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DRILLING AND DIRECTIONAL DRILLING A MODERATE-TEMPERATURE GEOTHERMAL RESOURCE

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INTRODUCTION

The high cost of geothermal well drilling has caused great concern in the geothermal community, because of the direct relationship of well cost to power-on-line costs. The utilization of large quantities of moderate-temperature geothermal fluids (300°F, or 150°C) for electric power production at the Raft River, Idaho Geothermal Project creates even larger concerns about well costs. Various techniques were used during the exploration and drilling of the present wells, to improve resource detection and well production. These techniques will be utilized in all future drilling at Raft River.

Some resources have been overlooked because of the use of standard drilling methods. Each type resource will require unique techniques for detection and enhancement. The lower the temperature of the resource, the more difficult it will be to detect. Dry steam and high-temperature water-dominated resources are rare anomalies. Moderate-temperature resources, however, should be quite abundant throughout the West. It is necessary to detect such resources, enhance the production or injection capabilities of each well, and at the same time increase well lifetimes in order to keep moderate-temperature resources competitive with other forms of energy.

Three production and two injection wells have been drilled in the Raft River Valley, with an additional production and an injection well to be completed in the summer of 1978. This paper describes the techniques used in the drilling and testing of these high-fluid-volume wells.

Exploratory Drilling

During the exploratory phase, only the surface casing was run and cemented; if no resource was found, the cost invested in the dry well would then have been as small as practical. Below the casing, the well was drilled with water, rather than mud. This prevented the plugging of permeable producing zones and fractures and kept the fluid column as light as possible, so that geothermal water could enter the hole. Air or foam would lighten the column even more, but these measures have not been necessary at Raft River. Water drilling may not be a necessity with very high-temperature resources, but is the only recommended method for medium temperatures and lower artesian pressures. Care must be exercised in the use of water drilling.

After drilling and locating the resource, the well can, in many cases, be completed by cooling with injected cold water and by cementing in the production casing. This control method did not work at Raft River. A very permeable zone between 1600 and 2400 ft (490 to 730 m) accepted the hot water from the reservoir and all injected cold water. The well could not be "killed" with this method. An alternate method, that of filling the lower portion of the hole with sand, was very successful and resulted in effective control prior to casing the well during well completion. Sand was then drilled out to complete the well.

Cost again became a major factor for design of RRGE-3. Two major areas of well cost are casing and cementing. Casing calculations determined that over a 30-year production period, a 1000-gallon-per-minute well, with 9-5/8 in. (24.45 cm) production casing, would be more economical (including the cost of pump operation and the increased pressure drop in the casing) than a well with 13-3/8-in. (34 cm) production casing. The length of the production casing was reduced by hanging it from the bottom of the surface casing (at 1200 ft); thereby lowering the total well cost. Utilizing a Basch-Ross liner hanger with circulating ports allowed crews to squeeze cement from the top of the hung production string in the event of remedial cementing. This reduced the very costly perforating squeeze cementing and saved more than 50%. The use of this technique has been considered acceptable by the State for such moderate-temperature (low-pressure) wells.

Also because of costs, much time and planning have been devoted to cementing techniques. Perlite and silica cements have been used, and stage cementing tried—all with less than desirable results. We are still attempting to find a cement and technique which will be effective for Raft River hole conditions. This year, two different cements are to be used in the wells, so that the application and long-term retrogression of two cements can be compared.
Multiple-Leg Wells

Well RRGE-3 became an experiment in well stimulation to reduce well costs by directionally drilling open-hole legs through the production zone below the casing. This increased production for a minor increase in well cost. The first leg was drilled westwardly to a depth of 5853 G.L., with disappointing production results. Analysis showed an apparent lack of producing fractures, so the decision was made to drill two additional legs, in hopes of encountering production fractures. Leg B was drilled northeastwardly to a depth of 4432 ft (1351 m); Leg C, northwesterly to a depth of 5917 ft (1803.5 m). Production increased by 500% with the completion of the third leg.

Although we were unable to prove what would happen in a homogeneous producing layer, our calculations for the Raft River reservoir imply that an extra leg that gets as far away as 400 ft (122 m) will increase the cost 20%, while increasing production 50%.

A second multiple-leg production well, RRGP-5, will be drilled this June. Injection Well RRGI-4 will be deepened and completed as a multiple-leg production well in October.

Where formations are tight, or where formation plugging is a problem, producing well life time and well operating pressures can be improved by using multiple-leg wells. Formation plugging in wells with two phase then is apparently most likely to occur near the well bore. By directionally drilling multiple legs, penetrating the injection zone, the rate of plugging should be proportionately reduced.