Monthly Research Performance Progress Report
Protected Data

Federal Agency and Organization: DOE EERE – Geothermal Technologies Program

Recipient Organization: Trabits Group, LLC
DUNS Number: 829739395

Recipient Address: PO Box 870404
Wasilla, AK 99687-0404

Award Number: DE-EE0002785
Project Title: Development Of An Improved Cement For Geothermal Wells
Project Period: 1/29/2010 through 9/30/2013

Principal Investigator: George Trabits
Trabits Group, LLC

Report Submitted by: Dr. Santanu Khataniar
University of Alaska Fairbanks

Reporting Period: January 2011

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This material is based upon work supported by the Department of Energy under Award Number DE-EE0002785

UAF work summary

The XRD and XRF tests on two zeolite samples, TG008 (Ferrierite) and TG014 (Analcime) gave some unexpected results. Analysis of TG014 (Analcime) showed that it did not contain any Analcime, and contained only 11% Zeolite (Celadonite). The rest of it was mostly Feldspar. Hence it was decided that another set of XRD and XRF tests need to be conducted on the sample TG015 (Calicined Analcime) to find out whether there is any Analcime present in TG015. The XRD and XRF tests on TG015 are currently in progress.

In the meantime, testing procedures and the equipment for the initial screening tests are being developed in accordance with the API Recommended Practices 10B as well as input from ThermaSource Cementing, Inc. Graduated cylinders sized according to the API Recommended Practices 10B for the Free Water Test are being procured.

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Principal Investigator: George Trabits
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Report Submitted by: Dr. Santanu Khataniar
University of Alaska Fairbanks

Reporting Period: February 2011

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Narrative for Feb. 2011

The XRD and XRF tests for sample TG015 (Calcined Analcime) have been conducted. The data are being analyzed to get a detailed and accurate measurement of the composition of the sample. Zeolites and Class H and Class G cements have reached UAF. About 20 grams of cement sample was removed from each of Class H and G cements and sent to CCE Technologies in order to conduct PSD analysis on them. Experimental protocols for the initial screening tests are being refined according to the API Recommended Practices 10B for oil well cements. Laboratory equipment and supply needs for initial tests at UAF were finalized and the items were ordered.

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Principal Investigator: George Trabits
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Report Submitted by: Dr. Santanu Khataniar
University of Alaska Fairbanks

Reporting Period: March 2011

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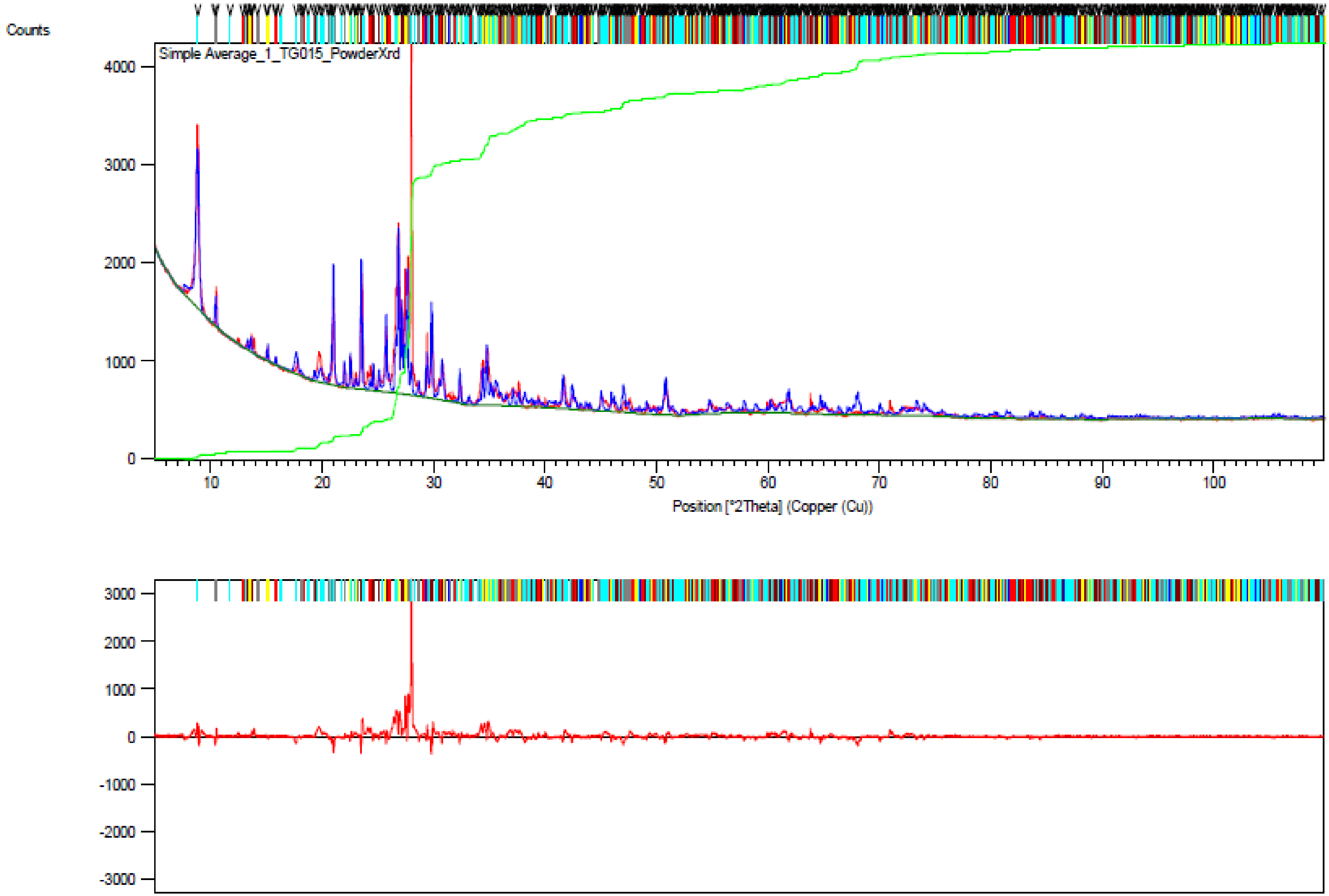
Project: Development of novel geothermal well cement using zeolite

Progress:

XRD and XRF tests and data analysis were completed on the Calcined Analcime sample (TG015). This sample was very complicated to analyze due to the presence of multiple minerals. The minerals were identified using a trial and error procedure.

Figure 1 shows the plots for the analysis. The red line on the upper plot is the reference data and the blue line is the match to that data. The lower plot is the difference plot between the reference data and the match

According to the analysis, TG015 contains Analcime (1%), Feldspar (61%), Quartz (4%), Calcite (3%), Montmorillonite (12%), Kyanite (12%), Cordierite (6%). The remaining 1% was labeled as undeterminable as it would have required unreasonable analyzing effort. All the percentages mentioned are based on weight. The results are consistent with the result for TG014 (Analcime), which had no Analcime present. Based on this analysis it is concluded that Analcime present in TG015 is a mere impurity in a sample containing mostly Feldspar.



Counts
Simple Average_1_TG015_PowderXrd
4000
3000
2000
1000
0
10
20
30
40
50
60
70
80
90
100
Position [°2Theta] (Copper (Cu))
3000
2000
1000
0
-1000
-2000
-3000

Figure 1: Results for the XRD analysis of TG015 (Calcined Analcime)

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Report Submitted by: Dr. Santanu Khataniar
University of Alaska Fairbanks

Reporting Period: April 2011

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UAF report for April

Experimental protocols have been developed for drying of zeolite samples, blending with cement, and performing free water tests. Cement slurries will be prepared and free water tests will be performed per API specifications for testing of oil well cements. The experimental protocols are summarized in the following section. Because of loss of partnership with ThermaSource Cementing Inc., UAF is preparing to take over the laboratory testing previously assigned to TCI. In this regard, we are in the process of identifying the additional equipment and additional personnel time needed. The UAF budget will be revised accordingly.

EXPERIMENTAL PROTOCOLS

Drying of zeolites:

The amount of moisture in the zeolite during testing should not exceed 5%. Zeolite samples will be baked in an oven to achieve required dryness.

1) Preheat the oven to 300˚F.
2) Spread the zeolite on an open tray in a layer not more than 5mm thick.
3) Place the tray into the preheated oven.
4) Let the zeolite stay in the oven for 30 minutes.
5) Turn off the oven and let the zeolite cool in the oven for 30 minutes to prevent moisture from entering the zeolites.
6) Remove the zeolites and mix it with dry cement according to proportion required for preparation of the cement slurry.

Preparation of Cement – Zeolite Slurry:

1) Prepare the dry cement-zeolite mixture according to the mixing proportion as weight percent of the cement.
2) Weigh the cement-zeolite dry mixture according to API Spec 10A Clause 7
3) Blend the dry mixture thoroughly.
4) Weigh distilled water according to API Spec 10A Clause 7 and add it to the mixer jar.
5) The cement and water should be weighed in dry containers.
6) The temperature of water and dry cement-zeolite mixture and water should be 73˚F ± 2˚F

7) Measure and record the temperature and weight of both, water and dry cement zeolite mixture.

8) Start the mixer at a low speed and let it stabilize.

9) Add the dry cement-zeolite mixture at a uniform rate into the rotating mixer in no more than 15 seconds.

10) Close the lid of the mixer and turn it at high speed for 35s ± 1s.

Free Water Test:

1) Free water test will be conducted according to API RP 10B, Clause 15.5

2) Clean and dry the graduated cylinder and the funnel to prevent contamination.

3) Pour the prepared slurry into the graduated cylinder up to the 250ml mark with the help of the funnel.

4) Cover it with plastic wrap to prevent any evaporation.

5) Keep it static for 2 hours.

6) Measure the amount of free water present on top of the slurry.

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University of Alaska Fairbanks

Reporting Period: June 2011

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Project: Development of novel geothermal well cement using zeolite

Progress:

Reproducibility of results is very important for conducting experiments using a certain set of procedure. Reproducibility tests were carried out for free water test as that it is the very first criteria for screening.

API Spec Cement Blender from Chandler Engineering and a regular table top blender were used to compare the repeatability of results. The major differences between both the blenders were:

1. Speed for the API Spec blender were fixed and controlled within ±500 rpm using a microcontroller. There is no specified speed for the regular blender. The speed does not remain constant under load and will vary considerably at both high and low speeds.

2. The API spec blender stops automatically upon completion of 50 seconds, whereas the regular blender has to be operated manually.

The cement used was Portland cement along with tap water. The water cement ratio used was according to API Spec 10A for Class C cements. Class C cement has the highest water: cement ratio and hence a more noticeable difference would be observed for the same. During the tests, API Spec 10A and API RP10B were followed as much as possible.

API Blender				**Regular Blender**			
Test	**Free Water (ml)**	**Total Volume (ml)**	**Free Water (%)**	**Test**	**Free Water (ml)**	**Total Volume (ml)**	**Free Water (%)**
1	4.2	250	1.68	1	5	240	2.08
2	4.1	250	1.64	2	4	240	1.67
3	4.2	250	1.68	3	3.6	240	1.50
4	4.1	240	1.71	4	3.8	240	1.58
5	4	240	1.67	5	3.7	240	1.54
6	3.5	240	1.46	6	3	240	1.25

Table 1: Free Water tests results for regular Portland cement using Regular Blender and API Spec Blender

From the results, it is clear that the reproducibility through the API Spec blender from Chandler Engineering is better than regular table top blender. The standard deviation for API Spec blender is 0.08% whereas for the regular blender it is 0.25%, which is more than 3 times higher. The following plot shows the results.

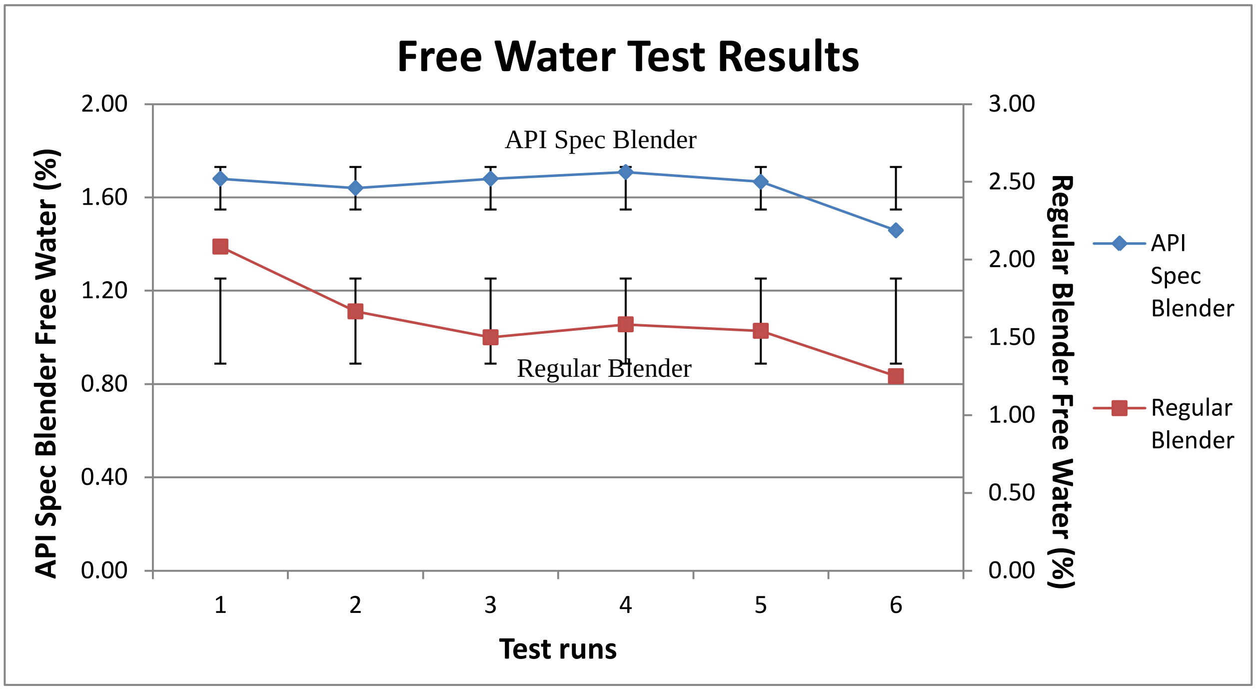

Figure 1: Free water test results. The top plot is for the API Spec Chandler Engineering Blender and the bottom plot is for the Regular Blender. Note that the Regular Blender standard deviation error bars are almost 3 times that of error bars for the API Spec Blender.

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Principal Investigator: George Trabits
Trabits Group, LLC

Report Submitted by: Dr. Santanu Khataniar
University of Alaska Fairbanks

Reporting Period: May 2011

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Project: Development of novel geothermal well cement using zeolite

Progress:

American Petroleum Institute (API) Specification 10 compliant cement blender/ mixer was tested by conducting free water test on regular Portland cement. The results were compared with those from mixing the same cement in a regular non-API spec mixer. The water cement ratios used in both the tests are kept the same for a valid comparison.
The mixing time in the non API spec blender was also kept at 50 seconds in accordance with the API Spec 10.

Cement slurry was prepared with water to cement ratio as mentioned in API Specifications. The blended mixture was poured in a 250 ml graduated cylinder and covered in order to avoid any water loss due to evaporation. After 2 hours, amount of free water on the top of the cylinder was measured. The results are tabulated below.

Free Water Test Results	**Regular Blender**		**API Spec Blender**	
	I (ml)	II (ml)	I (ml)	II (ml)
	1.2	1.4	2.8	2

Table 1: Free Water tests results for regular Portland cement using Regular Blender and API Spec Blender

Thus, mixing of cement in API specified blender is absolutely essential for this project.

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Project: Development of novel geothermal well cement using zeolite

Progress:

Free Water test was conducted on API Class G and Class H cements from Texas Lehigh Cements. Test was carried out using the API Spec Blender from Chandler Engineering. Cement slurry was prepared according to API Spec 10 and poured into the graduated cylinders. The results are tabulated below. The results show a good repeatability with four out of the five readings within the standard deviation as shown in the figure below.

Test	API Class G			API Class H		
	Free Water (ml)	Slurry Volume (ml)	Free Water (%)	Free Water (ml)	Slurry Volume (ml)	Free Water (%)
1	5	250	2	1.4	240	0.58
2	4.8	250	1.92	1.2	230	0.52
3	4.8	250	1.92	1.2	240	0.50
4	4.2	250	1.68	1.3	230	0.57
5	4.4	250	1.76	1.2	230	0.52

Table 1: Free Water Test Results for API Class G and Class H cements

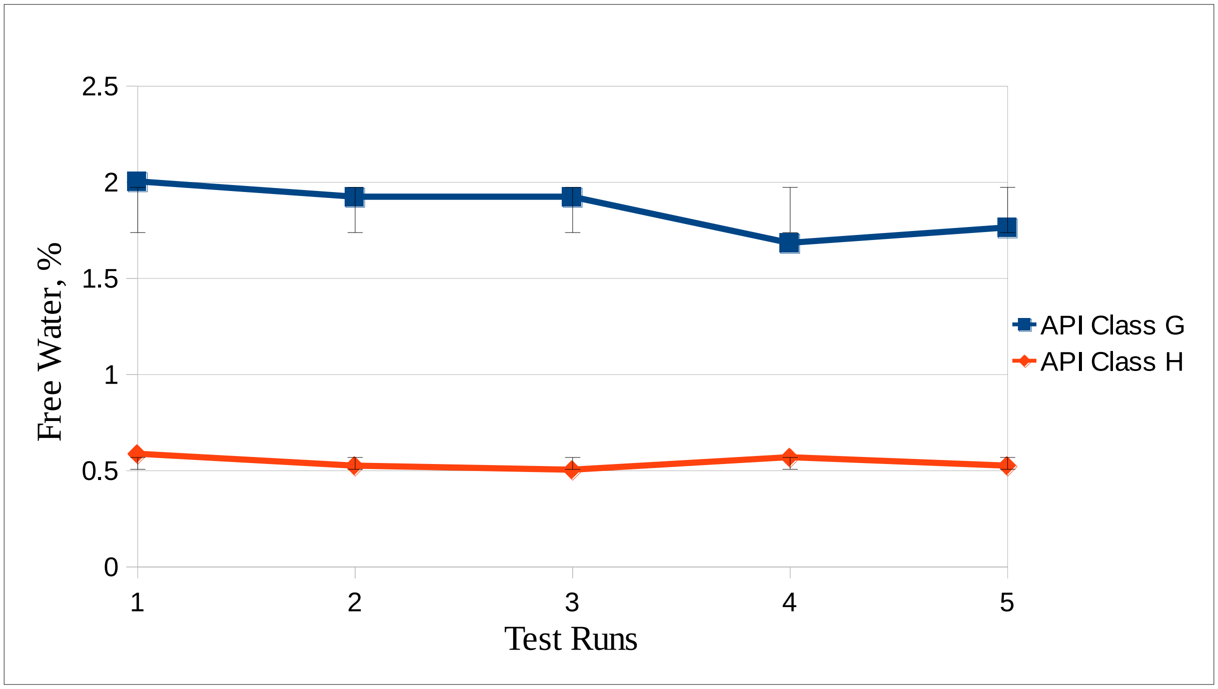

Fig 1: Free Water Test Results for API Class G and Class H cements

These results show that more zeolites might be needed to reduce the amount of free water in the API Class G cement than in Class H cement.

Halliburton Training at Rock Springs, WY:

Training was provided to two University of Alaska Fairbanks Graduate Students by Halliburton from 11th July to 15th July at their Rock Springs Facility in Rock Springs, WY. The training was for Halliburton Cementing Field Engineers as well as their Lab Technicians. The training exposed us to the equipments that will be used for the tests at UAF. Although the training was focused around the proprietary additives and their properties that Halliburton uses, we gained understanding on which additives to add and how much to add when cement slurry behaves in a certain way. We were allowed into their Laboratory to oversee some of the experiments that the Lab Technicians were doing and also we got to do some of the experiments ourselves. Several insights were gained on how to follow API specs wherever applicable. Handouts were provided which will help us in conducting the experiments at UAF in a safe and precise manner in a way that the industry does. Contacts were made during the training which will help us in the future with the project if we encounter any problems with the experiments at UAF.

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Report Submitted by: Dr. Santanu Khataniar
University of Alaska Fairbanks

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SUB AWARD ACTIVITIES

A Project Meeting was held at UAF on September 21st. In attendance were; George Trabits, Dr. Santanu Khataniar, Dr. Abhijit Dandekar, and Graduate Students Prachi Vohra and Dhaval Patel. The main topic of discussion was the cement blend screening matrix. The Statement of Project Objectives sets the methodology and goals of the screening process:

"A large number of cement samples will be prepared for initial screening using permutations of zeolite species, particle size, percent zeolite by weight of cement and certain additives. Cement samples may contain more than one zeolite species and particle size in a test blend to take advantage of the properties of each. Sample preparation will be a heuristic process as the sample composition will need to be fine tuned based on the feedback from sample testing. API Class G and Class H cements will be used as the base for making the zeolite test samples.

The following properties are expected to be the primary criteria for initial screening:

· Zero Percent free water
· Rheological properties of less than 200 reading at 300 rpm
· 24 Hour compressive strength greater than 500 psi
· Thickening time and consistency, end thickening under 70 Bc
· Slurry density less than 13.5 lbs/gal"

Using the above SOPO as the guide UAF prepared the following Testing Matrix:

		Class G						Class H						Total Samples
		11.5ppg slurry (Light)			13.5ppg slurry (Medium)			11.5ppg slurry (Light)			13.5ppg slurry (Medium)			
	Size	% Zeolite, replacement of cement						% Zeolite, replacement of cement						
Ferrierite	5	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	10	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	44	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
Clinoptilolite Mud Hills	5	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	10	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	44	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
Chabazite	5	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	Total
	10	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	Samples
	44	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	180
Clinoptilolite NM Mine 1	5	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	10	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	44	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
Clinoptilolite NM Mine 2	5	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	10	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	44	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
					Initial Screening Criteria						Initial Screening Criteria			

Given the critical importance of this initial screening the Project Team thought it advisable to seek Peer Review comments from Halliburton and Dr. Karen Luke with Trican Well Services. Dr. Luke was formally with Halliburton and the main inventor of the zeolite-containing cement technology.

The Project Team also reviewed the zeolite and cement inventory and determined that more than enough material had been prepared for the project.

Peer Review Comments

Halliburton commented only on the number of tests and thought the large number of individual tests at varying particle sizes, type of zeolite and slurry density would provide a good basis for screening.

Dr. Luke was more at issue with the test methods and in particular the use of Free Water and 24 Hour Compressive Strength as main elimination criteria. Dr. Luke's comments follow:

"My major concern over the current testing matrix at UAF is that the testing on free water does not really address the issues associated with geothermal wells and as such could eliminate some of the better performing zeolites in a geothermal environment. Free water tests are quick and easy but in this case not really applicable. Compressive strength retrogression is one of the primary major issues in geothermal wells and although it takes time to run the tests it is the one I would consider the best to give an indication on whether or not the zeolites are beneficial. My thought would be to take one zeolite and cure at temperature of interest over 1, 3, 7 and 28 days and determine the compressive strength and if possible permeability. You may also want to look at several different percentages of silica flour addition. Once you have that data you can focus in on one or two curing conditions and tests that give the best data or trend and then choose those test criteria to check out the other zeolites to see if their performance is better or worse.

Although zero free water is ideal, many low density slurries with added viscosifier can still have up to 0.4% free water and be acceptable. In terms of the current study if you do not have a viscosifier then I would consider the rejection point at 2.0% free water. Above 0.4% I would not recommend using the slurry for compressive strength measurements as settling will occur and densification of the slurry leading to erroneous results (overestimation of compressive strengths values)

Compressive strength at 24 hours will give no indication on the HTHP strength retrogression. This is due to a phenomena that occurs with a change in the cement chemistry whereby the amorphous non-structured C-S-H binder phase is converted into crystalline C-S-H phases that are distinct mineralogical species such as dicalcium silicate (associated with strength retrogression) or tobermorite, xonotlite, truscottite (on addition of silica flour and associated with good strength) or hydrogarnet, hydrogrossular etc associated with the aluminum phases in the cement or zeolite (tends to give lower strength) or anorthite with additional alumina(improved or poor strength depending on form). These phases only form above, around 302°F, and which phase(s) form depend on both the bulk chemistry of all inorganic products present and on localized concentrations. 24 hour compressive strength is not a good criteria for HTHP conditions. A sample could fail the 24 hours strength and give the higher strength, better permeability etc. at HTHP."

The Project Team has scheduled a conference call for October 6th to incorporate Dr. Luke's suggestions.

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Project: Development of novel geothermal well cement using zeolite

Progress:

Free Water test was conducted on blends of API Class G and Class H cements with Ferrierite and Calcined Analcime. Largest particle size i.e. 44µm of both the zeolites was used for the test. Test was carried out using the API Spec Blender from Chandler Engineering. Amount of zeolite added was 11.11% by weight of cement. The amount of water added to the blend of cement and zeolite was calculated by having a slurry density of 17.1ppg (Specific Gravity of 1.76) for all the blends. The results are tabulated below.

Test	Class G					
	Ferrierite			Calcined Analcime		
	Free Water, ml	Slurry Volume, ml	Free Water, %	Free Water, ml	Slurry Volume, ml	Free Water, %
1	4.40	250.00	1.76	1.40	250.00	0.56
2	4.40	250.00	1.76	1.50	250.00	0.60

Table 1: Results for API Class G cement using Ferrierite and Calcined Analcime

Test	Class H					
	Ferrierite			Calcined Analcime		
	Free Water, ml	Slurry Volume, ml	Free Water, %	Free Water, ml	Slurry Volume, ml	Free Water, %
1	2.90	250.00	1.16	1.00	250.00	0.40
2	3.00	250.00	1.20	1.00	250.00	0.40

Table 2: Results for API Class H cement using Ferrierite and Calcined Analcime

From the results we can see that addition of Calcined Analcime reduces the amount of free water for the slurry drastically than Ferrierite or even pure Class G and H cements. Performance of Ferrierite is almost on par with pure Class G and H cements. Although this slurry is slightly lighter than tests conducted on pure cements (18.3ppg). It would be interesting to note that in the XRD analysis, Calcined Analcime had just 1% Analcime and 61% Feldspar.

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Project Period: 1/29/2010 through 9/30/2013

Principal Investigator: George Trabits
Trabits Group, LLC

Report Submitted by: Dr. Santanu Khataniar
University of Alaska Fairbanks

Reporting Period: December 2011

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Project: Development of novel geothermal well cement using zeolite

Progress:

Atmospheric consistometer from Chandler Engineering was received, assembled, and calibrated to condition the cement slurries for all future tests in this reporting period. All the necessary plumbing work was performed to so as to make sure that the water does not leak into the equipment.

Free water tests were performed on the Mud Hill Clinoptilolite and the New Mexico Mine 2 Clinoptilolite for both 5µm and 44µm sizes at 15% replacement of Class H cement. The zeolites were spread on a tray in a thin layer heated in the oven for at least 30 minutes at 284°F (140°C) to make sure there was no moisture in the zeolites. The slurries after mixing were conditioned in the consistometer at 80°F for 20 minutes, per Halliburton test protocol, and then poured into the graduated cylinders for measuring the free water.

The results are very encouraging for both Clinoptilolites. The results are tabulated below. We also conclude from these results that the free water tests with the cylinder at 45 degree angle do represent the "worst case" scenario i.e. they show higher free water than the vertically placed cylinders.

Cylinder Position	44µm			5µm		
	Free Water, ml	Total Slurry, ml	Free Water, %	Free Water, ml	Total Slurry, ml	Free Water, %
	Mudhill Clinoptilolite					
45°	7.0	250	2.8	1.0	250	0.4
Vertical	3.4	210	1.6	0.6	210	0.3
	New Mexico Mine 2 Clinoptilolite					
45°	8.6	250	3.4	2.4	250	1.0
Vertical	3.6	210	1.7	1.0	200	0.5

Table: Results for free water test for 13.5 ppg slurry using 5µm and 44µm Mudhill and New Mexico Mine 2 Clinoptilolite and Class H cement at 15% replacement of cem

Monthly Research Performance Progress Report
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Federal Agency and Organization: DOE EERE – Geothermal Technologies Program

Recipient Organization: Trabits Group, LLC
DUNS Number: 829739395

Recipient Address: PO Box 870404
Wasilla, AK 99687-0404

Award Number: DE-EE0002785
Project Title: Development Of An Improved Cement For Geothermal Wells
Project Period: 1/29/2010 through 9/30/2013

Principal Investigator: George Trabits
Trabits Group, LLC

Report Submitted by: Dr. Santanu Khataniar
University of Alaska Fairbanks

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Project: Development of novel geothermal well cement using zeolite

Progress:

A 45° stand was made for measuring free water in an inclined cylinder. This procedure was suggested by Halliburton because it is supposed to provide free water under the worst case scenario. The difference in free water measurements using vertical cylinder (standard API procedure) versus inclined cylinder (Halliburton approach) was tested by using two graduated cylinders: one at vertical and the other at 45°. Two types of zeolites were used to compare, Mudhill Clinoptilolite and Ferrierite, both having particle size of 44µm.

Before preparing the slurry, the zeolites were dehydrated by spreading on an oven tray in a thin layer and heating in an oven at 266°F (130°C) for 30 minutes. This would ensure that there was no moisture content in the zeolites before blending the Class H cement and zeolites. In order to eliminate error associated with mixing separate slurries for vertical and 45° cylinders, only one blend was mixed and poured into the two cylinders.

The differences in results for vertical and 45° cylinders are significant. Ferrierite performed worse than Clinoptilolite due to its lower pore volume. The results are realistic as no well drilled is perfectly vertical. The results are tabulated below. Based on these results, it was concluded that free water test at 45 degree angle is indeed a more stringent screening test than the API standard procedure. Therefore, the 45 degree free water test would be used in all future free water tests.

Table 1: Comparison of free water test results for Mudhill Clinoptilolite and Ferrierite for vertical and 45° angle of graduated cylinder.

Cylinder Position	**Clinoptilolite**			**Ferrierite**		
	Free Water, ml	Total Fluid, ml	Free Water, %	Free Water, ml	Total Fluid, ml	Free Water, %
Vertical	3.2	250	1.28	6.2	250	2.48
45°	4.5	250	1.80	11.0	250	4.40

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Report Submitted by: Dr. Santanu Khataniar
University of Alaska Fairbanks

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Project: Development of novel geothermal well cement using zeolite

Progress:

The test matrix developed initially was revised and the numbers of samples to be tested in the initial screening were cut so as to optimally decrease the amount of time spent on the initial screening of samples. These changes took effect after several interactions with Dr. Karen Luke from Trican Well Services and phone meetings between the team at UAF and Trabits Group.
The primary concern from Karen Luke was using both Class G and Class H for the initial screening. The argument was that chemically Class G and H are similar, Class H being used in the USA and easily available, while Class G is used elsewhere. Hence Class G is not included in the revised matrix prepared for initial screening. The test matrix for Class G cement will be heuristically deduced from the results of Class H cement. Other concern shown by Dr. Luke was conducting the initial screening of samples under atmospheric conditions. Properties of cement drastically change with the increase in temperature. Strength development is rapid, retrogression is equally rapid. Hence she suggested conducting the initial screening under HPHT conditions. Although, given the equipment, time and effort constraints, it was decided to conduct initial screening will be conducted at atmospheric conditions. Although one more test for measuring the permeability using a probe permeameter was added for initial screening of the samples.
Addition of additives was discussed as well. It was decided to keep the blend as pure as possible so as to make it easier to blend and get consistent result on field. Although, additives might be added if the initial screening results for free water and compressive strength fall into an initial set limit.

The initial screening limits as decided are:

- Free Water: <2%
- 24 hour compressive strength: at least 500psi
- Permeability: <1mD
- Rheology: <200 reading at 300rpm

The samples will be prepared in two different densities of 13.5ppg and 12.5ppg. The test matrices are provided below.

Initial Screening Matrix								
Zeolites	**Class H, 13.5ppg slurry** % Zeolite, Replacement of Cement			**Class H, 12.5ppg slurry** % Zeolite, Replacement of Cement			**Tests**	
Ferrierite	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	1) Free Water Test: Acceptable free water of <2%	**Screened samples will be subjected to tests under HPHT conditions.**
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%		
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%		
Clinoptilolite-Mud Hill	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	2) Permeability using a probe permeameter: Acceptable permeability <1mD	
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%		
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%		
Chabazite	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%		
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	3) Rheology: <200 reading at 300rpm	
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%		
Clinoptilolite-NM1	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%		
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%		
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	4) 24hr compressive strength: Acceptable ≥500psi	
Clinoptilolite-NM2	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%		
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%		
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%		

Table 1: Initial Screening Matrix using Class H cement and the screening criteria

Zeolites	Class G, 13.5ppg slurry % Zeolite, Replacement of Cement			Class G, 12.5ppg slurry % Zeolite, Replacement of Cement			
Ferrierite	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	**This matrix will be heuristically modified according to results from tests using Class H cement**
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
Clinoptilolite-Mud Hill	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
Chabazite	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
Clinoptilolite-NM1	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
Clinoptilolite-NM2	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	
	15.0%	27.5%	40.0%	15.0%	27.5%	40.0%	

Table 2: Test matrix using Class G cement. This matrix will be reduced according to results from C