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DRILLING HISTORY AND GEOLOGY OF THE LANIPUNA NO. 6 GEOTHERMAL TEST, LANIPUNA PROSPECT HAWAII

for

BARNWELL INDUSTRIES, INC.
HONOLULU, HAWAII

by

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GeothermEx, Inc.
Richmond, California

December 1984

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ILLUSTRATIONS

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INTRODUCTION AND SUMMARY

The Lanipuna #6 geothermal exploration well is located approximately 3,000 feet east-northeastward of well HGP-A. The well is near the southern margin of the Kilauea East Rift Zone on the island of Hawaii (figure 1). The site is in the north-central part of the Tokyu prospect area. The elevation is 600 feet above sea level.

Access to the drill site is by way of a paved road (Hinalo Street) which intersects highway 132 at a point 3 miles south of the town of Pakona in the Puna District of Hawaii.

Lanipuna #6 was spudded on February 22, 1984. Total depth of 4,956 feet was reached on June 1, 1984. Gel-water muds were used as drilling fluids. In the course of drilling operations, there were interruptions for setting of 13-3/8" casing to 75 feet on February 23, 1984, the 9-5/8" casing string at 1,290 feet on March 6 and for cement plug backs between 4,200 and 4,300 feet between March 30 and May 9, 1984. The hole was accidentally side tracked at 1,460 feet on April 14, 1984, after plugging back to seal off lost circulation zones below 4,296 feet. The hole was subsequently redrilled to 4,300 feet depth. Lost circulation and consequently no cutting returns occurred below 4,300 feet. Clear water was used as drilling fluid from 4,300 feet to total depth. Lanipuna #6 penetrated a lithologic section of subaerial lava flows from surface to about 1,600 feet, shallow marine volcanic rocks from 1,600 feet to 3,300 feet and deeper submarine volcanic rocks from 3,300 feet to total depth. A principal high (?) angle normal fault system was crossed at 4,285 feet, and it is probable that there was some repetition of the section.

A maximum temperature of 335°F was recorded at a depth of 4,250 feet. The temperature gradient slope was linear to 4,250 feet and reversed

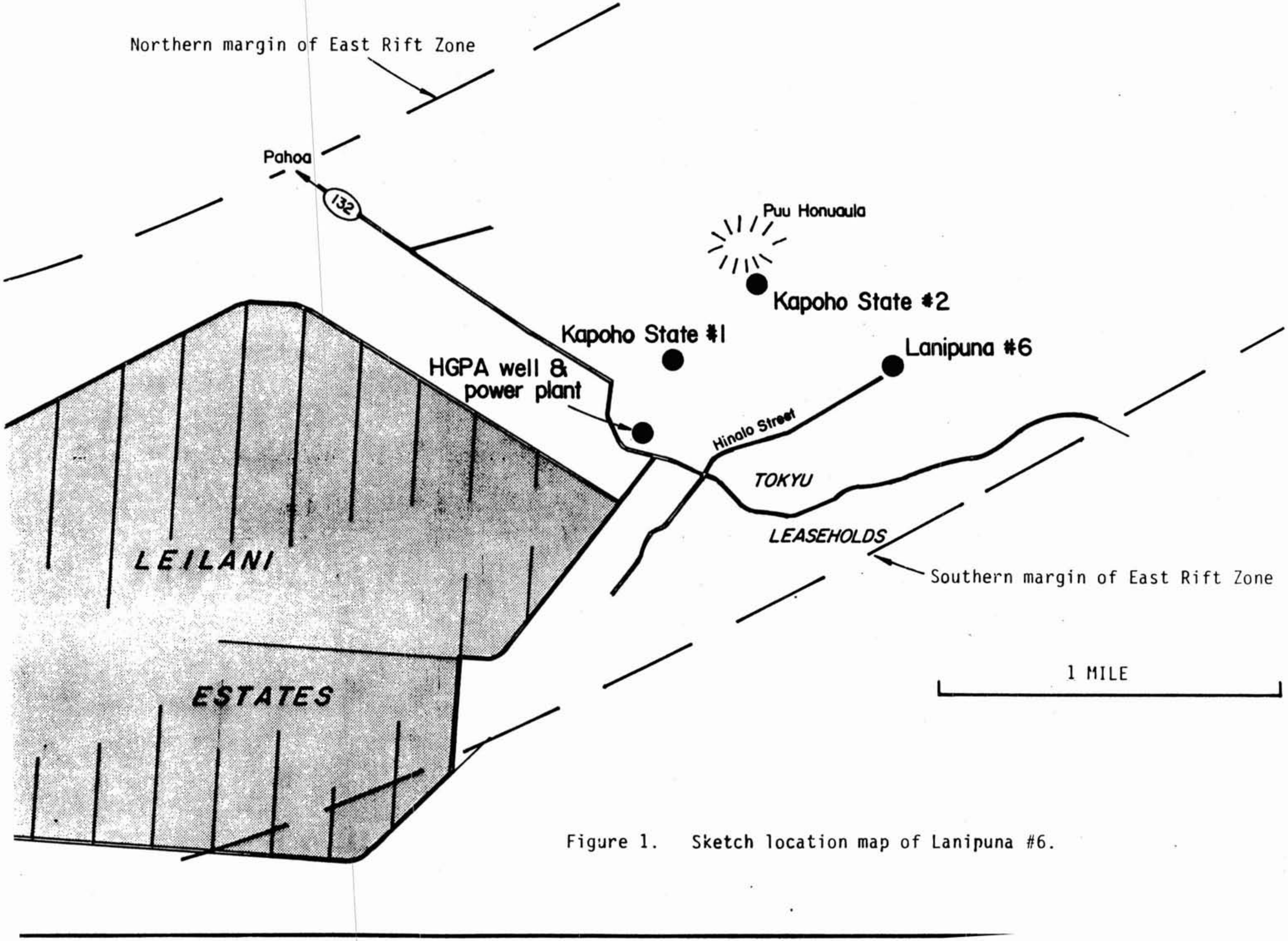

Figure 1. Sketch location map of Lanipuna #6.

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below that depth. The gradient then decreased rapidly to about 240°F at 4,350 feet and was essentially isothermal to total depth. The well does not have adequate temperatures for economic production of electricity with existing technology. Chemistry of the fluids unloaded by air from the well are typical of a diluted (mixed) sea water with meteoric and thermal water components. The well is located at the southern margin of the Puna District geothermal reservoir associated with well HGP-A and is influenced by outflow of thermal waters from the reservoir and rapid exchange with the "normal" island hydrology in the fault zone.

Continuous air H_2S sampling and monitoring as well as meteorologic records were provided by EAL under a subcontract with Thermal Power Company. No readings above ambient levels were recorded which resulted from drilling Lanipuna #6. The well has been shut in and suspended.

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DRILLING HISTORY

Phase 1: <u>Conductor Hole</u>

Lanipuna #6 was planned for economic and rapid investigation of the geothermal temperature regime and flow potential of the northeastern part of the Tokyu leasehold. Potential production was a secondary consideration. Consequently the well diameter was slimmer-than-usual for Puna District exploration holes.

The hole was spudded on February 22, 1984. A 12-1/4 inch diameter pilot hole was drilled and then reamed open to 17-1/2 inches to a depth of 75 feet.

Casing was run. A 61 pound, K-55, 13-3/8 inch buttress thread casing was set and cemented to surface on February 23 with 162 feet^3 of Readi-mix.

Phase II: <u>Surface Hole</u>

The surface hole was drilled with a 12-1/4 inch bit to 654 feet. The static fluid level was 568 feet from surface. A water sample was collected for the state on February 29. The hole then was deepened to 1,290 feet. Casing was run. A 54.5 pound, K-55, 9-5/8 inch buttress thread casing was set from 1,258 feet to surface and cemented in two stages. The operation waited on cement from March 6 to March 7.

A temperature survey was run on March 7, and the Blowout Preventers (BOP) were nippled up on March 7 and 8.

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Phase III: Intermediate Hole

On March 10, the 8-3/4 inch hole drilling commenced. Mud temperature measurements were started and the geologist was mobilized to examine lithologies and integrate data. Mud return temperatures were monitored, temperatures increased from 43.9°C on March 15 to 48.4°C on March 16, 57.4°C on March 21 and 61.5°C on March 23. Temperature surveys were run with the Gearhart-Owens electric tools at depths of 2,837 feet on March 17 (table 1), 4,168 feet on March 23) (table 2) 4,254 feet on March 24 (table 3) and 4,296 feet (March 27).

On March 27 at a depth of 4,296 feet, massive lost circulation occurred. The condition could not be corrected despite use of mud with added lost circulation materials (mica, bagasse, etc.) during March 27, 28 and 29. About 650 barrels (30,000 gallons) of fluids were lost.

A temperature survey was made on March 29 and drilling without returns commenced, to a depth of 4,326 feet, by March 30. At that depth, a LYNNES Packer was set and cement was injected through it. A total of 100 sacks of cement, with composition Class G, 1:1 perlite, 40 percent silica, 3 percent gel, and .05% CRF-2 retardant was used for the plug back. Of this, it was calculated that 193 feet^3 was injected into the formation and 42 feet^3 was left in the hole.

Circulation was attempted; continuous loss at the rate of 200 barrels per hour occurred. A temperature survey was run on April 3. The LYNES Packer was set again at 4,069 feet depth and the plug back operation was repeated successfully with no loss to the formation. The hole was drilled ahead to 4,375 feet, at which time complete lost circulation occurred. Drilling proceeded to 4,400 feet without returns. The hole was plugged back and a temperature survey run on April 6 (table 4). Circulation was not successfully restored.

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Plug back Nos. 3 and 4 were attempted, but circulation was not restored by April 10. Temperature survey was run.

Plug back No. 5 was made on April 11. Cement was encountered upon reentering the hole at 1,280 feet depth. The hole was drilled ahead in cement to 1,548 feet depth. Rock chips began to appear in the returns at about 1,460 feet depth. By April 13, at 1,763 feet depth, it was clear than an unintentional side track had occurred.

Plug back No. 6 was made to 1,331 feet and drilling proceeded on April 14. The side track persisted. Drilling ahead proceeded, and a temperature survey was made on April 21, when a depth of 2,634 feet was reached. Drilling ahead proceeded in the new side-tracked hole. The mud temperatures were continually recorded. The mud temperature out of the hole was 59.1°C at a depth of 3,740 feet on May 1, 1984. A temperature survey was made on May 2, at which time the BHT at 4,169 feet was 279°F about 3 hours after circulation stopped. A temperature survey was made on May 7, 1984 (table 5). A depth of 4,245 feet was reached in the side-tracked hole on May 4, 1984.

The 7-inch liner was run and cemented on May 9, 1984. The liner was made up of L-80, 32 pound Hydril.

The bottom of the liner was set at 4,239 feet and the top landed at 1,086 feet depth for a total length of 3,153 feet. The cement consisted of 244 sacks of Class G 1:1 perlite, 40% SiO_2, 3% gel, 3/4% CFR-2, tailed with 62 sacks of the same blend. Temperature and bond logs were run on May 11. The tie-back string was run and landed May 12.

The BOP was assembled, nippled up and tested May 15. Drilling started May 17, with a 6-inch bit. Lost circulation occurred on the same day at a depth of 4,285 feet. Plug back (No. 7) and cementing was completed on May 18, and drilling progressed to 4,309 feet. Lost circulation occurred when the depth was 4,298 feet. The well was again plugged back (No. 8) on May 19, cemented and drilled ahead to 4,395 feet. Circulation was lost. The well was plugged back (No. 9) on May 21, and drilled ahead.

Partial lost circulation occurred at 4,285 feet and total lost circulation occurred at 4,365 feet. Plug back (No. 10) was made on May 22, using a LYNNES packer and 1,600 pounds of pressure behind the cement; the hole was drilled out on May 23. Partial lost circulation occurred at 4,309 feet, complete lost circulation at 4,340 feet, and was regained, but lost again at 4,340 feet.

The hole was drilled ahead to total depth of 4,315 feet, plugged back (No. 11), cement was squeezed with a LYNNES packer to 1,600 pounds and drilling was attempted. Circulation was lost at 4,320 feet. A total of 700 barrels was lost, including mud and L.C. materials.

Temperature surveys were made on May 29, 1984 to a depth of 4,284 feet (table 6,7). The hole was drilled ahead without returns on May 25, using clear water, to a total depth of 4,956 feet on June 1, 1984. Temperature surveys were run on June 4, 1984, and then weekly to bi-monthly until July 6, 1984 (table 8).

From August 9 to August 10, 1984, the well was unloaded with compressed air and temperature measurements made (tables 9 to 16) each day after unloading and again after about 16 hours of inactivity. About 1,100,000 gallons were unloaded from the well. The hole was reentered on September 18, 1984; a bridge plug was set at 4,195 feet, and pressure tested to >1,600 psi. On September 20, an interval of 135 feet, from 3,975

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to 4,110 feet, was perforated at 4 holes per foot. The hole was then drilled and cleaned to 4,956 feet. Attempts to induce flow by unloading and pressurizing were unsuccessful. The hole has been shut in and suspended.

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TEMPERATURE REGIME

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Table 1. Lanipuna No. 6. temperature record, 3/17/84, 1130, 7 hours after circulation

Depth, feet	Temperature, °F
100	107.1
200	106.7
300	106.3
400	106.1
500	106.0
600	107.2
700	109.2
800	111.4
900	111.6
1,000	111.6
1,100	111.6
1,200	110.9
1,259	111.5
1,300	113.7
1,400	112.5
1,500	113.3
1,600	113.9
1,700	114.8
1,800	116.2
1,900	119.1
2,000	124.0
2,100	127.2
2,200	128.6
2,300	128.9
2,400	130.3
2,500	135.0
2,550	139.5
2,600	140.3
2,650	142.1
2,700	140.6
2,750	147.9
2,800	149.2
2,837	153.0 (rising to 164.2 in 7.5 minutes)

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Table 2. Lanipuna No. 6. temperature record, 3/23/84, 0850, 55 hours after circulation.

Depth, feet	Temperature, °F
100	111.0
200	115.3
300	113.9
400	114.3
500	114.2
600	116.7
700	118.8
800	122.0
900	126.3
1,000	127.7
1,100	127.1
1,200	128.4
1,300	131.3
1,400	130.8
1,500	132.0
1,600	132.3
1,700	135.7
1,800	137.1
1,900	140.3
2,000	143.6
2,100	144.8
2,200	149.0
2,300	151.1
2,400	155.2
2,500	159.7
2,600	161.7
2,700	164.0
2,800	165.8
2,900	170.0
3,000	173.3
3,100	178.0
3,200	184.4
3,300	187.9
3,400	191.6
3,500	198.0
3,600	199.7
3,700	207.0
3,800	214.6
3,850	216.8
3,900	220.8
3,950	227.1
4,000	233.7
4,050	233.5
4,100	244.1
4,150	230.3
4,167	254.2 (rising to 278° in 7.5 minutes)

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Table 3. Lanipuna No. 6. temperature record, 3/24/84, 0945, 55 hours after circulation.

Depth, feet	Temperature, °F
300	83.0
600	106.5
800	101.5
1,000	105.6
1,200	99.3
1,300	105.6
1,400	105.6
1,600	107.3
1,800	113.1
2,000	133.8
2,200	163.5
2,400	168.1
2,600	187.8
2,800	202.4
3,000	220.8
3,100	232.4
3,200	237.2
3,300	249.6
3,400	258.2
3,500	265.9
3,600	272.8
3,700	282.2
3,800	288.0
3,900	299.0
4,000	307.0
4,050	311.0
4,100	310.0
4,150	317.0
4,200	325.0
4,250	335.0

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Table 4. Lanipuna No. 6. temperature record, 4/6/84. Fluid level - 648 feet

Depth, feet	Temperature, °F
2,500	188.4
3,000	228.2
3,500	268.0
3,600	274.0
3,800	286.1
4,000	297.6
4,100	301.8
4,200	296.4
4,250	290.7
4,260	288.0
4,270	285.1
4,280	274.5
4,285	262.0
4,290	245.0
4,295	224.6
4,300	209.1
4,305	197.7
4,310	185.7
4,315	184.7
4,320	184.2
4,325	184.1
4,330	185.1
4,335	186.2
4,340	189.0
4,345	189.6
4,350	193.0
4,355	196.9
4,365	205.0
4,375	218.1
4,381	229.1
4,388	239.5

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Table 5. Lanipuna No. 6. temperature record, 5/7/84, 1400, 10 hours after circulation

Depth, feet	Temperature, °F
1,700	126.9
1,800	129.8
1,902	134.3
2,000	140.9
2,100	147.1
2,202	150.9
2,300	143.2
2,400	157.0
2,500	165.2
2,600	170.1
2,700	173.9
2,800	174.9
2,904	178.8
3,001	184.2
3,100	187.6
3,200	191.0
3,300	195.6
3,400	198.7
3,500	203.1
3,600	209.7
3,700	219.9
3,800	227.2
3,980	233.5
4,000	239.4
4,050	239.0
4,100	247.6
4,150	249.7
4,200	254.0
4,245	263.0 (rising to 299.9 in 7.5 minutes)

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Table 6. Lanipuna No. 6. temperature record, 5/29/84, 0825, 10 hours after circulation

Depth, feet	Temperature, °F
2,000	144.0
2,500	186.9
3,000	226.7
3,500	266.9
4,000	295.3
4,250	289.2
4,284	284.0

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Table 7. Lanipuna No. 6. temperature record, 5/29/84, 0845

Depth, feet	Temperature, °F
4,000	295.3
4,260	282.9
4,270	281.8
4,280	267.2
4,285	231.7
4,295	217.8
4,300	208.5
4,305	193.4
4,310	185.1
4,315	183.6
4,320	183.0
4,325	182.8
4,330	183.7
4,355	184.5
4,340	--
4,345	188.3
4,350	191.0
4,355	195.0
3,365	208.8
4,375	218.2
4,381	229.0
4,387	237.0

Bridge below 4,387

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Table 8. Lanipuna No. 6 temperature records, 6/4/84 to 7/25/84, 55 hours to 1,280 hours after circulation stopped (Kuster-type recordings)

Depth, feet	Temperature, °F					
	6/4	6/8	6/15	6/22	7/6	7/25
3,700	-	293	309	315	326	329.6
4,200	274	308	321	330	339	344.4
4,280	-	268	-	-	-	-
4,300	200	-	217	229	249	344.0
4,350	-	193	-	227	245	268.0
4,375	-	-	-	248	-	-
4,400	181	221	260	269	280	-
4,450	-	226	-	-	-	-
4,500	197	234	260	267	277	-
4,600	206	226	232	240	252	251
4,700	211	226	235	240	250	-
4,800	-	220	233	237	247	-
4,850	211	-	-	-	-	-
4,900	214	218	233	237	246	-
4,930±	-	209	226	230	241	-

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Table 9. Lanipuna No. 6. temperature record, 8/7/84, after pumping

Depth, feet	Temperature, °F
1,000	236.6
1,500	241.7
2,000	247.9
2,500	252.0
3,000	255.1
3,500	257.4
3,700	258.4
4,000	258.6
4,200	257.2
4,300	250.4
4,319	249.6

Bridged at 4,319

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Table 10. Lanipuna No. 6. temperature record, 8/7/84, after 16 hours rest

Depth, feet	Temperature, °F
1,000	137.8
1,500	137.8
2,000	187.3
2,500	227.0
3,000	261.2
3,500	298.3
3,700	312.4
4,000	325.2
4,200	320.9
4,300	274.6
4,325	251.7
4,400	274.7
4,500	271.9
4,600	257.1
4,700	255.0
4,800	251.8
4,900	250.7
4,935	247.3

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Table 11. Lanipuna No. 6. temperature record, 8/8/84, after pumping

Depth, feet	Temperature, °F
1,000	237.0
1,500	241.8
2,000	247.9
2,500	251.9
3,000	254.9
3,500	257.2
3,700	258.4
4,000	258.6
4,100	258.4
4,200	257.4
4,300	250.7
4,315	249.9

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Table 12. Lanipuna No. 6. temperature record, 8/8/84, after 16 hours rest

Depth, feet	Temperature, °F
1,000	147.2
1,500	147.4
2,000	194.1
2,500	229.8
3,000	261.3
3,500	295.6
3,700	308.8
4,000	320.0
4,100	320.4
4,200	315.6
4,300	259.2
4,315	251.3

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Table 13. Lanipuna No. 6. temperature record, 8/9/84, after pumping

Depth, feet	Temperature, °F
1,000	238.3
1,500	243.0
2,000	248.4
2,500	252.1
3,000	254.9
3,500	257.1
3,700	258.0
4,000	258.3
4,100	258.2
4,200	257.3
4,300	250.8
4,315	250.1

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Table 14. Lanipuna No. 6. temperature record, 8/9/84, after 16 hours rest

Depth, feet	Temperature, °F
1,000	152.8
1,500	153.1
2,000	190.6
2,500	230.4
3,000	260.8
3,500	293.0
3,700	306.0
4,000	317.0
4,100	317.3
4,200	312.7
4,300	266.4
4,315	251.0

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Table 15. Lanipuna No. 6. temperature record, 8/10/84, after pumping

Depth, feet	Temperature, °F
1,000	155.4
1,500	156.5
2,000	197.7
2,500	231.4
3,000	260.7
3,500	291.6
3,700	304.2
4,000	315.0
4,100	315.3
4,200	310.8
4,300	264.4
4,315	251.0

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Table 16. Lanipuna No. 6. temperature record, 8/10/84, after 16 hours rest. Fluid level - 648 feet

Depth, feet	Temperature, °F
1,000	238.9
1,500	243.7
2,000	249.2
2,500	253.0
3,000	255.8
3,500	257.8
3,700	258.8
4,000	259.0
4,100	258.8
4,200	258.0
4,300	251.5
4,315	240.7

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LITHOLOGIC DESCRIPTIONS OF DRILL CUTTINGS

Depth Interval, feet	Description
1,300-1,340	100% BASALT Nonvesicular to microvesicular (.1mm) lavas with scattered phenoscripts of olivine (<1mm) and plagioclase (<1mm) within a gray glassy groundmass.
1,340-1,360	100% BASALT as above, with scattered pyrite and quartz crystals (<1mm).
1,360-1,380	100% BASALT as above, with diminishing pyrite and quartz.
1,380-1,400	100% BASALT as above, with some evidence of flow banding and FeO on chip surfaces; possible flow margin.
1,400-1,440	100% BASALT as above,with no FeO.
1,440-1,460	100% BASALT subophitic to felted, microvesicular lava; scatterd pyrite.
1,460-1,480	100% BASALT nonvesicular to microvesicular (.1mm), lava with scattered pyrite and acicular plagioclase phenocrysts (<1mm) within a gray glassy groundmass.
1,480-1,520	100% BASALT as above, with some FeO, and quartz crystals lining vesicles.
1,520-1,540	100% BASALT as above, with pyrite on fracture surfaces. Pale blue- gray chlorophaeite lines vesicles.
1,540-1,560	100% BASALT as above, pale chlorphaeite alteration.

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Depth Interval, feet	Description
1,560-1,600	100% DENSE BASALT as above, lava with scattered phenocysts of olivine (<1mm), scattered FeO on chip surfaces.
1,600-1,620	100% BASALT Dense, vitreous flow with scattered phenocrysts of olivine and quartz (<2mm) within a gray matrix of distinct feldspar and feromognesian minerals (<1mm). Trace pyrite.
1,620-1,640	100% BASALT as above, with some flow banding.
1,640-1,680	80% BASALT as above, dense to vesicular fractions gray chlorophaeite lines vesicles. 20% ASH soft gray altered clayey material with fragments of volcanic breccia and free quartz and mica crystals.
1,680-1,740	100% BASALT as above, dense to vesicular fractions, gray chlorophaeite lines vesicles; scattered free quartz mica and feldspar crystals.
1,740-1,760	100% BASALT as above, scattered olivine and pyrite.
1,760-1,780	100% BASALT as above, increasing pyrite, decreasing olivine.
1,780-1,820	100% BASALT as above.
1,820-1,840	100% BASALT dense, fresh, fine grained flows with few pyrite and quartz crystals.
1,840-1,860	100% BASALT as above, scattered vitreous black fragments

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Depth Interval, feet	Description
1,860-1,920	100% BASALT 1 as above, with varying amounts of olivine and pyrite crystals (≤ 1mm) and occasional small vesicles lined with gray chlorophaeite.
1,920-1,940	80% BASALT 1 as above 20% BASALT 2 dense, dark gray, very fine grain
1,940-1,960	25% BASALT 1 as above 75% BASALT 2 as above
1,960-1,980	40% BASALT 1 as above 60% BASALT 2 as above
1,980-2,020	10% BASALT 1 as above 90% BASALT 2 as above, few microvesicular areas
2,020-2,040	10% BASALT 2 as above 90% BASALT 3 light gray coarse-grained lava comprised mainly of plagioclase and pyroxene with occasional amphibole, magnetite and olivine (all = 1.2mm)
2,040-2,060	10% BASALT 2 as above 65% BASALT 3 as above 25% CLAY gray altered volcanic ash
2,060-2,080	10% BASALT 2 as above 90% BASALT 3 as above

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Depth Interval, feet	Description
2,080-2,120	100% BASALT 3 as above, with cpr phenocrysts ($\leq$ 3mm), flow banding and some alteration of plagioclase to clays
2,120-2,140	65% BASALT 2 as above 35% BASALT 3 as above
2,140-2,320	100% BASALT 3 as above, with prominent dark cpr crystals and varying amounts of the fine-grained ($\leq$ .15mm) fraction of basalt 2, probably from spall of hole walls
2,320-2,340	85% BASALT 3 as above 15% FeO encrusted fragments, breccia fragments (1mm) cemented by gray clay
2,340-2,360	50% BASALT 3 50% BASALT 2
2,360-2,380	100% BASALT 3 as above
2,380-2,400	100% BASALT 3 as above, with clay alteration of 15% of the fragments, as well as some glass in matrix
2,400-2,420	100% BASALT 3 as above, with a few vesicular fragments
2,420-2,440	100% BASALT 3 as above, with (<5%) vein calcite, scattered crystals of pyrite and FeO fragments [Drilling Break]
2,440-2,460	100% CLAY gray pasty clay binder with $\leq$ 1mm breccia fragments of basalt 3

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Depth Interval, feet	Description
2,460-2,480	60% CLAY as above 40% BASALT 2 as above
2,480-2,540	100% BASALT 3 as above, medium-fine-grained lava with plagioclase phenocrysts (.15 mm), occasional FeO coated chips between 2,500 and 2,540 feet
2,540-2,560	50% BASALT 3 as above 50% BASALT 2 as above
2,560-2,580	25% BASALT 3 as above 70% BASALT 2 as above 5% CLAY with breccia fragments
2,580-2,620	25% BASALT 3 as above 75% BASALT 2 as above, some pyrite crystals and some faint traces of chloritization on lavas
2,620-2,660	100% BASALT 1 subophitic lava with crystals of pyroxene and plagioclase (< 1mm) in a gray ground-mass of the same minerals, some FeO coated chips
2,660-2,780	100% BASALT 2 as above, with traces of quartz and pyrite crystals at 2,700 feet
2,780-2,800	50% BASALT 2 as above 50% BASALT 2 as above, but with feldspars altered to clays and with some flow banding

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Depth Interval, feet	Description
2,800-2,840	100% BASALT 2 altered as above
2,840-2,880	85% BASALT 1 sub ophitic to dense, very fine-grain light-gray lava, with scattered hexagon-shaped inclusions of olivine 15% CLAY very dark gray
2,880-2,940	60% to 80% BASALT 1 as above, with occasional scattered pyroxene ($\leq$ 1mm) phenocrysts 20% to 40% CLAY as above
2,940-2,960	60% BASALT 1 as above 30% CLAY as above 10% BASALT 3
2,960-2,980	30% BASALT 1 pharitic, crystalline, dark purplish-gray groundmass with pyroxene ($\leq$ 1mm) phenocrysts 25% CLAY as above 40% BASALT 3 holocrystalline light gray matrix with felsic and mafic phases, with occasional sulfide (pyrite) clusters and veinlets
2,980-3,020	65% BASALT 1 as above 25% CLAY as above 10% BASALT 3 as above
3,020-3,040	25% BASALT 1 as above, very fine-grained lava, with elongate pyroxenes oriented in flow pattern and some purplish cast to matrix, scattered rounded olivine clusters and quartz(?) crystals

Depth Interval, feet	Description
	25% CLAY as above 50% BASALT 3 as above
3,040-3,060	15% BASALT 1 as above 5% CLAY 80% BASALT 3 as above, with equidimensional pyroxene phenocrysts (about .25mm), rare olivine, high felsic proportion ($\leq$ 70%)
3,060-3,100	100% BASALT 3 as above, possibly flow margin, traces of black glass, pyrite and quartz
3,100-3,120	10% BASALT 1 as above, aphanitic, but holocrystalline dark-gray lava 90% BASALT 3 as above, phaneritic medium-gray color, fine-grained, holocrystalline, but vitreous in appearance, with some flow banding, and scattered olivine and plagioclase phenocrysts.
3,120-3,140	70% BASALT 1 as above 25% BASALT 3 as above $\pm$ 5% BLACK VITROPHYRE $\pm$ 5% "GRAPHIC" INTERGROWTH of plagioclase and pyroxene
3,140-3,270	70% BASALT 1 as above 15% BASALT 3 as above 15% "GRAPHIC" INTERGROWTH or vein of plagioclase and pyroxene, traces of pyrite and quartz, clay-ash

Depth Interval, feet	Description
3,270-3,300	70% BASALT 1 as above 25% BASALT 3 as above ± 5% GRAPHIC vein material (scattered quartz(?) and pyrite) clay-ash
3,350-3,360	55% BASALT 1 as above 35% BASALT 3 as above 10% GRAPHIC vein material as above
3,360-3,380	25% BASALT 1 as above 60% BASALT 3 as above 15% GRAPHIC vein material as above
3,380-3,510	20% to 10% BASALT 1 as above 65% to 80% BASALT 3 as above 15% to 5% GRAPHIC vein material as above, with occasional olivine crystals and clots at about 3,420 feet
3,520-3,540	10% BASALT 1 as above 30% BASALT 3 as above ≤ 5% GRAPHIC vein material as above 55% BASALT 4 granular texture flow, mostly aphanitic holocrystalline with about 15% glass in matrix
3,540-3,550	15% BASALT 1 as above

Depth Interval, feet	Description
	75% BASALT 3 as above ≤2% GRAPHIC vein material as above ≤10% BASALT 4 as above
3,550-3,580	60% BASALT 1 as above 35% BASALT 3 as above ≤5% GRAPHIC vein material as above, some epidote (?) ≤5% BASALT 4 as above
3,580-3,640	40% BASALT 1 as above 60% BASALT 3 as above Trace of GRAPHIC vein material as above, giving way to traces of quartz and ashy fragments, some epidote (?)
3,640-3,650	35% BASALT 1 as above 50% BASALT 3 as above 15% BASALT 4 as above, with ashy and glassy phases Traces EPIDOTE
3,680-3,690	70% to 30% BASALT 1 as above 30% to 70% BASALT 3 as above Scattered PYRITE at 3,690 feet
3,690-3,740	25% to 15% BASALT 1 as above 65% to 75% BASALT 3 as above 10% to 20% VEIN MATERIAL plagioclase, pyroxene and quartz

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Depth Interval, feet	Description
3,740-3,780	25% BASALT 1 as above 75% BASALT 3 as above Traces of scattered olivine and FeO
3,780-3,800	15% BASALT 1 as above 75% BASALT 3 as above 10% VEIN MATERIAL, plogioclase, pyroxene, quartz
3,800-4,020	BASALTS 1 and 3 in the following proportions:

3,800-3,810	85%/15%, trace of quartz
3,810-3,820	75%/20%/5% GRAPHIC vein material of plagioclase and pyroxene
3,820-3,830	60%/35%/5% GRAPHIC vein material of plagioclase and pyroxene
3,830-3,850	60%/40%, traces of epidote
3,850-3,860	65%/35%, trace of olivine and pyrite
3,860-3,870	85%/15%, trace of plagioclase veins
3,870-3,890	60%/40%, trace of quartz(?)
3,890-3,900	70%/30%, trace of quartz(?)
3,900-3,930	80%/15%/5% GRAPHIC vein material, principally of plagioclase, chloritization
3,930-3,940	65%/30%/5% GRAPHIC vein material, principally of plagioclase
3,940-3,950	70%/25%/5% GRAPHIC vein material, principally of plagioclase
3,950-3,960	45%/50%/5% GRAPHIC vein material, principally of plagioclase
3,960-3,980	40%/55%/5% GRAPHIC vein material, principally of plagioclase
3,980-3,990	35%/60%/5% GRAPHIC vein material, principally of plagioclase
3,990-4,000	80%/20%
4,000-4,010	70%/25%/5% GRAPHIC vein material, principally of plagioclase, altered to clay, ash
4,010-4,020	45%/55%

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Depth Interval, feet	Description
4,020-4,030	60% BASALT 1 as above 30% BASALT 3 as above 10% BASALT 4 as above
4,030-4,080	40%-65% BASALT 1 as above 55%-30% BASALT 3 as above 5%-10% BASALT 4 as above
4,090-4,100	60% BASALT 1 as above 40% BASALT 3 as above
4,100-4,110	35% BASALT 1 as above 65 BASALT 3 as above
4,110-4,120	60% BASALT 1 as above 35% BASALT 3 as above 5% BASALT 4 as above
4,120-4,170	60%-35% BASALT 1 as above 35%-55% BASALT 3 as above 10-25% BASALT 4 as above
4,170-4,180	65% BASALT 1 as above 25% BASALT 3 as above 10% BASALT 4 as above, 20% surfaces coated with FeO

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Depth Interval, feet	Description
4,180-4,220	60% BASALT 1 as above 30% BASALT 3 as above 10% BASALT 4 as above
4,220-4,250	70% BASALT 1 as above 35% BASALT 3 as above, infrequent surfaces coated with FeO 5% CLAY
4,250-4,290	45% BASALT 1 as above 30% BASALT 3 as above 25% BASALT 4 as above, with 2% coarse granular quartz at 4,290 +
4,290	LOST CIRCULATION
4,240-4,300	REDRILL
	All as above, with addition of felsite at 4,260-4,270; light gray, medium (≤ .5mm) grain rock with white plagioclase, altered to clay, amphibole (?) pyrite and scattered magnetite, cement to 15%; pyrite on slickenslide surfaces of 4,270-4,280.

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FLUID GEOCHEMISTRY

The major element chemical composition of three water samples from Lanipuna #6 collected on August 3, 8, and 9, 1984, during unloading of the well, is listed in the attached table, along with chemical geothermometers for each, and the composition of sea water. Complete analyses, including minor and trace elements, ion balance (good for all samples) and ion ratios, are included in the appended laboratory reports.

There was very little change in composition between the second and third samples, indicating that well flow was probably nearly stable, chemically, when the third sample was collected.

The well water is interpreted as sea water which has become slightly diluted, heated and reacted with basic igneous rocks, probably basalts. The place of the dilution process in these events is uncertain. More likely, dilution occured as a very late event, although sea water could have been diluted with fresh water at depth to heating and reactions with rocks. This is suggested by the somewhat low level of SiO_2 and low SiO_2 temperatures relative to the cation temperature. If SiO_2 in the samples is "corrected" by +25 to 30%, the difference between the sample salinity and sea watr, the resulting SiO_2 concentrations have quartz temperatures which agree almost exactly with the Na-K-Ca temperatures. Because of this, we suspect that the samples are either diluted with drilling water (or injection water), or the well produces from both a deeper thermal zone (75%), and a shallower, cooler, lower SiO_2 zone (25%).

Cations in the samples show characteristics typical of the product of sea water-basalt interactions at moderate temperature; Ca has increased, coming from feldspar minerals, SO_4 is supressed by the heating and Ca, Mg is supressed by formation of chlorite minerals in the rocks.

Table 17. Chemical Composition of Water Samples from Lanipuna #6 [1]

Sample/Time	Species, ppm										Geothermometers, °F			
	Na	K	Ca	Mg	Tot. Alc	SO4	Cl	B	SiO2	TDS	pH	SiO_2 Qtz*/Chal	Na-K-Ca	Cl/B
8/3/84 - 1:20	7,750	397	1,393	14	50	430	14,400	3.5	137	24,570	8.4	298/268	347	4,110
8/8/84 - 4:00	8,230	408	1,480	14	39	430	15,400	3.4	133	26,130	8.2	297/264	345	4,530
8/9/84 - 4:00	8,380	420	1,524	15	34	403	15,600	3.4	135	26,510	8.3	297/266	327	4,590
Seawater	10,500	380	400	1350	142	2700	19,000	6.4	6.4	34,560				4,130

1 Chemical analyses by UURI

* quartz temperature is case for maximum steam loss.
For conductive cooling case, add 8°C (14°F)