Who Loves Clean Water?

Compact Laser Induced Breakdown Spectroscopy (LIBS)

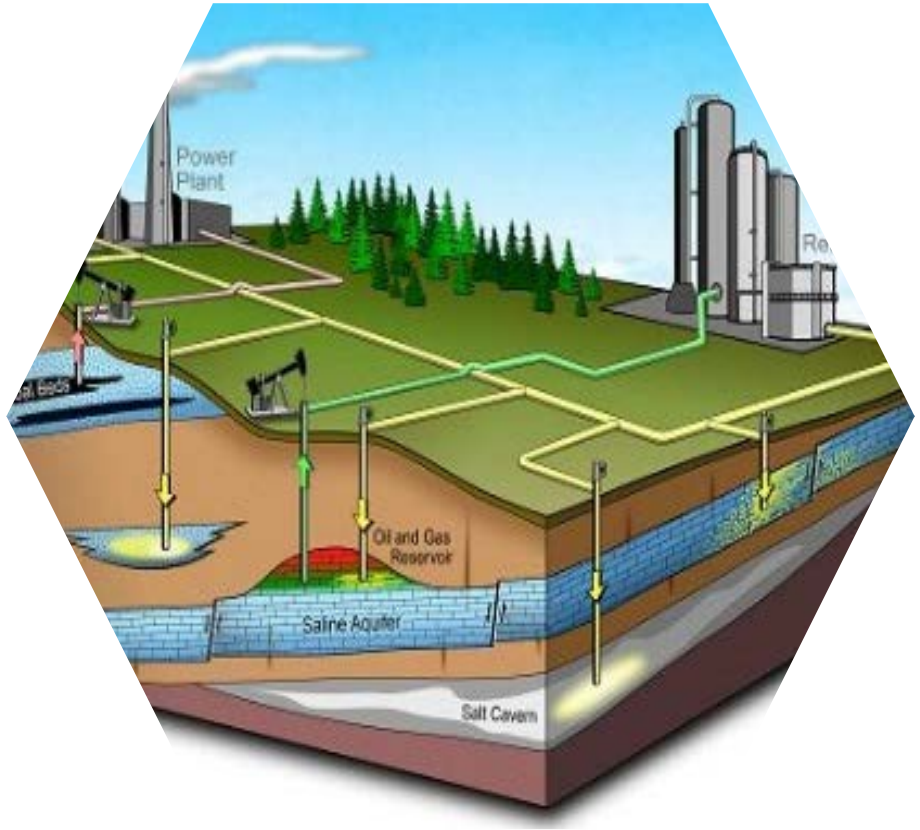
Dustin L. McIntyre, PhD, PE

Geophysics Team

10-26-2016

Problem/Opportunity

- **Everyone Loves Clean Water**
- **Displacement of fluids during fluid injection**
  - Potential fluid migration and contamination
    - Potable/Domestic Water
    - Industrial/Agricultural
  - Current measurement methods are laborious and time consuming
  - Potential to have an online high resolution in-situ elemental concentration measurement



Technology Proposition

- **What is it?**
  - A way to measure subsurface gases, liquids, and solids at subsurface conditions
- **Why is this a game-changing technology/process?**
  - No sample collection and No sample preparation
  - Continuous monitoring of an extreme environment
  - See changes in down hole fluid chemistry prior and post injection/fracturing
- **What situation ("pain") will you solve/exploit?**
  - Current sampling and analysis is labor intensive and significantly changes the sample by cooling and depressurizing
- **Why does the situation exist?**
  - Current analysis technology is not amenable for harsh environments

Competing Technologies

- **Gas Chromatography-Mass Spectrometry**
  - Gas phase only, Lab operations and conditions only
- **Inductively Coupled Plasma-Mass Spectrometry**
  - High degree of sample prep, Lab operations and conditions only
- **High Pressure Liquid Chromatography**
  - Liquid phase only, Lab operations and conditions only
- **Cavity Ring Down Spectroscopy**
  - Gas phase only, few ruggedized models available
- **Portable Raman**
  - Solids only, few ruggedized models available

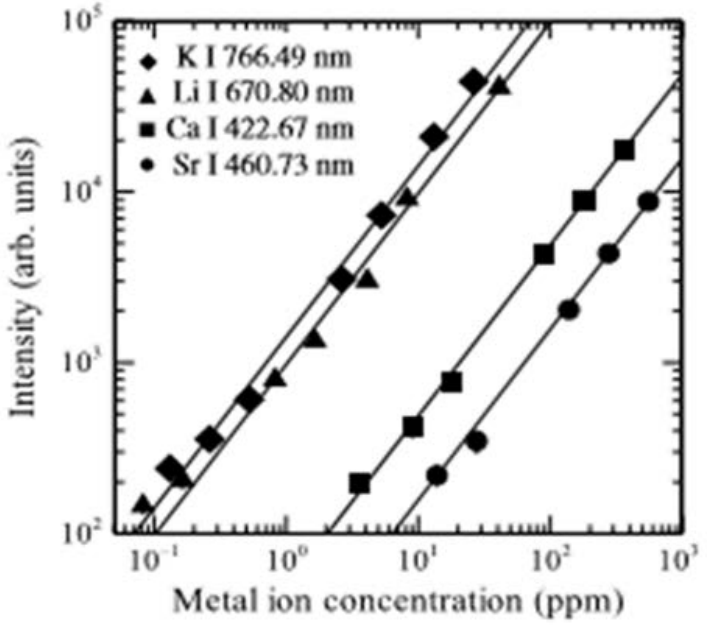
Commercialization Plan

- **Customers would include:** Regulatory Agencies, Exploration Companies, Municipalities, Land Owners
- **Adoption drivers**
  - Regulatory drivers/Mandatory monitoring prior and post activity
  - Ease of use, low cost, high data quality
- **Key tests and trials**
  - Completing proof of concept experimentation
  - Device/System design and development underway
- **Estimated price of product**
  - Will depend on number of sensor units
  - 8 sensor unit system < $100k
- **Intellectual property status**
  - LIBS system Patents Granted in July 2014 and March 2016
- **Licensing/CRADA**
  - Currently looking for commercialization partners

Experimental Work

STEP 1

- Ability to make measurement across relevant concentration ranges
- Determine linearity

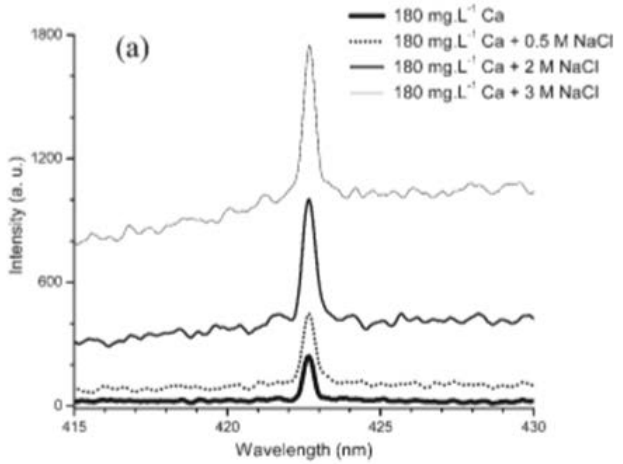


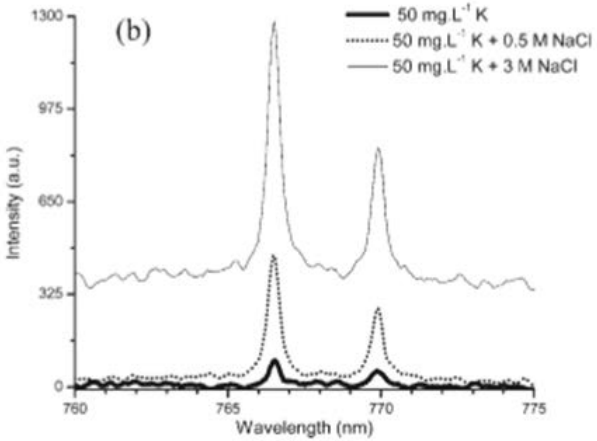
	R^2	LOD	LOQ
Sr	0.9990	2.89 ± 0.11 ppm	9.63 ± 0.39 ppm
Ca	0.9997	0.94 ± 0.14 ppm	3.11 ± 0.07 ppm
Li	0.9988	60 ± 2 ppb	0.19 ± 0.01 ppm
K	0.9977	30 ± 1 ppb	80 ± 4 ppb

[a]The coefficient of correlation (R^2) is indicated.

STEP 2

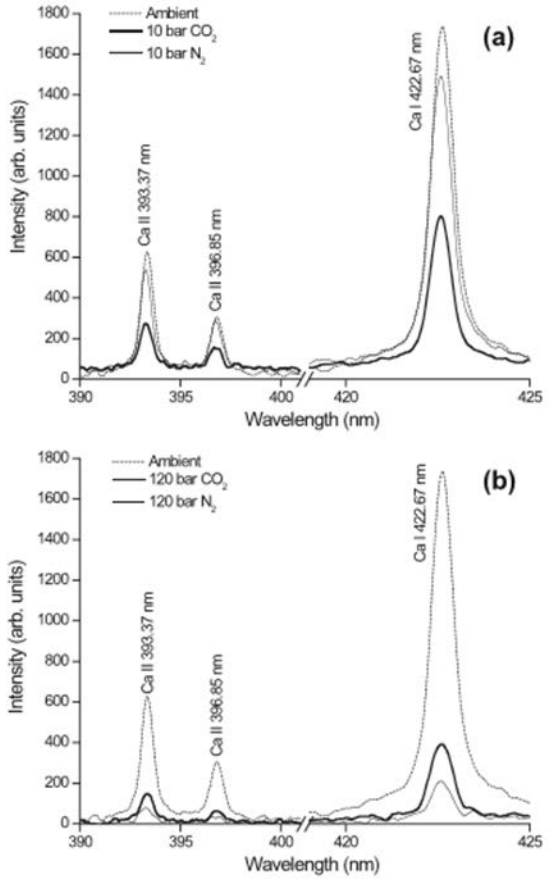
- Study interference from other high concentration species





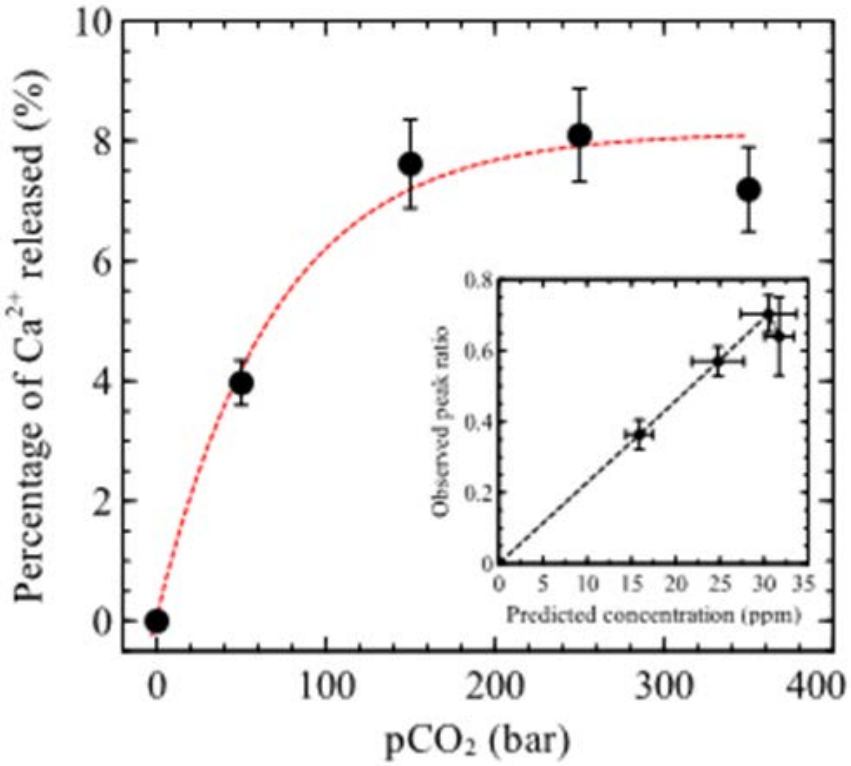
STEP 3

- Determine effects of pressure on measurement



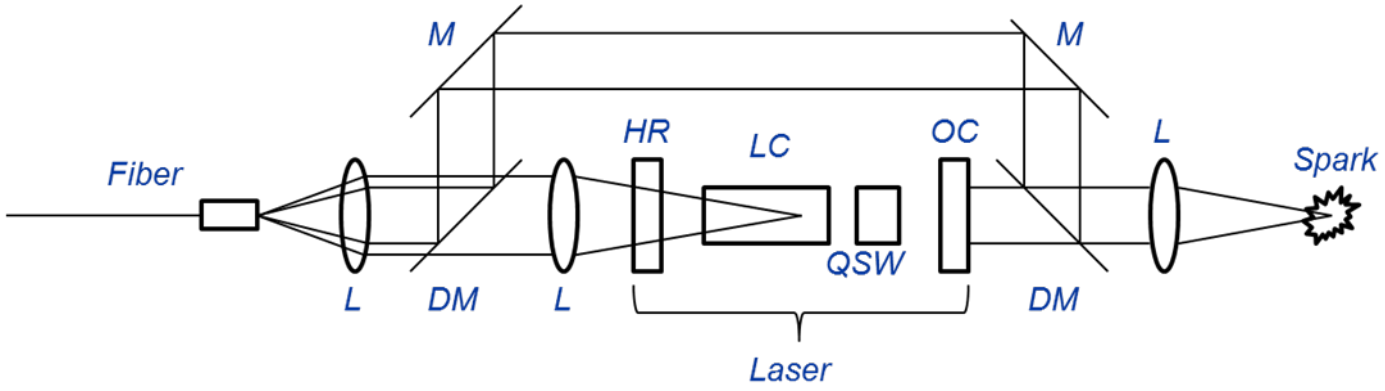
STEP 4

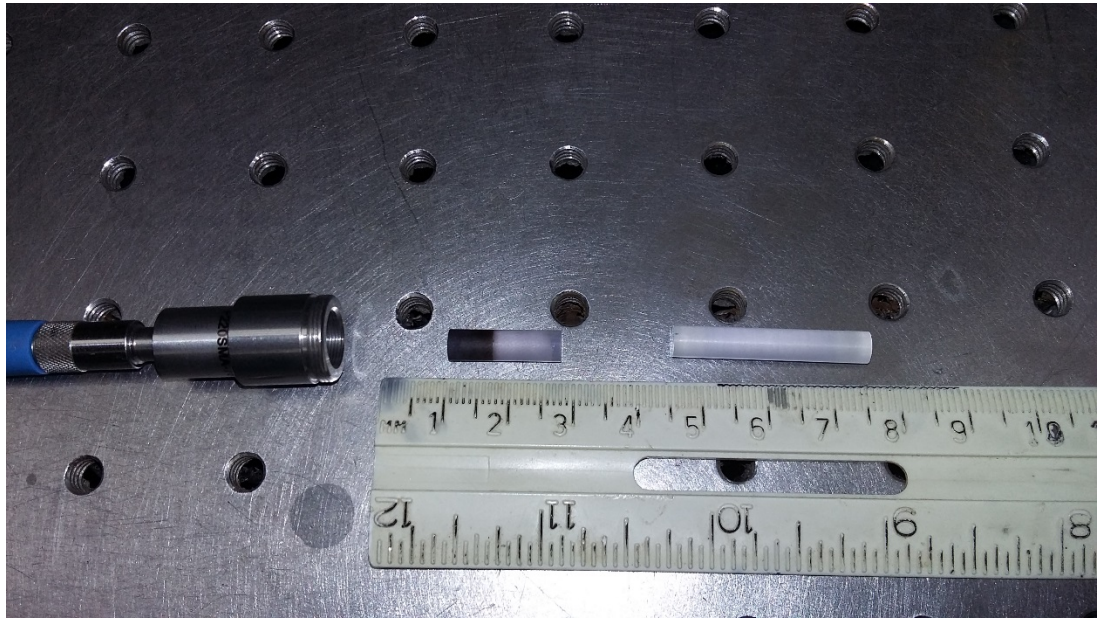
- Measure dissolution of synthetic rock at elevated Temp as a function of Pressure



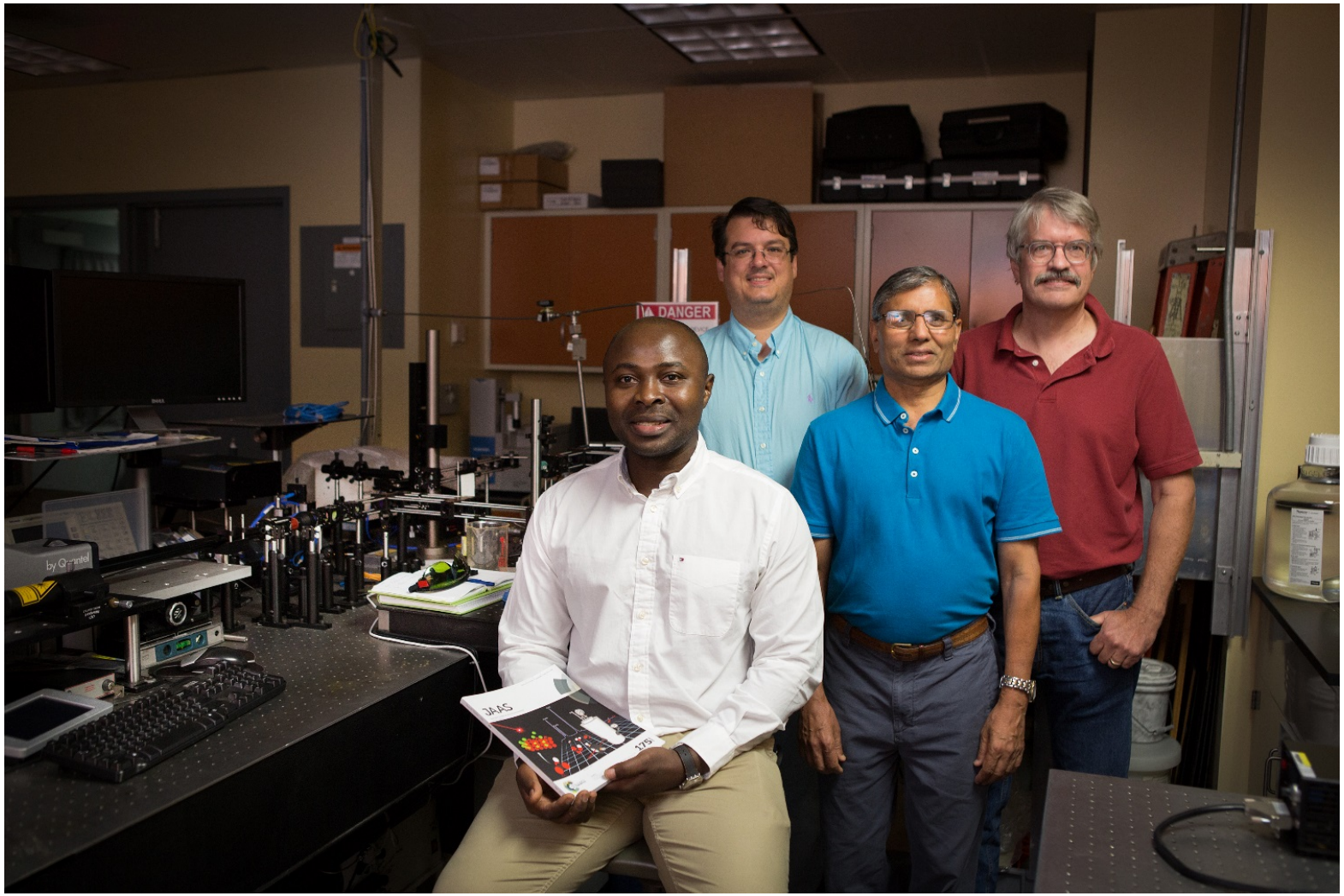
Prototype Development

- **Current Status**
  - Cover – Royal Society of Chemistry – JAAS
  - 2 Patents, 2 Patent Applications
  - Proof of concept demonstrated and published
  - Initial prototype operated in the lab Spring 2016
  - More complete prototype under development





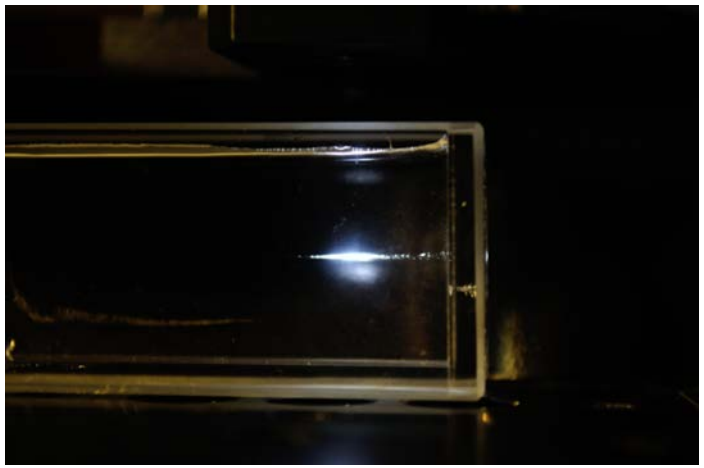
Research Team



- Dustin McIntyre, PhD, PE
- Christian Goueguel, PhD
- Jinesh Jain, PhD
- Hank Edenborn, PhD

- 15 Papers
- 2 Book Chapters
- 2 Patents

Summary



- **Thank You**
- **Recap:**
  - LIBS sensor system for down hole environmental sensing
  - Regulatory, Exploration, Municipal, Land Owner
  - Two patents granted since Jan 2014
  - Proof of concept complete, prototype system design phase
  - Looking for commercialization partners for licensing and/or CRADA