Study of Unconsolidated Sediments at Joint Tunnel Test Range (JTTR) on Yuma Proving Grounds, Arizona

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Sampling Acquisition Report to

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Introduction

Lithologic classification and correlation of distinct/key earthen intervals in the upper 30 m (100 m) from samples and borings at the proposed Joint Tunnel Training Range (JTTR) facility on the Joint Experimentation Range Complex (JERC1) site located within the Cibola Range at Yuma Proving Grounds (YPG), Arizona, will play an important role in future research into automated tunnel detection and discrimination methods. Samples and accessible cased borings were positioned to complement the geophysical-characterization studies already completed, as well as any future experimentation yet to be designed. Geophysical studies have included a wide range of methods and approaches. Future optimization of automated systems relies on confidently discriminating geologic noise from tunnel signatures. This invasive ground-truth (extensive material sampling program) study will be essential for the high-resolution, low signal-to-noise techniques that will be developed from data acquired at this site.

Task 1—*Continuous Sampling to 30 m (100 ft)*

Locations for the 25 continuous ~5-cm (2-in) diameter sampled boreholes that extend from the ground surface to a maximum depth of around 30 m (100 ft) at the planned JTTR facility were selected based on the relative footprint of the facility and proximity to other boring locations (Figure 1). Samples from these 25 borings will complement and significantly enhance the accuracy of geophysical characterizations already completed as well as those still to come. With little previously known about the site-specific geology, any information extractable from these samples and associated borings will enhance models and correlations of geophysical data to lithologies or material contacts. Ultimately, these samples and borings will represent a portion of the supporting data and analysis used to develop predictive models and automatic discrimination algorithms.

Conventional sampling using either auger or drive (e.g., direct push, CPT, etc.) techniques in this fine-grained, dry setting will produce severely altered and incomplete samples. Newly developed sonic-sampling technologies were thought to be the best option for sampling at this kind of site and for the ground-truth needs of geophysical characterization both underway and planned. It was reported that sonic-sampling techniques could retrieve up to 30 m (100 ft) of relatively undisturbed samples in a single day with recovery rates of over 90% for most materials. As it turned out, the extremely dry and very fine grained nature of material at this site presented challenges never before encountered with any sampling technique, and sonic sampling—although showing great improvement over conventional—was not the perfect solution. Sonic sampling, although better than any other approach available, lacked the necessary time efficiency required to meet all the expectations of this project.

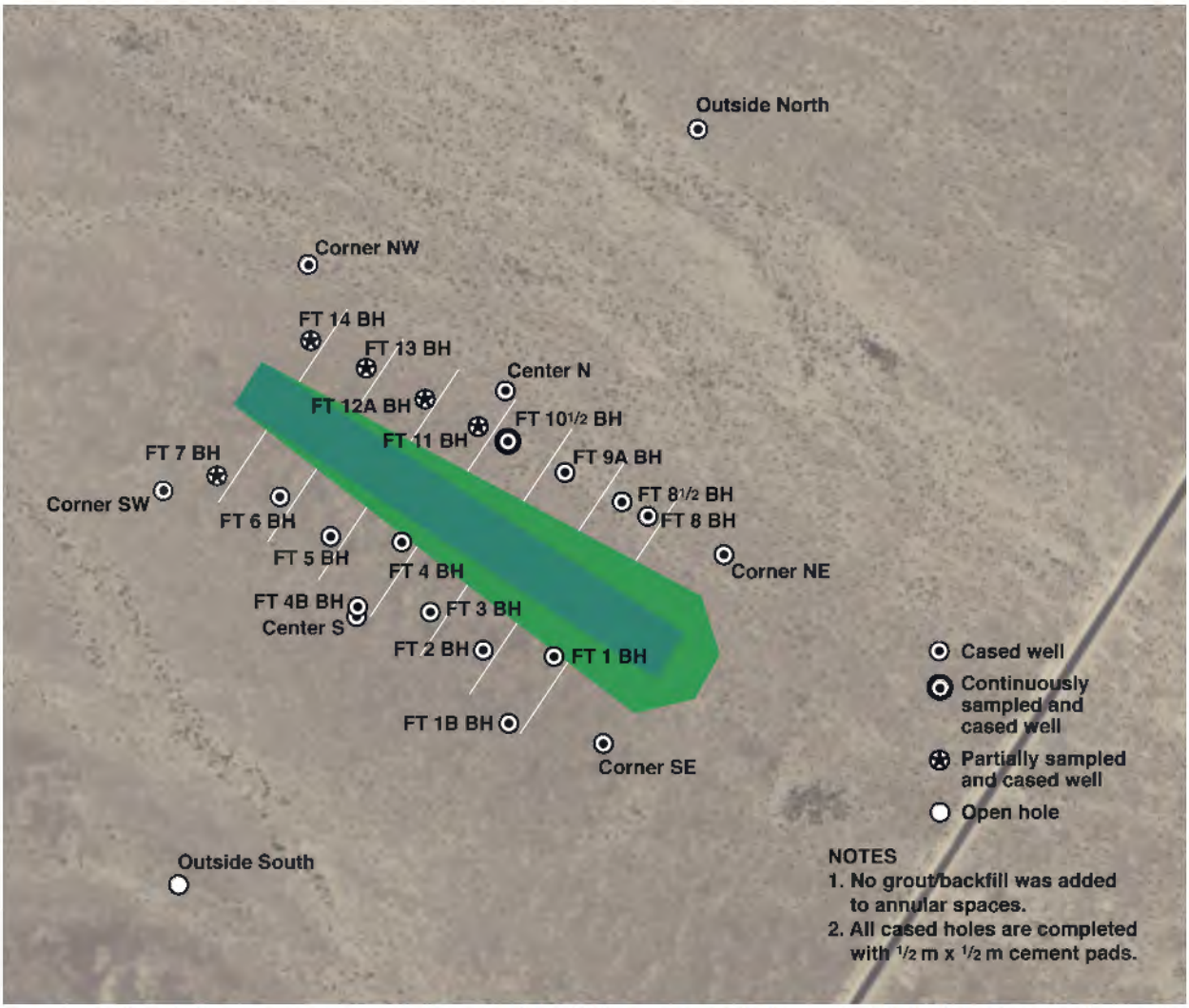


Figure 1. Spatially accurate aerial photo with GPS locations (±2 cm [±.75-in]) indicated for each cased and uncased boring completed by KGS. Cartoon of JTTR installation is approximate based on artist's conception and preliminary specifications. Only the wells are spatially accurate.

Sonic sampling is a unique drilling technology that does not generate spoils or leave an open hole following sample runs in most settings. This conventional method (sample barrel at end of drill rod, requiring that all the rod be retrieved from the hole after each 2-m [6.5-ft] sample run) uses a range of sonic vibrations between around 60 Hz and 120 Hz as well as minimal rotational and hydraulic pressure delivered at the drive head to penetrate unlithified soils. In saturated sediments the AquaLoc sampler draws the liquefied sediments into the 5-cm (2-in) barrel at a rate consistent with the downward movement of the drill rod. The sample is held in place by suction as the barrel is retrieved from the hole until the captured sample can be extruded into a sample tube at the surface. At the YPG site dry materials prevail, taxing the entire system as well as the physical principles that form the basis for this sampling method. After experimenting with a wide range of sampling approaches (various barrels, with and without drive casing, high-pressure water, low-pressure water, high-volume water, low-volume water, without water, with

and without rotation, various down pressure and frequency ranges at the drive head, etc.), the best combination of equipment and settings were determined and implemented at the last hole sampled (FT 10½ BH). At hole FT 10½ BH, the equipment and technique appear to have been optimized for the site, available equipment, and product specifications. The refined method involved minimal rotation, a relatively small amount of water above the sampler, variable vibration frequencies, short runs (<1 ft), drive casing placed several inches above the start point for each sample run, and the AquaLoc sampler.

With a wide range of start-up problems due to the unique nature of the sampling situation at JTTR, the initial six sample holes produced only partial samples (Figure 1). These partial samples were predominantly retrieved from the upper 15 m (50 ft) and possessed quality that ranged from excellent to poor as judged by contamination, continuity, changes in physical characteristics relative to native, and confidence in original sample depth (retrieved from a 2-m [6.5-ft] barrel). In most cases sampling was only discontinued in a particular hole due to degradation in hole conditions or multiple failed attempts to retrieve samples using different tooling and approaches. The seventh hole attempted resulted in about 75% recovery with only minimal alteration of the sample (small amounts water added for lubrication came in contact with a small percentage of the sample). Unfortunately, to honor the work schedule established months in advance, sampling had to be halted after the seventh borehole sampled so wells could be installed for the geophysical-logging crew (Appendix A). Task 1 was completed with limited success due to the unexpected and significant difficulty and extra time necessary to capture samples (Appendix B).

Based on the industry standard definition of refusal using a sampling system, the standard sonic-sampling method hit refusal about 2 ft (0.6 m) below ground surface at this site. Experimentation, modifications, and a variety of unique equipment configurations resulted in the development of a new approach for retrieving samples in this kind of geology/lithology. Relatively undisturbed samples between 1 m and 30 m (3 and 100 ft) below ground surface can be obtained using a double tube approach with the drive casing acting to maintain the hole and remove the friction between the rod/sampler string and the borehole walls. Water is necessary to advance the drive casing prior to each sample run, thereby exposing the very end of the sampler to water inside the drive casing. Sample runs ranged from 9 cm to 30 cm (3.5 to 11 in). Using the new approach, an average 30-m (100-ft) hole will require about seven to eight days to completely sample under YPG site-access restrictions.

Task 2—*Installation of 2.5-inch (6-cm) PVC at Sampling Locations*

Correlation of surface geophysical measurements with lithologic units, material properties, and/or anomalies identified in samples from boreholes is best accomplished with the aid of geophysical logging. Electric or geophysical logging has long been a mainstay in the petroleum-exploration business for defining key material properties (porosity, permeability, conductivity, seismic velocity, etc.) significant to fluid content and mobility. Of secondary demand and interest in geophysical logging have been various aspects of material/engineering properties (stiffness, density, fractures, anisotropy, etc.). To maximize JTTC's potential for developing tunnel detection and discrimination methods, as much geologic and geotechnical information as possible must be obtained and archived both before and after construction of the facility.

Open-hole (uncapped) geophysical logging at this site might be possible if the wireline log data were acquired within a few days of drilling the holes. Long-term access to any boring at JTTR will only be possible if casing is set immediately after drilling/sampling. A total of 25 holes were drilled and cased with 2.5-in (6-cm) flush joint casing between August 28 and December 12, 2009. With hole diameters just under 3 inches (7.5 cm), casing was inserted without the need to add fill material to the annular space. Earth materials encountered in these borings allow hole integrity to be maintained as long as the freshwater used during drilling/sampling remained in the hole. Once the water was absorbed, borehole walls collapsed, and the ¼ inch (0.6 cm) of annular space outside the PVC casing was filled with native sediments to form a tight seal between the casing and borehole walls. Each PVC-cased hole was completed with a 0.5 m x 0.5 m (1.5 ft x 1.5 ft) cement pad.

Scope of Work As Accomplished

Continuous samples were acquired at the JTTC site using the Kansas Geological Survey's 2009 US Exploration Co. model S-27 CRS sonic drilling machine (Appendix C). These approximately 5-cm (2-in) in diameter unconsolidated samples were collected in a 2-m (6.5-ft)-long barrel and then extruded into 1-m (3-ft)-long clear plastic tubes with water-tight end caps. Only the 30-m (100 ft)-deep hole at FT 10½ BH produced the full complement of material samples. The 62 tubes containing the samples from FT 10½ BH were stored and shipped in wooden crates designed to handle 27 1-m (3 ft)-long, 5-cm (2-in)-wide sample tubes. Partial samples from the other six sampled wells were handled and shipped in the same fashion. It was expected prior to arriving on-site that each 30-m (100-ft) hole would require approximately 10 hours to complete (assuming bit refusal was not encountered—boulder, lithified interval, over-compacted clays, etc.). However, once each of the multiple sampling problems was resolved, a sampling method was perfected for this site. Completely sampling a 30-m (100-ft) interval requires more than four days.

Each of the first six sampled holes generated one crate of samples. Each crate was transported to a YPG storage facility where it was designated for later shipping to Vicksburg.

At each of the 25 locations sited for samples to support the geo-investigation at JTTC, 2.5-in (6-cm) blank PVC casing was installed to around 30 m (100 ft) BGS (Appendix D). The first set of blank schedule 40 PVC casing (with no perforations) were installed through the drive casing, with later casings place into an open hole. Separation between outside casing wall and borehole walls provided an extremely small clearance with several casings requiring surface pressure to reach the bottom of the hole. Unlike most cased holes where foreign material (gravel pack, grout, etc.) is placed in the annular space to insure a cohesive seal to the borehole walls, at this site, with this minimal-clearance well-installation approach, the mobility of the native materials allowed flowage into the annular space within days of installation. This native-material seal will optimize any borehole measurement made in the PVC casing.

The unconsolidated to loosely consolidated nature of the near surface allowed boring walls to cave in after they were left for several days. This collapsing of borehole-wall material filled the annular space with native material shortly after the drive casing was removed from the hole and

PVC placed. For PVC installed into open, wet holes, as soon as the moisture was absorbed, the walls collapsed filling the annular space with native materials. Cased holes have a 2.5-in (6-cm) inside diameter and will accommodate any tool less than 2.25 inches (5.7 cm).

Drilling and installation of PVC at this site required less time than anticipated. A half-day was proposed to install PVC casing into holes left following the sampling process. It took about 1/3- to 1/2-day to install PVC regardless of whether the casing was being installed into a cased hole or a hole that was drilled specifically to accommodate the casing. Each cased well was completed with a cap on top and bottom and a 0.5 m x 0.5 m (1.5 ft x 1.5 ft) cement pad, with approximately 0.5 m (1.5 ft) of PVC sticking up above each pad. Each cased well was DGPS-rtk located (Appendix E), with the top of casing being the hold point for each well.

Appendix A—Work Schedule Calendar

8/26/09 YPG FT BH SS. 7

Drive 1: 0-2 meters

Tube 1:

Lithology → Granules 2-4 mm. Very coarse sand, to very fine sand. Significant amounts of silt and clay mixed in. Subrounded to subangular granules. Bottom 30 cm (≈1 ft.) of the 1st meter is composed of clay and silt.

Note: Drive 1, tube 1 has a plastic end-cap wedged inside of it. Disregaurd it.

Recovered 39" for tube 1, Majority of it wet, ≈ 60 percent clay and silt, ≈ 30 percent very coarse sand to very fine sand, ≈ 10 percent granules 2-4 mm. Poorly sorted.

8/26/09 YPG FT BH SS 7

Drive 1: 0-2 meters

Tube 2:

Lithology → Granules 2-4 mm. Very coarse sand to very fine sand. Subrounded to subangular granules. Sample is predominantly composed of clay, silt, and granules 2-4 mm. ≈ 50 percent clay and silt, 30 percent granules 2-4 mm, ≈ 20 percent very coarse sand to very fine sand, Majority of sample is wet. Poorly sorted material, Recovered 32" for tube 2.

9/1/09 YPG FT BH SS. 7

Drive 2: 2-4 meters

Tube 1:

Lithology → granules 2-4 mm, very coarse sand to clay. Predominantly silt and clay, with very coarse sand to very fine sand. ≈ 20 percent granules 2-4 mm, ≈ 60 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand. The deeper we are going on this tube the 2-4 mm granules start to fade out. Majority of sample is wet or damp, Subrounded to subangular grains.

9/1/09 YPG FT BH SS 7

Drive 2: 2-4 meters

Tube 2:

Lithology → Few pebbles 4-64 mm. Granules 2-4 mm. Coarse sand to clay. Predominantly clay and silt. ≈ 80 percent clay, ≈ 10 percent pebbles and granules, ≈ 10 percent coarse sand to very fine sand. Still very clay-rich. Poorly sorted material, subrounded to subangular grains. Recovered 39" for tube 2. Majority of it is damp. Majority of sample is crumbled due to extraction.

9/2/09 YPG FT BH SS 7

Drive 3: 4-6 meters

Tube 1:

Lithology → granules 2-4 mm, very coarse sand, coarse sand, medium sand, fine sand, very fine sand, silt, and clay. Predominantly clay, silt, and very fine sand. It seems the deeper we go the coarser the material is becoming. More 2-4 mm granules. Starting to see pebbles >10mm. ≈ 40 percent pebbles and granules, ≈ 50 percent clay and silt, ≈ 10 percent very coarse sand to very fine sand. Subrounded to subangular granules and pebbles. Yet, the deeper we go on drive 3, start to see less granules and more clay and silt. ≈ 70 percent clay, ≈ 30 percent granules to very fine sand.

About 49 cm from the top of tube 1 there is a section about 10 cm thick (4 inches) that is highly rich in clay, denoted by black streak coloration on outside edge of sample. Recovered 39" for tube 1. Majority of it is wet. Poorly sorted material. Majority of sample is crumbled due to extraction.

- Samples for Bore Hole 7 are/were ≈ 80-90 percent wet.

Depth at where we quit sampling is, about 5 meters, or, 16'5"

Total depth of Bore Hole 7 is 99.5'

9/11/09 YPG FT BH SS 14

Drive 1: 0-2 meters

Tube 1:

Lithology → Significant amount of pebbles ranging from 1-14mm in diameter. Very coarse sand to very fine sand along with silt. High amounts of clay too. Sample is made up mostly of pebbles, silt, and clay. -Subangular grains. ≈40 percent clay and silt, ≈40 percent pebbles ranging from 1-14mm, ≈20 percent very coarse sand to very fine sand. Note: Recovered 1 meter for tube 1. Subrounded to subangular grains, poorly sorted.

9/11/09 YPG FT BH SS 14

Drive 1: 0-2 meters

Tube 2:

Lithology → Sample is very clay-rich with significant amounts of granules 2-4mm and pebbles 4-64mm. Sample seems to be getting coarser. Between 10-19 inches from the top of drive 1, tube 2 there are pebbles and granules and is very coarse. Some of which is debris that fell in the hole when the casing was being lifted and some is part of the natural stratigraphy. The deeper we drill, the more clay-rich it becomes. Not as much coarse material. The clay is very hard and brittle. Note: Recovered 1 meter for tube 2. Poorly sorted, subrounded to subangular grains. ≈50 percent clay and silt, ≈30 percent pebbles 4-64mm, granules 2-4mm, ≈20 percent very coarse sand to very fine sand.

9/14/09 YPG FT BH SS 14

Drive 2: 2-4 meters

Tube 1:

Lithology → very coarse sand, coarse sand, medium sand, very fine sand, silt, and clay. Granules 2-4mm Very clay rich. Note: Drilled down 2 meters and only recovered 29 inches (74cm). Only one tube was needed to take sample. ≈60 percent clay and silt, ≈30 percent very coarse to very fine sand, ≈10 percent granules 2-4mm. Subrounded to subangular, poorly sorted.

9/15/09 YPG FT BH SS 14
Drive 3: 4-6 meters
Tube 1:

Lithology → Very few pebbles 4-64mm, granules 2-4mm, very coarse sand to clay, but predominantly clay. Grains are subangular to subrounded. ≈ 60 percent clay, ≈ 30 percent very fine sand and silt, ≈ 10 percent pebbles 4-64mm. Note: Recovered 30 inches from tube 1. Poorly sorted,

9/15/09 YPG FT BH SS 14
Drive 3: 4-6 meters
Tube 2:

Lithology → Very clay rich with significant amounts of silt and very fine sand. Very few amounts of pebbles 4-64mm. Predominantly clay. ≈ 70 percent clay, ≈ 20 percent silt and very fine sand, ≈ 10 percent pebbles 4-64mm. Pebbles are subangular. Note: Only able to recover 23" (57cm) for tube 2. Poorly sorted.

9/15/09 YPG FT BH SS 14
Drive 4: 6-8 meters
Tube 1:

Lithology → Few granules 2-4mm, very coarse sand, coarse sand, silt and clay. ≈ 60 percent clay and silt, ≈ 30 percent very coarse sand and coarse sand. ≈ 10 percent granules 2-4mm. Still much clay, however, it seems to be getting coarser. Note: From about 19½" (49cm) from the top of tube 1, begins a significant coarsening of the soil. It is about a foot thick. Believed to be a small sand lense. It is ≈ 80 percent very coarse sand to very fine sand, ≈ 20 percent clay. Note: While drilling, it was much easier to drill through the sand than the clay and silt. Around 6.82 meters deep. Note: Recovered 1 meter for tube 1. Subrounded to subangular grains

9/15/09 YPG FT BH SS 14

Drive 4: 6-8 meters

Tube 2:

Lithology → Mostly clay. Note: we are out of the sand lense. Granules 2-4 mm, Very coarse sand, coarse sand, medium sand, fine sand, very fine sand, and silt. Granules are subangular to subrounded. ≈ 50 percent clay and silt, ≈ 40 percent very coarse sand to very fine sand, ≈ 10 percent granules 2-4 mm. Note: Recovered 1 meter for tube 2. Poorly sorted.

9/16/09 YPG FT BH SS 14

Drive 5: 8-10 meters

Tube 1:

* Change of sampling tactics * (used aqualock)

Lithology → Few pebbles around 8mm in diameter, granules 2-4mm. Lots of very coarse sand to very fine sand, along with silt and clay. ≈ 50 percent clay and silt, ≈ 30 percent very coarse sand to very fine sand, ≈ 10 percent granules 2-4 mm, ≈ 10 percent pebbles greater than 4 mm in diameter, seems to be getting a little coarser. Note: Only able to recover 33 inches (84 cm) of drive number 5. Only used one sample tube. Note: Harder than hell to get the sample out of the sampler. Poorly sorted, Subangular to subrounded grains

9/16/09 YPG FT BH SS 14

Drive 6: 10-12 meters

Tube 1:

Lithology → Very coarse sand to very fine sand. Granules 2-4 mm silt and clay are very predominant. ≈ 60 percent clay and silt, ≈ 30 percent very coarse to very fine sand, ≈ 10 percent granules 2-4 mm. Could only recover ≈ 37 inches (≈ 1 meter) of Drive 6. Only used one tube. Note: Samples seem to be more in tact, but still can't recover all of a drive. Poorly sorted, subangular to subrounded grains.

9/17/09 YPG FT BH SS 14

Drive 7: 12-14 meters

Tube 1:

Lithology → Very coarse sand to very fine sand. Predominantly clay. ≈ 80 percent clay, ≈ 20 percent very coarse sand to very fine sand. Note: Got very good recovery for this tube. Only able to recover one tube on this drive. * This is when we changed tactics again because no water was coming out of the hole. * Recovered 1 meter for tube 1. Poorly sorted, subrounded to subangular grains

9/17/09 YPG FT BH SS 14

Drive 8: 14-16 meters

Tube 1:

Lithology → granules 2-4 mm along with very coarse sand to very fine sand. - Clay and silt. ≈ 60 percent clay, ≈ 30 percent very coarse sand to very fine sand, ≈ 10 percent granules 2-4 mm. Grains are subangular to subrounded. Poorly sorted. Recovered 1 meter for tube 1.

9/17/09 YPG FT BH SS 14

Drive: 8 14-16 meters

Tube: 2

Lithology → Very clay rich. More so than Tube 1 of Drive 8. Coarse sand to very fine sand, silt. ≈ 80 percent clay and silt, ≈ 20 percent coarse sand to very fine sand. Only recovered 25 inches for tube 2. Poorly sorted, subrounded to subangular grains.

9/18/09 YPG FT BH SS 14

Drive 9: 16-18 meters

Tube 1:

Lithology → Hardly any coarse sand, but there is a little near the top of the sample. Near the bottom of the sample there isn't any coarse sand. Fine and very fine sand, silt, and clay. The sample is very clay rich. ≈ 85 percent clay and silt, ≈ 15 percent fine to very fine sand. Note: Could only recover 20 inches (≈ 51cm) of Drive 9. The reason is unclear why we got so little. Only used one tube for Drive 9.

9/18/09 YPG FT BH SS 14

Drive 10: 18-20 meters

Tube 1:

Lithology → Very coarse sand to very fine sand, silt, and clay. Very clay rich. ≈ 85 percent clay and silt, ≈ 15 percent very coarse sand to very fine sand. Note: only recovered 1 meter from Drive 10. Only one tube was used for this drive.

9/24/09 YPG FT BH SS 14

Drive 11: 20-22 meters

Tube 1:

Lithology → granules 2-4mm, fine to very fine sand, silt, and clay. We did a 2 foot run and only recovered 5 inches of wet sample. Drilled another foot and 3½" (to get to a meter) and recovered 3 inches of somewhat wet sample. Toward to bottom of this meter the clay and silt content increases. Amount of fine and very fine sand decreases. No granules 2-4mm. Lower 3" of sample is ≈ 80-90 percent clay, ≈ 10-20 percent very fine sand. Only one tube for this drive, but we only drove 1 meter. Got a recovery of only 8 inches. The lower 3 inches was only →

somewhat wet. we questioned if it was because of the drill rig water, or if there is actually ground moisture at that depth. Note: Due to poor quality and little recovery of samples we decided to stop and just drill down to set the casing and install the monitoring well. The deeper we drilled, the less success we had with getting a dry, good recovery of the sample. Depth at approx. 21 meters.

Notes: Did 11 drives, used 15 tubes total. 7 drives that only required 1 tube. Majority of samples are/were wet. Stopped sampling at 21 meters, 68.9'

Total depth of Bore hole 14 is 98.5'

9/26/09 YPG FT BH SS 13

Drive 1: 0-2 meters

Tube 1:

Lithology → Pebbles 4-64mm, granules 2-4 mm, very coarse sand, coarse sand, medium sand, fine sand, very fine sand, silt, and clay. ≈ 10 percent pebbles and granules. ≈ 70 percent clay and silt, ≈ 20 percent very coarse to very fine sand. Only recovered 26 ½ inches of 1st meter (tube 1). About 80 percent of sample tube 1 is wet sample. Subrounded to subangular grains, poorly sorted.

9/26/09 YPG FT BH SS 13

Drive 1: 0-2 meters

Tube 2:

Lithology → High clay content along with granules 2-4 mm. Very coarse sand down to silt. Subangular grains. ≈ 40 percent pebbles and granules, ≈ 40 percent clay and silt, ≈ 20 percent very coarse to very fine sand. The bottom of sample tube 2 has a few pebbles 4-64mm. Only recovered 30 ½ inches for sample tube 2. About 80 percent of sample tube 2 is wet sample. Subrounded to subangular grains, poorly sorted.

9/28/09 YPG FT BH SS 13

Drive 2: 2-4 meters

Tube 1:

Lithology → Pebbles 4-64 mm, granules 2-4 mm, very coarse sand to clay. ≈ 40 percent clay and silt, ≈ 20 percent pebbles 4-64mm, ≈ 20 percent granules 2-4mm, ≈ 20 percent very coarse sand to very fine sand. Note: As we drill deeper, the sample becomes finer grained. ≈ 20 percent pebbles and granules, ≈ 20 percent very coarse to very fine sand, ≈ 60 percent clay and silt. Sample Tube 1 becomes finer grained yet, ≈ 90 percent clay and silt, ≈ 10 percent medium sand to very fine sand. Note: 26 inches of recovery for tube 1. About 50 percent of sample tube 1 is wet sample. Subrounded to subangular grains, poorly sorted.

9/28/09 YPG FT BH SS 13

Drive 2: 2-4 meters

Tube 2:

Lithology → still very clay rich and silt rich. ≈ 85-90 percent clay and silt. ≈ 10-15 percent medium sand to very fine sand. Getting coarser the deeper we go for tube 2. Very few pebbles 4-64mm and granules 2-4mm. Lots of very coarse sand. ≈ 70 percent clay and silt, ≈ 30 percent pebbles 4-64mm, very coarse sand to very fine sand. Deeper yet, high clay and silt content. ≈ 90 percent clay and silt, ≈ 10 percent granules 2-4 mm to very fine sand. Deeper yet, bottom 3½ inches of tube 2 has granules 2-4 mm and lots of very coarse sand to clay. ≈ 70 percent granules 2-4mm to very fine sand, ≈ 30 percent clay and silt. Note: Believed to have hit a very thin sand lense. Only recovered 24½" of tube 2. About 70 percent of sample tube 2 is dry sample. Subrounded to subangular grains, poorly sorted.

9/28/09 YPG FT BH SS 13

Drive 3: 4-6 meters

Tube 1:

Lithology → Out of the thin sand lense. Very clay and silt rich. ≈ 90 percent clay and silt, ≈ 10 percent medium sand to very fine sand. Toward the bottom of sample tube 1 it becomes slightly coarser. ≈ 80 percent clay and silt, ≈ 20 percent granules 2-4 mm, very coarse sand to very fine sand. Note: Recovered all of sample tube 1. (Great samples). About 90 percent of sample tube 1 is dry sample. Subrounded to subangular grains, poorly sorted.

9/28/09 YPG FT BH SS 13

Drive 3: 4-6 meters

Tube 2:

Lithology → Granules 2-4 mm, very coarse sand to silt and clay. ≈ 70 percent clay and silt, ≈ 30 percent granules 2-4 mm to very fine sand. Clay and silt rich near the top of tube 2. About 13 inches down from the top of tube 2 I saw a few pebbles ≈ 10mm in diameter. ≈ 40 percent clay and silt, ≈ 10 percent pebbles, ≈ 20 percent granules 2-4 mm, ≈ 30 percent very coarse to very fine sand. Note: Seems to be getting coarser. Note: I was away for about an hour getting water for the drill, and was not able to view the sample when it was being extruded from the sampler. Possibly a small sand lense. Near the bottom of the tube it gets somewhat finer in grain size, ≈ 60 percent clay and silt, ≈ 40 percent granules 2-4 mm, very coarse sand to very fine sand. Note: Very hard to get a sample. Sampler shoe began to crack and the cutting edge began to wear down and become rounded. Not sure why... Figured we hit something hard, but we were still able to pull very short samples up. The samples don't show anything irregular than from previous soil samples taken. We switched to a spare shoe, but we noticed the cutting edge on it is starting to become rounded. Only recovered 20 inches for tube 2. Bore Hole 13 has samples that are/were ≈ 50 percent wet. Poorly sorted material, subrounded to subangular grains - Stopped sampling at a depth of 5.86 meters, or 19.29 feet. Soon, sheared off 5 bolts from the adapter. Had to order new washers and bolts. Also, Aqualock water pump went to hell. Had to wait for new seal to be delivered. Third seal for the water pump.

Total depth of bore hole 13 is 100.95'

10/2/09 YPG FT BH SS 12A

Drive 1: 0-2 meters

Tube 1-2

* No sampling for drive number 1. It is such a huge effort to take samples for the first two meters based on the drill rig rods and casings. We decided to drill down two meters and then start sampling to save a lot of time, and get as much done as possible. *

10/2/09 YPG FT BH SS 12A

Drive 2: 2-4 meters

Tube 1:

Lithology → granules 2-4 mm, very coarse sand to very fine sand, silt, clay. Very high clay and silt content. ≈80 percent clay and silt, ≈5 percent granules 2-4 mm, ≈15 percent very coarse sand to very fine sand. As we drilled deeper, the sample fined a little, and then became coarser. ≈20 percent pebbles 4-64mm, granules 2-4mm, ≈40 percent clay and silt, ≈40 percent very coarse sand to very fine sand. Note: Only recovered 19½ inches for tube 1. About 50 percent of the sample is wet. Subrounded to subangular grains, poorly sorted.

10/2/09 YPG FT BH SS 12A

Drive 2: 2-4 meters

Tube 2:

Lithology → granules 2-4mm, very coarse sand to very fine sand, silt, clay. ≈50 percent clay and silt, ≈10 percent granules 2-4mm, ≈40 percent very coarse to very fine sand. Note: Recovered 20 inches for tube 2. Tube 2 is ≈60-70 percent dry. Subrounded to subangular grains, poorly sorted.

10/2/09 YPG FT BH SS 12A
Drive 3: 4-6 meters
Tube 1:

Lithology → granules 2-4 mm, very coarse sand to very fine sand, silt, clay. ≈ 80 percent clay and silt. ≈ 10-20 percent granules 2-4 mm, very coarse sand to very fine sand. Note: Recovered 29½ inches for tube 1. ≈ 80-90 percent of sample tube 1 is dry or a little damp. Subrounded to subangular grains, poorly sorted.

10/2/09 YPG FT BH SS 12A
Drive 3: 4-6 meters
Tube 2:

Lithology → About the top 4½ inches of sample is very coarse sand, granules 2-4 mm, and a few pebbles 4-64 mm. ≈ 70 percent very coarse to very fine sand, ≈ 20 percent pebbles 4-64 mm and granules 2-4 mm, ≈ 10 percent clay and silt. Hit a small sand lense, only about 3 inches thick. (Depth @ about 5 meters 8½"). Sample reverts back to being mostly clay and silt. ≈ 80 percent clay and silt, ≈ 20 percent medium sand to fine sand. Note: Had to stop sampling on account of water pump breaking again. Recovered 10 inches for sample tube 2. ≈ 50 percent of it was dry. Stopped sampling at a depth of 5.48 meters, or 17.9'
Subrounded to subangular grains, poorly sorted.

Total depth of bore hole 12A is 100.72'

10/29/09 YPG FT BH SS 11

Drive 1: 0-2 Meters

Tube 1:

Lithology → clay rich. Granules 2-4mm to clay. ≈ 40 percent clay and silt, ≈ 30 percent very coarse sand to very fine sand, ≈ 30 percent granules 2-4mm. Recovered 25 ½" of dry sample. No wet sample.

Note: Using a new tactic, using a wax lubricant to help with intrusion and extrusion of the sample. We are also using a sample tube "Button Bit" with the Aqualock to drill down for sampling. We are advancing the sampler ahead of the drill casing, meaning that the casing is not attatched to the drill. The sampler can rotate without the casing rotating with it. We did this in hopes that the sampling would go faster. It did to some extent. The button bit was used to prevent our other drill sampler shoes from being destroyed by the excess use in the conditions, and to possibly help with speed. We found that the wax lubricant and the button bit were not any more effective than the conventional manner in which we use the Aqualock. With this tactic we did not flush water down the hole in hopes that samples would not be as wet. It seemed to work. However, with the absence of water the sampler Button Bit would become very hot. Even after the sample was extruded from the sampler it was warm to the touch. Later, starting about Drive 3, tube 1, I noticed a white coloration in the samples, mostly around the outside of the sample. I observed the samples and concluded that it was native to the ground. I asked Tony if heat could be a factor in creating a white ring. He said yes, but didn't think the white coloration was due to heat.

10/29/09 YPG FT BH SS 11

Drive 1: 0-2 Meters

Tube 2:

Lithology → More clay rich than tube 1. ≈70-80 percent clay and silt, ≈20 percent very coarse sand to very fine sand. Subangular grains. Only 9" of recovery for tube 2. All of it was dry. Poorly sorted material

10/29/09 YPG FT BH SS 11

Drive 2: 2-4 meters

Tube 1:

* started to segregate wet and dry samples *

Lithology → Very clay rich. ≈ 80 percent clay and silt, ≈20 percent very coarse sand to very fine sand. Subangular grains. Tough to drill through. Recovered 19½" for tube 1. (6" is wet, 12½" is dry) Drive 2, tube 1(wet) goes on the bottom side of drive 2, tube 1(dry). Poorly sorted material.

10/30/09 YPG FT BH SS 11

Drive 2: 2-4 meters

Tube 2:

Lithology → samples are very clay-rich. ≈ 80 percent clay and silt, ≈20 percent very coarse sand to very fine sand. Observed very few granules 2-4mm, maybe 1 or 2. Subangular grains. Poorly sorted material. Recovered 35½" of sample. (11½" wet, 24" dry) Note: Because some samples are wet and some are dry they are in a different order in the tubes that do not coincide with the correct stratigraphic layering. Bottom Line... it is going to be a jigsaw putting them back in the correct order. But, Never fear, here is a key. These are in order from Top to Bottom. Youngest sediment at the Top, oldest sediment at the bottom. →

1" wet, 1½" wet, 2" dry, 8" dry, 6" dry (put wax inside aqualock in between piston and the valve) 1½" wet, 2" dry, 4" wet, 2" wet, 3" dry, 1½" wet.

Note: This means that 1" of wet sample is at the very top of the sample tube. The next one that was taken was 1½" of wet sample. It was also placed in the "wet" tube just below the first 1" of wet sample. The next sample was 2" of dry material. It was placed in the dry tube. Next, 8" of dry sample was taken and placed just below the 2" of dry material. etc.

Note: Aqualock got hung up on the casing. Had to use a significant amount of vibration to come loose. Probably why we lost some sample. Another explanation is that the clay is so hard and brittle that it is easily dislodged.

10/30/09 YPG FT BH SS 11

Drive 3: 4-6 meters

Tube 1:

* No more wax in sampler *

Lithology → High clay content. ≈ 80 percent clay and silt, ≈ 10 percent very coarse sand to very fine sand, ≈ 10 percent granules 2-4mm. Whitish, chalky coloration of parts of the sample. Looks almost like salt. Some of it is granular. Put some in my mouth, - felt like clay. I believe some of it is quartz. Possibly pulverized by the drilling vibration and rotation. Also, kind of rusty reddish brown tint to some of it. Getting a little coarser now. ≈ 80 percent clay and silt, ≈ 10 percent very coarse sand to very fine sand, ≈ 10 percent granules 2-4mm and pebbles 4-64mm. Sample very dry and brittle. Last 8" of sample I saw small specs of green or blue minerals. Recovered 28" for this tube. (24½" dry, 3½" wet) →

1½" wet, ∅, 1" dry, 5½" dry, 2" wet, 10" dry, 8" dry.
Note: Getting much better samples as far as moisture content goes, much drier. Not a whole lot faster, but drier and better recovery.

10/30/09 YPG FT BH SS 11
Drive 3: 4-6 meters
Tube 2:
Lithology → Predominantly clay. ≈75 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand, 5 percent granules 2-4 mm. White, salt looking chalky coloration mineral, possibly evaporite, in some of the samples. Note: some samples may have a black indention where it was pushed against the piston. As we go deeper in the sample it seems to become a little more coarser.
About the same as above but with several 4-64 mm pebbles. ≈ 70 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand, ≈ 10 percent granules 2-4 mm and pebbles 4-64 mm. Poorly sorted. Subangular grains. Recovered 24½" for tube 2. (17½" dry, 7" wet). ∅, 1½" dry, 1½" wet, 3" dry, 1" wet, 5" dry, 3" dry, 1" wet, 1" wet, 5" dry, 1" wet, 1½" wet.

10/31/09 YPG FT BH SS 11

Drive 4: 6-8 meters

Tube 1:

Lithology → Predominantly clay. Observed quartz granules 2-4mm. ≈ 75 percent clay and silt, ≈ 5 percent granules 2-4 mm, ≈ 20 percent very coarse sand to very fine sand. More whitish coloration, not much throughout the sample, ≈ 3-5mm parts. Samples are getting more clay-rich. ≈ 80 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand. Seems to be a slight fining of sediment. The last 3" of wet sample seemed to have more of the white salty-looking material. Looked like some of it was quartz. It was a little damp and started to fall apart easier than usual. Inside it looked and felt more fluffy. Like it wasn't packed as much. Possible that the more white material there is the less cohesive it is. Also, noticed some more of the small greenish blushish specs. Not many; believed Sediment was poorly sorted with subangular grains. to be chlorite.

Recovered 31" for tube 1. (8" wet, 23" dry).

6" dry, 2" wet, 8" dry, 2" wet, 4" dry, 1" wet, 5" dry, 3" wet.

Note: Joe mentioned this drill run was easier than usual. Although, the sampler was closer to the casing, possibly making it easier to drill.

10/31/09 YPG FT BH 55 11

Drive 4: 6-8 meters

Tube 2:

Lithology → ≈ 70 percent clay and silt, ≈ 30 percent granules 2-4 mm, very coarse sand to very fine sand. A little coarser than the end of the last tube. Joe mentioned this run was easier to drill than usual too. More white material, some granular form, some not. Put some in my mouth and it felt like clay. Also felt some crystals. Possibly pulverized quartz. Observed more chlorite. No pebbles in the sample, just granules 2-4 mm.

Note: The head on the sampler broke. Had to stop sampling. Putting in a well. Subangular grains, poorly sorted. Recovered 7" for tube 2. (2" wet, 5" dry).

Stopped sampling at a depth of 7.28 meters, or 23.8'

Total depth of bore hole 11 is 100.37'

11/3/09 YPG FT BH SS 10½

Drive 1: 0-2 meters

Tube 1:

Lithology → Very coarse. ≈ 30 percent pebbles 4-64 mm and granules 2-4 mm, ≈ 40 percent very coarse sand to very fine sand, ≈ 30 percent clay and silt. subangular grains, poorly sorted. After a depth of about 19" the sediment begins to fine. From there it is ≈ 60 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand, ≈ 20 percent granules 2-4 mm and pebbles 4-64 mm. The pebbles have a black coloration to them. observed very few, very small grains of what appears to be quartz. The samples are hard, dry, and if not careful very crumbly. Recovered 29½" for tube 1. (26½" dry, 3" wet). 6½" dry, 5" dry, 2" wet, 3" dry, 5" dry, 5" dry, 2" dry, 1" wet.

Note: No wax was used inside the sampler. Our technique changed once again. We would sample down maybe 2 meters, take the sampler off, put on the big casing with a solid face bit and drill down to the depth where the sampler was. We then removed the big casing and proceeded to take samples with the sampler. No casings were in the hole while sampling. Hoping to be slighly faster and not have clay wedged in between the casing and the sampler, bogging it down.

11/3/09 YPG FT BH SS 10½

Drive 1: 0-2 meters

Tube 2:

Lithology → Sediment starting to fine a little bit. ≈60 percent clay and silt, ≈30 percent very coarse sand to very fine sand, ≈10 percent granules 2-4mm and pebbles 4-64mm. Observed what appeared to be grains of quartz, very small and very few of them. Black colored granules and blotchy white coloration.

Sediment starts to fine slightly more. ≈70 percent clay and silt, ≈20 percent very coarse sand to very fine sand, ≈10 percent granules 2-4mm. Starting to see a slight fining of sediment. More blotchy white coloration. Also, Bronze colored "pipe dope" contamination on outside of a small sample. The last 1" of the sample has a reddish tint to it. Almost like a red sandstone along with black granules and quartz grains. Throughout the samples I observed light pinkish pebbles and grains. I believe it to be the mineral of Potassium Feldspar from erosion of the nearby mountains. Recovered 26" for tube 2. (21½" dry, 4½" wet). 1" dry, 1½" wet, 3½" dry, 5" dry, 1" wet, 3½" dry, 4½" dry, 4" dry, 1" wet, 1" wet. Poorly sorted sediment, subangular grains.

11/3/09 YPG FT BH SS 10½

Drive 2: 2-4 meters

Tube 1:

Lithology → Poorly sorted subangular grains. Predominantly clay. ≈ 70 percent clay and silt, ≈ 20 percent very coarse to very fine sand, ≈ 10 percent granules 2-4 mm, pebbles 4-64 mm. As we drilled a little bit deeper the samples become even more clay rich. ≈ 80 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand, granules 2-4 mm. Observed more of the pinkish mineral (potassium feldspar), blotchy white material, black minerals. Samples are becoming harder to obtain. It seems we cannot drill down as easily. Seems...we can only drill down about 3", or so, at a time. As we drill deeper it seems to coarsen a bit. ≈ 70 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand, ≈ 10 percent granules 2-4 mm, pebbles 4-64 mm. Recovered 27½" for tube 1. (14½" dry, 13" wet)

3½ wet, 2½ dry, 2½ dry, 1" wet, 1" dry, 2" wet, 2" dry, 1" dry, ½" dry, 2" wet, 2" wet, 4" dry, 2½" wet, 1" dry.

11/4/09 YPG FT BH SS 10½

Drive 2: 2-4 meters

Tube 2:

Lithology → Sediment is very clay rich. Observed a white chalky material. It is harder to see color differences when the samples are dry and powdery. ≈ 80 percent clay and silt, ≈ 15 percent granules 2-4 mm, very coarse sand to very fine sand, ≈ 5 percent pebbles 4-64mm. Grains are subangular and poorly sorted. Throughout the samples I observed black, pink, green, gray, and translucent colored grains. About 11" down from the top of the sample the outside half of the sample is a white clay. The sample becomes slightly coarser the deeper we drill. ≈ 70 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand, ≈ 10 percent granules 2-4 mm, along with very few pebbles 4-64mm. Black streak of clay on outside of sample. There is also a black indentation on the end of the sample where the piston pushed against it.

Recovered 29½" for tube 2. (20½" dry, 9" wet)

1½" dry, Ø, 2½" dry, 1½" wet, 5" dry, 2" wet, 2" wet, 8" dry, 1" wet, 2" dry, 1½" wet, 1½" dry, 1" wet.

11/4/09 YPG FT BH SS 10½

Drive 3: 4-6 meters

Tube 1:

Lithology → Predominantly clay and silt, ≈ 80 percent clay and silt, ≈ 15 percent very coarse sand to very fine sand and granules 2-4 mm, ≈ 5 percent pebbles 4-64 mm. Subrounded to subangular grains, poorly sorted. Seldomly observe what appears to be biotite, quartz, and K-feldspar, along with chlorite. There is a white clay and a reddish colored clay too. Within some of the samples I observe grains that resemble salt, but they disentegrate easily into a powder when mashed, possibly an evaporite. Also observe a blotchy white clay within the samples. I can't see the (evaporite) crystals on the outside of the sampler simply because they get pulvarized. 23½" down from the top of the sample I do not observe any pebbles 4-64 mm. Few granules 2-4 mm. Fining of sediment. ≈ 80 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand along with few granules 2-4 mm. Recovered 31" of sample for tube 1. (27" dry, 4" wet) For the most part samples are dry and have good recovery. 2" dry, 6½" dry, 6" dry, 1" wet, 5½" dry, 1" wet, 1½" dry, 2" wet, 5½" dry.

11/4/09 YPG FT BH SS 10½

Drive 3: 4-6 meters

Tube 2:

Lithology → very clay-rich. ≈ 80 percent clay, ≈ 20 percent very coarse sand to very fine sand, granules 2-4mm. After extruding the samples from the sampler they are very warm, sometimes even hot. The samples are hard and brittle. 13½" down from the top of the sample to the end of the drive for tube 2 the drill had an easier time than usual drilling through the sediment. About 18½" down from the top of the sample I observed a few pebbles 4-64mm. Now, ≈ 80 percent clay and silt, ≈ 15 percent very coarse sand to very fine sand, granules 2-4mm. ≈ 5 percent pebbles 4-64mm. Black grains, K-spar, chlorite. It appears the samples are made up of mostly a white clay. Very hard and brittle. Subrounded to subangular grains, poorly sorted. At one point we easilly drilled down 14" but only recovered 2" of sample. It makes no sense why we did not get good recovery. We did not do anything different than previous times. Note: We started having problems with the drill rig water pump, but that would not have an affect on our sample recovery.

Note: It seems the local wildlife is against us too. Cyotes made off with our drill rig scrub brush.

Recovered 22½" for tube 2. (15" dry, 7½" wet).

ϕ, 5" dry, 4½" wet, 1" wet, 8" dry, 2" dry, 2" wet

11/4/09 YPG ET BH SS 10½

Drive 4: 6-8 meters

Tube 1:

Lithology → ≈ 80 percent clay and silt, ≈ 15 percent granules 2-4mm, very coarse sand to very fine sand, ≈ 5 percent pebbles 4-64mm. Significant amount of white clay. Black grains along with small amounts of quartz, K-feldspar, and chlorite.

Sediment fines just a little bit 6" from the top of the sample. ≈ 85 percent clay and silt, ≈ 10 percent very coarse sand to very fine sand, ≈ 5 percent granules 2-4mm. Observed blotchy white clay with reddish colored clay. 14" down from the top of the sample there is a significant coarsening of the sediment. We are also starting to reclaim some of previous samples. ≈ 60 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand, ≈ 20 percent granules 2-4mm and pebbles 4-64mm. Observed small amounts of quartz, pebbles 4-64mm of K-spar and possibly sodium feldspar, chlorite and black grains. Though the drilling is much easier it is harder to get them out of the sampler, probably due to the low-pressure of the drill rig water pump. Forced to use a hammer and beat the sediment out of the sampler. This destroys some of the sample. Samples a very hard and crumbly. Majority of the samples are dry. Frequently a black streak is left on the outside of the sample when being extruded. This can be a normal thing with clays. Poorly sorted, grains subrounded to subangular. Around 29½" down from the top of sample tube 1, at a depth of 21½' there is even more of a coarsening of sediment. ≈ 50 percent clay and silt, ≈ 30 percent very coarse sand to very fine sand, ≈ 20 percent granules 2-4mm, pebbles 4-64mm. Joe mentioned that it drilled very easily. This is the start of a sand bed. Awesome recoveries of samples, reclaiming sediment. Recovered 47½" for tube 1 cont... to 1A. (35" dry, 12½" wet) 1" wet, 5" dry, 2" wet, 6" dry, 4" wet, 11" dry, 6" dry, 2½" wet ... →

7" dry, (4½" dry in tube 1A), 1" wet. At a depth of about 21'5½" is where a sand bed begins.

11/5/09 YPG FT BH SS 10½

Drive 4: 6-8 meters.

Tube 2:

Lithology → Very sandy. ≈ 40 percent clay and silt, ≈ 40 percent very coarse sand to very fine sand, ≈ 20 percent granules 2-4mm and pebbles 4-64mm. Observed Biotite, quartz grains, pink grains (K-spar) chlorite. Hard to get samples out of sampler. First part of sample now is usually destroyed and crumbled. Grains are subrounded to subangular and poorly sorted. Very easy to drill. Samples become even coarser. , ≈ 30 percent clay and silt, ≈ 50 percent very coarse sand to very fine sand, ≈ 20 percent granules 2-4 mm and pebbles 4-64mm. Seeing larger quantities of grains as well as larger grains themselves. About 25" down from the top of the sample I observed the blotchy white clay along with significant amounts of evaporite material.

Now, ≈ 40 percent clay and silt, ≈ 50 percent very coarse sand to very fine sand, ≈ 10 percent granules 2-4mm and pebbles 4-64mm. Still easy drilling. Parts of the sample that come out of the sampler in tact are much easier to break apart than before. This is due to not as much clay and more sand. Getting awesome recoveries not seen before. Some of it due to reclamation of previous samples. Samples do not come out warm or hot anymore. Recovered 55½" for sample tube 2. (49" dry, 6.5" wet) High recoveries also due to the crumbly, unpacked nature of the samples when trying to get them out of the sampler.

11½" dry, 2½" wet, 11" dry, 6½" dry, 2" wet, 7" dry (end of tube 2)

(starting tube 2A) 13" dry, 2" wet.

11/5/09 YPG FT BH SS 10½

Drive 5: 8-10 meters

Tube 1:

Lithology → Samples are becoming less coarse. ≈70 percent clay and silt, ≈25 percent very coarse sand to very fine sand, granules 2-4mm, ≈5 percent pebbles 4-64mm. About 9" down from the top of the sample it is ≈60 percent clay and silt, ≈30 percent very coarse sand to very fine sand, ≈10 percent granules 2-4mm and pebbles 4-64mm. Sediment is poorly sorted and has subrounded to subangular grains. Samples are hard and brittle. The centers of the samples are more soft and have a tendency to break apart easier than the outside of the samples. Observed K-spar mineral, black grains along with Biotite, chlorite, and small amounts of quartz. There is not so much of the blotchy white clay, but there is still some present in the sample. It is easier to see the different colored clays and grains if the sample is damp or wet.

In part of the sample about 16" down from the top of the sample I found an odd pinkish-Brown pebble that I have not seen before. It is striated and grooved. It appears fiberous, but is not. It is also very hard. I believe it to be petrified wood.

The last 2" of the sample in tube 1 is very coarse and fell apart easily.

Recovered 53" for tube 1. (44" dry, 9" wet). High recovery to do possible reclamation of previous samples, and crumbled parts of samples that are not compacted.

5" dry, 3" wet, 12½" dry, 3" wet, 8" dry, 1" wet, 10½" dry, (end of tube 1)(start of tube 1A), 8" dry for tube 1A, 2" wet.

Sand bed ends at a depth of about 26' 4".

11/5/09 YPG FT BH SS 10½

Drive 5: 8-10 meters

Tube 2:

Lithology → very coarse sediment. Subrounded to subangular grains. ≈50 percent clay and silt, ≈40 percent very coarse sand to very fine sand, granules 2-4mm, ≈10 percent pebbles 4-64 mm. Lots of chlorite, Black, pink, gray, brown minerals along with quartz. Small spots of what appears to be an evaporite. White material transparent crystals within, very soft and is easily destroyed when mashed. Not much of the Blotchy white clay anymore. The grains and minerals are more distinct because there are more of them and they are bigger than before. A lot of the samples are crumbled when they exit the sampler due to us forcing them out with a hammer. Also, because the samples are more coarse they break apart a lot easier. There's becomes a slight fining of sediment.

≈ 65 percent clay and silt, ≈30 percent very coarse sand to very fine sand, granules 2-4 mm, ≈ 5 percent pebbles 2-4mm. The 11" after that was more difficult for the drill to go through.

More fining of sediment. ≈ 70 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand, ≈ 10 percent granules 2-4 mm. The bottom 11" of the sample was very hard to recover.

≈ 75 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand, ≈ 5 percent granules 2-4mm. The samples are coming out warm and sometimes even hot.

Recovered 36" for tube 2. (35" dry, 1" wet).

12" dry, 8½" dry, 1" wet, 3½" dry, 3" dry, 8" dry.

11/6/09 YPG FT RH 55 10½

Drive 6: 10-12 meters

Tube 1:

Lithology → Samples are becoming a little coarser. ≈ 60 percent clay and silt, ≈ 35 percent very coarse sand to very fine sand, granules 2-4 mm, ≈ 5 percent pebbles 4-64 mm. There is a medley of minerals and colors. Small quartz grains, K-spar (pink) white grains, chlorite, black grains, biotite, brown grains. Sediment is poorly sorted and grains are subrounded to subangular. Still having issues with getting samples out of the sampler. A significant amount of the samples are destroyed. This leads to a bias in the recovery rate because the samples are not completely packed. It is crumbled. Samples are usually hard on the outside and slightly softer on the inside due to extreme heat and pressure of the sample entering and exiting the sampler. There becomes a slight coarsening of sediment. ≈ 50 percent clay and silt, ≈ 40 percent very coarse sand to very fine sand, granules 2-4 mm, ≈ 10 percent pebbles 4-64 mm. Black streak of clay on outside of parts of the samples. Usually near the end of the sample that is a little wet or damp. Observed blotchy white clay. Observed a slight fining of sediment. , ≈ 60 percent clay and silt, ≈ 35 percent very coarse sand to very fine sand, granules 2-4mm, ≈ 5 percent pebbles 4-64mm. The sample came out hot.

The sediment fined a bit more. ≈ 70 percent clay and silt, ≈ 25 percent very coarse sand to very fine sand, granules 2-4mm, ≈ 5 percent pebbles 4-64mm. Very little blotchy white clay. Recovered 45½" for tube 1. (42" dry, 3½" wet) 0", 1½" wet, 13" dry, 1" wet, 7½" dry, 1" wet, 10" dry, 4½" dry, (end of tube 1)(start of tube 1A) 3½" dry, 3½" dry.

11/6/09 VPG FT BH SS 10½

Drive 6: 10-12 meters

Tube 2:

Lithology → samples becoming slightly coarser. Majority of the samples are torn apart/crumbled. ≈60 percent clay and silt, ≈ 30 percent very coarse sand to very fine sand, granules 2-4 mm, ≈ 10 percent pebbles 4-64 mm. Medley of grains and minerals. Quartz, K-spar (pink), chlorite, biotite, other feldspars (Sodium), black grains, grey colored grains. Sediment is poorly sorted and grains are subrounded to subangular. Still having trouble extruding samples. Samples are now coming out warm and/or cool. About 11" down from the top of the sample there is a little of the blotchy white clay. Sediment starts to fine slightly. ≈ 70 percent clay and silt, ≈25 percent very coarse sand to very fine sand, granules 2-4mm, ≈5 percent pebbles 4-64 mm. Unable to obtain last 7½" of the drive due to a valve malfunction on the sampler when trying to extrude the sample. There was sample in the tube but what sample was in there was shot out of the sampler like a potato out of a potato gun. The sample disentegrated. Recovered 27½" for tube 2. (27½" dry).

11" dry, 6" dry, 6" dry, 4½" dry.

11/13/09 UPG FT BH SS 10½

Drive 7: 12-14 meters

Tube 1:

Lithology → ≈70 percent clay and silt, ≈25 percent very coarse sand to very fine sand, granules 2-4 mm, ≈5 percent pebbles 4-64 mm. Grains subrounded to subangular. Observed blotchy white clay along with a medley of grains and colors. White grains, black, grey, a few pink grains, quartz, chlorite.

Note: Fixed water valve on the sampler, samples are coming out in fact. Samples are hard and brittle. About 17 inches down from the top of the sample, it becomes very clay-rich. ≈90 percent clay and silt, ≈10 percent very coarse sand to very fine sand. Still seeing the blotchy white clay material. Could only observe black colored grains in the sample. Note: Had a very difficult time getting the sample out of the sampler, most likely due to the high clay content. Sample is hard and did not break apart very easily. Seemed to drill easy. Recovered 25 inches for tube 1. (21½" dry, 3½" wet)

1½" wet, 8" dry, 7½" dry, 2" wet, 6" dry.

11/13/09 YPG FT BH 55 10½

Drive 7: 12-14 meters

Tube 2:

Lithology → First few inches of sample at the top of tube 2 came out like a cow pie. The valve on the sampler was stuck open. water was also present in the hole. Could not recover the first couple inches. About the first 7 inches down from the top of the sample it is very clay rich. ≈ 90 percent clay and silt, ≈ 10 percent very coarse sand to very fine sand. Observed blacks grains and minerals. The bottom 18½ inches of the sample is slightly coarser but not much. ≈ 85 percent clay and silt, ≈ 15 percent very coarse sand to very fine sand. The drilling seems to be going fairly easy. Not getting very good recovery. Having more problems with the water pump and valves. Going to put a T-valve on the sampler. Grains are subangular to subrounded.

Recovered 25½ inches for tube 2. (22" dry, 3½" wet).

Ø, 1" dry, 2" wet, 4" dry, Ø, 1½" wet, 17" dry

11/14/09 YPG FT BH 55 10½

Drive 8: 14-16 meters

Tube 1:

Lithology → Subangular to subrounded grains.

≈ 80 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand. Different colored grains and minerals. Black, grey, and pink grains, chlorite also present. Seems to be getting slightly coarser.

≈75 percent clay and silt, ≈ 25 percent very coarse sand to very fine sand. Pink, black, white, and grey colored grains and minerals. Noticed some blotchy white clay, along with chlorite. Becomes a little coarser ~~yet~~.

≈ 70 percent clay and silt, ≈ 30 percent very coarse sand to very fine sand. About 22 inches down from the top of the sample I saw more of a blotchy white coloration. ≈ 80 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand. About 29 inches down from the top of the sample it is ≈ 70 percent clay and silt, ≈ 30 percent very coarse sand to very fine sand, and granules 2-4 mm. Again; different colored grains and minerals. Drilled fairly easy. Recovered 39½ inches for tube 1. (34" dry, 5½" wet)

1½" wet, 6½" dry, ½" wet, 5½" dry, 3" wet, 5" dry, 7" dry, ½" wet, 5" dry, 5" dry.

11/14/09 YPG FT BH 55 10½

Drive 8: 14-16 meters

Tube 2:

Lithology → ≈ 75 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand, ≈ 5 percent granules 2-4mm. Lots of different colored grains and minerals. Pink, green, grey, black, and some quartz. Subrounded to subangular grains. The inside of the samples fall apart somewhat easily. The outside of the samples are hard and brittle.

There is a slight coarsening of sediment. ≈ 60 percent clay and silt, ≈ 35 percent very coarse sand to very fine sand, granules 2-4 mm, ≈ 5 percent pebbles 4-64mm. Drilling is about the same, still fairly easy. About 12 inches down from the top of the sample the sediment fines. ≈ 85 percent clay and silt, ≈ 10 percent very coarse sand to very fine sand, ≈ 5 percent granules 2-4mm. About 24 inches down from the top of the sample it coarsens slightly. ≈ 75 percent clay and silt, ≈ 25 percent very coarse sand to very fine sand. About 30 inches down from the top of the sample there is a great coarsening. ≈ 55 percent clay and silt, ≈ 40 percent very coarse sand to very fine sand, granules 2-4 mm, ≈ 5 percent pebbles 4-64mm. Quartz and chlorite, along with other grain colors and minerals. Black, green, pink, gray, white. Center of samples fall apart easily and don't seem to be as packed. Very powdery. Subangular to subrounded grains. Drilling fairly easy. Note: It makes no sense because it should be much harder drilling in higher clay contents. Not like we are doing anything different. There is no rhym or reason to it.

Recovered 36½" for tube 2. (30½" dry, 6" wet)

Ø, 1" wet, 5" dry, 1" wet, 5" dry, 1" wet, 6½" dry, 4½", 6" dry, 3" wet, 3½" dry.

Another Sand bed that starts at a depth of about 52'1" and ends at a depth of about 52'11."

11/16/09 YPG FT BH 85 10½

Drive 9: 16-18 meters

Tube 1:

Lithology → The top 3 inches of sample are coarse. ≈55 percent clay and silt, ≈40 percent very coarse sand to very fine sand, granules 2-4mm, ≈5 percent pebbles 4-64mm. After that the sediment fines. ≈85 percent clay and silt, ≈15 percent very coarse sand to very fine sand. Observed black grains, cannot see much more than that. Some blotchy white clay material. Samples are hard all the way through and still somewhat brittle. About the bottom 12½ inches of sample it is very clay-rich. ≈90-95 percent clay and silt, ≈5-10 percent coarse sand to fine sand. Very hard and compact. Hard to break apart. Grains are subrounded.

Drilled fairly easy. Recovered 28½" for tube 1. (11" wet, 17½" dry).

3" dry, 1" wet, 4" dry, 2½" wet, 5½" dry, 5" dry, 4" wet, 3½" dry.

11/16/09 YPG FT BH SS 10½

Drive 9: 16-18 meters

Tube 2:

Lithology → ≈ 90 percent clay and silt, ≈ 10 percent coarse sand to very fine sand. Observed chlorite along with pink grains and crystals that resemble an evaporite. Samples are very hard and compact. Subrounded grains, poorly sorted.

Sediment becomes a little coarser.

≈ 80 percent clay and silt, ≈ 20 percent very coarse sand to very fine sand. There is a medley of different colors of grains and minerals. Black, grey, pink, a few white, and green, which is chlorite.

Note: It seems that the optimum for sample recovery at this time is drilling down about 4"-6" at a time. Very slow going. Recovered 18½" for tube 2. (17" dry, 1½" wet) 1½" wet, 6" dry, 4" dry, 5" dry, 2" dry.

11/16/09 YPG FT BH SS 10½

Drive 10: 18-20 meters

Tube 1:

Lithology → ≈ 90 percent clay and silt, ≈ 10 percent coarse sand to very fine sand. Observed evaporite crystals and chlorite, along with Black and pinkish grains. About 11½ inches down from the top of the sample it becomes slightly coarser. ≈ 85 percent clay and silt, ≈ 15 percent coarse sand to very fine sand. Still see pink, black and green grains.

grains. Not very good recovery for this tube. Recovered 16 inches of dry sample for tube 1, no wet. Drilled fairly easy

11/17/09 YPG FT BH SS 10 ½

Drive 10: 18-20 meters

Tube 2:

Lithology → ≈ 85 percent clay and silt, ≈ 15 percent very course sand to very fine sand. Pink, grey, and black grains along with white evaporite crystals which dissolves easily in water. Chlorite also present. Blotchy white clay. About 8 1/2 inches down from the top of the sample the sediment fines slightly. ≈ 90 percent clay and silt, ≈ 10 percent medium sand to very fine sand.

Grains are subrounded. Samples are hard and brittle on the inside and outside. Recovered 28 inches for tube 2. (26" dry, 2" wet) Drilled fairly easy.

4½" dry, 4" dry, 4" dry, 4½" dry, 5" dry, 4" dry, 2" wet.

11/17/09 YPG FT BH SS 10½

Drive 11: 20-22 meters

Tube 1:

Lithology ⇒ very clay-rich. ≈ 90 percent clay and silt, ≈ 10 percent very coarse sand to very fine sand. Subrounded grains. Drilling fairly easy. Observed black grains, couldn't see much else. About 20½" down from the top of the sample the inside of the sample is soft and brittle, almost powdery. Seeing a little bit of evaporite crystals. Recovered 27 inches for tube 1. (18½" dry, 8½" wet)
1" wet, 4½" dry, ½" wet, 4" dry, 2½" wet, 3½" dry, 1" wet, 3½" dry, 3½" wet, 3" dry.

11/17/09 YPG FT BH SS 10½

Drive 11: 20-22 meters

Tube 2:

Lithology → very clay-rich. ≈ 90 percent clay and silt, ≈ 10 percent very coarse sand to very fine sand. A few black grains, not much else. Poorly sorted, subrounded grains. Outer parts of sample are hard and brittle. Inner part is soft, brittle, and a little bit powdery. Small amounts of evaporite looking crystals. I believe the reason the inside of the samples are powdery is because they are drier and because the silt amount is increasing. About 8½ inches down from the top of the sample the very coarse sand fades out. ≈ 90 percent clay and silt, ≈ 10 percent coarse sand to very fine sand. Recovery very poor for this tube. Recovered 15 inches for tube 2. (10½" dry, 4½" wet)

4½" dry, 4" dry, 2" dry, 4½" wet.

Note: Progress going slow. Hard to keep the drill rod clean. Decided to run casing and leave it in the hole, then run drill rod inside of it. Will speed up drilling process. As a result, some water got in the hole. Some samples might be wetter than usual. Drilled fairly easy, do not know why recovery is so poor.

11/17/09 YPG FT BH 55 10½

Drive 12: 22-24 meters

Tube 1:

Lithology → Predominantly clay, ≈ 90 percent clay and silt, ≈ 10 percent coarse sand to very fine sand. About 5½ inches down from the top of the sample it becomes a little bit coarser. ≈ 85 percent clay and silt, ≈ 10 percent very coarse sand to very fine sand, ≈ 5 percent granules 2-4 mm. Subangular to subrounded grains. Observed chlorite along with pink and black colored grains and minerals. Samples are hard on the outside and soft and powdery on the inside. About 11½ inches down from the top of the sample observed a little bit of white evaporite material. Starting to see a little more silt in the samples. This is related to the powdery texture.

Recovered 24 inches for tube 1. (8½" dry, 15½" wet)
5½" wet, 1" wet, 5" dry, 5" wet, 2½" wet, 3½" dry, 1½" wet.

11/18/09 VPG FT BH SS 10½

Drive 12: 22-24 meters

Tube 2:

Lithology → very clay-rich. ≈ 90-95 percent clay and silt, ≈ 5-10 percent medium sand to very fine sand. Inside of samples are solid and hard along with the outside. Some blotchy white clay. Drilled easy, but getting poor recovery. There is some water in the hole and some samples are coming out like a cow pie, others we just are not getting. About 13½" down from the top of the sample it becomes a little coarser. ≈ 85 percent clay and silt, ≈ 15 percent very coarse sand to very fine sand, granules 2-4mm. Black grains, could not see much else. Very wet, yet samples are hard all the way through.

Recovered 19 inches for tube 2. (9" dry, 10" wet)

5½" dry, 2½" wet, 3½" dry, 2" wet, 5½" wet.

11/18/09 4PG FT BH SS 10½

Drive 13: 24-26 meters

Tube 1:

Lithology → clay-rich. ≈ 90 percent clay and silt, ≈ 10 percent medium sand to very fine sand. Drills fairly easy. Center of samples are somewhat soft and fall apart easily. Very hard to recover any sample at all. Note: Having problems now with the valve inside the sampler. Going to try different strategy with the push-rods. Don't know why it is doing this. Recovered 11 inches for tube 1. (5" dry, 6" wet)
1" wet, 5" dry, 1" wet, 4" wet.

11/18/09 YPG FT BH SS 10½

Drive 13: 24-26 meters

Tube 2:

Lithology → very clay-rich. ≈90-95 percent clay and silt, ≈5-10 percent medium sand to very fine sand. Soft and brittle on the inside of some of the sample. Silt content increasing, powdery. About 10 inches down from the top of the sample it becomes slightly coarser. ≈80 percent clay and silt, ≈15 percent very coarse sand to very fine sand, granules 2-4 mm, ≈5 percent pebbles 4-64 mm. The pebbles are pink colored. Observed black grains, could not see much else. About 20 inches down from the top of the sample the sediment starts to fine again. ≈90 percent clay and silt, ≈10 percent coarse sand to very fine sand. Observed evaporite deposits. Sediment is powdery and somewhat soft on the inside, hard on the outside. About 29 inches down from the top of the sample it coarsens a little. ≈80 percent clay and silt, ≈15 percent very coarse sand to very fine sand, ≈5 percent granules 2-4 mm. Saw black, white, pink, green colored grains and minerals. The bottom 6 inches of the sample returns to ≈90 percent clay and silt, ≈10 percent coarse sand to very fine sand. Drilled easy.

Reclaiming some sample. Recovered 43 inches for tube 2. (30" dry, 13" wet)

7" wet, 3" dry, 1" wet, 9" dry, 2" wet, 7" dry, 1½" wet, 6½" dry, 1½" wet, 4½" dry.

11/19/09 YPG FT BH SS 10½

Drive 14: 26-28 meters

Tube 1:

Lithology → ~90 percent clay and silt, ~10 percent medium sand to very fine sand. Sample is very hard, but kind of powdery in the center. Observed some evaporite crystals, but not many. Samples are hard to get out of the sampler. Drilled easy. Recovered 24 inches for tube 1. (20" dry, 4" wet)

2½" dry, 2½" wet, 4" dry, 7" dry, 1½" wet, 4½" dry, 2½" dry

11/19/09 4PG FT BH SS 10½

Drive 14: 26-28 meters

Tube 2:

Lithology → ≈90-95 percent silt and clay, ≈5-10 percent medium sand to very fine sand. Sample is soft and crumbly, (Powdery). The silt content has increased but very hard to distinguish between the percentages of clay versus silt, especially when the samples are dry. About 3½ inches down from the top of the sample the sediment becomes hard and compact. Less silt, more clay. Samples are still coming out damaged and broken. About 26 inches down from the top of the sample I observed some blotchy white clay and that is about it. Drilled easily. Recovered 33½ inches for tube 2 (13" dry; 20½" wet)
3½" wet, 2½" wet, 7" dry, 13" wet, 1½" wet, 6" dry.

11/19/09 YPG FT BH SS 10½

Drive 15: 28-30 meters

Tube 1:

Lithology → very clay and silt rich. ≈ 90-95 percent clay and silt, ≈ 5-10 percent medium sand to very fine sand. About the top 14½ inches of sample I observed a blotchy white clay, but no evaporite crystals. No distinguishable grain colors. Easy to drill. Samples are hard on the outside, relatively soft on the inside, a little powdery because of the silt. About 14½ inches down from the top of the sample it becomes a little coarser, but not very much. observed chlorite along with black and brown grains and minerals. Samples are becoming hard all the way through. Drilled easily.

About the last 2 inches of the sample for tube 1 the colored grains disappear. ≈ 95 percent clay and silt. Hard and compact. Blotchy white clay along with white evaporite crystals.

Recovered 27½ inches for tube 1. (22½" dry, 5" wet) 2" wet, 6" dry, 1" wet, 5½" dry, 5" dry, 1" wet, 5" dry, 1" wet, 1" dry

11/19/09 YPG FT BH 55 10½

Drive 15: 28-30 meters

Tube 2:

Lithology → very clay and silt-rich, ≈ 90-95 percent clay and silt, ≈ 5-10 percent medium sand to very fine sand. White evaporite crystals. Drilled easily, samples hard and compact all the way through. Small amounts of the samples come out crumbled and damaged. Used a fairly small amount of water for Bore Hole 10½ compared to other Bore Holes. Used around 1,000 gallons of water. Recovered 22 inches for tube 2, all dry.
4½" dry, 7" dry, 10½" dry.

Note: We are now at a depth of 100 feet. The last tube we only had to drill down 32 inches to reach 100 feet. We are 7½ inches off from where we thought we were. Most likely as we measured the rods when we were in the hole we must have measured in a slightly different spot, or not been completely on the bottom of the hole. This probably occurred throughout the entire hole in very small increments.

Note: On a small scale (describing about 6" - 12" at a time) the sediment is poorly sorted. But, if we step back and observe the whole 100 foot bore whole on a large scale the sediment is fairly well sorted, with gradational changes of the sediment.

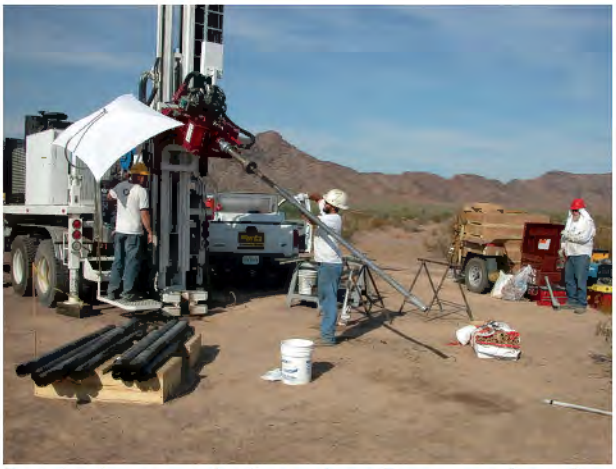
Sampled all of bore hole 10½.

Well 10½ has a total depth of 99.9'

Appendix C—Pictures During Drilling

KGS 2009 US Exploration S-27 CRS sonic drilling machine at JTTR from August to December 2009.

Two drillers (Tony Wedel and Joe Anderson) with site geologist (Owen Metheny) prepare to retrieve sample as Principal Investigator (Rick Miller) looks on.



Retrieving sample from AquaLoc sampler after barrel has been removed from hole and angled for easier extraction.

Retrieving sample.

Drillers and geologist confer and study sampling approach.

6x6 International truck transporting sonic drill.

Using hydraulic clamps to break tool joints.

Drill site.

Drilling operations in JTTR at JERC1 on YPG.

Dump mast raised and drill shut down for day under YPG 10-hour-a-day operating limit.

Well depths at YPG

* depths measured in tenths.

Corner SE	101.2'
Well 1	100.8'
Well 1B	100.8'
Well 2	100.3'
Well 3	100.75'
Well 4	103.1'
Well 4B	102.9'
Center South	102.65'
Well 5	102.9'
Well 6	103.1'
Well 7	99.5'
Corner SW	102.87'
Outside South	No casing. Too Muddy.
Corner NW	100.56'
Well 14	98.5' Muddy, well had already been logged.
Well 13	100.95'
Well 12A	100.72'
Center North	100.85'
Well 11	100.37'
Outside North	101.25'
Well 10½	99.9'
Well 9A	100.5'
Well 8½	100.35'
Well 8	88.85'
Corner NE	101.15'

Appendix E—DGPS-rtk Coordinates of Each Well

Well	Easting	Northing
Corner NE	749932.686m	3704858.514m
Well 8	749879.042m	3704886.251m
Well 8.5	749860.875m	3704895.514m
Well 9A	749820.384m	3704916.648m
Well 10.5	749780.572m	3704938.262m
Well 11	749759.031m	3704948.948m
Well 13	749680.461m	3704990.074m
Well 14	749641.728m	3705009.792m
Well 7	749575.310m	3704914.29m
Well 4B	749674.140m	3704821.278m
Center South	749673.987m	3704816.970m
Well 3	749725.796m	3704818.227m
Well 4	749705.820m	3704867.368m
Well 2	749762.564m	3704791.319m
Outside South	749548.536m	3704626.676m
Corner SE	749847.491m	3704725.500m
Well 1	749812.862m	3704786.637m
Well 1B	749781.012m	3704739.994m
Well 5	749655.385m	3704871.544m
Well 6	749619.716m	3704899.199m
Corner SW	749537.410m	3704904.321m
Corner NW	749639.729m	3705063.065m
Well 12A	749721.363m	3704968.715m
Center North	749778.449m	3704974.600m
Outside North	749914.329m	3705158.755m