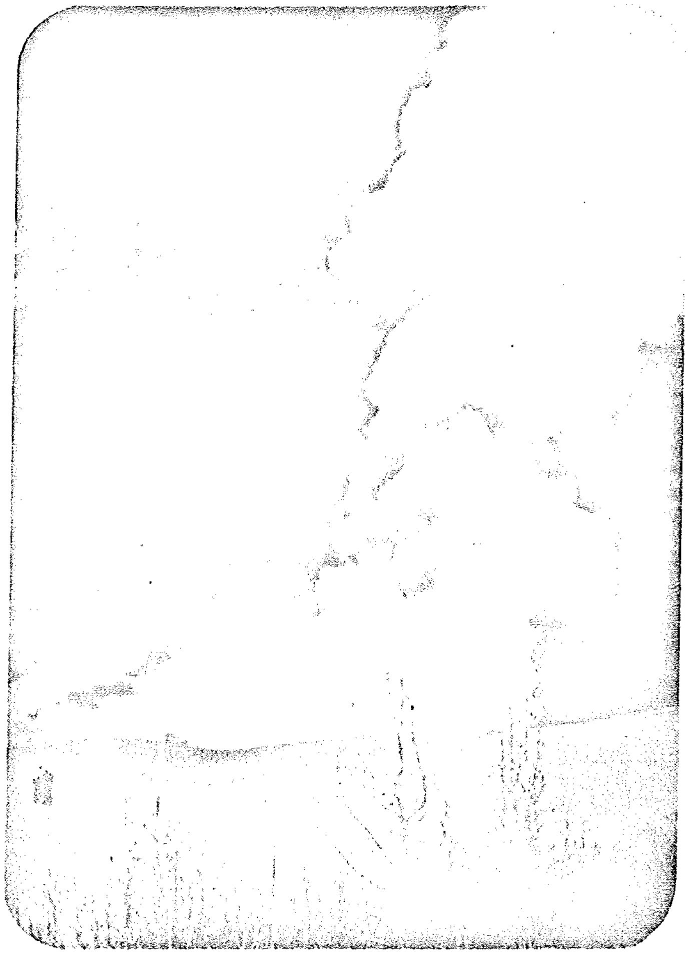
BLOWOUT OF A

GEOTHERMAL WELL

THE GEYSERS GEOTHERMAL FIELD, SONOMA COUNTY, CALIFORNIA



Geothermal well blowout, view northwest. Note the size of the persons in relationship to the affected area which extends far to the left of the steam.

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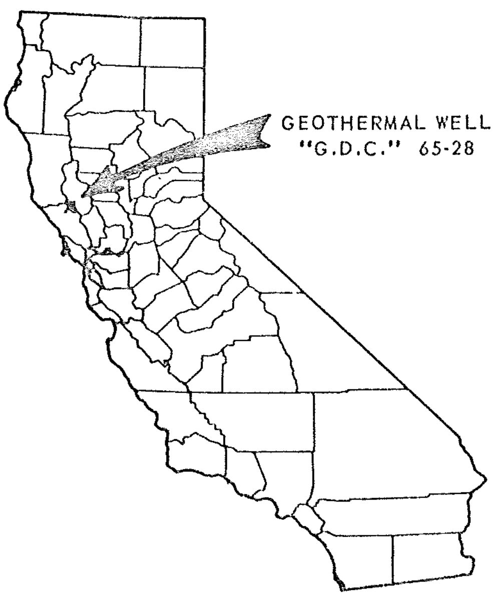


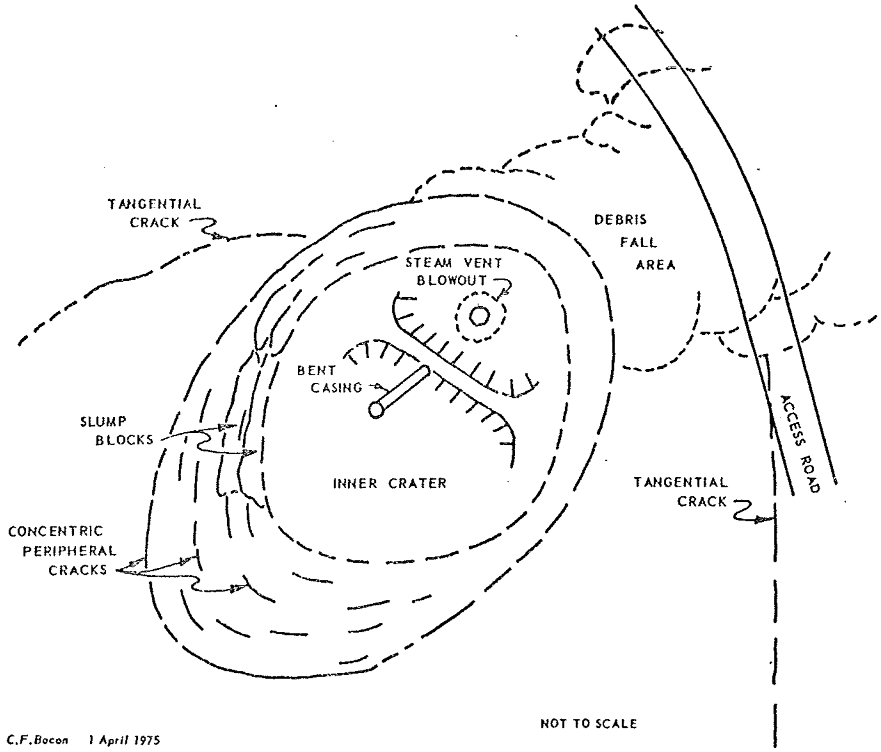
Index map showing the location of the blown-out well.

On the evening of 31 March 1975 at approximately 6:45 P.M., Union Oil Company geothermal well "G.D.C." 65-28 blew out. The well, which had been on standby since its completion 7 September 1968, is located in a remote area of the Mayacmas Mountains 4 miles southeast of the main Geysers geothermal area; the blowout apparently was not witnessed.

On the day following the blowout, an oblong crater with maximum dimensions about 100 by 120 feet, had been blown out to a depth of about 20 or 25 feet. Strong peripheral cracking had developed, and slumping was taking place, stair-step fashion, around most of the perimeter. The maximum size of the affected area was approximately 120 by 180 feet.

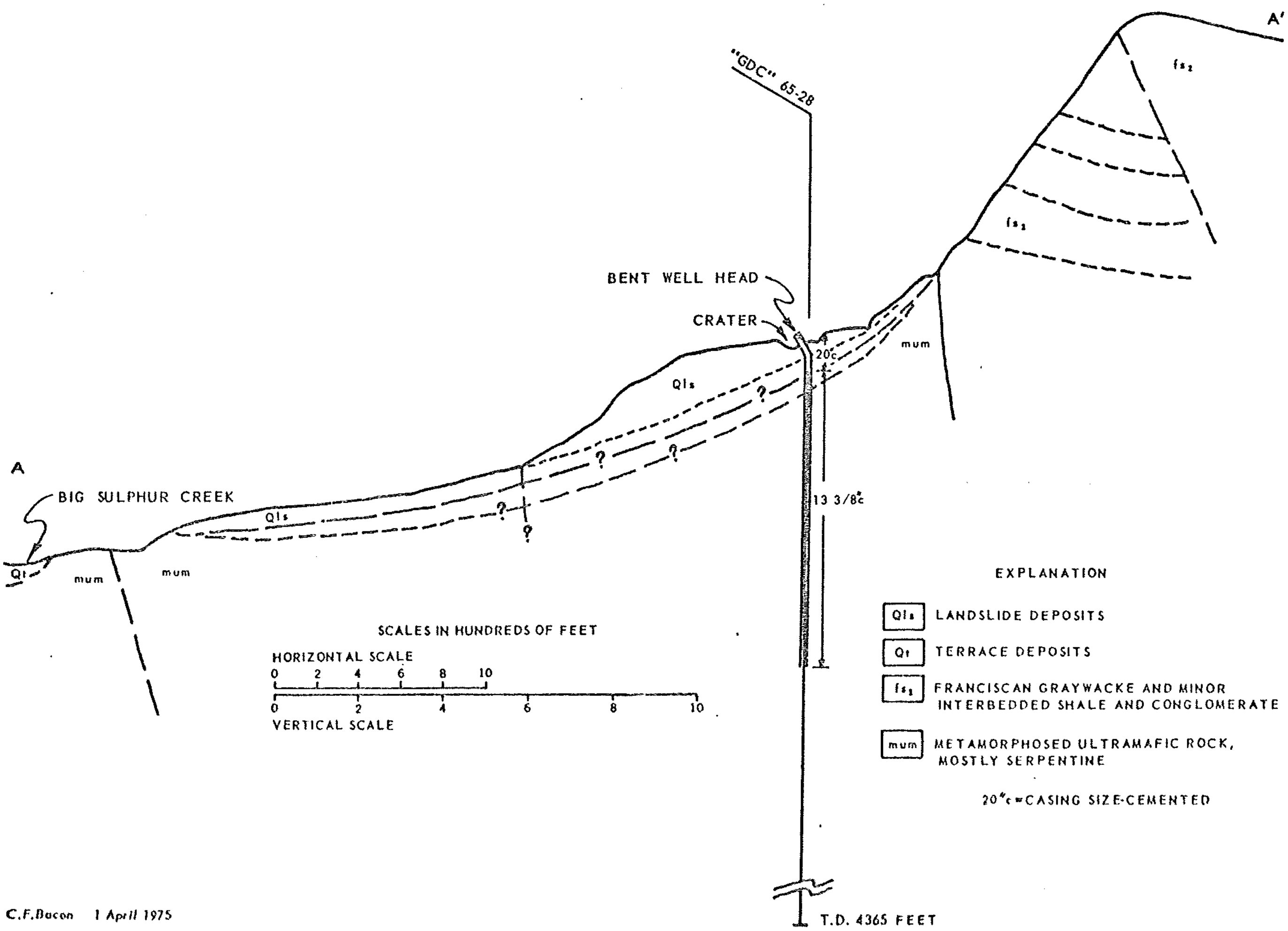
Steam was issuing from two sources within the crater: (1) from a 3 inch bleeder valve nipple opening on the bent-over well head, and (2) from an open hole close to the former position of the well head and 20 inch surface casing. A mixture of sand, dust, and rock fragments accompanied the steam venting from the open hole, but mostly clean, dry steam issued from the well head which was bent 35° to the southwest (down slope). At intervals small rock fragments were thrown as high as 150 to 200 feet in the air; 6-inch to 10-inch fragments were found scattered over much of the drill site.

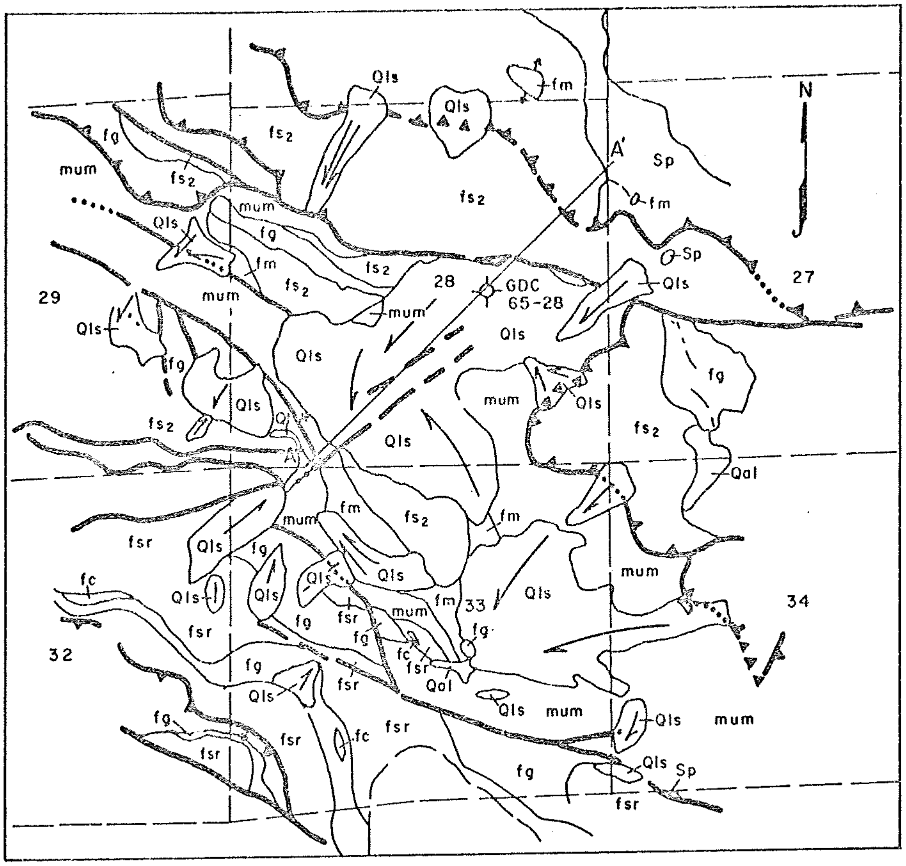
This well, like over 50 percent of the wells drilled at The Geysers, was sited on a Quaternary landslide. Since the blow-out, a great deal of time, money, and effort has been spent to regain control of the well and to try to determine whether or not the well blew out as a result of renewed movements on the old slide.



← Diagrammatic sketch map of blowout crater, well "G.D.C." 65-28 prior to excavation and abandoning.

Diagrammatic geologic section showing possible relationships to blown-out geothermal well "G.D.C." 65-28.





Geologic map, vicinity of Union Oil Co. Well "G.D.C." 65-28. Adapted from USGS Open-file map 74-238, *Preliminary geologic map of The Geysers steam field and vicinity, Sonoma County, California* by Robert J. McLaughlin, 1974.

EXPLANATION

Qls	Landslide deposits
Qt	Terrace deposits
fs_2	Franciscan Graywacke and minor shale (Melange)
fsr	Sedimentary and Tectonic Melange
fc	Chert and interbedded layers of tuff
fg	Greenstone
fm	Blueschist
mum	Metamorphic ultramafic rock
Sp	Serpentine

MAP SYMBOLS

Contact

Fault

Landslide deposit Arrows indicate direction of movement

SURFACE CRACKING

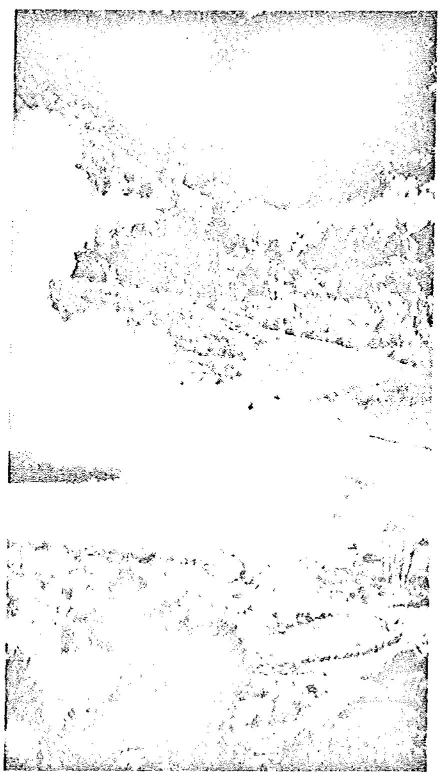
Immediately following the blowout, a pair of surface cracks tangential to the crater, one somewhat arcuate and the other nearly straight, were projected to intersect on the upslope side of the well location, near the area of heaviest debris fall. The cracks, which were situated on opposite sides of the well, had been partly to completely bridged or covered by falling debris, making it difficult to trace them. The actual point of intersection could not be seen.

The time of origin and cause of these cracks are still open to question: were they the result of downslope movement of landslide materials—movement which also triggered the well casing failure and blowout—or were they merely the result of the blowout, with attendant loss of support around the crater, and perhaps also steam and water movements within the earth materials? The fact that these cracks were not aligned with the multitude of concentric slump cracks around the crater, but were tangential to those cracks, suggests that they were the result of downslope movement of landslide materials.

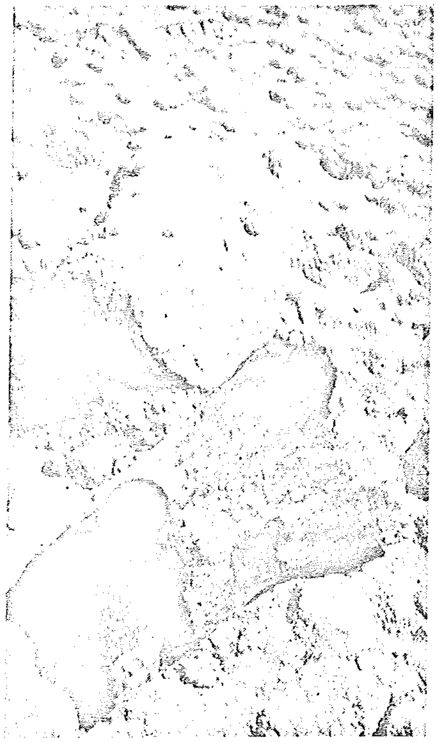
Peripheral cracking and stair-step slumping at the western side of the crater. Note the coating of sand and dust on the bush in the foreground.

GROUND WATER

One factor which could have contributed to downslope movement of the slide materials is a high groundwater table. There were seeps and springs at several points near the well site. One spring was flowing from a 10 foot bank cut for the road at the upper edge of the drill site. Water was ponded along the edge of the road and a small stream flowed in the drainage ditch along the northeast edge of the drill site. Just to the west of the well was a pond and marshy area. The pond had a large water surface, about 15 feet below the level of the graded drill pad, and contained an abundance of algae. Cattails and other aquatic plants were growing around the periphery. A stream flowed into the pond from the north and subsurface springs apparently supplemented the outflow, which amounted to several gallons per minute. The pond was probably improved for use in the drilling of this well. One of the first steps taken, in the efforts to regain control of the well, was the digging of two deep drainage ditches above the well site to dewater the slopes.



View southeast, showing the large pond and abundant aquatic plants located on the west edge of the well pad.



One of the large rock fragments blown 150 feet from the well. The black object is a large camera lens cap.

GEOLOGIC RELATIONSHIPS

Geologic mapping recently completed by McLaughlin (1974) indicates that geothermal well "G.D.C." 65-28 is situated on the upper part of a large landslide nearly 1 mile long. Two other wells are sited on this same slide area and the nearest one, "Little Geysers" 2, which was drilled in 1964, was plugged and abandoned with much difficulty in 1971. Additional work is still needed on that site to seal small steam vents and a bubbling pool located in a hole on the site. A count of geothermal wells located within The Geysers area and within the bounds of McLaughlin's map area, showed that over 90 wells are located on landslides.

A preliminary geologic section drawn through the "G.D.C." 65-28 well site revealed that the 20-inch surface casing, which was set 80 feet deep, might have just barely reached in-place rock—or possibly might have been cemented in slide material. However, subsequent examination of the materials encountered in the excavation that was made around the well in the efforts to regain control, together with other evidence, indicates that the slide is at least 125 feet deep.

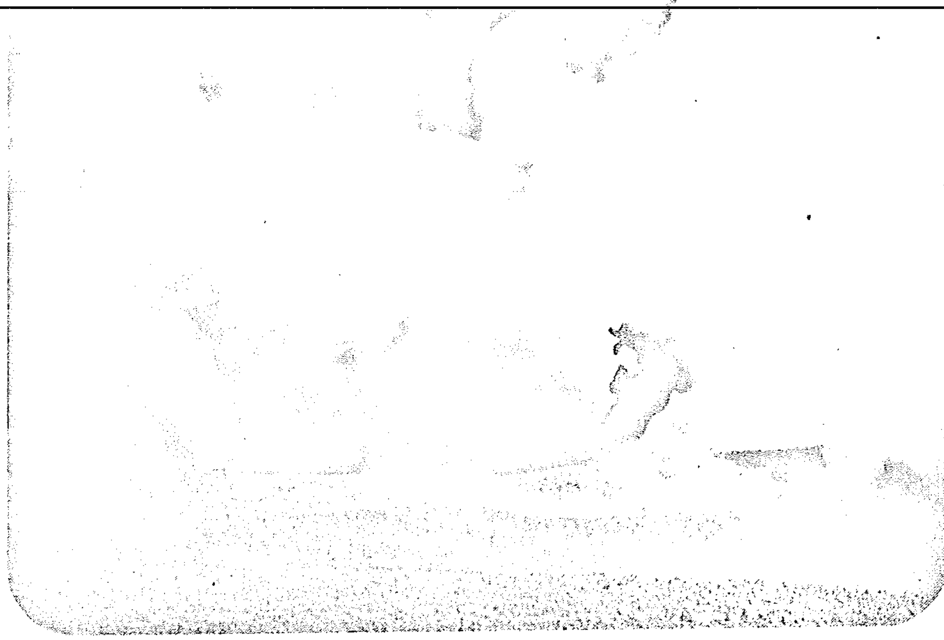
Information which had been published previously indicated that the hole was cased to a depth of 750 feet with 13⅜-inch casing. A lost string of tools at 4671 feet necessitated cementing the hole back to 1338 feet. The hole was then redrilled to 4365 feet and steam was tested at 149,000 pounds per hour (lbs/hr.).

A bent and broken segment of casing, including the 20 inch surface pipe and 13⅜-inch casing removed from the excavation at a point approximately 50 feet below ground surface.

CONTROLLING THE WELL

In the effort to regain control of the blown-out well, a great bowl-shaped depression, involving removal of over 120,000 yards of material, was excavated around the well casing to a depth of approximately 82 feet. Materials encountered during the excavation included, in addition to the usual landslide debris in the upper portions, masses of intensely sheared and broken up serpentinite alternating with lenses or layers of granular to pulverulent serpentinite materials. Large blocks and chunks of firm serpentinite were found embedded in the weaker matrix materials. In some instances subhorizontal shear planes could be traced for many feet in the walls of the excavation.

Oversteepening of the walls and unsafe conditions in the excavation forced abandonment of the plan to go deep enough to reach the lowermost break in the casing and to replace all of the bent and broken parts with new casing. Instead, two steam relief systems were installed: one was slotted into the well casing near 80 feet below the original ground surface and the other was drilled down to capture steam escaping into the rock from the casing break below. New segments of casing were welded on to replace those removed during excavation and the hole was backfilled to a depth 42 feet below the ground surface. The well was "killed" or quenched by pumping in large volumes of cold water and a cement plug was installed below 160 feet.



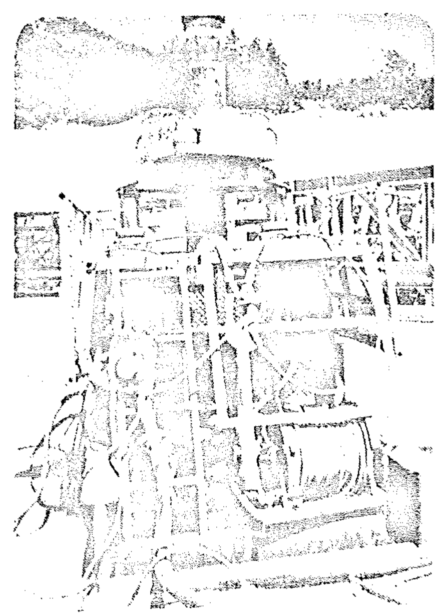
The inner crater and bent over well head. The heavy volume of steam and debris coming up on the left marks the former position of the well head and 20-inch casing which can be seen bent over to the right.

View southwest, showing the 80 foot deep excavation made at the well site in the unsuccessful attempt to get below the damaged casing sections.

The cause, geometry, and location of the casing failure were investigated using 1) a bore hole video camera and 2) impression mold techniques. Results showed that the 13⅜-inch casing was sheared off at approximately 125 feet below the original ground surface and was offset in a downslope direction by approximately half the casing diameter. Circumstances such as these almost certainly indicate slippage of earth materials in the old slide mass—probably moving along a plane similar to those exposed higher up in the excavation walls. On 28 July 1975 an unsuccessful attempt using hydraulic jacks was made to retrieve the damaged portion of the casing for metallurgical tests. Similar tests run on damaged portions of casing retrieved from higher up have disclosed a low resistance to impact but no other unusual conditions.

The blown-out well was drilled using techniques and standards now outdated. Union Oil Company has initiated a program to inspect all of their early wells and to rework them to bring them up to present standards. It is hoped that other companies in the area will follow suit. However, the problem of wells sited on landslides still exists. Each wet winter season charges the slopes and slides with high moisture and causes renewed slide activity. Each winter sees reactivation of old slides at The Geysers, and quite frequently the initiation of new ones in the steep terrain of the area. It is difficult, if not impossible, to predict ahead of time which slide or potential slide will be the next to move. Remedial measures can often be taken which will help to stabilize an old slide—or to prevent a new one. However, these measures are often costly and, for some types of slides, ineffective. A careful and complete geologic investigation of each site, prepared by a professional geologist before a site is accepted, can prevent costly mistakes.

The total cost of controlling, analyzing, plugging, and abandoning well "G.D.C." 65-28 is still not known, but it is expected to be at least as high as the cost of drilling a new well. A cost-benefit analysis of 1) drilling a new well, 2) taking corrective action after a blow-out has occurred, or 3) requiring competent engineering geology analysis to prevent or minimize ground failure at the well site, will come out heavily in favor of alternative number 3. ⚒



The heavy duty hydraulic jacking equipment used in the attempt to bring the remaining broken off segment of casing to the surface after completion of the excavation and backfill (see text).