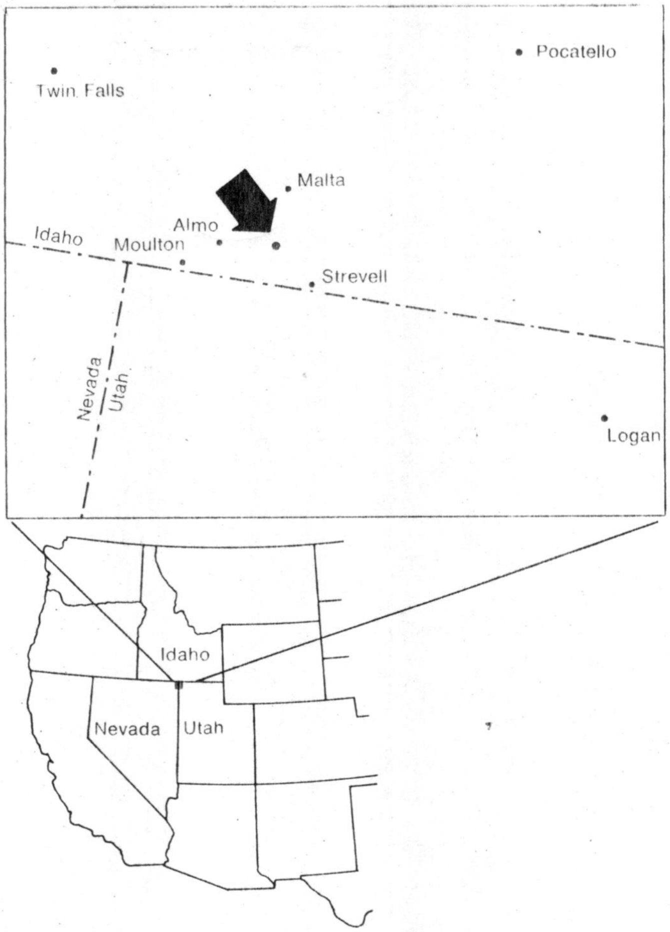

Fig. 1—Raft River Idaho Geothermal Project is located in southern Idaho, a few miles east of the Nevada-Utah state line.

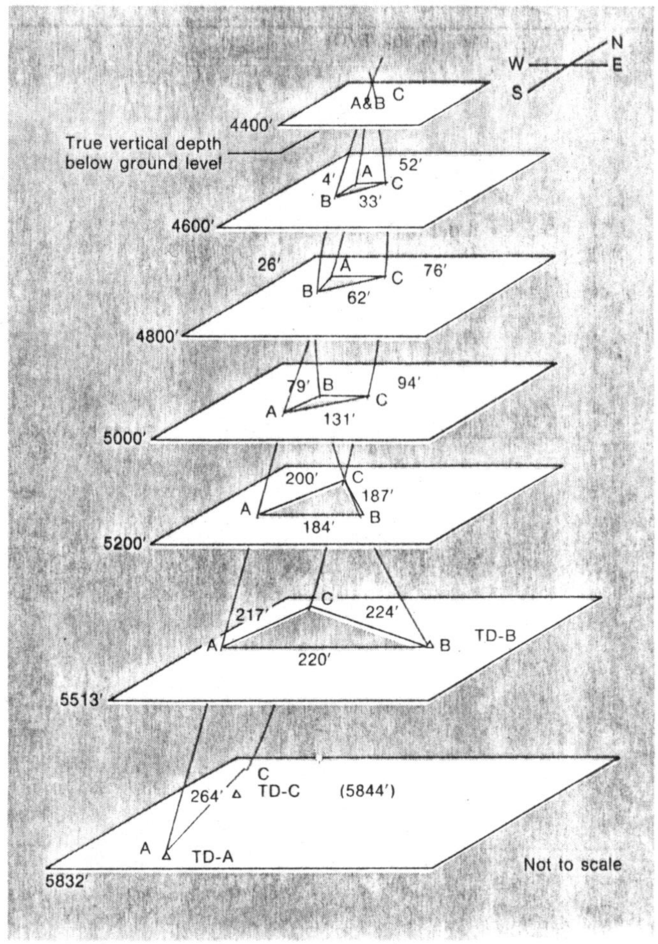

Fig. 2—Plot of the three legs in RRGE 3 shows the total depth of each hole and the relationship of the holes at several levels.

Drain-hole drilling can increase productivity

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Editor's note

Multi-legged (drain-hole) completions are becoming increasingly popular in areas where production depends primarily on reservoir fracture systems. It is not a new technique, having been used in the West Texas Spraberry in the early 1950s, and possibly before then. But it was not used extensively because of the high cost of directional drilling at the time. Drain-hole drilling in Spraberry was marginally economical unless one leg intersected a large, well-developed fracture system. Improved directional drilling techniques, lowering cost as a function of return, makes the method worth investigating in tight, fractured reservoirs. It is more applicable in thick formations such as the Austin Chalk in South Texas. Primary disadvantage is the inability to control fluid entry if stimulation is necessary.

Using high-temperature geothermal water to provide energy for electric power generation has been discussed for years. Power generated using geothermal steam started in Italy in 1904, and one plant is operating in California. However, direct heat transfer from high temperature water into electrical energy is in the development stage, economically. High cost of delivering the water volume necessary is the main economic problem. In an effort to solve this problem, the Idaho National Engineering Laboratory (INEL) built a research center in the Raft River Valley in southern Utah, Fig. 1. Named the Raft River

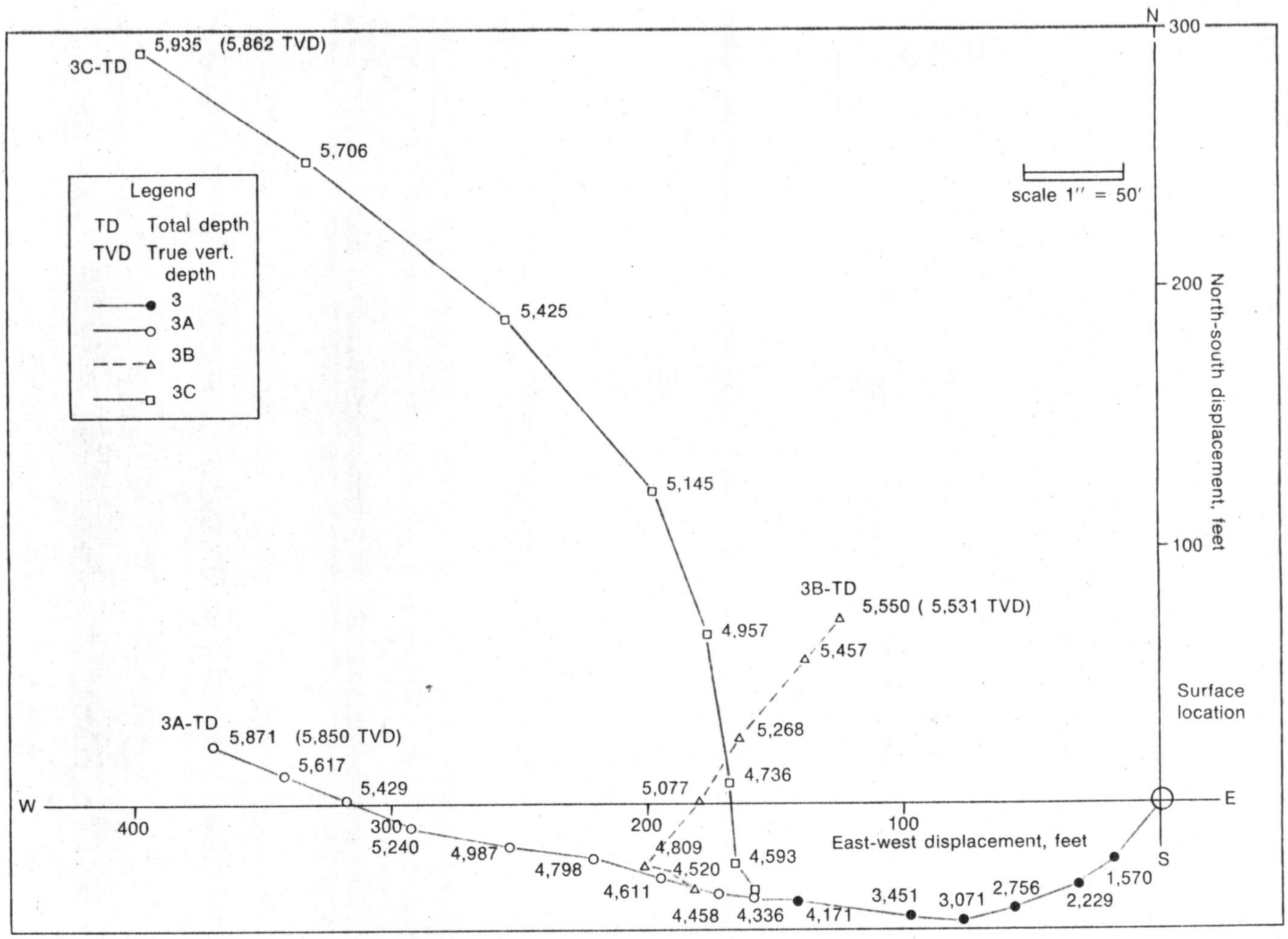

Fig. 3—Horizontal position of each hole from kickoff point to TD is shown on this directional plot.

Geothermal Exploratory (RRGE) project, its objective was to decrease hot water production costs. One of the techniques used is discussed in this article.

Five deep geothermal wells have been drilled at the site, and a small 60-kw generator is producing electricity. Construction of a 500-kw generator is planned for next year using direct contact heat exchangers. The five existing wells will be used for a 5-mw pilot power plant, presently under construction. When completed, the field will consist of seven wells: three production wells, two injection wells and a reserve well of each type. A *new* drilling technique was used to enhance the production of one of these experimental wells. The third Raft River well, RRGE 3, was completed with three directionally drilled legs, drain-holes. Addition of two extra legs improved the well's production by 500%, from an initial rate of 80 gpm to 425 gpm.

The first two wells were drilled in early 1975 and cost $899,000 and $803,000, respectively. They were drilled to 5,000 and 6,000 feet and fitted with 13⅜-inch production casing. Primary production comes from the Basal Tertiary Salt Lake formation consisting of tuffaceous silts and sands, and from the fracture areas of the Upper Precambrian metamorphics and quartz monzonite intrusives. Wells were completed as open holes below casing that is set at the top of the production zones.

DRILLING PLAN

Several alternatives to increase production were considered. Considerable computer analyses conducted on multi-leg-type holes indicated up to 50% increases in fluid production. This prompted the decision to multi-leg drill the next production well. A production increase of 30% would pay for the extra cost of drilling.

Plan was for the legs to be separated by 400 feet. No cement plugs would be used as kick-off points in the open-hole section because of the possibility of sealing off production in the open hole. Water would be used below the casing to prevent possible formation damage caused by mud.

A 9⅝-inch liner was cemented at 4,227 feet. Leg A was begun at 4,360 feet and directed westward. The leg accumulated a drift angle of 8 degrees in the first 300 feet. Legs B and C could then kick off from the low side of this angled, 300-foot section. Leg C would be angled away from the main bore at a point above where Leg B separated, Figs. 2 and 3.

At kick-off point, a shoulder is built on the low side of the hole using a milltooth bit, 1½-degree bent sub and mud motor assembly that allows easy entry and builds directional angle. When both angle and direction are achieved with the directional tools, a conventional, highly stabilized drill string is used to deepen and further angle the hole.

Orientation of the directional string is achieved with a wireless, orientation indicator with surface readout. Tool is contained in a special sub located just above the bent sub. Signals are generated by a plunger that transverses a series of seven annular restrictions to produce pressure pulses in the mud stream. Signals are received by a recorder located on the drilling floor and the number of pulses relates directly to the degree of inclination or orientation of the tool in relation to the low side of the hole.

RESULTS

Leg A produced an artesian flow of only 80 gpm although reservoir engineers had predicted a flow of about 800 gpm. With only one leg drilled, RRGE 3 was practically a dry hole. Legs B and C were angled northwest and northeast toward major fault systems, to encounter as much fracturing as possible. After Leg C was completed, RRGE 3 produced an artesian flow of up to 425 gpm. Drain-hole drilling had increased the flow by 500%.

The technique caused two problems.

- Since there was no way to control re-entry into individual legs, each had to be logged as it was completed. However, this was accomplished without difficulty.

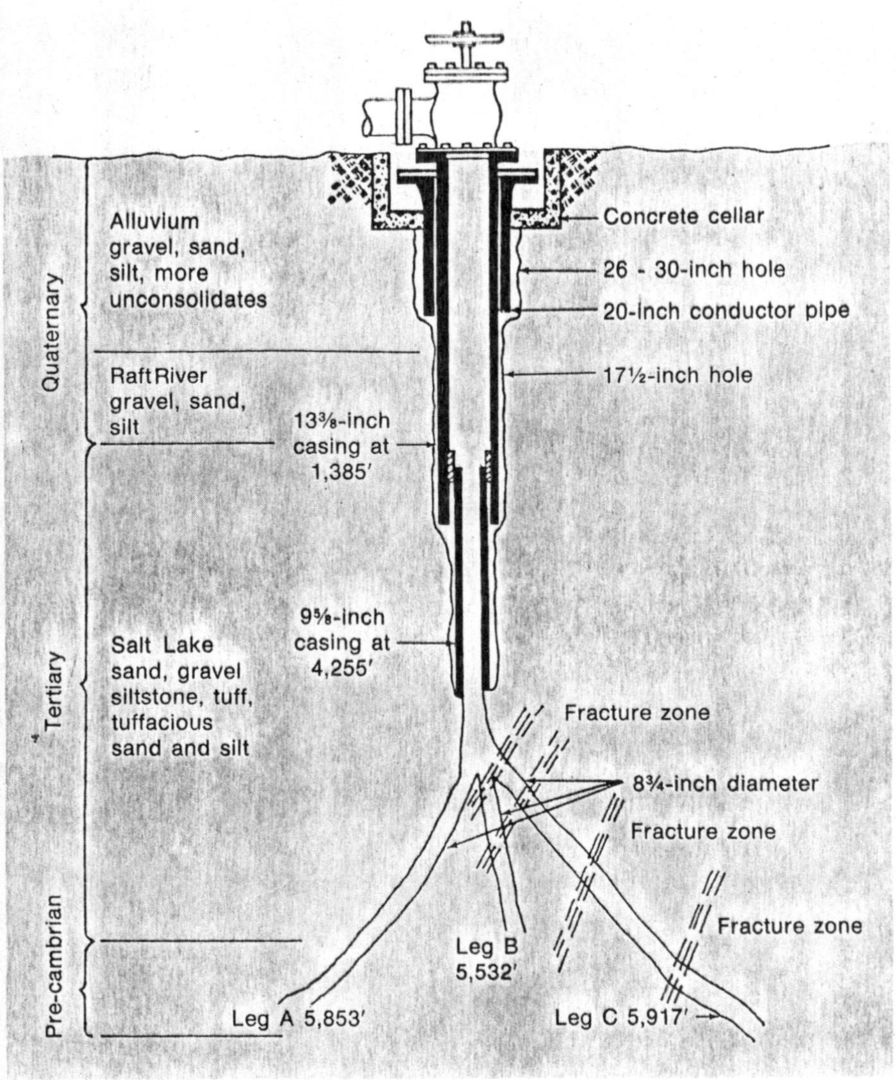

Fig. 4—Completion configuration of RRGE 3 shows location of fracture zones and indicates the reason for the low productivity of only Leg A.

- Bottomhole temperatures reached 305° F, causing rubber parts of the mud motor, rated at 250° F, to disintegrate.

Even though the mud motors were used only to build angle and direction, three different tools were required for the project. By using a high-temperature turbo-drill, this problem may be avoided on future wells. Project involves drilling a multiple leg well and deepening, with multiple legs, an existing injection well, using the same design as RRGE 3, Fig. 4.

In spite of these difficulties, a five-fold increase in production was purchased for only a 20% increase in cost. Without directional drilling, an 80-gpm well would have cost $500,000. Because of the stimulation technique, the money was well spent for a well that has been produced at rates as high as 800 gpm. The experience also demonstrated that production at Raft River depends more on fracturing than on permeability or porosity, further enhancing the economics of drain-hole drilling.

Because the technique produced such a dramatic productivity increase for a nominal cost increase, future Raft River production wells will be similarly designed. Multiple leg completion also is being considered for injection wells to increase wellbore area and alleviate pressure buildups. If the technique succeeds with the wells now being drilled for Raft River's 5-mw power plant, it should improve the overall economics of generating electricity using geothermal energy.

ACKNOWLEDGMENT

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