles, thus giving the crust its blackened appearance.

A Tour of Some Buildings and Monuments

Introduction

Places to visit on this trip have been divided into several areas so the trip can be done either in segments or all in one day. Buildings and monuments in each area will be examined during the walking tour; a suggested tour route is described within each area. Room is provided in this guide for any notes you may wish to make during your examination of the buildings.

Ideally, a car provides the most efficient transport between areas, however parking may be a significant problem. The Metro system can easily be used to visit all areas except the Jefferson Memorial. The closest metro stations and a suggested route for using the Metro system are given at the end of this guide.

You will need comfortable walking shoes and you may want to bring along a camera, a hand lens (~10x magnification) for observing details of minerals and weathering, and a pair of binoculars for closer examination of inaccessible areas. You may also want to be prepared for the sun and heat. Keep in mind that summer in Washington can be quite hot and we often get sudden afternoon thundershowers in the summer. Despite these concerns, it can be educational and fun to observe the different aspects of our buildings and monuments. Hopefully this guide will get you started so that you can recognize and observe many different geologic features in addition to the historical and architectural aspects of buildings and monuments, wherever you travel.

The area of the National Capitol

This area includes the Capitol building, the Peace Monument, the Grant Memorial, and the Botanic Gardens. We begin the tour at the south east corner of the Capitol, and go clockwise around the Capitol (south, to west, to north) we then follow a walkway trending west, from the north east corner of the Capitol to see the Peace Monmument at the intersection of First Street and Pennsylvania Avenue, NW. We continue south along First Street to the Grant Memorial and then south again to the Botanic Gardens.

The Capitol Building. The Capitol was built in sections; the cornerstone of the main building was laid in 1793, the north wing was completed in 1800, and the south wing was completed in 1807. Both wings were burned by the British in 1814. The capitol was then rebuilt and it has been variously modified throughout the years. A major cleaning, replacement, and repair effort was begun in

the late 1980s. The center building of the Capitol is sandstone (painted), but the north and south wings for housing the Senate and the House chambers are marble. Around the Capitol we will observe various examples of dissolution and blackened alteration. We will especially be examining effects on the marble balustrade that surrounds the south, west, and north sides of the building.

Beginning at the southeast corner of the building (using binoculars) we can see blackened alteration in the Corinthian column capitals. A more accessible example of blackened alteration is found under the overhang of the large square ends of the marble balustrade at the southeast corner of the building. The black crust is made of gypsum plus dirt that accumulates in sheltered areas. Note that in the sheltered area there is no black crust where there are cracks between the stones; rain water probably flows in these areas, dissolving the gypsum and preventing accumulation of a crust. As you examine this corner baluster be aware that not all black areas are gypsum: in some "blackened" areas of this marble block, near the bushes, you can see greenish-black moss growing on the stone. Note the relative deterioration effects of exposed and sheltered areas visible on the balustrade: the top surfaces of the marble balustrade are coarse and rough (because of dissolution between grains) compared to areas that are more protected from running or washing water.

Another dissolution feature of marble is the pock-mark effect on the square bases of the building columns. Non-calcite inclusions in the marble were loosened by the dissolution of the surrounding calcite, causing the inclusions to "pop" out of the stone. A particularly good example of this is found on the fourth column west from the southeast corner of the Capitol building. Note that the pock mark dissolution is not restricted to the base of the building.

We will more or less follow the marble balustrade around the building, noting differences in deterioration. Some parts of the balustrade have obviously been replaced, thus enabling us to make comparisons, and to observe various stages in the stone deterioration. Note especially the edges of the balusters (sharp when new, rounded when older), note also the accumulation of blackened alteration on the sheltered sides of the balusters and under the overhanging top of the balustrade. In some spots under the

rail the blackened crust has spalled off, exposing fresh surfaces and more vulnerable stone. Note the carvings on the balustrade corners, some are worn while others have blackened alteration; this may be due to local effects of wind and rain. Along the steps leading to the terrace on the west side of the Capitol, gypsum has accumulated on large areas of the wall surface. Gypsum can accumulate anywhere that it is not washed, and thus dissolved by water, not just in nooks and crannies.

As you walk north along the west side of the Capitol, take a look at the central part of the building. The walls here are formed of painted sandstone. Despite recent restoration of the building, evidence of past stone deterioration is still visible: note the accentuated lines from bedding in the stone and pock marks where rounded inclusions have disappeared. We will see an example of this same stone that is not painted when we visit the buildings near 17th Street.

At the northeast corner of the Capitol building the marble balustrade ends in square blocks similar to the ones we first examined. Here you can see an example of preferential dissolution where the inclusions remain and the calcite around them has been dissolved away. Also, on the north side of this block, examine the blackened grains on the top surface with a hand lens. Not all of the black material you see on stone is gypsum, some is of biological origin, probably an algae or a fungus.

To continue the tour, follow the pathway that trends west along the north side of the Capitol, towards First Street. As you approach First Street you will see a sandstone, diabase, and granite fence with various carvings and minimal deterioration.

The Peace Monument. This monument, dedicated in 1878, is made of marble from Carrara, Italy. The statue does not show any pronounced deterioration so it has probably been cleaned and maintained. However, if you look closely, you can see alteration crusts (some are light orange) in protected places and graininess and roughness in places that are exposed to rain. Carved statues have many intricate areas that present varied surfaces that direct rain washing and runoff.

Continue south along First Street to the Grant Memorial on your right.

The Grant Memorial. This memorial, dedicated in 1922, consists of a grouping of bronze sculptures mounted on marble bases. The most notable stone deterioration visible here is the green stains on the marble bases. The surfaces of the bronze statues alter to a green color. The green colored runoff from the statues flows onto the bases and stains them green. Bronze weathers in the outdoor environment if it is not cleaned and waxed regularly. Like stone, bronze dissolves where it is exposed to rainfall, developing a green color and a pitted surface, and it alters in sheltered areas, with accumulation of a blackened layer.

Continue south, crossing Maryland Avenue, to the Botanic Gardens.

Botanic Gardens Building. This limestone building was built in 1931. Like many of the limestone buildings in Washington DC, this building has been cleaned, so it does not have an accumulation of surficial dirt. However, the cleaning process, and/or regular washing by rainfall, has accentuated the fossils in the stone which dissolve less readily than the calcite matrix. There are minor blackened crusts on some parts of the sculpted heads above the arches of the building. On the east side of the building, microorganisms contribute to the deterioration (blackening) of the stone, where water drips from a joint in the roof.

This is the last stop in the Capitol area of the tour; you may wish, however, to see some bronze alteration on the Garfield Memorial (First St. and Maryland Ave.) and the accentuated fossils with surrounding algae/fungus on the limestone posts near the Capitol Reflecting Pool.

Jefferson Memorial

The Jefferson Memorial is a marble building, dedicated in 1943. This building is maintained and cleaned regularly by the National Park Service. One of the most striking deterioration features to observe here is the preferential loss of silicate inclusions in the marble columns because of dissolution. Close examination of the grooves shows flakes of mica and sometimes grains of pyrite. Some blackened crusts are visible on the column capitals where the orientation of carved surfaces has hindered cleaning.

Buildings along 17th Street, NW

We will begin this segment of the tour at the corner of 17th St. and Constitution Ave. with the Capitol Gatehouse. We will then cross 17th Street and examine several buildings along 17th Street as we walk north towards Pennsylvania Avenue.

Capitol Gatehouse. This small sandstone building was built around 1828 and was located at the west entrance to the Capitol until 1874. In 1880 it was reconstructed (along with a twin and four gateposts) at its present site. This building is interesting because it is made of the same sandstone that was used in the central part of the Capitol and in the White House. Three types of deterioration are readily visible at the gatehouse: spalling, pockmarks, and preferential weathering of layers in the stone. Note that the degree of deterioration in this stone may be more severe than is present in the Capitol or the White House, because of variations in stone quality and maintenance to the buildings.

To continue, we will cross 17th Street and examine parts of several buildings as we walk north.

Organization of American States Building. This marble building was dedicated in 1910. Two sculptures in the front of the building show some alteration crusts in sheltered areas and dissolution in exposed areas. In back of the building there is a patio with severely deteriorated marble balusters. The blackened crusts are extensively developed and in many places the crusts have blistered or spalled off exposing new surfaces to alteration. Take care to notice the difference in the patio and garden sides of the balustrade. In general, the patio sides of the balusters are in much better condition than the sides that face the garden, perhaps because washing of the patio has slowed accumulation of gypsum crusts.

Continue north through the garden and parking lot and cross C Street to the Daughters of American Revolution Buildings.

DAR - Constitution Hall. The main deterioration noticeable on this limestone building, built in 1930, is the blackening of the side balustrade from algae or fungus.

The limestone in this building is quite homogeneous and shows little preferential dissolution, except for removal of calcite matrix relative to the fossil fragments. The porous nature of the stone will cause it to retain moisture, thus encouraging growth of organisms.

Continue east along C Street to Memorial Continental Hall.

DAR - Memorial Continental Hall. The porch area on the south side of this marble building built in 1909 is a good place to look at some contrasts in marble deterioration. Replacement of several parts of the balustrade for the porch are noticeable by differences in color and texture of the stone. Again, you can see relative coarsening of the exposed stone surface along the top of the balustrade compared to the surfaces in more sheltered areas. The columns on this porch are carved around the base so you can examine the effects of exposure to rain on the carving details. The more exposed carvings have lost their sharp edges and definition compared to the sheltered carvings. Some nice examples of pyrite weathering in marble can be seen in the base of the columns as well. Note the window sill and its support on the west side of the porch. The sheltered part of the support shows development of an alteration crust that is quite similar to the crusts we will see on the test briquette samples at the acid deposition exposure site (rather than a black crust, a dull white accumulation on the stone surface).

At the corner of 17th and C Streets, turn left and walk north along 17th Street. Enroute to the Corcoran Gallery, we will pass the Red Cross building (marble, 1917). Some of the same types of marble deterioration observed at other locations are also present here.

Corcoran Gallery. The Corcoran Gallery is marble with a granite base. It was built in 1879 and enlarged in 1927. Ornate carving around the roof, doors, and windows have blackened crusts of gypsum as do portions of the marble pedestals supporting the bronze lions at the front door. The marble bases also have inclusions that stand in relief relative to the surrounding calcite.

Continuing north along 17th Street towards Pennsylvania Avenue, you will see several modern granite office buildings and the Executive Office building (formerly

the State-War and Navy building) which was built 1871-1888. Turn right onto Pennsylvania Avenue and proceed to the Renwick Gallery on the northeast corner of the intersection of 17th Street and Pennsylvania Avenue.

Renwick Gallery. This building of brick and sandstone, completed in 1859, is interesting from a preservation point of view. The decorative sandstone panels were badly deteriorated so the panels were impregnated with an epoxy-type material. This treatment accelerated the deterioration because when water penetrated behind the epoxy-impregnated zone, large portions of the treated panels spalled off. A second renovation attempt was necessitated two years after the first and the present panels are cast sandstone. A post of the original sandstone stands at the southeast corner of the building.

The next portion of the tour begins at Vermont Avenue and H Street NW, at the northeast corner of Lafayette Park. To get there, walk east along Pennsylvania Avenue, past the Blair House to Lafayette Park, situated on the north side of Pennsylvania Avenue, across from the White House. While walking through Lafayette park you can see a number of bronze statues that have been cleaned fairly recently.

"City Block Area"

This segment of the trip begins at the northeast corner of Lafayette Park. We will walk clockwise around 2 blocks: Vermont Ave to I Street, east to 15th Street, then south to Pennsylvania Avenue, and finally west to Madison Place. In this area we can see examples of the many types of building stones that have been used in the city: limestone, granite, marble, sandstone, terra cotta, and brick. Some varied deterioration is visible on these buildings, and some efforts at cleaning and repair are also visible.

Export-Import Bank. This limestone building, built in 1940, is on the corner of Vermont Avenue and H Street. Note the dirt on the walls and the washing pattern around the windows. Up close, you can see some relief presented by the fossil fragments in the stone, but the fossil details

are not quite as pronounced as those found on the stone surfaces of the Botanic Gardens building, perhaps this is because the fragments are smaller here or because more aggressive cleaning at the Botanic Gardens site has accentuated the fossils.

Continue north along Vermont Avenue to I Street and turn right onto I. Walk east along I Street, cross 15th Street and then turn right and head south along 15th Street.

The Bowen Building. This limestone building has some columns that show very good examples of preferential sheltering and the development of alteration crusts and dirt. Also note the southwest corner of the building. Here you can compare the dirt on the south wall that faces an alley with the relatively cleaner area of the corner and the west facade of the building that face 15th Street. You can see washing, drip, and dirt patterns above the first floor on the limestone building across the street.

Continue south along 15th Street. The building adjacent to the Bowen building is made of terra cotta, a fired ceramic clay material. As you continue south along 15th Street cross H Street and look at the variety of building materials used in the buildings here. On the east side of 15th Street you will see the Woodward building which is marble on the first two floors and then brick above. Next is the Securities building which is painted stone at the base and limestone above. The next two buildings, #727 and #725 are marble.

727 15th Street and 725 15th Street (the Folger building). These marble buildings show the marked contrast of new marble when it is incorporated with old marble. Note the dissolution deterioration on the marble columns outside #727, and the attempt at patching spalled and cracked stone under the window at #725.

Continue south on 15th Street to the next building.

Crestar Bank Building. This building is built mostly of brick, but the base is Seneca sandstone, the same stone that is used in the Smithsonian Castle building. Note the spalling of the stone at the north end of the building.

At the intersection of 15th Street, New York Avenue and Pennsylvania Avenue, turn right, and cross 15th Street to walk west along Pennsylvania Avenue.

American Security Bank. This granite building shows how durable a building material granite seems to be. Across Pennsylvania Ave. is the Treasury building, which is also made of granite.

Continue west along Pennsylvania Avenue and turn right at the next corner, onto Madison Place. Walking north along Madison Place to get back to where this segment began, you can see several examples of brick buildings. Note that limestone has been used for window sills and other decorative details on some of the brick buildings.

Washington, DC Exposure Site for Acid Deposition Studies

The exposure site is located on the roof of the West End Branch of the Washington DC Public Library, at 24th and L Streets, NW. It is not accessible to the general public. Access to the site is via a vertical rung ladder, and then up through a hatch onto the flat roof.

This site was used as part of the National Acid Precipitation Assessment Program materials effects study. It was set up to allow exposure of metal and stone materials mounted in standard configurations, with simultaneous monitoring of rain chemistry and amount, temperature, wind speed and direction, and air pollution levels. Our objective in exposing known samples in a standard configuration under monitored conditions, was to determine what incremental contribution acid precipitation makes to materials deterioration.

The stone samples were placed at the site in August of 1984. One by two foot slabs of limestone, marble, and glass are used for study of the rainfall runoff chemistry. Separate briquette samples of limestone and marble are used for various destructive tests of the stone. Rainfall runoff from the slabs is collected and analyzed after each rain event. Briquette samples are collected on a quarterly or yearly basis and sent to various researchers for analysis. Similar sites were established in 1984 in Newcomb, New York, Chester, New Jersey, and Research Triangle Park,

North Carolina. Another site was added in Steubenville, Ohio in 1986.

The limestone and marble briquette samples show some of the exposure effects that we have observed on various buildings and statues. The exposed (skyward) surfaces show signs of dissolution: fossils are accentuated with surrounding preferential removal of calcite matrix, and where inclusions are present in the marble, the stone surface is slightly roughened. The sheltered (groundward) surfaces of the briquettes show signs of alteration; they have slightly accentuated "spots" that contain the mineral gypsum. Note, that since these samples have at most had only 6 years exposure, the deterioration effects are not nearly so pronounced as those we observed on older buildings. The alteration spots developed within one to two years after the stones were placed at the site. Dissolution effects on the skyward surfaces of the briquettes are subtle, and were not noticeable until the samples were exposed for about 4 years. Particulates of dust, auto exhaust, and other pollutants have accumulated around the edges of the alteration spots and along the rails that support the samples. Just as on buildings and statues, the shape and location of the alteration spot on the briquette samples is controlled by the pathway available for water to flow across the samples. We have also seen the influence of biological deterioration on these samples. On the top surfaces of the limestones black organisms concentrate in the pore spaces between the fossil fragments and appear more abundant when the stone surface is moist.

Some interim results from these experiments have been published in scientific and technical journals. A summary, "State of Science" document for the National Acid Precipitation Assessment Program will be completed in the summer of 1990; the stone exposure studies are included in chapter 19 of that document. Further, more specific reports are being prepared by the individual researchers involved in the stone exposure program.

Maps

Map of the downtown-mall area of Washington, DC. This map is from the Tourist Washington map made by the National Geographic Society, Washington, DC, June 1989. Starting points for the areas visited on this tour are located as follows:

1. Capitol Area - D11
2. Jefferson Memorial - E7
3. 17th Street Area - C6
4. City Block Area - B7
5. Washington, DC Exposure Site - A4

Detail maps of the Capitol Area and the 17th Street to City Block Areas show the suggested routes to examine the buildings described above.

Using the Metro subway system for this trip

Metro subway stations are fairly close to most of the areas discussed on this trip. The closest Metro stations to each area, and a tour outline using the subway system, are given below.

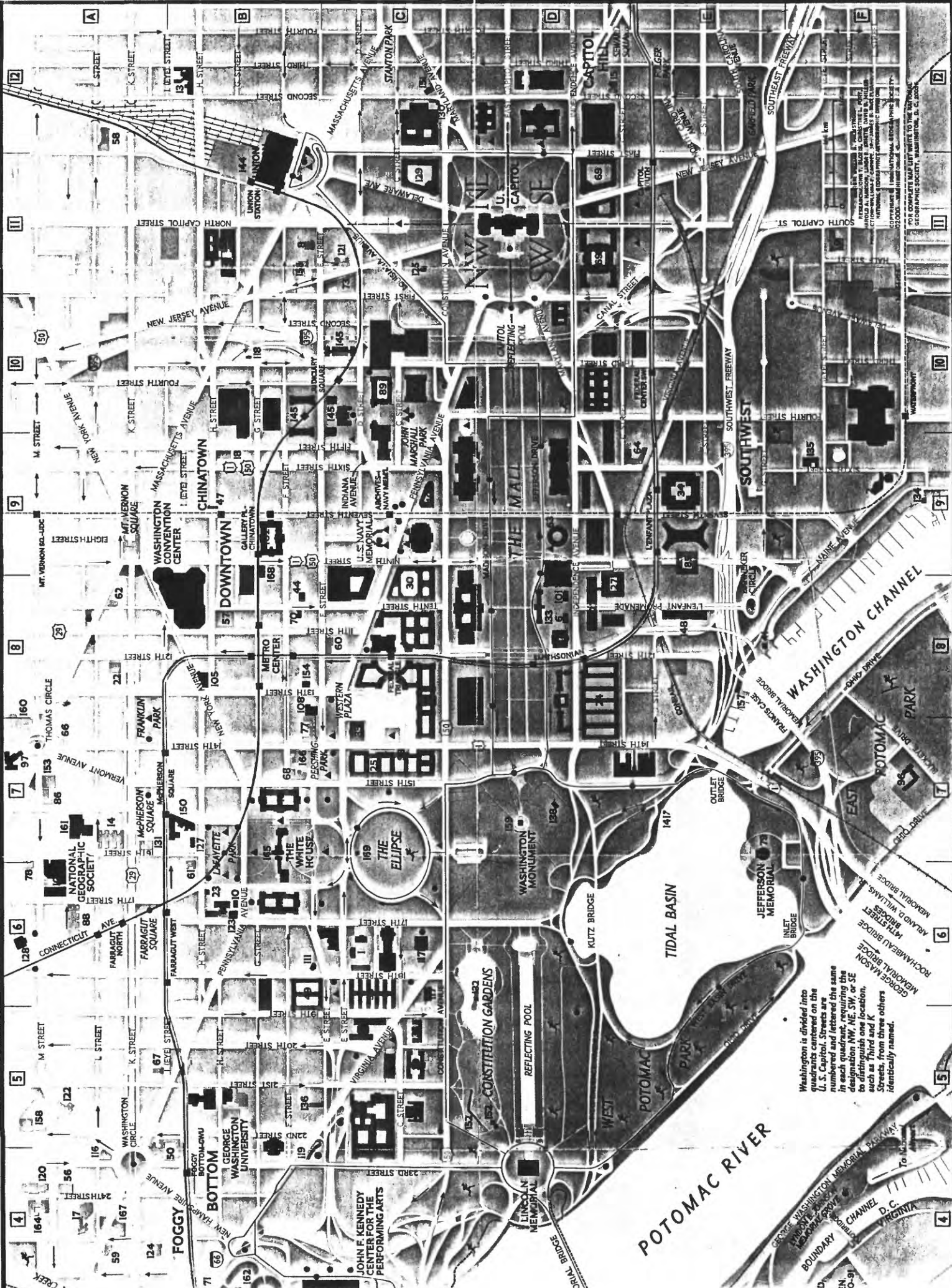
1. Capitol Area - The closest Metro station to the beginning of the tour is Capitol South. Walk north along 1st Street to the Capitol grounds at 1st and Independence. Note the marble buildings along the way: the House Office building on the west side of 1st Street and the new Library of Congress building on the east side of 1st Street. At the end of your tour of this area, walk west on Independence Ave, then south on 3rd Street, to Federal Center SW Metro station at 3rd and D Streets. Note the deterioration of some of the limestone on the Wilber J Cohen Federal Building as you walk along 3rd Street.

2. Jefferson Memorial - There is no nearby Metro station; the L'Enfant Plaza or Smithsonian stations would be the closest, but the roads are not convenient for pedestrians to reach the monument.

3. Buildings near 17th Street, NW - Although the nearest metro station to this area is about five blocks away, it is an interesting walk. From the Federal Triangle station, walk south along 12th Street, turn left onto Constitution Ave, and walk west along Constitution until you reach 17th Street to begin this segment. On the north side of Constituion Ave, you will pass several limestone buildings and the ellipse; on the south side of Constituion Ave you pass the Smithsonian buildings and the Washington Monument. This section of the tour connects directly to the next section at Lafayette Park.

4. "City Block Area" - On this segment of the tour you will walk past the McPherson Square Metro station at the corner of Vermont Ave and I Street.

5. Washington, DC Exposure site - The site is not open to the general public, but the library is located at 24th and L Streets, about three blocks from the Foggy Bottom Metro station.

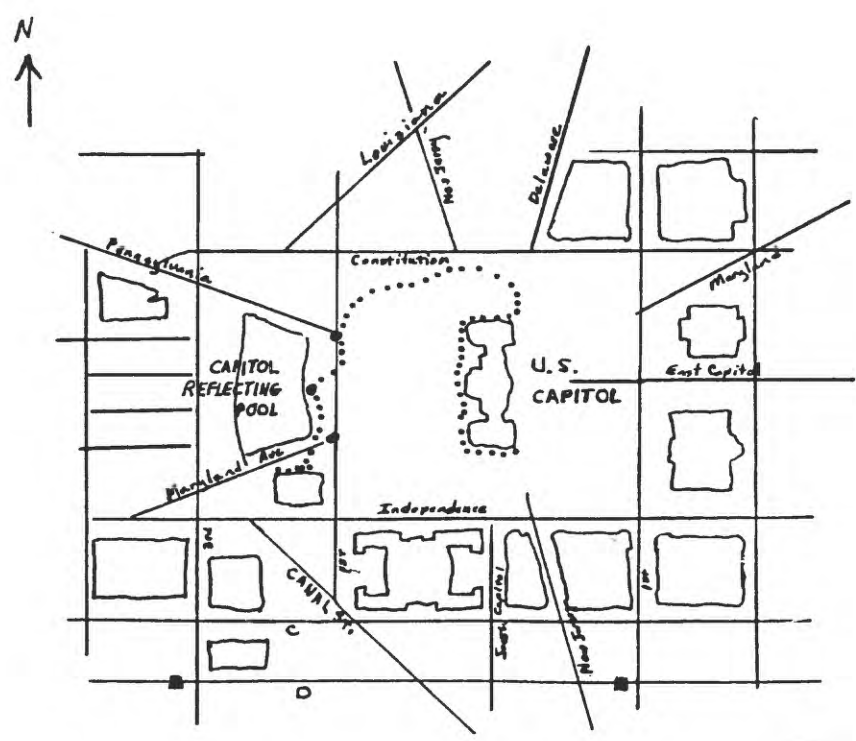
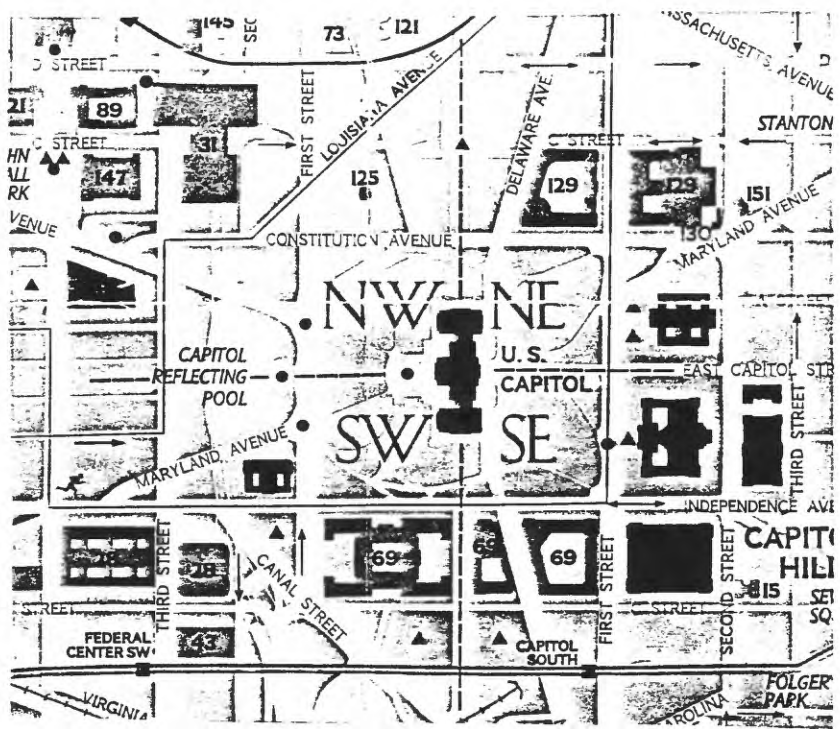


Washington is divided into quadrants centered on the U.S. Capitol. Streets are numbered and lettered the same in each quadrant, requiring the designation NW, NE, SW, or SE to distinguish one location, such as Third and K Streets, from three others identically named.

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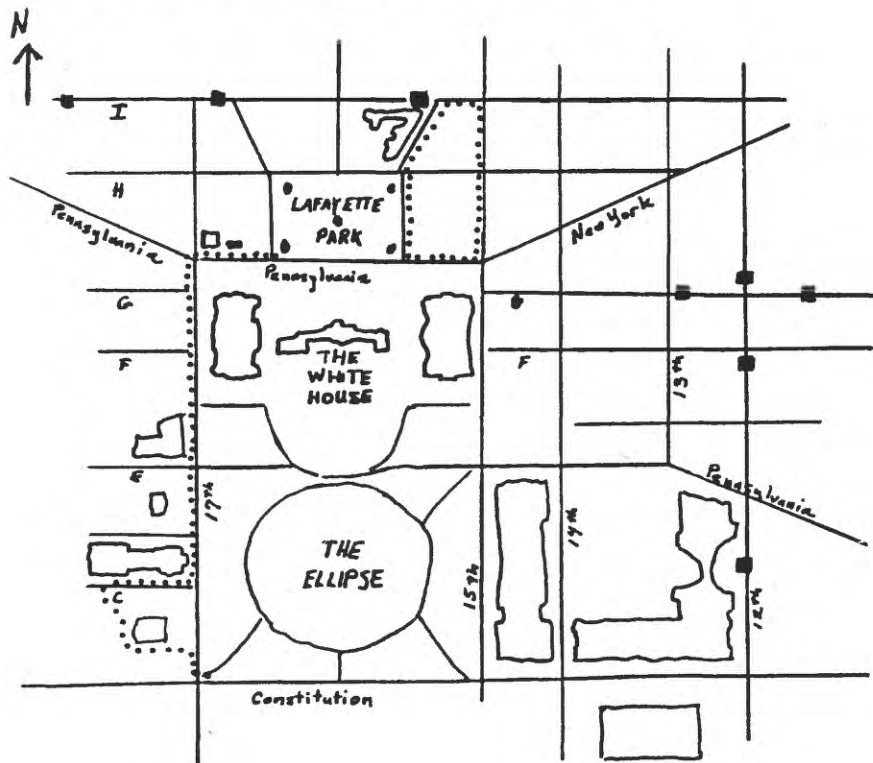
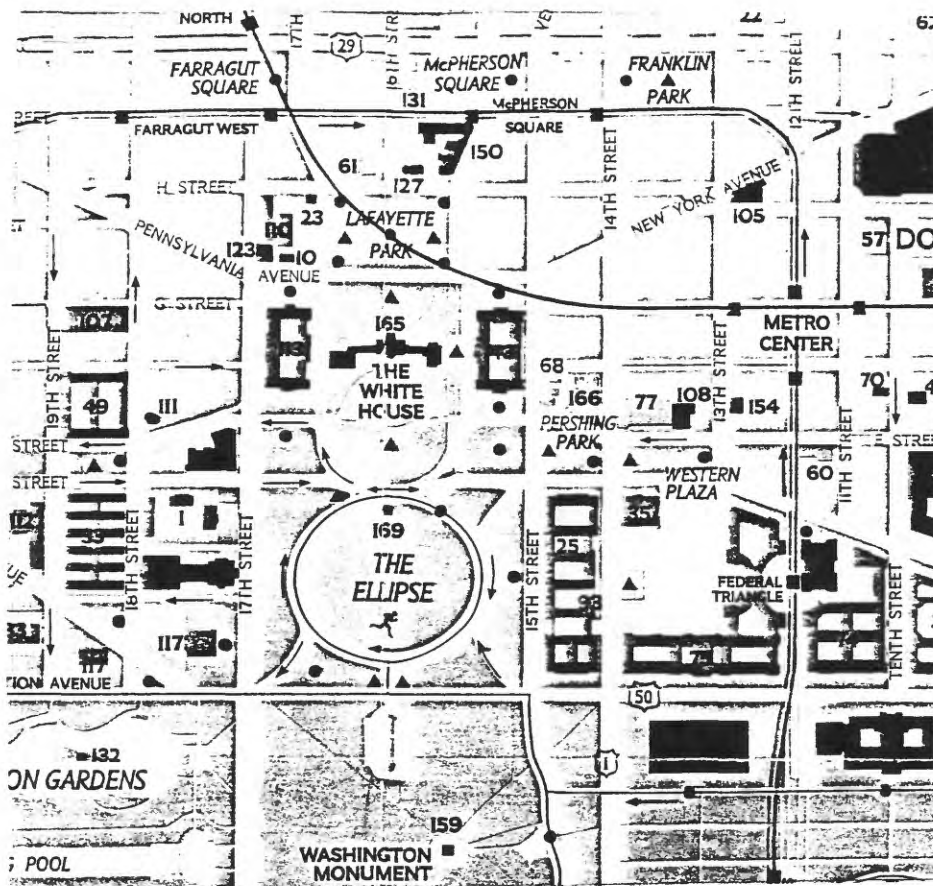
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Detail Map: Capitol Area



Small dots show route for tour of the area.
 Small black squares are Metro stations.

Detail Map: 17th Street to City Block Areas



Small dots show route for tour of the area.
 Small black squares are Metro stations.

Further Resources

Some sources of additional information that you may find useful or interesting include:

Information about building stones used (to see varieties of rock types, etc):

1. Building Stones of our Nation's Capital, a publication by the US Department of Interior Geological Survey, USGS: INF-74-35. This publication will be updated sometime in the near future.

2. O'Connor, James V., 1989, Building Stones of Pennsylvania Avenue. *in*: Moore, John E. and Jackson, Julia A. (eds), 1989. Geology, Hydrology, and History of the Washington, D.C. Area. American Geological Institute, Alexandria, Virginia.

3. National Park Service brochures, available at individual monuments (eg. Jefferson, Lincoln, Washington).

4. Videotape; O'Connor, J.V. and Deike, R., 1989, The Heart of the Nation's Capital as a geological textbook. Geological Society of America, Abstracts with Programs, Northeast Section, p55. Videotape from: Video in verse libre, Ruth Deike, 226 Ayrhill Ave., Vienna, VA 22180.

Field trips to examine deterioration of buildings:

1. Roth, J. Walter, 1982, Some illustrative preservation problems and treatments in Washington, DC. *in*: Conservation of Historic Stone Buildings and Monuments, National Academy Press, Washington, DC.

2. Doe, Bruce R., 1989, A different view of stone monuments, memorials and buildings of Washington, DC. Field Trip Guidebook T235. American Geophysical Union, Washington, DC.

Related information that may be of interest:

1. Goode, James M., 1974, The Outdoor Sculpture of Washington, D.C.: A Comprehensive Historical Guide. Smithsonian Institution Press, Washington, DC.

2. Moore, John E. and Jackson, Julia A. (eds), 1989. Geology, Hydrology, and History of the Washington, D.C. Area. American Geological Institute, Alexandria, Virginia.

3. Pickering, R.J., 1987, Acid Rain, Water Fact Sheet, U.S. Geological Survey Open-File Report 87-399.

4. Acid Rain: The Facts, 1988; a Canadian publication available from: Inquiry Centre, Environment Canada, Ottawa, Ontario, Canada K1A 0H3.