Microbial Induced Calcite Precipitation to Stabilize Florida High-Organic Soils

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Motivation for Research

• High-OM soil needs to be stabilized

• Previous studies/attempts
  – Ground tire rubber (GTR) – not successful
  – Soil-mixed vertical columns – expensive
  – Cut-and-replace – often not feasible
  – Lime Kiln Dust (LKD) – may be a carcinogen

• Need a sustainable, cost-effective solution!
Microbial Induced Calcite Precipitation

• Governing Reactions (Ureolytic Microbes):

  – \( CO(NH_2)_2 + H_2O \rightarrow NH_2COOH + NH_3 \)

  – \( NH_2COOH + H_2O \rightarrow NH_3 + H_2CO_3 \)

  – \( 2NH_3 + 2H_2O \leftrightarrow 2NH_4^+ + 2OH^- \)

  – \( H_2CO_3 \leftrightarrow HCO_3^- + H^+ \)

  – \( HCO_3^- + H^+ + 2NH_4^+ + 2OH^- \leftrightarrow CO_3^{2-} + 2NH_4^+ + 2H_2O \)

  – \( Ca^{2+} + CO_3^{2-} \leftrightarrow CaCO_3 \)
Project Objectives

• Determine MICP’s feasibility as an environmentally-friendly and sustainable method for treating Florida’s high-OM soils for roadway construction

• Tasks will include literature review; MICP column experiment; create stabilized sand using ureolytic microbes; experimentation with native/non-ureolytic microbes; optimize MICP procedure; high-OM soil column treatment
Task 1 – Literature Review

*S. Pasteurii* Photograph (Bang 2014)

Result of precipitation and nucleation (Qabany et al. 2012)
Task 1 – Literature Review

MICP Photographs (DeJong 2012)

Fully-Cemented Specimen (Qabany et al. 2012)
Task 2 – MICP Column Experiment

Proposed MICP Setup
Task 3 – Produce and Characterize MICP-Stabilized Sand and OM-Rich Soils using Ureolytic Microbes

- *Sporosarcina Pasteurii* – aerated, “fed” with urea, and pumped through soil tube

- pH and inorganic C analysis used to monitor development

- XRD used to evaluate solid product mineralogy

- Triaxial, scanning electron microscopy (SEM), permeability tests
Task 3 – Equipment for Analysis

Dr. Zimmerman and Organic Geochemistry Lab at UF
Task 3 – Equipment for Analysis

UNF Geotech Lab Equipment
Task 4 – Optimization

• pH, urea-microbe ratios, food sources, etc. will be varied to produce **soils of greatest stability**
Task 5 – Native Microbes

• Microbe introduction good; Bio-stimulation better!

• Techniques
  – Fe reducer *Shewanella oneidensis*
  – Sulfate-reducing bacteria treated with Na$_2$ and sodium dithionite
  – Microbes isolated from Florida aquifer and measured for sulfate/acetate consumption

• Testing – same tests used for *S. Pasteurii* specimens

• [http://www.cnn.com/2015/05/14/tech/bioconcrete-delft-jonkers/](http://www.cnn.com/2015/05/14/tech/bioconcrete-delft-jonkers/)
## Timeline

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QUESTIONS?