LOW TEMPERATURE DRILLING TECHNIQUES FOR DIRECT APPLICATIONS

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ABSTRACT

The geothermal drilling one hears about most frequently is that of large oil rigs drilling for deep high-temperature resources. There is a vast resource yet untapped within shallower depths for direct heat applications. As a result, most geothermal drilling can be done using conventional drilling equipment with a few modifications. Most of the difference is in techniques such as drilling with water rather than mud so the porosity and permeability of the producing geothermal formation is not destroyed. The various techniques, equipment, and solutions to problems in geothermal drilling will be discussed in the following text.

INTRODUCTION

Drilling is a necessary part of geothermal resource development. There are conventional drilling methods from both the oil and gas industries and the water well industry which apply to geothermal drilling. The aspects that make geothermal drilling unique are: temperature, fracture dominated reservoirs, and to some degree, volume of flows.

REGULATIONS AND CLASSIFICATIONS

Prior to drilling, the appropriate regulations must be reviewed to determine well construction requirements and permitting requirements. Environmental restrictions governing fluid disposal must also be considered. These regulations will vary from state to state, as will the classification of the well, i,e. exploratory or production. The regulations which will apply are also a function of how the state regulatory agency classifies the geothermal resource, i.e, as a mineral, or water resource. The variations in the regulation and classification of geothermal wells are dependent on which state agency performs the regulatory function, the Oil and Gas commission, or the Water Resources agency

WELL COSTS

Well costs must be analyzed prior to drilling because of the significance of well cost to the total project. Well costs generally average 30% to 50% more than the same depth oil and gas or water because of regulations, governing construction, environmental constraints and larger hole size. Hole size and depth directly effect casing and cement costs. The impact of drilling on the project costs can be as much as 50% of the development costs. Therefore, it is critical that the drilling program consider anticipated drilling problems and incorporate good geothermal drilling practices. The following discussion addresses various geothermal drilling techniques that should be considered in any geothermal drilling program.

GEOTHERMAL DRILLING TECHNIQUES

Drilling geothermal wells involves no specialized equipment, but does involve using adequate standard equipment to contain and safely handle hot fluids. Regulations governing casing and drilling requirements are more stringent than for water wells to protect and minimize damage to the environment, usable groundwaters and surface property. Threaded casing is recommended rather than butt weld to provide better anchorage, greater strength and less chance of parted casing.

Geothermal regulations generally require all casings to be cemented solidly in place and do not allow drill and drive methods. Cements are critical for two reasons: 1) to prevent leakage to the surface, and 2) to prevent blowouts around the casing. Special cements have been developed to combat the severe lost circulation problems occurring while cementing, to prevent cement degradation from exposure to hot corrosive fluids, and to help insulate and reduce thermal losses during flow up the wellbore. A geothermal cement most widely used consists of Class G cement with 30-40% silica flour and perilite or gilsonite as additives. Test and field results indicate that the addition of silica flour will increase the cement strength and retard cement retrogression. The addition of perlite or gilsonite will lighten the weight of the cement and act as a bridge at zones of lost circulation.

Lost circulation, or loss of fluids to the formation, is a common problem in geothermal drilling, both during drilling and cementing, because of the highly fractured and permeable formations. Corrective measures for lost circulation during drilling include adding lost circulation materials to the drilling fluid to plug off the zone of loss, or setting a cememt plug at the zone of loss. When these methods fail, the more courageous drilling contractor will "dry drill", drill ahead without fluid returns to the surface, a method which increases substantially the risk of sticking the bit.

State requirements may specify some type of containment device while drilling below surface casing. If containment is not required, it is still advisable to be prepared to control hot flows. The containment device can be as simple as a gate valve to a more complex BOP stack containing double gate and bladder preventors. A flowline to the mud pit installed below the containment valve can help relieve pressures at the working surface during trips. To increase limited clearance for containment equipment, a pony substructure or a celler can be used. Permanent wellheads, too, can vary from a simple gate valve to a complex arrangement of valves and flow ties. States should stipulate minimum requirements for permanent construction. Be aware that there will be thermal expansion with hot flowing wells. Employment of an expansion spool in the wellhead construction can allow the inner casing to thermally expand, reducing the potential of "growing" wellhead and/or pipe failure at the wellhead.

Open hole completions are used whenever possible. This technique, while saving substantial costs, reduces wellbore clogging problems and eliminates the danger of permanently sealing off fractured production zones with cement when setting production casing. Because of low permeabilities and pressures, geothermal systems respond negatively to wellbore restriction. In some cases, there has been noted as much as 30-40% reduction in transmissivities after setting slotted liners. Cementing production liners and perforating at production zones creates the greatest potential for permanent loss of production because of formation sealing by drilling muds, cements, and restriction of fluids into the wellbore by the perforated or slotted liner. This is particularly critical in fractured production zones where 4 to 8 shots per foot are expected to penetrate a 1/4" or smaller fracture which has been picked from a well log with a scale accuracy of 100'/5" scale.

DRILLING FLUIDS

Water, used as a drilling fluid, is considered the most important or critical geothermal drilling technique. This concept cannot be stressed enough. Many potentially good producing wells have suffered permanent loss in production when drilled with mud. Bentonite mud systems, according to 1975 data, are not stable above temperatures of 250° F and will bake and seal off hot production zones. Even with a light mud system, the pressure differences between the wellbore fluid and the formation are significant enough to damage the formation regardless of temperature, i.e., an 8.5 lb./gal. mud will exert 63 psi on the formation at 3000' depth. Whereas, a water system will match the formation pressure which will reduce the risk of formation damage. The problem is enhanced in fracture-dominated systems and compounded with increased temperatures.

Hole stability is a persistent problem, in drilling shallow systems. Therefore, the solution to instability appears to be to drill with air or mud for the cased portions of the hole above the production zones, and then drill with water through the production zones. Water systems can always be converted to mud systems, but to convert from a mud system to a water system is not recommended.

A related problem which involves drilling fluids is the wellbore temperatures will show significant cooling from the drilling fluids. It will take considerable time, maybe months, for the wellbore to establish thermal equilibrium. Equilibrium will be established faster under flowing well conditions.

WELL COMPLETION

Well cleanout is the final consideration of a drilling program. Pumping the well appears to have the most positive effect for well cleanout. Low permeability, low pressure wells must be stimulated to see the production capability, This is costly and time consuming, and generally is a process of elimination. But the process is necessary for the hydrologist or reservoir engineer to establish if lack of production is due to lack of permeability or formation damage. If formation damage is the determination, stressing the well by pumping, acidizing or hydrofraturing might be considered.

SUMMARY

Be aware of and consider what are good geothermal drilling techniques. Application of such techniques for site-specific drilling programs can reduce the risk of drilling and permanent production losses.