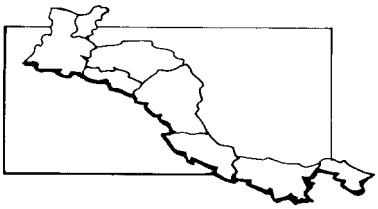
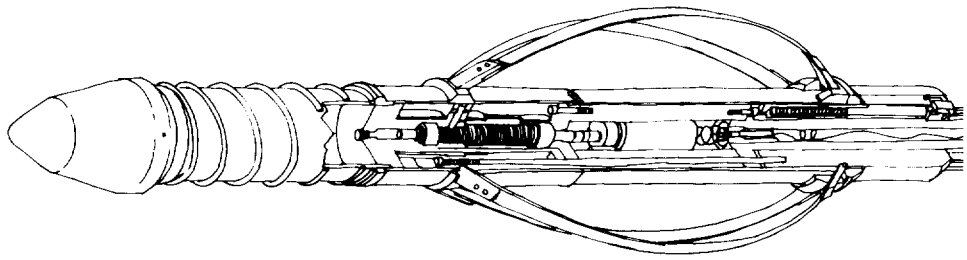
Caribbean Basin Proyecto





High-Temperature Borehole Measurements at Miravalles, Costa Rica

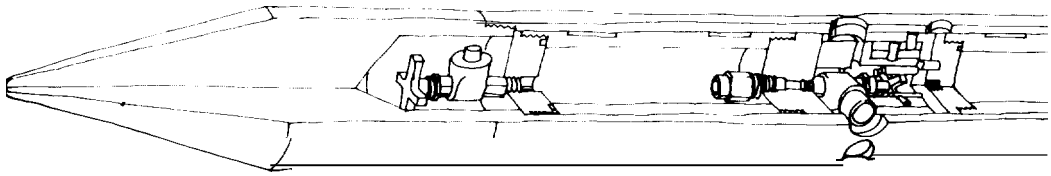
by Bent R. Dennis and Robert J. Hanold

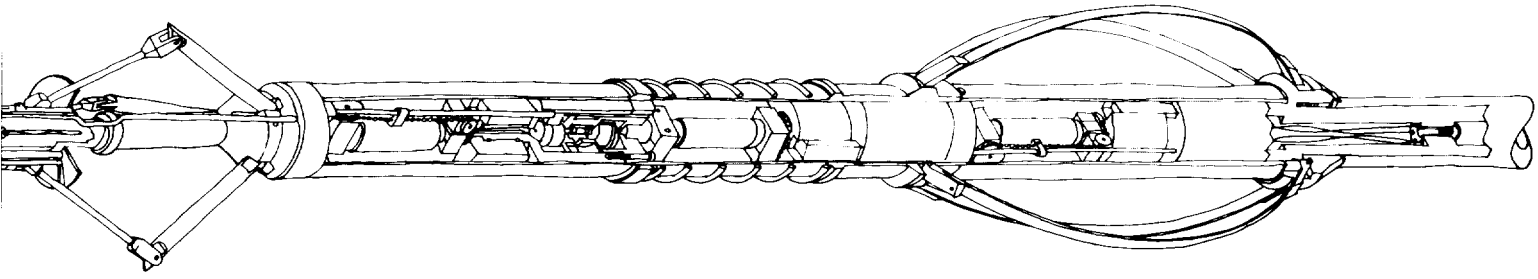
Costa Rica is developing its first geothermal power plant on the southern flank of the Miravalles Volcano in the Guanacaste Volcanic Range. If successful, this development will complement the vast hydroelectric resources of the country and help eliminate the need for fossil-fueled power plants. At present the import of petroleum contributes significantly to the trade imbalance of the country.

The development at Miravalles began about ten years ago with reconnaissance efforts, sponsored by the United Nations, that identified the slopes of Miravalles and Rincon de la Vieja volcanoes as potential sites for development of geothermal resources. The Power Planning Division of the Costa Rican Institute of Electricity (ICE) then began drilling deep production wells at Miravalles. The results were encouraging; the production wells have penetrated a 240°C-reservoir of geothermal brine at a depth of less than 2 kilometers, and the flow rates in the wells are very high (39 to 76 kilograms per second). So far so good. But when the initial wells were flow-tested, ICE engineers detected the presence of calcite ($CaCO_3$) deposits in the well bores. Since they lacked instruments to make measurements in the high-temperature environment downhole, they had no way to assess the scope of the problem.

Well-1ogging equipment on site at the Miravalles geothermal field.

Then, while attending a 1984 Los Alamos workshop for Central Americans on geothermal energy development, ICE engineers learned of the specialized instruments developed by the Laboratory's Earth Science Instrumentation Group to satisfy the diagnostic needs of the Los Alamos hot dry rock geothermal energy





▲**Fig. 1. The three-arm caliper and contour tool developed at Los Alamos yields precision measurements of borehole dimensions and in situ casings. An electric motor extends or retracts the caliper arms on command from the surface logging rig.**

program. These unique logging tools are capable of operating at temperatures up to 300°C and pressures up to 15,000 psi for durations between 8 and 30 hours. The Costa Ricans explained their problem, and with support from the U. S. Agency for International Development, these instruments were made available to ICE for downhole diagnostic measurements at the Miravalles wells.

Los Alamos engineers and technicians overhauled a surplus well-logging rig and equipped it with 3 kilometers of special cable and a cablehead assembly, designed at Los Alamos, for interfacing with the downhole tools. A computer-driven data-acquisition system was installed in the logging cab. After being tested in a local geothermal well, the unit was shipped to Costa Rica together with logging tools for measuring temperature and pressure as a function of depth, flow rate throughout the production layer, and the contour and average diameter of the well casing and for collecting samples of brine from the reservoir without loss of dissolved gases.

Two wells at the Miravalles field were logged. A single borehole instrument measured temperature. pressure, and flow rate. This new tool significantly increases the efficiency of measurements in a hot, high--pressure well because only a single entry and removal through the pressure lock is required. Figure 1 shows the tool used to measure the contour and average diameter of the well casing. Figure 2 shows the tool used to collect pressurized fluid samples at various locations in the well.

We are currently analyzing the logging data, and the brine samples are enroute to Los Alamos for chemical analysis. Bottom-hole temperatures in both wells approach 240°C, an excellent temperature for efficient generation of electricity.

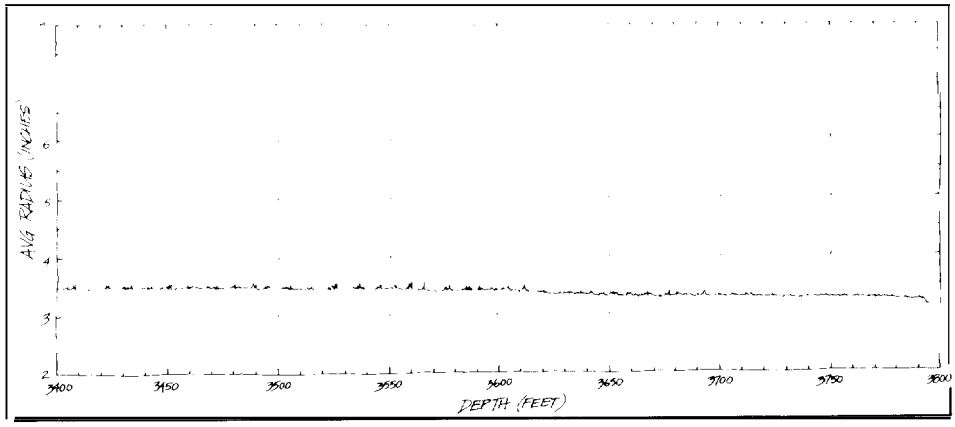


Fig. 3. Results of a caliper survey of a well at the Miravalles geothermal site. Accumulated scale deposits have caused a decrease in the inside radius of the slotted production liner from 3.5 inches at a depth of 3400 feet to 3.2 inches at 3800 feet. The slots in the production liner, which provide the passageway for the reservoir fluids into the production well, are evident in the caliper data at shallower depths but essentially disappear at depths below 3600 feet. These slots are apparently being plugged with calcite deposits.▲

The caliper surveys confirmed the suspicions of the ICE engineers by indicating considerable buildup of calcite in the lower sections of one of the wells (Fig. 3). Such deposits will ultimately reduce the flow rate from the well.

The initial logging experiences at Miravalles indicated the need for some modifications in the logging tools to improve their durability in the high-flow-rate wells. When these modifications are completed, the equipment will be returned to Costa Rica and used to log additional production wells. Data from these logging surveys could lead to an improved drilling strategy for the rest of the production wells. ■

Participants in the logging efforts included David Anderson, Gloria Bennett, Lynn Brewer, Pete Chavez, Benny Garcia, Ray Jermance, Jerome Kolar, Richard Maestas, and Even Stephani of Los Alamos National Laboratory and Rodrigo Corrales and Manuel Corrales of ICE.

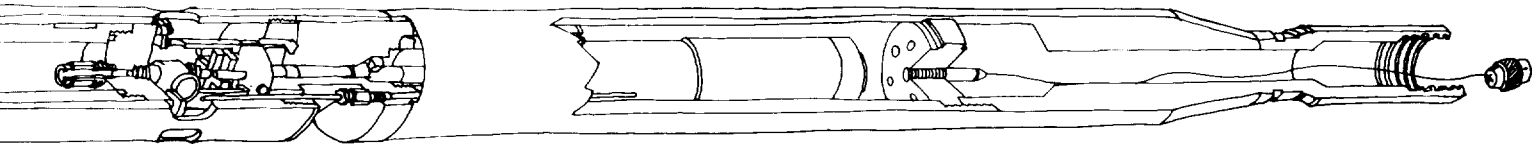


Fig. 2. The fluid sampler tool has two chambers for collecting samples. The motor that opens and closes the sample chambers is activated on command from the surface logging rig.▲