

3580

SUMMARY OF 1979 GEOTHERMAL DRILLING
WESTERN UNITED STATES

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In 1979, successful geothermal drilling expanded the geographical limits of proven steam production at The Geysers field to the north, east and south. The successful wells were drilled by Union, NCPA, and Geothermal Kinetics. The year also saw The Geysers electric generating capacity increase 161 Mw with the start-up of PG&E Unit 12 (106 Mw) and Unit 15 (55 Mw), bringing the total installed generating capacity up to 663 Mw.

A 1979 new field discovery was made at Steamboat Springs, Nevada, by Phillips where they encountered a shallow commercial hot water reservoir. Another new field discovery may have been made by Occidental, who drilled into what appears to be a mixed steam/hot water reservoir 6 miles north of The Geysers.

The other 1979 highlights occurred in the Imperial Valley, where Magma at East Mesa sold the first electricity in the United States generated from a hot water reservoir, and Republic Geothermal made a successful two mile stepout to the northeast of the Salton Sea Field.

During 1979, there were 77 geothermal exploration and development wells drilled in the western states of California, Oregon, Nevada, Idaho, Utah, and New Mexico. All development wells and all exploration wells programmed to be drilled to depths in excess of 2,000 feet are included. This total of 77 wells is an increase of 19 (33%) over the geothermal wells drilled in 1978. Table 1 separates these 77 geothermal wells into development, exploration, and direct utilization categories for each state (or

region). Included are all wells spudded during the calendar year. The 39 intended development wells, of which 38 were successful as producers or injectors, account for 51% of the 1979 geothermal wells drilled. Two wells were spudded for direct application use, and the remaining 36 wells were classified as exploratory. Of these exploration wells, 2 of the 17 wildcat wells and 5 of the 11 stepout wells are now considered commercially productive, and several others may yet prove to be when adequate testing is performed.

Table 2 summarizes the drilling activity and results by Regions, and Table 3 by Operator. The total footage drilled in 1979 was 552,329 feet, which represents a 20% increase over the 433,703 feet drilled in 1978. The most active operators, based on drilled footage, were Union, Sunedco, McCulloch, Aminoil, and Republic Geothermal.

CALIFORNIA

Imperial Valley

During 1979, the Imperial Valley's geothermal fields continued to undergo exploration and development with 13 new wells being drilled. The total footage drilled in the valley was 72,910 feet. In addition, Magma's East Mesa experimental geothermal power plant has now begun selling the first electricity to be generated from a hot water field in the United States, and Union/Southern California Edison started construction of a 10 Mw geothermal plant at North Brawley.

TABLE #1 1979 GEOTHERMAL WELLS BY CATEGORY, PRIOR TO DRILLING.

| <u>Area</u> | <u>DEVELOPMENT WELLS</u> | | | <u>EXPLORATION WELLS</u> | | | <u>DIRECT USE</u> | <u>Total</u> |
|---------------------|--------------------------|------------------|-----------------|--------------------------|----------------|--------------------|-------------------|--------------|
| | <u>Production</u> | <u>Injection</u> | <u>Workover</u> | <u>Stepout</u> | <u>Wildcat</u> | <u>Observation</u> | <u>Wildcat</u> | |
| Southern California | 6 | 3 | — | 1 | 2 | 1 | -- | 13 |
| Northern California | 21 | -- | 2 | 6 | 4 | -- | -- | 33 |
| Eastern California | -- | -- | -- | -- | 2 | 1 | -- | 3 |
| Idaho | -- | -- | -- | -- | 1 | 1 | -- | 2 |
| Nevada | 2 | -- | 1 | 4 | 6 | 2 | -- | 15 |
| New Mexico | 4 | -- | -- | -- | -- | -- | -- | 4 |
| Oregon | -- | -- | -- | -- | -- | 3 | 1 | 4 |
| Utah | -- | -- | -- | -- | 2 | -- | 1 | 3 |
| TOTAL | 33 | 3 | 3 | 11 | 17 | 8 | 2 | 77 |

TABLE #2

SUMMARY BY STATES, 1979

GEOTHERMAL DRILLING, WESTERN UNITED STATES

| State, Region | Area | Operator | WELLS | PROD. | SUSP. | ABD. | INJ. | OBS. | DIRECT | FOOTAGE (Feet) |
|--------------------|--------------|---------------------|-------|-------|-------|------|------|------|--------|-------------------|
| CALIFORNIA | | | | | | | | | | |
| Imperial Valley | East Mesa | Republic Geothermal | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 12,161 |
| | Brawley | Union | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 14,627 |
| | So. Brawley | Chevron | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2,419 |
| | | McCulloch | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 4,147 |
| | Salton Sea | Republic Geothermal | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 10,013 |
| | | Magma | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1,500 |
| | | Union | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 9,482 |
| | Westmorland | MAPCO | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 8,761 |
| | Mineral H.S. | McCulloch | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 9,800 |
| | The Geysers | Main Geysers | Union | 18 | 18 | 0 | 0 | 0 | 0 | 0 |
| GKI | | | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 15,414 |
| Thermogenics | | | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 15,108 |
| SE. Geysers | | Aminoil | 5 | 4 | 1 | 0 | 0 | 0 | 0 | 34,820 |
| | | Shell | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 21,321 |
| | | Natomas | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 10,897 |
| N. Geysers | | McCulloch | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 10,308 |
| | | NCPA | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 9,618 |
| Boggs Lake | | Occidental | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 9,852 |
| Tyler Valley | | Sunedco | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 10,620 |
| Eastern California | Long Valley | Union | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 11,757 |
| | | Chevron | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2,200 |

TABLE #2

SUMMARY BY STATES, 1979

GEOTHERMAL DRILLING, WESTERN UNITED STATES

| State, Region | Area | Operator | WELLS | PROD. | SUSP. | ABD. | INJ. | OBS. | DIRECT | FOOTAGE (Feet) |
|---------------|----------------|------------|-------|-------|-------|------|------|------|--------|-------------------|
| IDAHO | E. Snake Plain | DOE | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 10,350 |
| | Island Park | Occidental | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 4,000 |
| NEVADA | Dixie Valley | Sunedco | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 22,140 |
| | | Thermal | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 19,840 |
| | Stillwater | Union | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 6,940 |
| | Desert Peak | Phillips | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 9,640 |
| | Ruby Valley | Union | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 3,140 |
| | Beowawe | Chevron | 4 | 2 | 0 | 0 | 0 | 2 | 0 | 7,840 |
| | Rye Patch | Phillips | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 8,060 |
| | Steamboat | Phillips | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 3,070 |
| | Fly Ranch | Sunedco | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 5,210 |
| | Monte Neva | Hunt | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 4,500 |
| NEW MEXICO | Valles Caldera | Union | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 20,150 |
| | Los Alamos | LASL | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 13,990 |
| OREGON | Mt. Hood | USGS | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2,000 |
| | Newberry | USGS | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2,070 |
| | Bully Creek | Chevron | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 2,820 |
| | Ontario | Ore-Ida | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 10,050 |
| UTAH | Milford | McCulloch | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 12,640 |
| | Cove Fort | Union | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 2,620 |
| | Salt Lake | Utah Roses | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 5,000 |
| TOTALS | | | 77 | 42 | 11 | 6 | 3 | 13 | 2 | 552,320 |

TABLE #3 SUMMARY BY OPERATOR, 1979

GEOTHERMAL DRILLING, WESTERN UNITED STATES

| Operator | Wells Drilled | Producible | Suspended | Abandoned | Injection | Observation | Direct Use | Total Footage Drilled |
|---------------------|------------------|------------|-----------|-----------|-----------|-------------|---------------|-----------------------------|
| Union | 31 | 26 | 1 | 1 | 0 | 3 | 0 | 220,091 |
| Sunedco | 4 | 1 | 3 | 0 | 0 | 0 | 0 | 37,975 |
| McCulloch | 4 | 1 | 0 | 2 | 1 | 0 | 0 | 36,901 |
| Aminoil | 5 | 4 | 1 | 0 | 0 | 0 | 0 | 34,820 |
| Republic Geothermal | 3 | 2 | 0 | 0 | 1 | 0 | 0 | 22,174 |
| Shell | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 21,321 |
| Phillips | 3 | 1 | 0 | 0 | 0 | 2 | 0 | 20,775 |
| Thermal | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 19,840 |
| Thermogenics | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 15,108 |
| GKI | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 15,414 |
| Chevron | 7 | 2 | 0 | 1 | 0 | 4 | 0 | 15,286 |
| Occidental | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 13,852 |
| LASL | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 13,995 |
| Natomas | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 10,897 |
| DOE | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 10,356 |

TABLE #3 SUMMARY BY OPERATOR, 1979

GEOTHERMAL DRILLING, WESTERN UNITED STATES

| Operator | Wells Drilled | Producibile | Suspended | Abandoned | Injection | Observation | Direct Use | Total Footage Drilled |
|------------|------------------|-------------|-----------|-----------|-----------|-------------|---------------|-----------------------------|
| Ore-Ida | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 10,054 |
| NCPA | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 9,618 |
| MAPCO | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 8,761 |
| Utah Roses | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 5,009 |
| Hunt | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 4,506 |
| USGS | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 4,076 |
| Magma | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1,500 |
| TOTALS | 77 | 42 | 11 | 6 | 3 | 13 | 2 | 552,329 |

East Mesa Field

Republic Geothermal drilled East Mesa #74-30 as a 7,659 foot production development well, and was immediately followed by a 4,502 foot injection well, #56-19, as their tenth well at East Mesa. Both wells have been successfully operated at rates suitable for the proposed dual-flash 76 Mw (gross) power plant that Jacob's Engineering Group Inc. plans to construct at Republic's East Mesa Field.

North Brawley Field

Union also drilled and tested their tenth well, "Veysey" #9 (7,800 feet) at North Brawley during 1979. Veysey #10 (6,827 feet) was then later drilled. These wells, with others, will be utilized by the 10 Mw geothermal plant now under construction. Union, owner of the resource, will sell steam to Southern California Edison, operator of the plant that is scheduled for completion in mid-1980 at an estimated cost of \$18 million. Approximately 20 miles east of Brawley, Phillips drilled an intermediate depth (1,000 to 2,000 feet) temperature hole within the Glamis KGRA.

South Brawley Field

At the start of the year, McCulloch skidded the rig from their previously successful "Mercer" #1-28 site and drilled "Mercer" #2-28 as a 4,147 feet injection well. Testing at the Mercer site yielded 75,000 #/hr. of flashed steam under restricted flow with a 422°F wellhead temperature. McCulloch estimates that "Mercer" #1-28 is capable of delivering 200,000 #/hr. of steam.

Two miles west of the "Mercer" location Chevron completed an observation well, "Holly" C #275, at 2,419 feet. During the year they also drilled at least 4 temperature gradient holes of 2,000 foot depth on this "Holly" lease near the north end of the Imperial Fault.

Union Oil Company, in a joint venture with Southern California Edison Co. and Southern Pacific Land Co., further developed the southwestern part of the

Salton Sea Geothermal Field by drilling three new wells. The first well, "IID" #5, was completed at 3,132 feet. The drilling rig was immediately moved one-half mile north to drill "IID" #6 to 3,500 feet. Union tested both wells and declared them capable of commercial production. Two months later, Union spudded "Sinclair" #13 (2,850 feet) approximately one-half mile east of "IID" #5. "Sinclair" #13 also is a producing well. All three wells are believed to have encountered a hypersaline geothermal reservoir that exceeds 500°F.

Several miles northeast, near the Salton Sea Demonstration Geothermal Plant, Magma drilled "IW" #5 as a 1,500 foot injector. It will be utilized for water disposal and reservoir pressure maintenance.

Near the end of the year, Republic Geothermal spudded "Fee" #1 as a Salton Sea Field northeast stepout well located approximately two miles northeast of proven production. "Hudson" #1, the previously most northerly well in the Salton Sea field, was tested in 1964 at a 432,333 #/hr. mass flow rate with 22% flash. The Republic "Fee" #1 was drilled through thermally metamorphosed siltstones and sandstones until fractures were encountered below 8,000 feet. "Fee" #1 was successfully completed barefooted at 10,013 feet with a static bottom hole temperature greater than 550°F. Preliminary testing indicates an electricity generating potential in excess of 3.5 Mw.

Westmorland Field

Westmorland Geothermal Associates, a 50-50% MAPCO and Republic Geothermal partnership, received a \$29 million loan guaranty in 1979 to develop the Westmorland geothermal field discovered by Republic in 1976. At that time (July 1979), the four production and two injection wells existing in the northern Westmorland Field had intersected a 100,000 ppm TDS reservoir exceeding 500°F. The first well drilled under the

loan guaranty, MAPCO "Currier" #1, was sited 4-1/2 miles south of these wells on a related but separate temperature gradient anomaly. By year-end the "Currier" #1 had been drilled and temporarily suspended at 8,761 feet. It has commercial temperatures of about 500°F. A second well was immediately programmed to be drilled nearby so that long-term testing and evaluation could be undertaken.

Hot Mineral Spa

McCulloch drilled a deep well in the Hot Mineral Spa area located near the Salton Sea's eastern shore. "Hot Mineral" #1-15 was abandoned at 9,800 feet.

The Geysers Area

Drilling activity in The Geysers area increased from 28 wells drilled during 1978 to a total of 33 wells in 1979. Ten exploratory wells, 2 workovers and 21 development wells were drilled, with the successful exploration wells increasing The Geysers' known production boundary by at least 1150 acres.

Geothermal Kinetics and Union slightly extended the southern edge known production. Union also extended the northern limits of known production with "Binkley Ranch" #1, and the northeastern edge with their successful "Northeast Geysers Unit" #2 well. The Northern California Power Association (NCPA) wildcat well "Cobb Valley" #1 (9,618 feet), sited north of Union's "Binkley" #1 and approximately one mile north of McCulloch's Francisco wells, reported commercial quantities of steam. Further testing is required to confirm this preliminary report; however, this could represent a major discovery and open up considerably more acreage for development. Even more significant, if proven, is the apparent steam discovery by the Occidental "Neasham" #1, drilled six miles north of the NCPA location. Attempts by Aminoil, Natomas and Shell to extend known production southeasterly were unsuccessful when three wells failed to encounter commercial quantities of steam.

Union Oil Co. was successful in drilling and completing 13 new development wells, two workovers and three exploratory stepout wells at the Geysers during 1979. Development wells "DX State 4596" #40 (8,413 ft.), #43 (8,718 ft.) and #44 (8,559 ft.) will supply Units #7 and 8, "Cobb Mountain" H.C. #7 (8,713 ft.) and "DX State 4596" #33 (9,736 ft.) are for Unit #12, and "DX State 4596" #45 (8,334 ft.) appears to be for a future plant location or for use in Unit 11. The Union "GDC" wells #1 (7,375 ft.), #2 (6,105 ft.), #7 (5,166 ft.) and #9 (6,581 ft.) are for Unit #14. "GDC" #12 (7,318 ft.) and "Ottoboni State 4596" #2 (8,131 ft.) may be used as make-up wells. The success of Union's stepout wells, "Binkley Ranch" #1 (10,520 ft.), "Northeast Geysers Unit" #2 (9,237 ft.) and "Curry" #1 (7,520 ft.), demonstrates that the boundary of The Geysers steam field is not yet established and future expansion is imminent. Union also deepened and worked over two existing wells, "L.F. State 4597" #6 (6,769 feet) and #9 (7,422 feet).

During 1979, Aminoil drilled five wells at Castle Rock Springs in the southeastern portion of The Geysers. Four wells, "D & V" #3 (6,935 feet), "CA 1862" #57-27 (5,468 feet), "CA 958" #86-34 (7,362 feet), and "CA 956" #37A-34 (5,186 feet), are successful development wells for Unit 13. This unit started power production in April 1980 and is currently generating 135 Mw electricity at full capacity. Aminoil's single stepout well, "MLM" #3 (8,885 feet), was directionally drilled a significant distance to the northeast, but did not encounter commercial steam. Natomas also unsuccessfully drilled near the southeast corner of the field where the "Davies Estate" #1 (7,021 feet) was suspended without encountering commercial quantities of steam.

Geothermal Kinetics (GKI) drilled two wells, "Rorabaugh" #2 (6,738 feet) and #3 (6,770 feet) on the eastern part of their lease that contained their previously existing "rorabaugh" #1 well. These two new commercial wells extend the southern edge of The Geysers, and with Union's "Curry #1", expand known production nearly 200 acres. GKI is currently nego-

tiating with the Department of Water Resources (DWR) for a 55 megawatt plant in this area.

Shell drilled two wells during 1979 in the southeast Geysers. "U.S. Geothermal" #53-2 (6,975 feet) was located near known steam production and was a successful development well. The other well, "U.S. Geothermal #72-1 (8,753 feet), drilled as a wildcat east of the known production boundary, only encountered subcommercial quantities of steam and was suspended. Shell is also negotiating a contract with the DWR to sell steam for generating electricity. This 110 megawatt DWR power plant is expected to be on line in 1982.

McCulloch drilled a single well, "Coleman" #1-5 (10,308 feet) in The Geysers during 1979. It was reported to be a successful well, bringing their total commercial wells to three in the northern Geysers area. McCulloch has negotiated a contract with the DWR for a 55 megawatt plant, and additional wells are expected to be drilled soon.

Thermogenics drilled, redrilled twice, and finally abandoned "Rorabaugh" #A-12 (7,269 feet), located on the existing production boundary near their new 55 megawatt power plant, Unit 15. Unit 15 started generating electricity in June, 1979.

Sunoco Energy Development Co. drilled a wildcat well, "Bud Taylor" #1, on the northwest side of The Geysers near Tyler Valley, and approximately two miles northwest of proven steam. The "Bud Taylor" #1 was drilled to 10,620 feet, where an unsuccessful fishing operation forced suspension. The "Bud Taylor" #1 is rumored to have a high bottom hole temperature.

Occidental drilled "Neasham" #1 six miles north of proven steam production at a location two miles north of Mt. Hanna. The well, as part of a farm-in on Republic Geothermal leases, was being drilled ahead at 9,852 feet when a fish was lost. After an unsuccessful fishing attempt, the well was initially tested before collapsed casing forced temporary suspension. Oxy is preparing to renew

operations to confirm this apparent significant discovery.

Eastern California

The Long Valley KGRA located in California on the east side of the Sierra Nevada is the site of young volcanism and numerous boiling springs. At one of these springs, Casa Diablo, existing shallow wells of 600 to 1000 ft. depth penetrate a 360°F aquifer. In anticipation of the upcoming KGRA competitive sale, Union drilled "Mammoth" #1 (5,263 feet) adjacent to Casa Diablo Hot Springs. Three miles to the northeast, where a clay mine occurs in hydrothermally altered rock, they drilled "Clay Pit" #1 to 6,494 feet. Both are classified as observation wells. Also near this clay mine, Chevron drilled several temperature gradient holes and a single 2,200 foot observation well, "LV" #19.

Phillips drilled a single intermediate depth temperature hole near Amboy Crater, California.

IDAHO

The east-central Snake River Plain is a geological down-warp containing a thick pile of recent sediments and lava flows. The youngest volcanics, 20,000 years old, suggest that a near-surface heat source may still exist in the region. After conducting geological and geophysical surveys over the Plain, DOE sited a deep test well located 20 miles east of Arco near a federal facility. "INEL" #1 was drilled to 10,356 feet into the down-warp, but it has only a 302°F bottom hole temperature and is now used only as an observation well.

Further eastward are Island Park Caldera and Yellowstone Park. Occidental began evaluation of their Island Park geothermal leases by drilling a 4,000 foot observation well, "Sturm" #1. The well bottomed in Tertiary volcanics and is rumored to lack encouraging temperatures.

NEVADA

With the successful discovery in Dixie Valley in 1978, combined with prior discoveries at Rye Patch and Desert Peak, Nevada geothermal drilling dramatically increased last year. The previous yearly highs of six geothermal wells drilled in 1976, and 25,093 feet drilled in 1978, were greatly exceeded in 1979 by the geothermal industry's drilling 15 wells with a total footage of 90,418 feet.

Dixie Valley

In 1979, Sunedco drilled two stepout wells from "S.W. Lamb" #1, their 1978 Dixie Valley discovery well that had encountered commercial resource below 7,200 feet in fractured rock. The second well, "S.W. Lamb" #2, was drilled to 8,901 feet where hole problems forced a re-drill. The redrill bottomed at 8,588 feet with 7 inch liner hung to 7,994 feet. Although the well has produced steam, mechanical troubles caused several "clean-out" operations and eventual suspension. With a rig skid, Sunedco then spudded "S.W. Lamb" #3 as a confirmation well. The well was easily drilled to 9,126 feet and successfully tested as a commercial producer.

Thermal Power Co., on a Southland Royalty farmout, utilized matching DOE funds to drill "Dixie Federal" #45-14, a deep wildcat well sited 10 miles southwest of the Sunedco wells. The well drilled out of volcanics at 2,525 feet, and was drilling in metasediments at 4,618 feet when a 20° hole angle forced a redrill. The redrill, kicked off at 3,508 ft., was suspended at 9,022 feet when bit cones were lost. Subsequent logging determined the bottom hole temperature to be 385°F.

Thermal then moved the rig five miles northward to spud "Dixie Federal" #66-21. The hole reportedly encountered a hot water entry at approximately 4,680 feet, and after testing the entry, Thermal elected to drill ahead to a final depth of 9,780 feet where they suspended operations.

Carson Sink Region

This past year saw drilling activity in the two Carson Sink Region geothermal areas of Stillwater and Desert Peak. At Stillwater, Union, participating in DOE's industry-coupled program, tested for a deeper geothermal resource with "Debraga" #2. The well encountered alluvium, sediments, and volcanics to its final suspended depth of 6,946 feet. Testing determined a maximum subsurface temperature of 335°F with a 150,000 #/hr. total mass flow rate.

Prior to 1979, Phillips' three wells at Desert Peak had located a commercial geothermal resource. In 1979, Phillips drilled "Desert Peak" B23-1 to 9,641 feet. It has continued to be observed, and temperature logs indicate a maximum down-hole temperature of 414°F.

Beowawe

The Beowawe area continued to undergo active geothermal development by Chevron in 1979. They drilled a shallow production well, two observation wells, and deepened another. The sequence started late in 1979 when Chevron spudded "Beowawe" #33-17. After coring, a liner was run to 1,300 feet, with production slots located from 754 to 1,280 feet. Testing indicates the well is a producer. The rig was then used to reenter "Rossi" #21-19, which had been suspended in 1976 at 5686 feet. The well was deepened to 7,215 feet and declared to be a producer. The remaining two wells, "HSR" #22 and "D-DR" #79, are reservoir delineation (observation) wells drilled to 2,540 and 2,478 feet respectively.

The remaining 1979 wells were scattered throughout Nevada. Phillips drilled the "Campbell #E-2 as a confirmation-development well at Rye Patch. The well is being evaluated at 8,061 feet, with a reported 382°F maximum temperature.

Union drilled their initial Ruby Valley well, "Stonier" #2 (3,149 feet), near a large boiling spring. Although surface geology and surface water geochemistry

indicated this to be an excellent geothermal prospect that received high KGRA bonus bids back in 1976, it is rumored that the "Stonier" subsurface temperature logs are not encouraging.

At Fly Ranch, located in northwestern Nevada, Sunedco drilled "HLR" #1-2-FR near a steaming geyser and 15 miles from their "HLR" #1-15-G (drilled to 5,871 feet in 1978). The 5,213 foot well is reported to have a commercial temperature, and is suspended temporarily.

In eastern Nevada, north of Ely, Monte Neva Hot Spring flows a slightly saline water at 176°F. Five miles due north of the spring, Hunt drilled the "Federal" #37-23. The well was abandoned at 4,506 feet with a surveyed temperature of less than 200°F.

The geothermal discovery of 1979 in Nevada occurred at Steamboat Springs, a few miles south of Reno. This large old spa has been the site of at least six shallow drilling attempts in the last three decades. Phillips commenced their 1979 Steamboat drilling operation at the "Steamboat" #1 by drilling through major lost circulation down to 344 feet. After cementing 20" casing, they reached a total depth of 3,073 feet. Phillips reports finding a liquid reservoir at greater than 400°F that flows at commercial rates. They are waiting for water removal application approvals before drilling a confirmation well.

Intermediate depth (1,000 - 2,000 feet) temperature holes were drilled by Chevron at Soda Lake and Beowawe, by Earth Power at McGee and Baltazor, and by the Navy at Fallon.

NEW MEXICO

The Valles Caldera area in the Jemez Mountains was the only site of 1979 geothermal drilling in New Mexico. Union completed "Baca" #18 at 5,250 feet, "Baca" #19 at 5,610 feet, and "Alamo Canyon" #1 at 7,400 feet as successful

development wells located inside the caldera. Thirty-day flow tests determined these wells to be successful producers from a 500°F plus reservoir. Present plans call for construction to commence this summer on a 50 Mw power plant located on private land, after an Indian religious infringement question had been successfully resolved. Estimates predict that 17 geothermal producers will be required initially to supply the steam for the plant.

The remaining New Mexico well is located outside the caldera, at LASL's hot dry rock project. "EE" #2, the third well at the project site, is located within 400 feet of the other two. "EE" #2 was drilled to 10,067 feet, where fishing delayed the operations, and the well eventually reached a total depth of 13,995 feet. LASL now has plans to hydraulically fracture this well to establish communication between all three wells.

OREGON

Geothermal drilling in Oregon was limited to one direct heat utilization well and three observation wells. The direct application "Ore-Ida" #1 was located at Ore-Ida's Ontario plant near the Oregon-Idaho border. It was drilled to 10,054 feet and bottomed in basalt. After hanging a 7-inch liner to 10,038 feet the well was tested, but it failed to produce at satisfactory rates although the water temperature of 350°F is adequate for use in Ore-Ida's food processing factory.

Twenty-five miles west of Ontario, Chevron drilled an observation well at their Bully Creek prospect. The "Jordan" #1 was planned as a 3,000 foot test, but was abandoned after reaching 2,820 feet because of a fish in the hole.

The two remaining Oregon wells were drilled by the USGS as observation wells. "Pucci Chairlift" on Mt. Hood is suspended at 2,000 feet until next summer, when it is programmed to be deepened to 3,000 feet. In central Oregon, the USGS drilled a temperature hole between the two lakes inside Newberry's caldera. Heavy snow forced the suspension of "New-

berry" #2 at 2,076 feet before its planned depth of 3,000 feet was reached.

Intermediate depth (1,000 - 2,000 feet) temperature holes were drilled by Republic at Vale, by Union at Alvord and in the High Cascades, by Anadarko at Alvord, by Eugene Water and Electric in the Cascades, by Francana Resources at Glass Buttes, and by Northwest Natural Gas in the Cascades.

UTAH

At Cove Fort, Union's "CFSU" #14-29, their fourth well in the area and their third to be drilled with DOE financial assistance, was drilled and abandoned after reaching only 2,620 feet. The carbonate formation at this depth produced severe lost circulation and hole sloughing problems. There now appears to be little hope for a geothermal resource generation of electric power in this area.

North of Milford, and west of the Roosevelt KGRA, McCulloch drilled "Accord" #1-26 as a wildcat reportedly situated on a separate geophysical anomaly. At a depth of 12,646 feet the effort was abandoned and the well was plugged.

In Salt Lake County's Jordan Valley, Utah Roses Inc. attempted to locate and produce 105°F water to provide greenhouse space heating. With funding from DOE they drilled "BG" #1 to 5,009 feet. The well has been tested at a 10 gpm rate with a 104°F surface temperature. The measured bottom hole temperature is 135°F.

Biographies

Dr. Smith, Vice President-Exploration, received his education as a geologist at Middlebury College and Indiana University. After spending a decade as an explorationist with Standard Oil Company of California, he has been with Republic Geothermal for the past five years.

Mr. Matlick, an exploration geologist-geochemist, joined Republic in 1975 after completing his M.S. in geology at Arizona State University.

Mr. Ehni joined Republic in 1979 and has over five years' experience as a geothermal geologist working for Thermogenics and Aminoil in The Geysers.

CALIFORNIA DEPARTMENT OF WATER RESOURCES SOUTH BRAWLEY GEOTHERMAL PROJECT

The State of California, Department of Water Resources is seeking the services of a qualified firm or individual to advise the Department on the potential for electrical generation applications of liquid dominated geothermal resources in the Imperial Valley at South Brawley.

The work will include: reviewing an ongoing test program to determine the capabilities for proving the electrical generation potential of the resource; analyzing test data and making recommendations based on findings which will assist in determining the commercial viability of the geothermal resource; and coordinating with the Department's design staff and any additional consultants required to consider the feasibility of a power plant. Such an advisor will be called upon intermittently, as needed, throughout the Department's program.

Information regarding the project and all proposal requirements is available and can be obtained through September 22, 1980, by contacting Ms. Judy Warburg at P.O. Box 388, Sacramento, California, 95802, (916) 323-4026. Proposals must be mailed to the above address or hand delivered to 1416 Ninth Street, Room 440-4, Sacramento, California, not later than 10 a.m., October 14, 1980.

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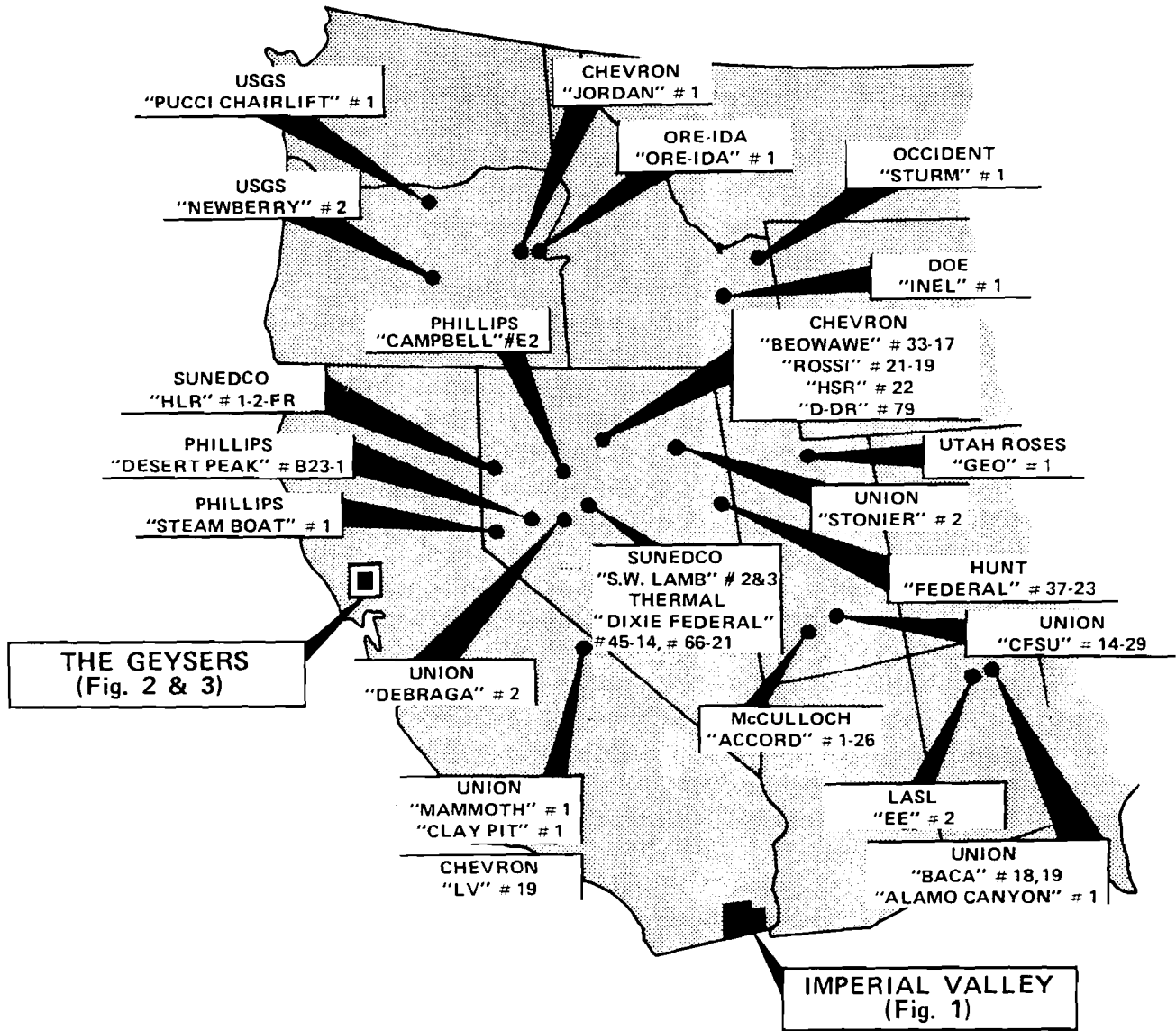


FIGURE 4. 1979 GEOTHERMAL WELLS, WESTERN UNITED STATES