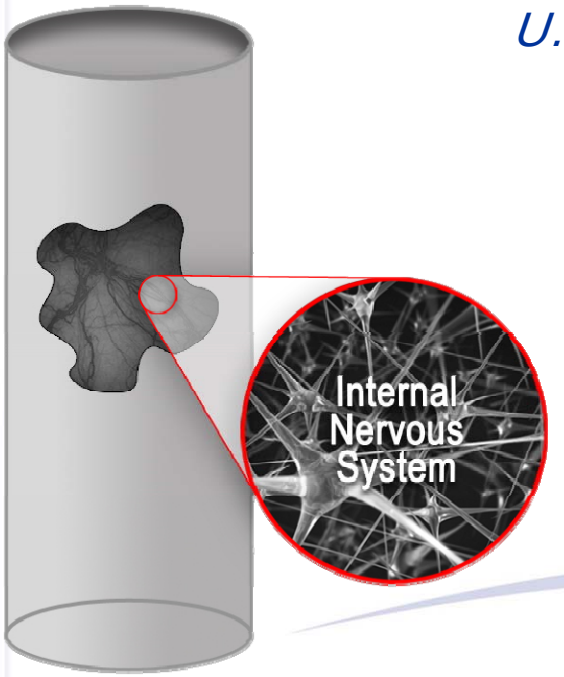
NANITE™ for Better Well-bore Integrity and Zonal Isolation

U.S DoE CONTRACT NO: DE-FE0014144



DoE NETL
Technologies Review Meeting
August 16–18, 2016
Pittsburgh, Pennsylvania

Vinod Veedu, PhD
Director of Strategic Initiatives
Email: Vinod@oceanit.com

oceanit

Acknowledgements

- NETL / DOE
  - Bill Fincham (Program Manager)
  - Roy Long (Offshore Technology Manager)
- JIP Partners and Industry Cementing Experts

Oceanit Overview

- Founded 1985 in Hawai'i
- 160+ Employees
- Multi-Disciplinary Staff (25% PhDs)
- Awards
  - *2014 Oceanit Spin-Out IBIS Networks wins East meets West*
  - *2013 Pacific Edge Commitment to Green Employer of the Year*
  - *2012 ASCE Outstanding Civil Engineering Achievement Award – Best Study & Research Project*
  - *2011 U.S. Army Corps of Engineers – Project Excellence Award*
  - *2010 Army SBIR Quality Award for FLASH*
  - *2009 Pacific Business News Finalist – Most Innovative Company*
  - *2008 NASA's Nano 50 Award for Nanoconcrete*
  - *2007 Pacific Business News' "Best in Business" large business*
  - *2006 National Tibbetts Award*
  - *2006 Best Places to Work in Hawaii*
  - *2005 AFRL's Technology Transfer Team of the Year Award for HANDS*
  - *2005 Top 10 Best Places to Work in Hawaii*
  - *2004, 2005 Surfrider Foundation's "Environmental Company of the Year"*
  - *2003 Pacific Business News' "Best in Business" Small Business*
  - *1997 US Chamber of Commerce Blue Chip Enterprise Award*

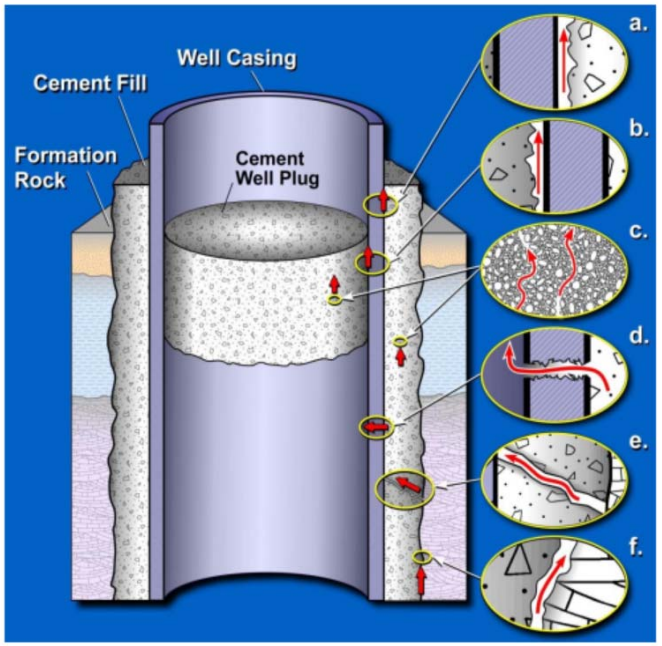
oceanit

Program Overview

- 2 Major International Oil Companies
- 1 National Oil Company
- 1 Independent Oil Company

Benefit to the Program

- Annulus formation in the casing string can lead to reduced well efficiency, aquifer contamination, or well failure.
- Poor cementing can lead to well integrity and performance failures (Deepwater Horizon disaster in the Gulf of Mexico).
- Fracking should not begin until the wellbore has been properly cased and cemented.
- Pressure exerted during the fracking process can cause the cement to crack.
- Conventional techniques used to inspect the integrity of cementing behind multiple casing strings have proven to be inaccurate, insufficient, and unreliable.
- Continuously monitoring the integrity of cement plugs throughout their lifetime using conventional approaches is not a viable option.



Impact: Improve the economics of drilling by helping to increase blowout prevention and resolve environmental concerns.

oceanit

Primary Project Goal

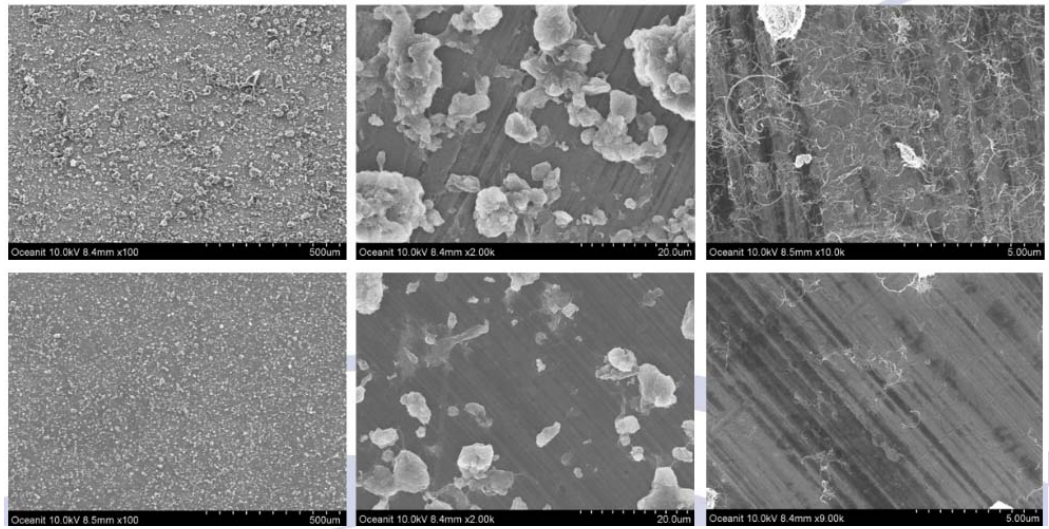
- Demonstrate how real-time sensing of Nanite can improve long-term wellbore integrity and zonal isolation in shale gas and applicable oil and gas operations.
- Transform conventional cement into a smart material responsive to pressure (or stress), temperature, and any intrinsic changes in composition.
- Demonstrate Nanite's electrical and acoustic responses; improved chemical and physical properties; and durability.

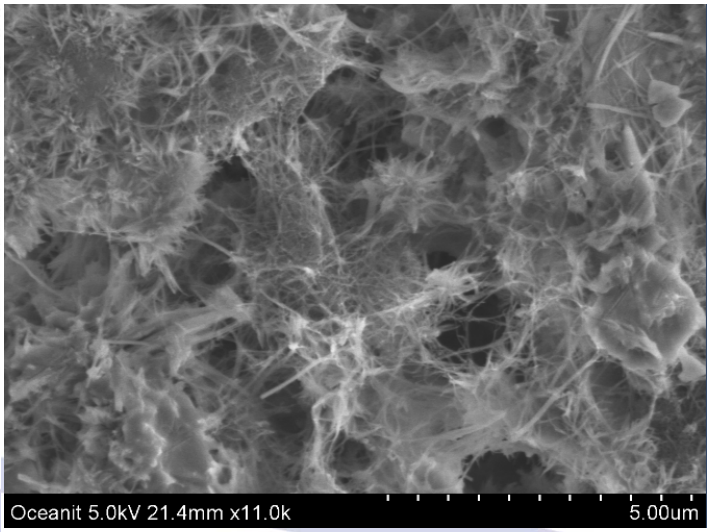
Smart Materials + Detection Methods + Data Analysis =

Large amount of new information regarding cement location and condition

- Investigate 2-3 interrogation mechanisms/modes.

Material Design, Formulation, and Optimization

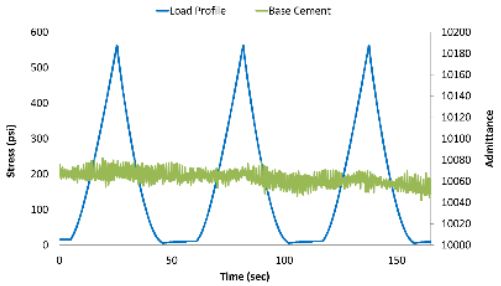




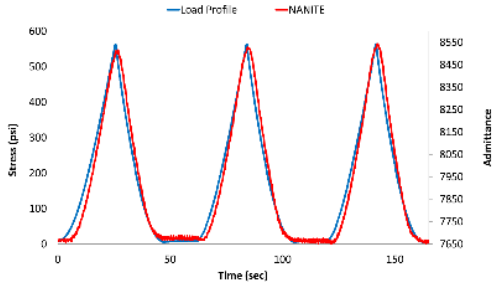
Nanite Load Sensitivity

Mechanical load monitoring

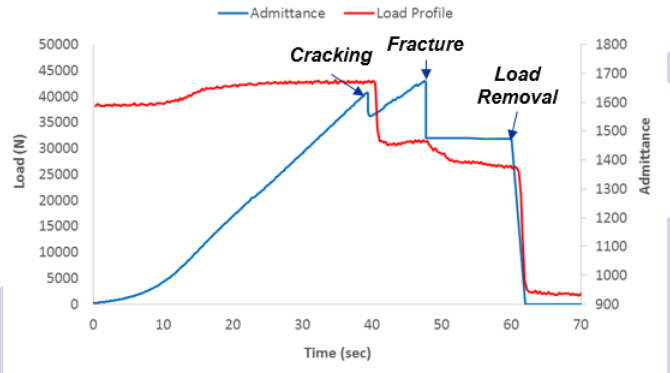
Base cement response to load



Nanite response to load



Cracking and failure detection

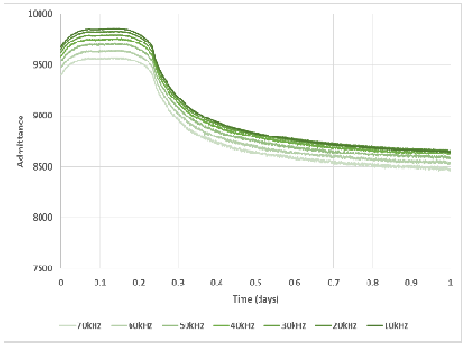


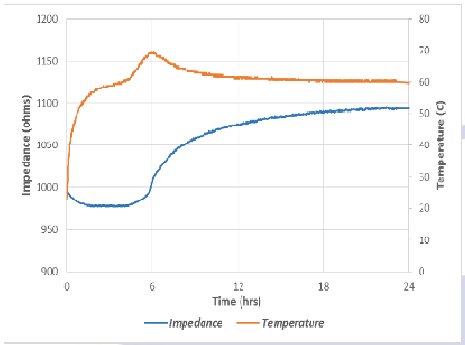
oceanit

Baseline Monitoring and Calibration of Curing Process

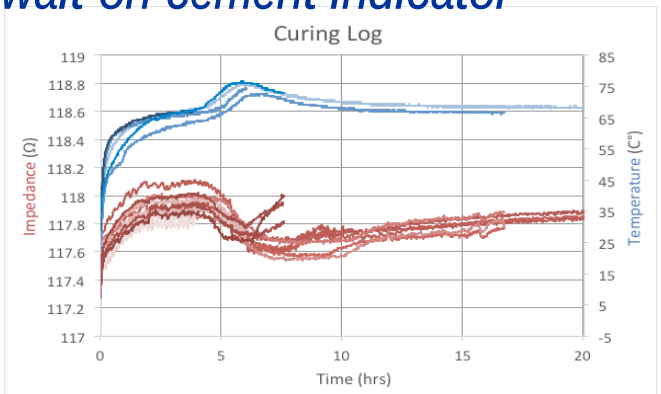
Monitoring Early Stage Curing

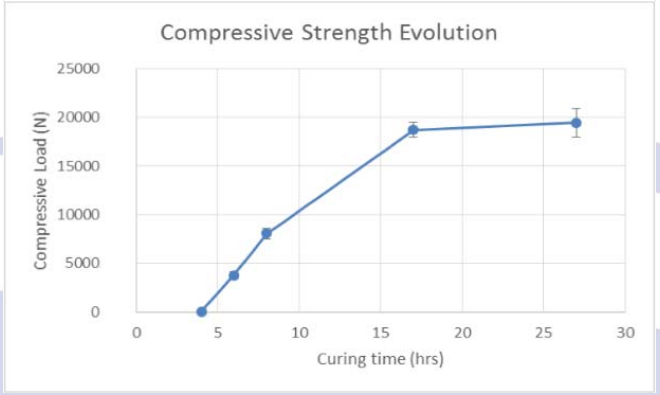
- *Nanite can be used as a wait-on-cement indicator*

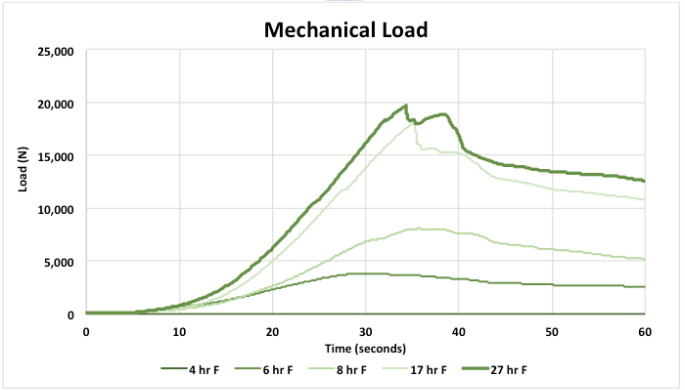


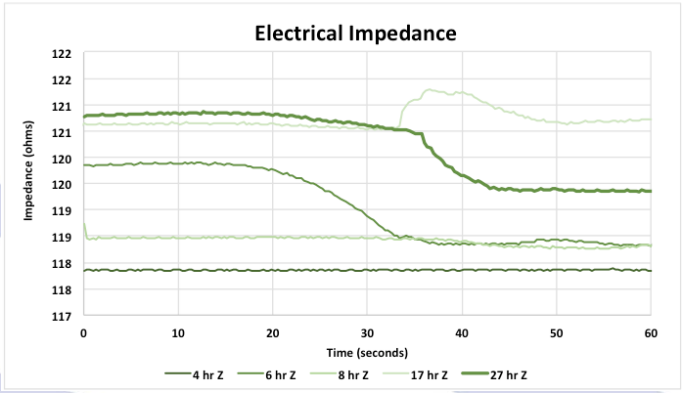


Monitor Nanite curing









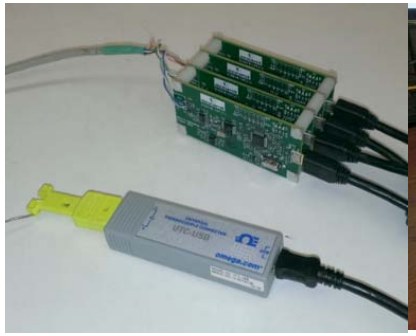
Compressive strength evolution

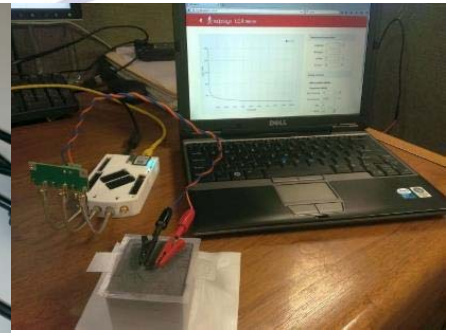
Electrical Resistivity Tool

Hardware Design Goals:

- High resolution / Low noise
- High sample rate
- Compact, low power, portable
- Inexpensive

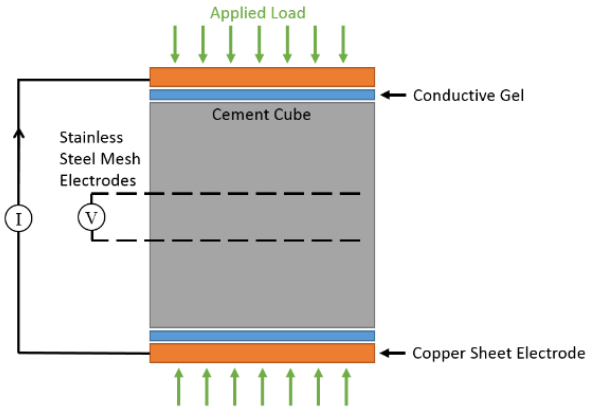
Electrical impedance analyzer board development





Optimization of Electrodes:

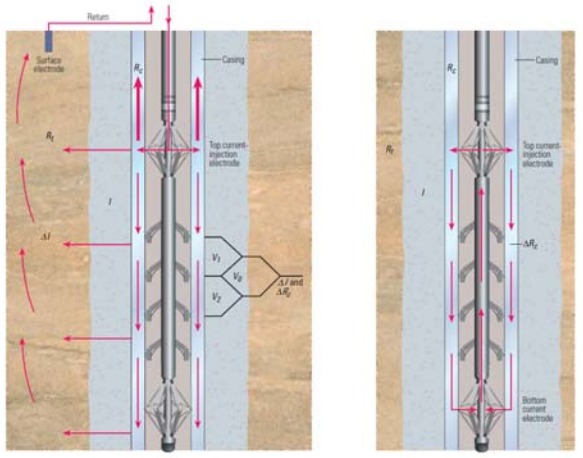
- Geometry
- Materials
- Fabrication
- Casting



oceanit

Subscale Proof Testing

- Development of multipurpose hydraulic pipe expansion test fixture
- Nanite for use with acoustic cement bond log tools
- Formation and cement salinity measurement
- Through-casing resistivity logging tools
- Plug-and-abandonment



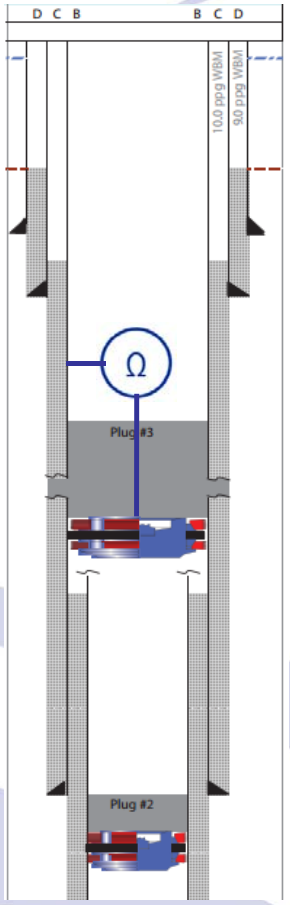


Image adapted from:

Campbell, K., & Smith, R. (2013, October). Permanent Well Abandonment. Society of Petroleum Engineers.

Image, credit *Oilfield Review* Spring 2001, pg5

oceanit

NANITE™ Smart Cement

Videos found at

http://www.oceanit.com/products/nanite

Key Accomplishments

- Developed and optimized a nanomaterial admixture to imbue well cement with sensing characteristics and enhanced mechanical properties.
- Assessed the properties of Nanite cements according to API specifications.
- Characterization of Nanite's electrical properties and the development of a specialized resistivity measurement tool.
- Established processes for reliable and repeatable detection of compressive loads applied to Nanite samples, detection of fractures, and curing state.
- Evaluated Nanite's suitability for acoustic interrogation modes.
- Currently performing subscale testing focusing on rapid technology field trial potential.