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Results of the US Navy Geothermal Program Office 2010 Drilling Project at Hawthorne Army Depot, Nevada

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Keywords

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ABSTRACT

From September 3rd to September 23rd, 2010, the U.S. Navy Geothermal Program Office (GPO) drilled an intermediate depth (contract with Barbour Well, Inc.), geothermal exploration slim-hole on the eastern section of the Hawthorne Army Depot (HAD), Hawthorne, Nevada. Shallow temperature gradient hole (TGH) drilling by the GPO (contract with Dan's Water Well and Pump Service) in 2010 along the eastern margin of HAD identified a shallow outflow plume of hot water. The integration of TGH data with previous geologic mapping, shallow (0-500 feet depth) stratigraphy determined from TGH cuttings, plus gravity and magnetic data yielded a slim-hole drilling target northwest of the center of this TGH anomaly.

HAD-1 was drilled and completed to a depth of 3000 feet. Completion consisted of inserting capped tubing to total depth (TD) and filling with water, and then allowed to equilibrate for 90 days before the final temperature survey was acquired. While drilling, a total mud loss zone was encountered at 525 feet, and this was defined as a zone of high temperature flow based on the final temperature profile. A maximum temperature of 210° F was measured at 525 feet with a bottom hole of 182° F at 3000 feet. Based on the change in lithology at the 525 foot interval, there is strong evidence of a high temperature out-flow or up-flow zone at a shallow depth.

Introduction

During the past 10 years, the U.S. Navy Geothermal Program Office (GPO) has been actively pursuing a geothermal exploration program at the Hawthorne Army Depot (HAD) in Hawthorne, Nevada. In the past three years, this effort culminated in two phases of drilling with phase I resulting in HWAAD-3 and HWAAD-2A being drilled, and phase II drilling of HAD-1. Phase I drilling and previous work is summarized in the paper by Lazaro et al, 2010 GRC Transactions. The results of geophysical /geological assessments along with 2-meter probe survey data and 500 foot temperature gradient hole drilling and equilibrated temperature survey data defined a target area in the Eastern Magazine area (Figure 1). This paper will provide a summary of the drilling results of the intermediate geophysical test hole HAD-1 (phase II drilling).

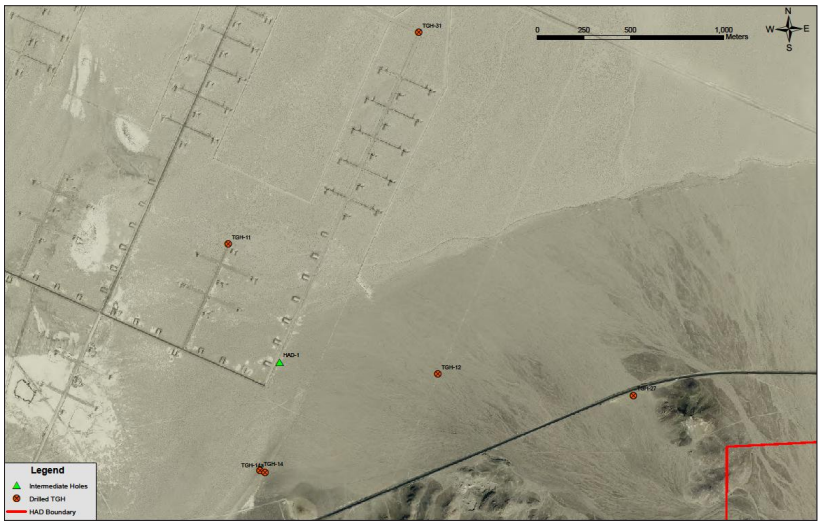

Figure 1. Location map of the Hawthorne Army Depot (HAD) with the boundary shown in red, and location of HAD-1 shown as green triangle (intermediate geophysical test hole).

Drilling and Completion

Drilling of HAD-1 began on September 3rd, 2010 (Figure 2), and the planned hole design and project incorporated drilling to a depth of 3000 feet, run geophysical logs, set capped tubing to bottom hole, fill with water, allow to reach thermal equilibrium and acquire an equilibrated temperature survey.

Figure 2. Drill Rig 77 on site at HAD-1, Hawthorne Army Depot, Hawthorne NV.

The drilling project began when a surface conductor (13⅜ inch pipe) was set and cemented to a depth of 115 feet. After the conductor was set, the large rotary Rig 77 (Barbour Well, Inc) was mobilized to the site and began drilling a 12¼ inch hole to 1222 feet. As drilling progress to a depth of 525 feet, a total loss zone was encountered, and an LCM (lost circulation material) pill was set to regain circulation (Figure 3). There was a change in lithology from sediments to meta-volcanics associated with this total loss which indicates a permeable zone separating these lithologic regions.

Drilling continued to 1222 feet and a mud loss zone was intercepted at 767 feet with a 40 barrel loss, but no other mud loss zones were encountered to 1222 feet. Lithology in this section varied from meta-volcanics below the loss zone at 526 feet to 1120 feet where the lithology changes to meta-rhyodacite. At a depth of 1222 ft, the 9⅝ inch casing string was set and cemented. After cement cured and the casing was reamed, drilling began and continued to 3020 feet (total depth, TD) with extra footage for fill. While drilling this section, the lithology changed at 1330 feet from meta-rhyodacite to quartz monzonite and remained in quartz Monzonite to the final depth (TD). No mud loss zones were encountered during this phase of drilling. A suite of geophysical logs (caliper, gamma ray, self potential, resistivity and temperature) were run is each section of open-hole from 100 feet to 1222 feet and from 1200 feet to 3020 feet. After the last open-hole log run was completed, 4½ inch capped tubing was set in the hole down to 3020 feet and filled with water.

The hole was allowed to reach thermal equilibrium, and after ninety days of heating up an equilibrated temperature survey was run in the hole to TD (Figure 4). This graph (Figure 4) summarizes the temperature data that was acquired for HAD-1 beginning with the mud in and out temperatures that were measured while drilling the hole. Also shown on the graph, are the temperature survey data from the shallow section (100 feet to 1222 feet) survey, the entire hole (0 feet to 3020 feet) that was surveyed before the capped tubing was set in the hole, and the last equilibrated temperature survey which was run inside the water filled capped tubing. The results from the final temperature survey (equilibrated) indicate a high temperature out-flow from a nearby or localized source. The 210° F measured at 525 feet and the profile of the temperature log suggest that there is a possible up-flow source of the hot fluids is in this same region of the HAD-1. Finding the source of this hot/geothermal fluid is the next step in the exploration process.

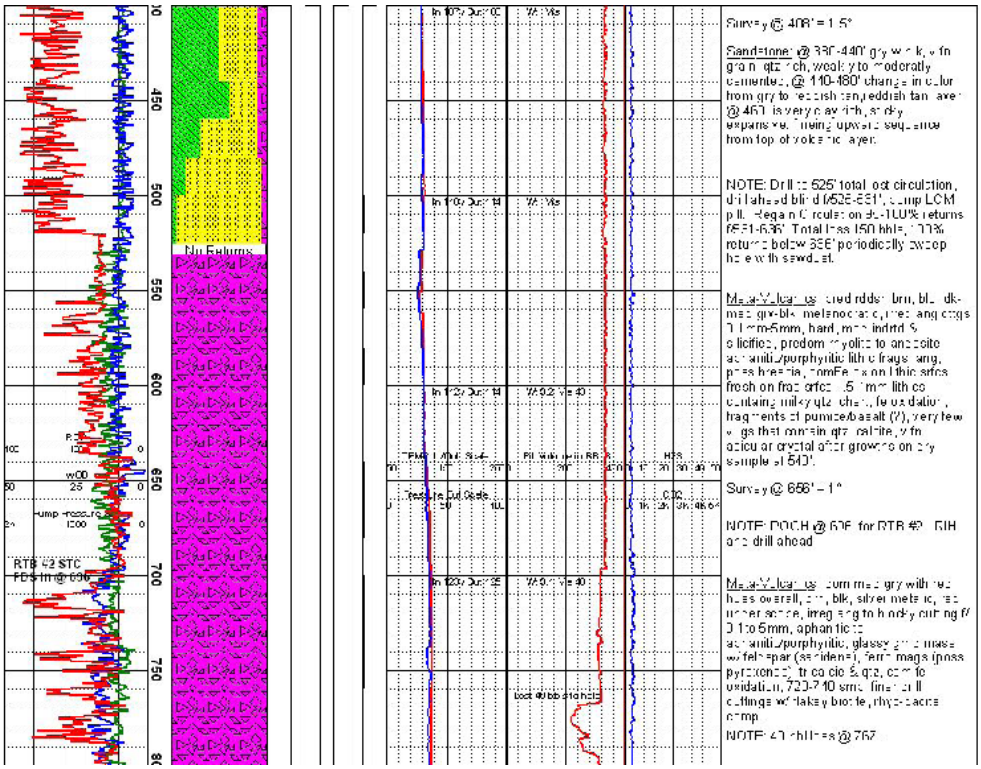

Figure 3. Lost circulation zone encountered at 525 feet.

Conclusions

The exploration drilling and geological/geophysical studies have established potential for a low to moderate geothermal resource at Hawthorne in both the Western area and the Eastern area of the depot. Finding the source of

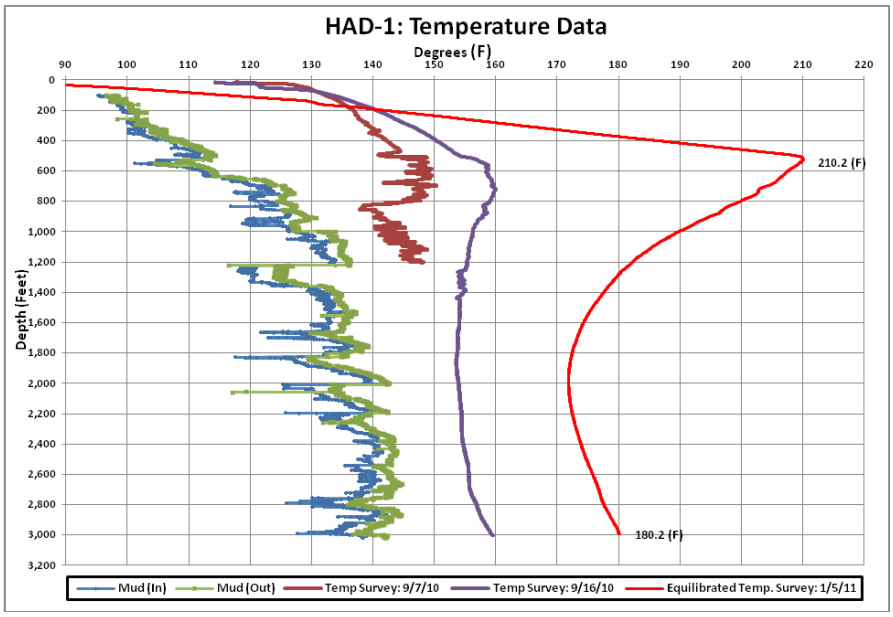

Figure 4. Drilling mud temperatures and temperature survey data for HAD-1.

these fluids and quantifying the possible resource potential is the plan for moving forward with this project area. Ongoing studies for this hole and the two western intermediate/deep test holes will include 3D modeling of fluid-inclusion stratigraphy (FIS) and wellbore petrographic and hydrothermal-alteration analysis to map and determine fluid types, major fault zones, mineralization and hydrothermal alteration of the subsurface lithology. This work should be in progress 3rd to 4th quarter of 2011. These studies and subsequent results along with integration of previous work will help provide a better understanding of the geothermal resource potential for this area.

References

Lazaro, Michael, et al, *United States Department of the Navy Geothermal Exploration Leading to Shallow and Intermediate/Deep Drilling at Hawthorne Ammunition Depot, Hawthorne, NV,* GRC Transactions, 2010.