

Research Proposal to the State of Florida

**Title: Pilot project on public safety impacts from quarry blasting in
Miami-Dade's limestone mining district**

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1. Research overview.

Many homes and public buildings in the vicinity of the Lake Belt mining district in northwest Miami-Dade and southwest Broward counties experience frequent cracking of the house walls, floors, and subsidence of the driveways. These damages not only require costly repairs but expose the residents to unique hazards to their safety and health. Differential dynamic settlement of the foundations due to ground vibrations may compromise the structural stability of the affected buildings, thus creating a safety hazard for the occupants. The health hazards include (i) mental distress because of fears of building collapse, (ii) mental distress because of high bills to repair the damaged homes, (iii) mental and/or physical distress because of the sensation of occasionally strong air blasts, which could particularly impact vulnerable elderly and/or disabled populations living in nursing homes or in adult living facilities.

We propose a three-component investigation firmly grounded in geological sciences, geotechnical engineering and social sciences to understand whether the quarry blasting impacts the safety and health of the residents. The overall objective is mitigating any confusion and public mistrust, and enabling a *frictionless co-existence of people and the mining industry*.

First, we will use satellite remote sensing to identify public buildings that are undergoing rapid and unusual ground settlements. Second, we will conduct a geological investigation of the subsoils near damaged structures to better understand the root causes of the damages. Knowing that muck deposits present in the local geology do undergo long-term secondary compression (slow creep deformation) as a natural process, our research will investigate if the rapid differential settlements and resulting damages observed by many local residents are triggered by anthropogenic causes such as blast-induced vibrations and ground shaking. To address this question we will combine methods from satellite remote sensing, seismology, and infrasound, with in-situ and laboratory geotechnical testing for determining creep and settlement parameters. Third, we will conduct a social sciences investigation to determine whether the residents suffer from anomalous health conditions that could be related to the mining operations.

2. Affected population and public buildings.

The quarry blasting is generally felt to a distance of up to ~4 miles from the mines and occasionally to 6 miles distance. There are approximately 157,000 housing units within this distance from the White Rock quarry (9 zip codes), i.e. about 420,000 people are exposed to the blasting. A similar amount of people is affected by the CEMEX quarry to the south with some populations feeling the blasts from both quarries. Public buildings experiencing the blasts from White Rock include the Barbara Goleman, Mater Lakes, American, Everglades, Jose Marti, Hialeah Gardens and Hialeah-Miami Lakes senior high schools. Elementary and Middle schools within 4 miles from the mine include Palm Spring North, Spanish Lakes, Hialeah Gardens, West Lakes, Hive, Mater and Bob

Graham, Miami Lakes, Lawton Chiles in Miami-Dade County, and the Glades Middle, Coral Cove, Dolphin Bay, Panther Run, Silver Lakes, Franklin, Somerset, Pembroke Pines Charter and Sunset Lakes Elementary Schools in Broward County.

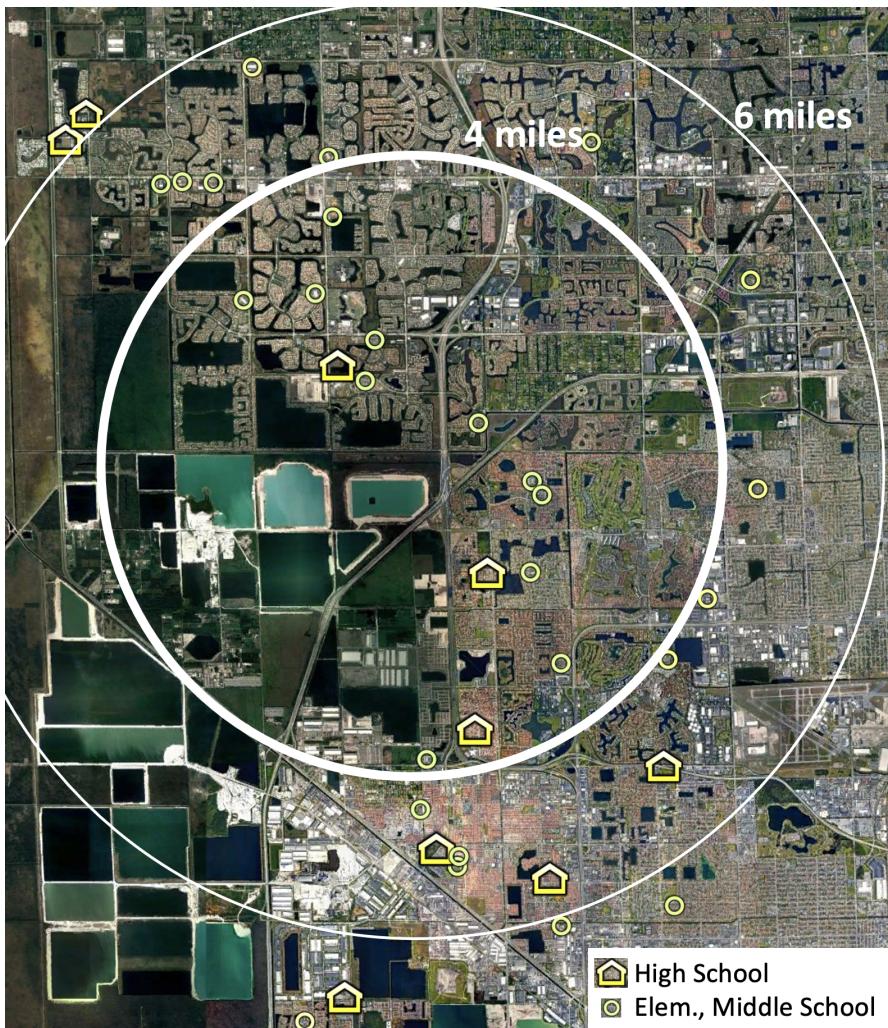


Fig. 1. Population and Schools exposed to the physical effects of blasting at the White Rock Quarry in Miami-Dade County. The CEMEX quarry further south impacts a similar population.

3. Proposed research

Safety of public buildings. The repeated formation of cracks raises concerns that the structural integrity of buildings could be compromised. Differential movements not only cause cracks in the walls but also increase the stresses within structural beams which could lead to failures. We will use satellite-based interferometric synthetic aperture radar (InSAR) data to monitor roof-top displacements that could indicate issues with the structural integrity of the buildings. We will provide this information to the Schools so that they can investigate and take mitigative actions if warranted. Preliminary InSAR data show that a portion of the roof of the Everglades High School in Miramar subsided by ~1 inch in June 2020 (Fig. 2). The Appendix features additional examples of affected schools. In the InSAR technique hundreds of SAR images are combined to measure changes in distance between the ground and the satellite orbit. The technique can identify subcentimeter displacements.

Causes of the damages. The causes of the damages to the homes and the public buildings are not understood. Possible explanations are natural settlement of the muck-rich soils, vibration-triggered dynamic settlement of the fill underlying the shallow foundations, or creep deformation of the

water-rich muck, quite possibly accelerated by ground vibrations. Possible vibration sources are pile driving for highway and overpass construction, heavy truck traffic/railroads, and seismic and acoustic waves from the blasting.

To investigate the causes of the damages we will use seismological, geotechnical and space-geodetic methods. We will (i) identify homes that undergo settlement using InSAR data, (ii) place seismometers and infrasound sensors on affected properties to measure ground shaking, and (iii) conduct laboratory geotechnical testing of the subsurface material in order to determine the susceptibility for vibration-triggered creep deformation. This data will address how both the muck and the fill under the slabs respond to vibrations, and whether the spatial distribution of satellite-detected settlements correlates with distance from the blasting, and/or with the seasons. Hypotheses that we will test include that the seasonally changing water table in the underlying aquifer is responsible for the settlements and/or that the seismic waves act to expel the water from the muck.

Impacts on public health. We will employ established methods from social sciences to quantify the human health effects of the mine-blasting. We will assemble focus groups and examine the records from local hospitals to document mental distress and health-related events related to cracks in the homes and to the blasts. Control groups elsewhere in South Florida will establish whether there are anomalies that could be attributed to the mine blasting. We also will investigate whether the acceptance or fear of cracks and blasts is influenced by knowledge of the Champlain Towers South collapse in Surfside.

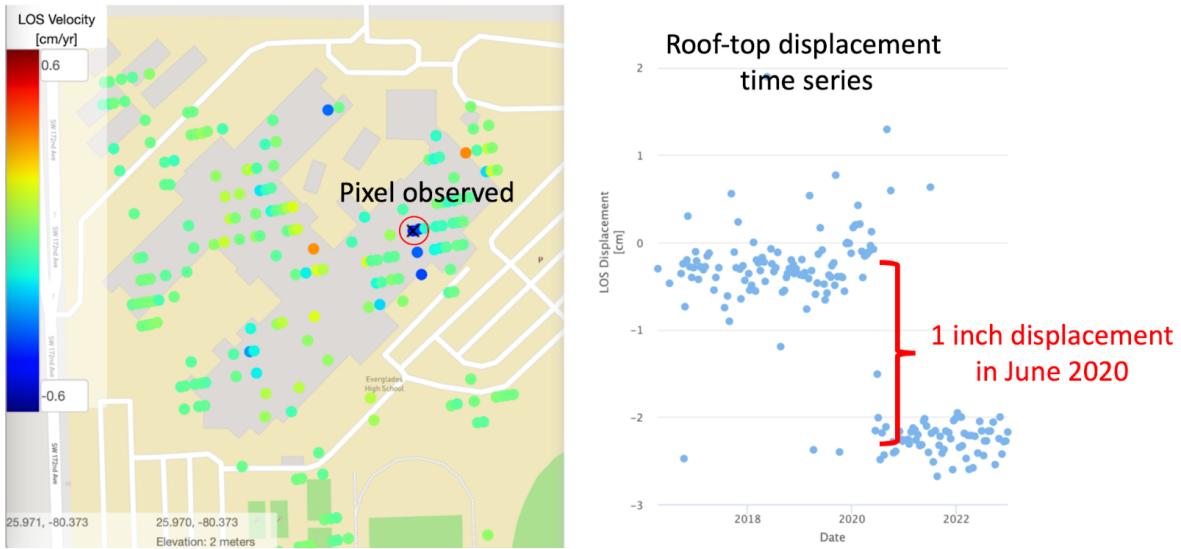


Fig. 2. (Left) Roof-top average velocity from satellite-based interferometric synthetic aperture radar (InSAR) of the Everglades High School in Broward. Green dots: no displacements. Blue dots: displacements. **(Right)** Displacement time series for a selected pixel on the roof. Each dot represents one SAR image. This section of the roof was displaced by ~1 inch in June 2020. For examples of InSAR-detected subsidence elsewhere in Miami see <https://youtu.be/1qZKXI7cNTk>

4. Team composition.

Our multi-disciplinary team will be led by professors from geology (Amelung), seismology (McNutt), geotechnical engineering (Sobhan) and public health and human geography (Moise), at the University of Miami, University of South Florida, and Florida Atlantic University, respectively.

5. Deliverables.

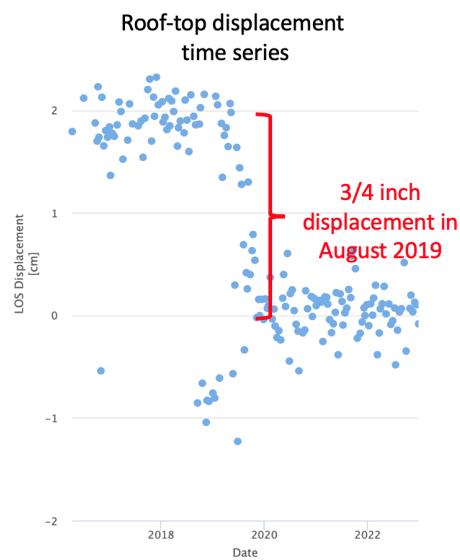
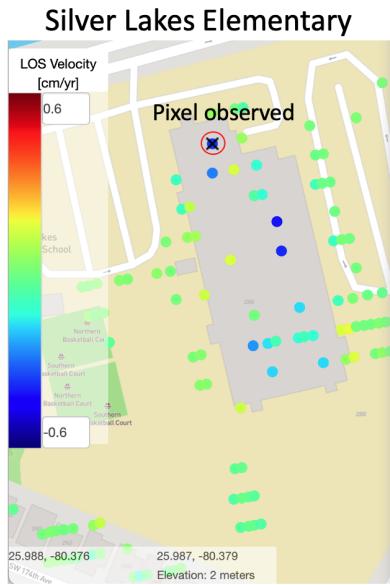
The project deliverables are intermediate and final reports as well as peer-reviewed articles in the scientific literature.

6. Pilot project and budget

We request \$400k/yr for a 2-year pilot project to support 4 graduate students (including tuition and indirect costs). The results from this pilot will inform a comprehensive multi-year project with the National Science Foundation (NSF) to investigate the response of the local geology to the seismic waves, possibly combined with a project with the National Institute of Health (NIH) to address the mental and physical health conditions linked to quarry blasting (if they exist).

Appendix

This Appendix presents two more examples of sudden displacements at schools within 6 miles from the mine.



Charles D. Wyche Elementary

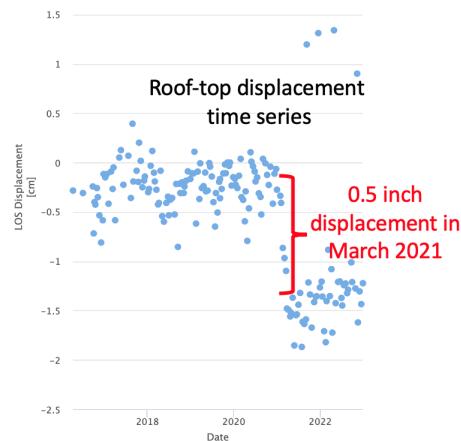
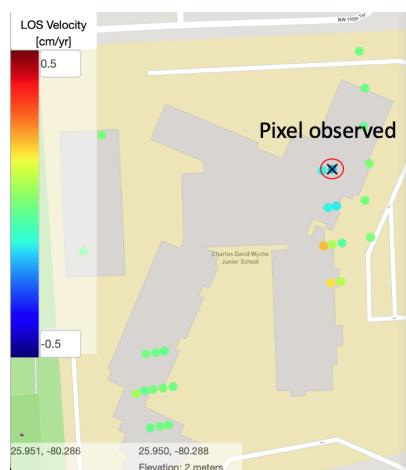


Fig. A. Same as Fig. 2 but for the Silver Lakes Elementary School in Broward and the Charles D Wyche elementary School in Miami-Dade.