Lawrence Berkeley National Laboratory
FWP ESD 12011
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Quarterly Report
10/01/14 – 12/31/14

In this quarter we had planned to perform a test examining hydrate formation and dissociation in a layered system while measuring heat fluxes into the sample. This report describes the task, provides a synopsis of our progress, and finally provides a quantification of our spending over the quarter.

Task Description - Task 8.0 Gas production from layered hydrate
Variation of sediment sizes during sediment deposition results in bedding. Hydrate formation in sediments will be strongly influenced by the bedding structure. Production of gas from the resulting hydrate will be influenced by the total resulting structure. In this investigation, hydrate will be formed in horizontal layers in a laboratory-made structured porous medium amenable to placing in a cylindrical pressure vessel (See Figure 1). Following the formation of methane hydrate, the hydrate will be water saturated and the sample will be allowed to equilibrate while X-ray CT observations are performed, and then the sample will be dissociated by depressurization. Heat transfer will be controlled, attempting heat transfer from primarily the top and bottom, as would be expected in a reservoir. Heat flux sensors will be used to quantify heat transfer to the sample.

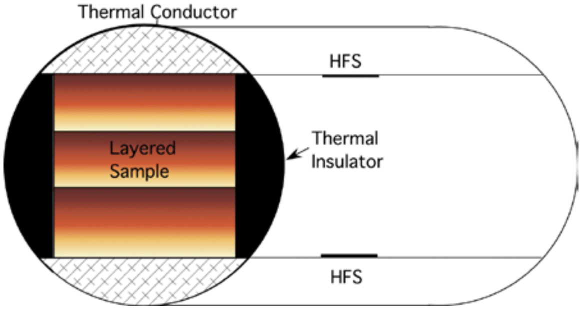


Figure 1. Layered sample geometry. Heat flux sensors (HFS) will be placed in critical locations.

Previous work using a layered sample was strongly influenced by the cylindrical geometry of the test. Thermal conductors (aluminum plates) on the top and bottom, and insulators (insulating rubber) on the side will be used to control heat transfer direction. This will also provide additional understanding related to directional heat transfer and hydrate formation. Additionally, we would be able to detect compaction if it were to occur during the dissociation.

Planned Date: December 31, 2014

Verification Method: Production of complete data set for one test with temperature, pressure, X-ray CT data, and heat flux measurements.

Progress:

Test design is mostly complete and most components have been ordered. Using a rectangular parallelepiped in a cylindrical vessel with X-ray CT has some extra challenges as cross-shaped artifacts in CT data will result. We are machining aluminum heat conductors (thermal conductivity of 6061 aluminum is 167 W/m.K) and PVC insulators (thermal conductivity 0.19 W/m.K) to fit inside of a 2.5 inch i.d. jacket. These will cast their own shadows, however because they are rounded and have electron densities closer to the medium than the confining fluid, they will offset (but not eliminate) artifacts from the test geometry. Other techniques to mitigate the artifacts are being considered including averaging scans from multiple energies which tend to have different noise structures.

Setting up a sample in the geometry shown in Figure 1 above is a challenge. The methods considered include:

1. Pouring in layers through water into a bread-pan-sized container, freezing the sample, and cutting it as a rock when frozen. We have had success with a similar process of coring sands when frozen to -80C.
2. Use a tremie-pipe device to place the sand while vibrating the sample. We think that this would not likely result in reasonably homogeneous layers as desired.
3. Use sandstone plates as a low permeability layers between higher permeability sand layers. An estimate of the permeability of our F110 sand as packed is about a darcy. Three sandstones have been ordered to fit the sample size to be used. These include Berea Sister sandstone (~45 mD, 21% porosity), Kirby sandstone (9mD, 21% porosity) and Boise sandstone (500 mD, 28% porosity).

The heat flux sensors (HFS) have been received. These sensors function by placing a stack of thermocouples (to increase voltage output) on both sides of a known thermal conductivity material. Figure 2 shows an image of one of the sensors, slightly over an inch x an inch x 0.007 inches. We anticipate that we may have some wiring difficulties, particularly where the wires enter the HFS. We plan to pot the wires next to the HFS with epoxy to reduce water and gas entering the sensor. To keep gas from escaping between the metal wire and the insulation, we will either bare portions of the wire while potting them in a tube, or potting lacquer-coated wires in a tube extending out of the vessel.

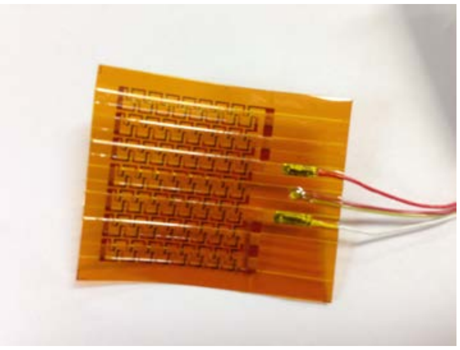
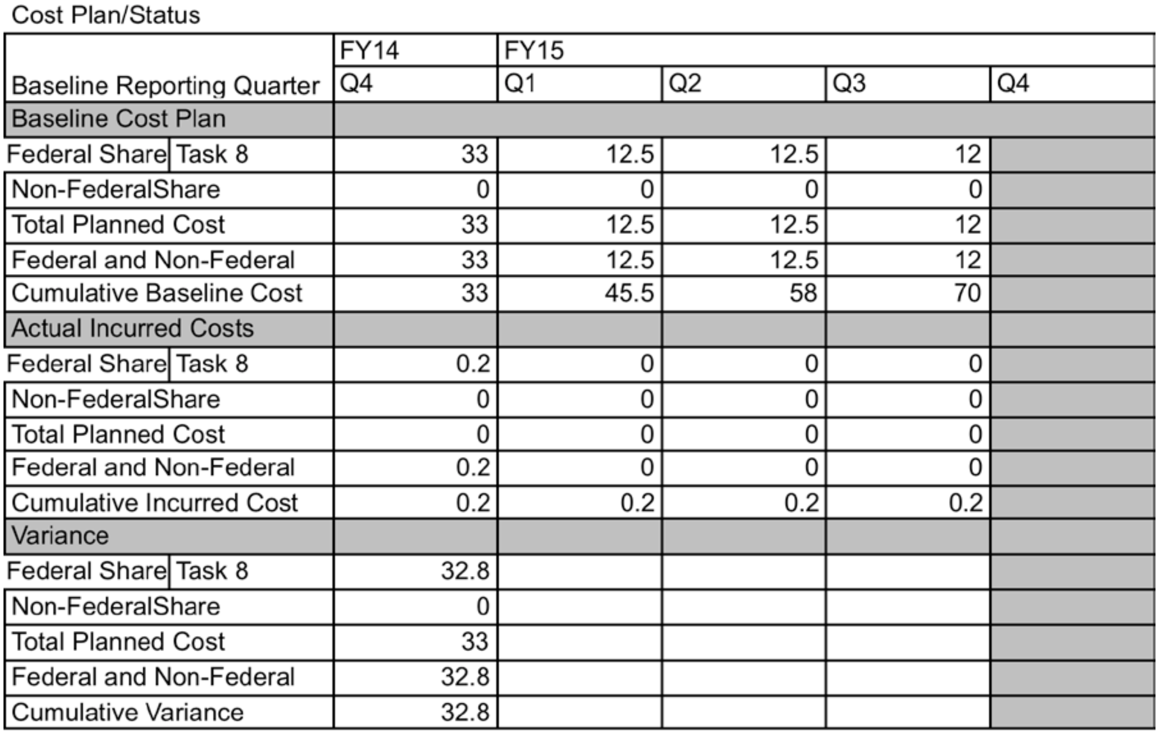


Figure 2. Heat flux sensor.

Status and Budget

Our task is behind schedule and under budget. At the end of FY 14, we lost key personnel, and are making an effort to hire an experienced laboratory scientist with gas hydrate experience. Our Cost Plan/Status table is presented below.

Table 1. Cost Plan/Status



Cost Plan/Status

	FY14	FY15			
Baseline Reporting Quarter	Q4	Q1	Q2	Q3	Q4
Baseline Cost Plan					
Federal Share Task 8	33	12.5	12.5	12	
Non-FederalShare	0	0	0	0	
Total Planned Cost	33	12.5	12.5	12	
Federal and Non-Federal	33	12.5	12.5	12	
Cumulative Baseline Cost	33	45.5	58	70	
Actual Incurred Costs					
Federal Share Task 8	0.2	0	0	0	
Non-FederalShare	0	0	0	0	
Total Planned Cost	0	0	0	0	
Federal and Non-Federal	0.2	0	0	0	
Cumulative Incurred Cost	0.2	0.2	0.2	0.2	
Variance					
Federal Share Task 8	32.8				
Non-FederalShare	0				
Total Planned Cost	33				
Federal and Non-Federal	32.8				
Cumulative Variance	32.8				