# MISSISSIPPI MINERAL RESOURCES INSTITUTE
## UNIVERSITY OF MISSISSIPPI
### SCHOOL OF ENGINEERING

# Using geophysics to understand the shallow geologic framework beneath the National Mall and Memorial Parks of Washington, D.C., and map the trend of a Quaternary fault

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## INTRODUCTION

Prior to the $M_w$ 5.8 Mineral, Virginia earthquake of 2011, few in Washington, D.C. were concerned about the potential for earthquakes. Despite having an epicenter more than 125 km to the south (Figure 1), this earthquake resulted in substantial damage to many important structures in the D.C. area, including the Washington Monument, the National Cathedral, the Capitol Building, and the Smithsonian Castle. Over the last century, construction in the city has revealed a number of faults near the surface, but these were all presumed to be ancient faults that posed no risk. One of these faults, the Adams Mill fault, is significantly younger than previously believed, revealing there is considerable uncertainty in what is known about the seismic hazard these faults may present to our nation's capital.

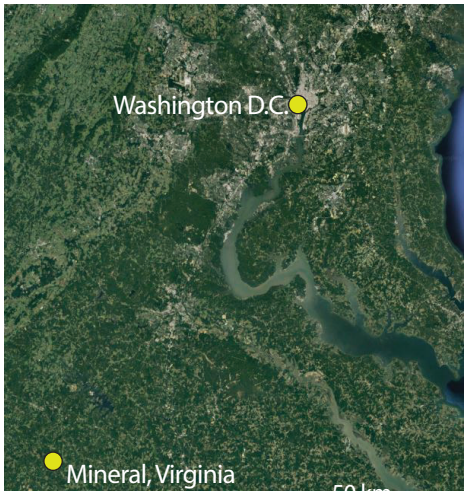



Figure 1. The $M_w$ 5.8 Mineral, Virginia earthquake did considerable damage to the nation's capital despite having an epicenter over 125 km away.

## FAULTS IN WASHINGTON, D.C.

Several faults have been discovered in the heart of the city. The Adams Mill fault was first identified in the early 20th century in a fresh road cut near the original entrance to the Smithsonian National Zoological Park in the heart of downtown Washington, D.C. It is a high-angle reverse fault that thrusts bedrock 2.4 meters over younger Potomac River gravels (Figure 2). To the west of the Adams Mill fault and approximately 800 meters south, an excavation revealed a gravel displaced by 1 meter east of the Calvert Street bridge over Rock Creek. Another fault displacing gravel 8 meters was uncovered during an early 20th century building excavation at 18th and California Streets. The ages of these faults were presumed to be close to the ages of the gravels, which were believed to be millions of years old. U.S. Geological Survey (USGS) geologists in the early 20th century did not believe these faults were part of a continuous fault zone but were isolated, local zones of uplift.

A recent USGS investigation for a D.C. Metro tunnel identified a fault in Lafayette Park across the street from the White House. A 1: 24,000 scale USGS map (1994) shows the Adams Mill fault is part of one continuous fault that begins at the National Zoo and stops in front of the White House (Figure 3). A 2017 USGS map (1: 100,000 scale) shows this fault extends from the Smithsonian National Zoo, continues through Lafayette Park, under the White House, and to the Thomas Jefferson Memorial, where it connects with the Stafford fault system (Figure 4). The trend of this inferred fault crosses many important landmarks and buildings in Washington, D.C., including the East Wing of the White House, the Washington Monument, and the Jefferson Memorial. These faulted gravels were assumed to be several million to tens of millions years old; however, the USGS obtained a preliminary luminescence age of the gravel faulted by the Adams Mill fault, indicating it is a 450,000- year-old Quaternary gravel. This represents a maximum age of the Adams Mill fault, which could be significantly younger.

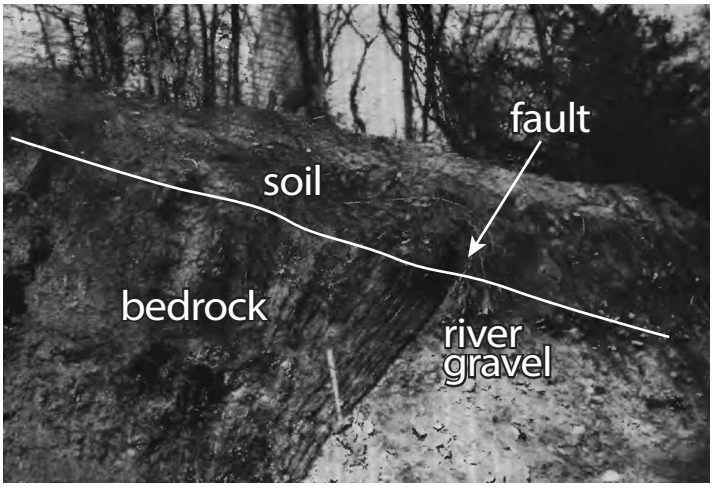



Figure 2. The Adams Mill fault exposed near the original entrance of the Smithsonian National Zoological Park. Photo was taken by N. Darton (USGS) in 1925. View is to the east.

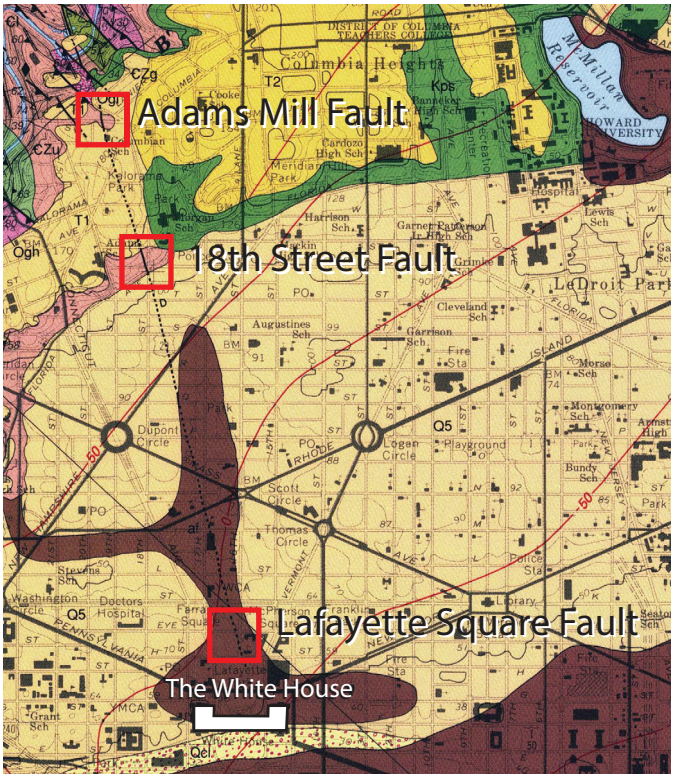



Figure 3. Quadrangle map by Fleming et al. (1994) infers the Adams Mill fault stops in Lafayette Park across the street from the White House.

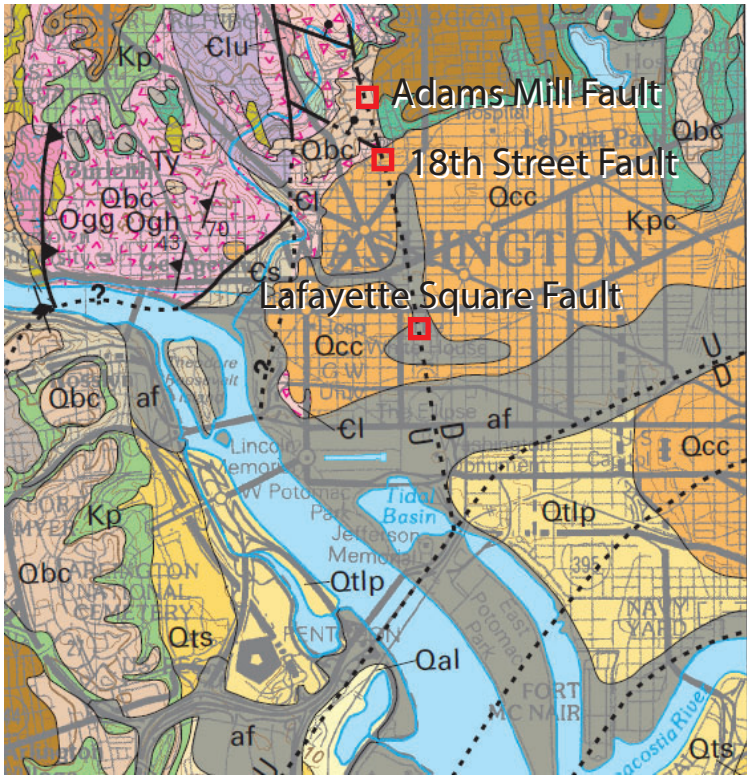



Figure 4. Lyttle et al. (2017) show the Adams Mill fault continues south, under several significant landmarks, and connects with the Stafford fault system, under the Jefferson Memorial.

## USING GEOPHYSICS TO MAP THE ADAMS MILL FAULT IN WASHINGTON, D.C.

With funding from the U.S. Geological Survey's Earthquake Hazards Program, researchers from the University of Mississippi (UM) used noninvasive, shallow geophysical methods that included ground penetrating radar (GPR) electrical resistivity tomography imaging (ERT), and passive seismic refraction (ReMi) data collection in the vicinity of the National Mall and the surrounding Memorial Parks and Monuments (Figure 5). The work was done over a period of 12 days to image the fault in a dense urban environment. The UM scientists also collected additional samples for luminescence age dating, which will help to confirm the preliminary age for the fault.

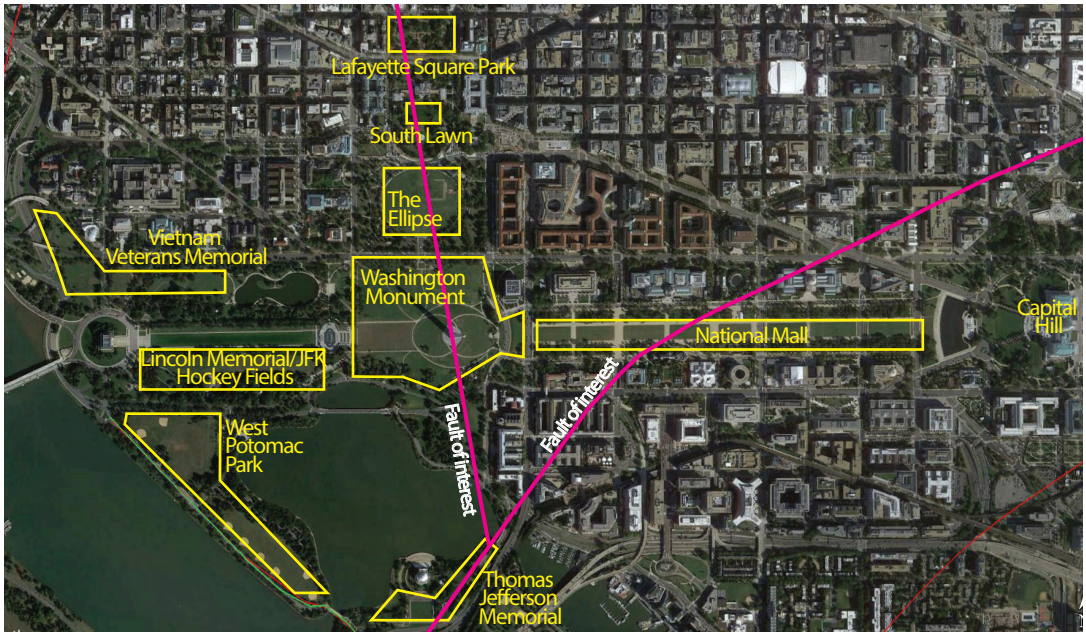



Figure 5. Areas where UM researchers collected geophysical data in Washington, D.C. during the summer of 2021. Not shown are East Potomac Park to the south of this image (1.5 km) and the Smithsonian National Zoo to the north (5 km).

## SMITHSONIAN NATIONAL ZOO

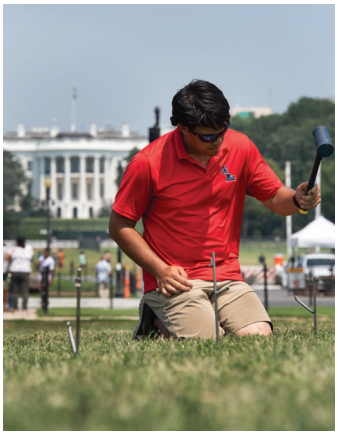
The research campaign began at the Smithsonian National Zoo. Although the fault is visible in an exposure at the zoo and its location is already known, the team wanted to collect ER and GPR data over the fault to see what it looked like in the geophysical data to make it easier to identify in data collected where the fault location was inferred (Figure 6). The second goal at the zoo was to collect a luminescence sample for age dating. In 2016, a 2.4 meter pit was hand dug on the zoo property by the USGS for the preliminary luminescene sample. To confirm this preliminary age, the UM research team collected a second luminescence dating sample. Hand digging a pit in the cobble-gravel was extremely difficult, and it took the team two additional days at the zoo to dig and acquire the sample (Figure 7).


Figure 6. Graduate student Kristian Macias attaches electrodes to the ER system.

Figure 7. UM graduate students Kristian Macias (left) and Jodi Messick (right) along with Dr. Counts (center) begin to dig a pit to collect a sample for luminescence dating. It took an additional 2 days of digging to reach 1.75 m.

## NATIONAL MALL AND MONUMENTS

The remainder of the 12-day research trip involved collecting GPR, ER, and ReMi data at the Lincoln Memorial, south of the Reflecting Pool on the JFK Hockey Fields, the Washington Monument, the Jefferson and Vietnam Memorials, the National Mall, and East and West Potomac Parks. Data are still being processed and results will be incorporated into Kristian's thesis and then published in peer-reviewed journals.




All photos courtesy of University of Mississippi Digital Imaging Services.