CONTROLLED-POROSITY CERAMIC MATERIAL FOR HIGH TEMPERATURE DOWNHOLE APPLICATIONS

Formed-in-place ceramic plugs and screens for geothermal wells

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The problem

Severe thermal, pressure, and corrosive conditions challenge conventional fluid control and sealing materials, particularly in geothermal exploration and production applications. Steel casing and screen materials suffer degradation from exposure to corrosive conditions, microbial activity and high dissolved solids in wellbore fluids. High temperature and pressure operating environments particularly challenge the development of advanced geothermal power systems.

A ceramic solution

Olympic Research is developing a ceramic borehole sealing system for challenging applications in nuclear waste, CO_2 injection, geothermal, and oil and gas, where very low permeability and porosity are necessary. This methodology can be extended to applications where increased porosity and permeability are desired, as in geothermal well screening applications.

Application conditions (extremes)

- Depths – 1.5 to 5 km
- Diameters – 9-5/8” to 13-3/8”
- Thermal – 80 to 400° C
- Pressure – 15 to 50 Mpa (___ psi)
- Fluid state – steam, liquid water
- Chemical – corrosive, H_2S, CO_2, dissolved solids

Performance and property targets (planned)

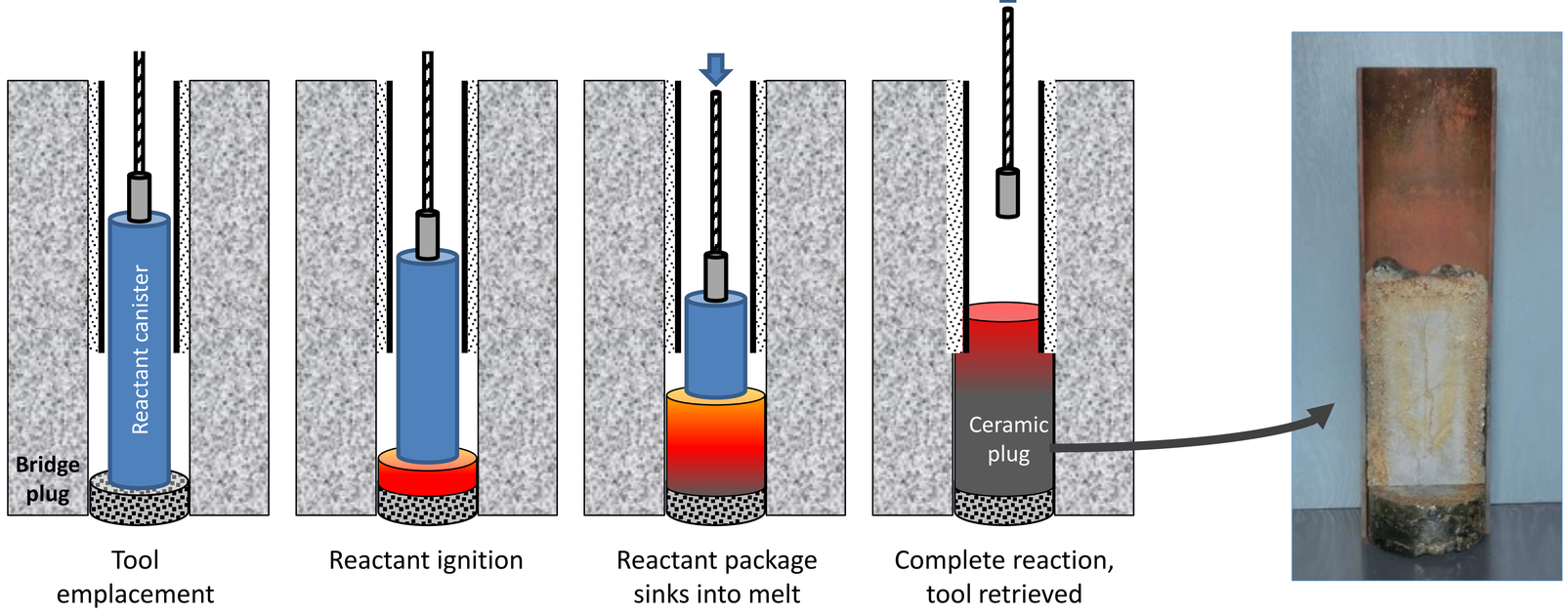
- Fast emplacement via wireline or slickline
- Forms in minutes, achieves design strength in hours
- Drillable
- High inherent corrosion resistance of ceramics
- Very high service temperature (>1000°C)
- Very high compressive strength
- Target permeability: low to >100 Darcy

Forming ceramic features in-situ using the SHS process

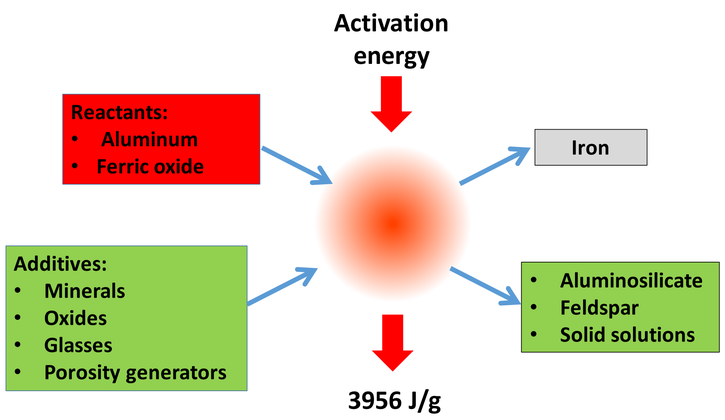
Self-propagating **H**igh-temperature **S**ynthesis

SHS uses the thermal energy of solid phase metal/oxide (thermite) reactions, supplemented by mixtures of minerals and oxides, to form monolithic ceramic components in place. These reactions are moderated and controlled, self-oxidized, and run to completion under downhole water pressure. The method has been developed for low permeability sealing applications, and is being extended to applications benefitting from intentionally-generated porosity in the ceramic material:

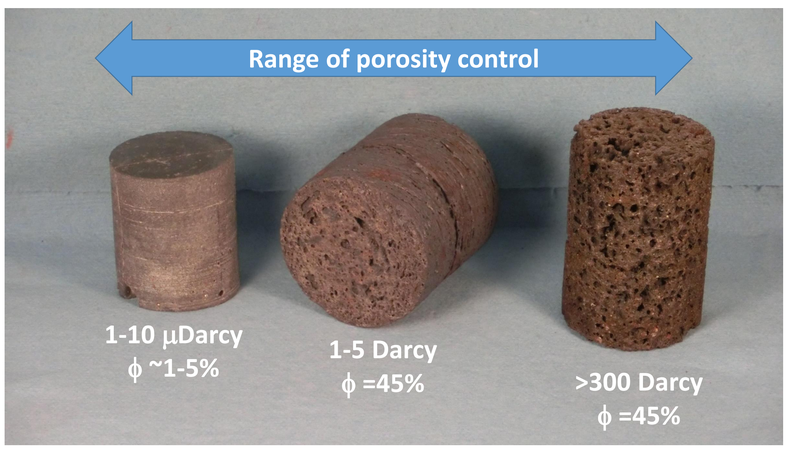
- Screen or sand control
- Lost circulation control
- Borehole stabilization
- Bridge plugs



Engineering the reaction process to control porosity



The SHS reaction is optimized to form products with specific properties. Plug and sealing applications require very low porosity, low permeability products. Screens and borehole stabilization applications require high porosity matrices. Product forms are largely aluminosilicate with other oxides and minerals. Reactants are designed to achieve specific reaction rates, peak temperatures, and product rheology.



Phase I SBIR project (complete Dec 2017)

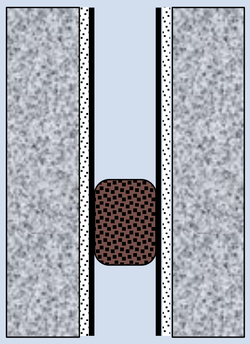
- Characterize required operating conditions
- Identify range of flow characteristics desired
- Evaluate range of porosity/permeability possible with SHS formulations, under anticipated pressure and saturation conditions
- Conceptual design of emplacement and formation process
- Evaluate applications and market potential

Proposed follow-on (Phase II proposal, 2018)

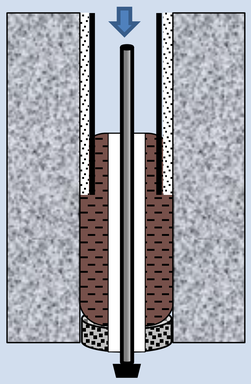
- Refine reaction systems for applications
  - High porosity/low porosity
  - High permeability/low permeability
  - Degrees of expansion
- Integrate with ORI plug emplacement system (controls, mechanical hardware, wireline interfaces)
- Field tests in various geothermal settings/wells

Applications

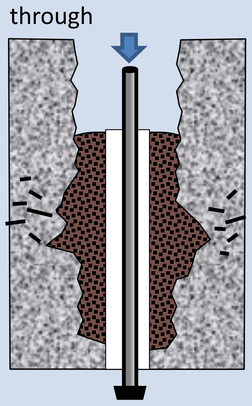
Plug: Form low porosity plug as sealing or bridge plug, cased or uncased



Screen: form high porosity ‘plug’, then drill through



Lost circulation control: Form low porosity ‘plug’, then drill through



Research team

- Olympic Research (project management, lab testing, system engineering): Bill Lowry (PI), Alex Lockwood, Ken Coates, Ken Wohletz, Sandra Dunn
- South Dakota School of Mines & Technology (Lori Groven, energetics, materials analysis)
- DOSECC Exploration Services (Dennis Nielson, geothermal technologies, slimhole applications)

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