SUBSURFACE LASER DRILLING APPLICATIONS

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OUTLINE

- Unbelievable Power
- Unlimited Potential
- Early Laser Tests – Hard Rock
  - Summary of Lab Results
- Focus on Environmental Drilling
UNBELIEVABLE POWER
US ARMY MIRACL LASER

- “Satellite Killer”
- Up To 1.6 Megawatts
- We Accessed Only 0.9-1.2 Mw
- 3.4 Microns Wavelength
- 6 Inch Beam Diameter

8 inch hole, 4 seconds
UNBELIEVABLE POWER

Solid State Lasers
- Nd:YAG 15 kW
- Fiber Diode 5+ kW

Chemical Lasers
- Chemical Oxygen Iodine Laser (COIL) 7+ kW
- Mid-InfraRed Advanced Chemical Laser (MIRACL) >1,000 kW

Gas Lasers
- CO₂ 200+ kW
SUMMARY OF LAB RESULTS

- Laser Can Cut Through Any Rock Type, From Shale To Granite
- Energy Requirements Much Less For Cutting Than Melting Or Vaporizing
- Each Rock Type Has Own Parameter Requirements
- Infrared Laser Type Relatively Unimportant – Other Considerations Will Make Decision
TEST GOAL: ABSOLUTE SPECIFIC ENERGY

Better S.E. Approximation Due to New Experiment Design
EFFECT OF ONSET OF MELTING

Measured Average Power (kW)

- No melt Zone
- Melt Zone
- Linear (Melt Zone)
- Linear (No melt Zone)

Thermal spallation zone

Shale Data on Nd:YAG

Melting zone
2002 WAS BREAKTHROUGH FOR LIMESTONE

Limestone Requires Higher Absorbance For Most Efficient Cutting
LARGER HOLES THROUGH GROUPING
LARGER HOLES FROM GROUPING
POTENTIAL UNLIMITED

- Environmental Drilling
- Subsurface Tunneling
- Unexploded Ordinance Removal
- Structural Foundation Examinations
FOCUS ON ENVIRONMENTAL DRILLING

- Hazard Plumes
  - Characterize
  - Monitor
  - Remediate

- Previously Unattainable Control
  - Direction
  - Position
  - Sensing Capability
LASER DRILLING BENEFITS

- Positionable Through, Within or Around Plume
- Real-time Characterization While Drilling
- Stabilization of Hole, If Desired
- Transformation to Monitoring
- Progression to Remediation
PLACEMENT THROUGH, AROUND OR WITHIN PLUME

- Flexible, lightweight drill string
- Maneuverable through beam control
- Real-time sensors assist in steering
  - Detection of set levels of pollutants
  - Data flow much faster than sampling techniques
REAL-TIME CHARACTERIZATION WHILE DRILLING

- Measurements on Effluent
- Sensors on Downhole Assembly
STABILIZATION OF HOLE IF DESIRED

• Creation of Sheath While Drilling
  - “Welding” of grains
  - Result can be more tough ceramic than brittle glass

• Capability Can be Controlled from Surface
  - Point of melting depends on lithology
  - Power levels determine if material is spalled or melted
CERAMIC FROM SOIL
TRANSFORMATION TO MONITORING FUNCTION

• Drilling Assembly Can Be Left in Hole
  ■ Energy or Data Flow Reversed Using Same Fibers
  ■ Low Cost Flexible Bundle

• Stabilized Hole Can Be Re-entered With More Sophisticated Instrumentation
PROGRESSION TO REMEDIATION FUNCTION

- Tubing Previously Used to Circulate Drilling Gas or Fluid Can Be Used to Inject Remediation Fluids
- Continuous Sensing to Determine Effectiveness of Treatment
PROJECT NEEDS

- Additional Studies in the Laboratory
- Bench Prototype
- Field Prototype
ADDITIONAL STUDIES IN THE LABORATORY

- Soft Sediment and Soils Optimization
- Stabilizing Sheath Characterization and Optimization
- Design, Fabrication and Testing of Drilling Head Alternatives
BENCH PROTOTYPE

- Fabricate Downhole Assembly

- Test Series
  - Optimize laser parameters
  - Develop sensors for steering while drilling
FIELD PROTOTYPE

- Fabricate Downhole Assembly
- Test Series
  - Fine tune laser and jetting parameters
  - Refine sensors for directional steering while drilling
- Develop Environmental Sensors to Measure While Drilling
CONCLUSIONS

- Laser Drilling Has Been Shown to be Possible and Efficient

- Laser Drilling Has Several Important Benefits To Offer The Environmental Industry
  - Flexibility
  - Penetration
  - Instrumentation
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