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!

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Microbial Induced Calcite Precipitation

- Governing Reactions (Ureolytic Microbes):
  - $CO(NH_2)_2 + H_2O \rightarrow NH_2COOH + NH_3$
  - $NH_2COOH + H_2O \rightarrow NH_3 + H_2CO_3$
  - $2NH_3 + 2H_2O \leftrightarrow 2NH_4^+ + 2OH^-$
  - $H_2CO_3 \leftrightarrow HCO_3^- + H^+$
  - $HCO_3^- + H^+ + 2NH_4^+ + 2OH^- \leftrightarrow \boldsymbol{CO_3^{2-}} + 2NH_4^+ + 2H_2O$
  - $\boldsymbol{Ca^{2+} + CO_3^{2-} \leftrightarrow CaCO_3}$

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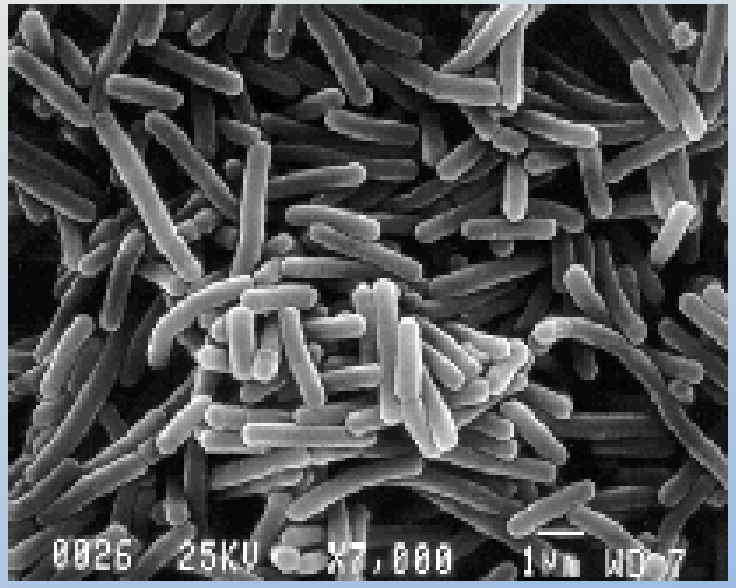
Project Objectives

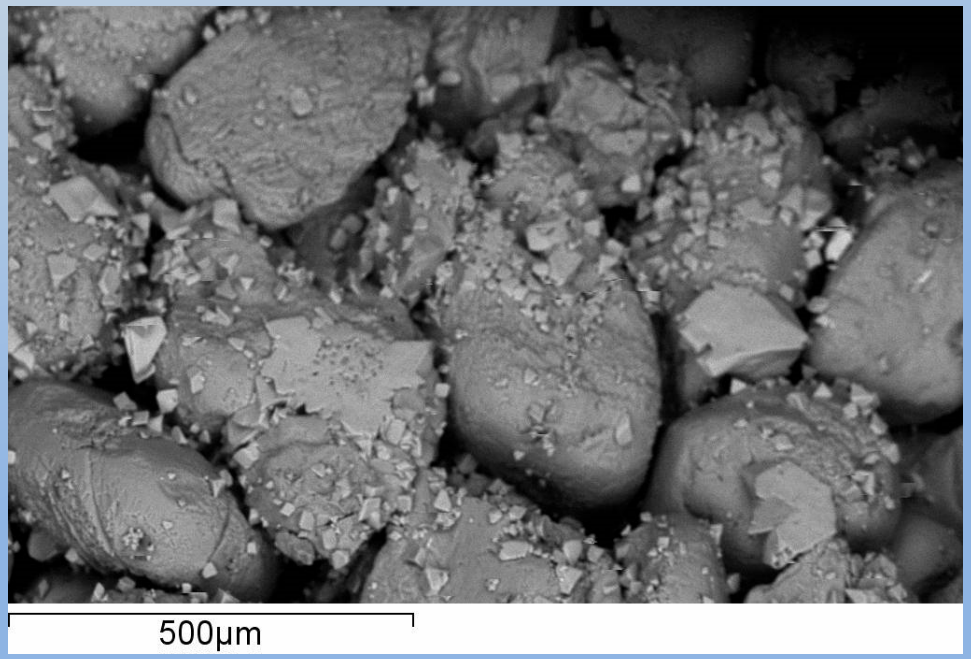
- Determine MICP's feasibility as an environmentally-friendly and sustainable method for treating Florida's high-OM soils for roadway construction

- 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

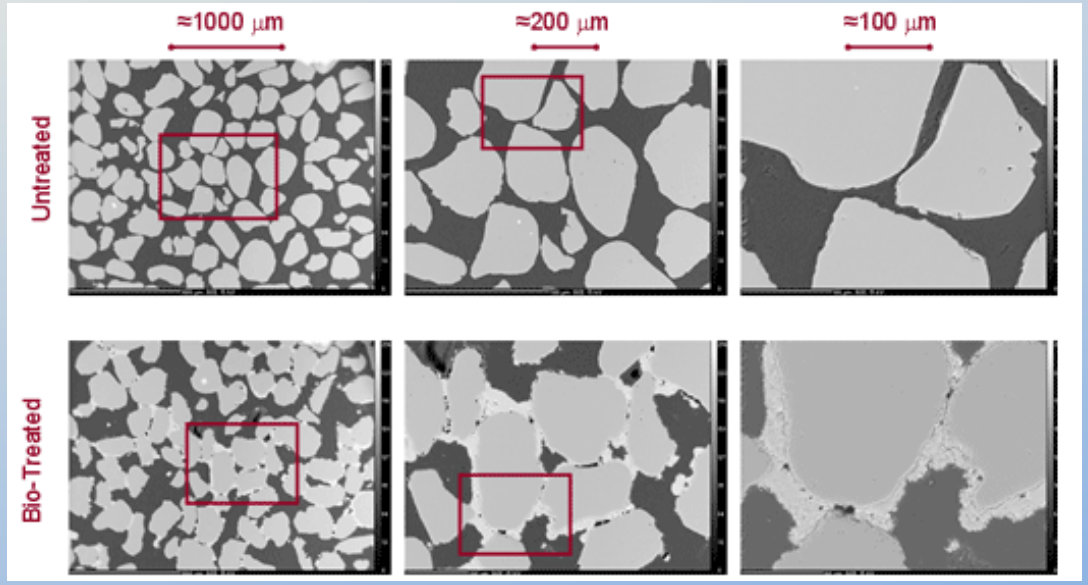


***S. Pasteurii* Photograph (Bang 2014)**



Result of precipitation and nucleation (Qabany et al. 2012)

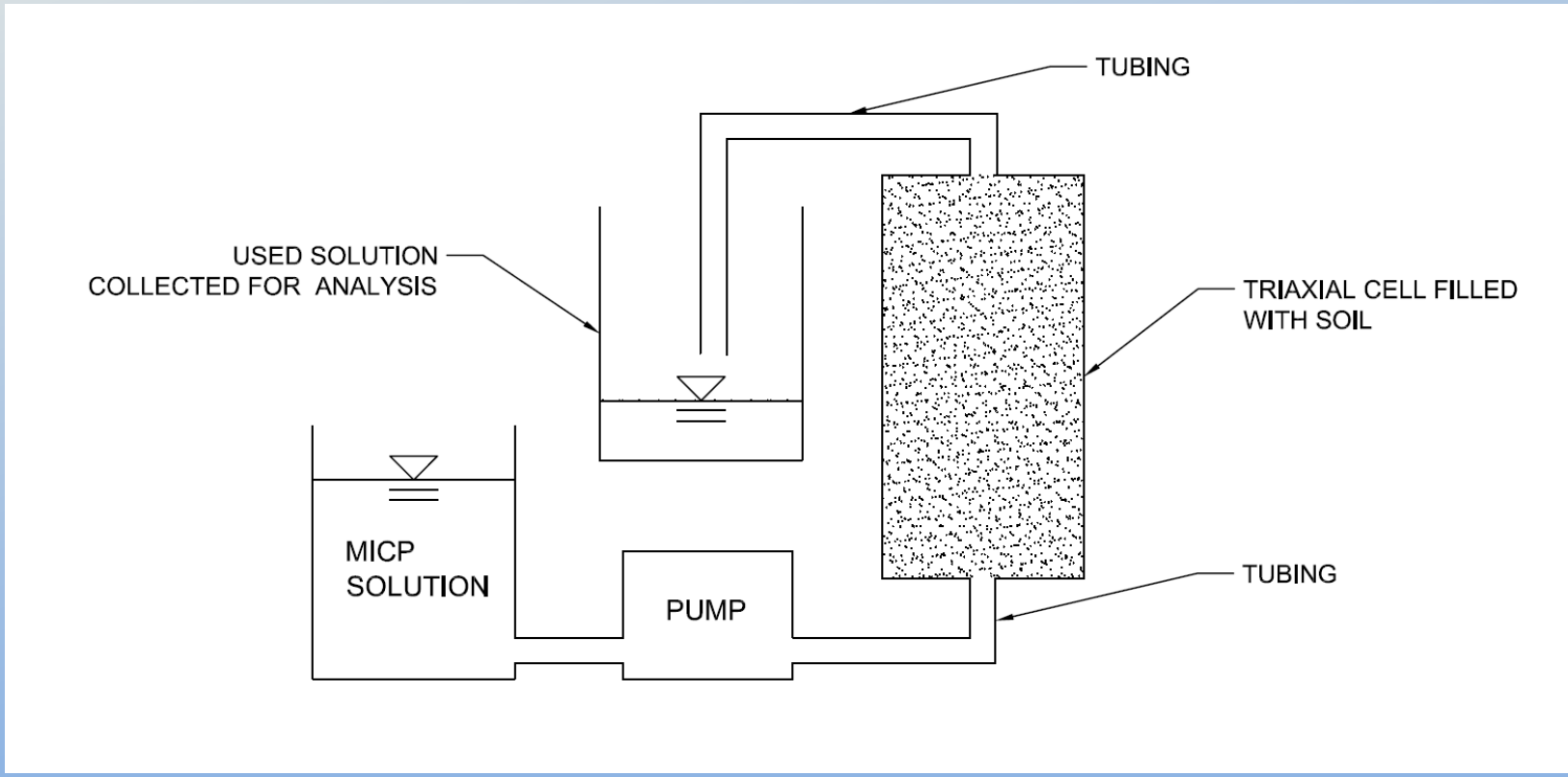
Task 1 – Literature Review



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

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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/

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Timeline

Task Description	Anticipated Timeframe (months)
Project Kickoff Meeting	1
Task 1 – Literature Review	3
Task 2 – Laboratory column experiment	1
Task 3 – Ureolytic microbe treatment/testing	7
Task 4 – Optimization	4
Task 5 – Native/non-ureolytic microbe treatment/testing	4
Task 6 – Draft Final Report	1
Task 7 – Final Report	3
Total Duration of Project	**24**

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QUESTIONS?