MZAI-11A

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C.E.C.I.

BLM: Geothermal Drilling
Permit No. OR920-85-WN-001
DOGAMI: 116

Form: USGS 9-1958

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY, CONSERVATION DIVISION

Form Approved
Budget Bureau No. ______

GEOTHERMAL SUNDRY NOTICE

The U.S. Geological Survey requests this form or other Supervisor approved form to be prepared and filed in triplicate with requisite attachments with the Supervisor. The Supervisor must approve this permit prior to any lease operations.

1a. WELL TYPE: PRODUCTION ( ) INJECTION ( ) HEAT EXCHANGE ( ) OBSERVATION ( ) OTHER (X)
Temperature Gradient Core Hole

1b. WELL STATUS:
Temporarily Abandon

2. NAME OF LESSEE/OPERATOR
California Energy Company, Inc.

3. ADDRESS OF LESSEE/OPERATOR
3333 Mendocino Ave., Ste. 100, Santa Rosa, CA 95401

13. LOCATION OF WELL OR FACILITY
Approx. 2225' E and 725' N of SW Corner Sec. 10 T31S R7½E

4. LEASE SERIAL NO.
OR 34669

5. SURFACE MANAGER: BLM ( ) FS ( ) Other ( )
Winema NF

6. UNIT AGREEMENT NAME
Mazama I

7. WELL NO.
MZI-11A

8. PERMIT NO.
See Above

9. FIELD OR AREA
Winema Nat'l Forest

10. SEC., T., R., B.& M.
Sec. 10 T31S R7½E

11. COUNTY
Klamath

12. STATE
Oregon

14. TYPE OF WORK

| | | | | | |
|---|---|---|---|---|---|
| CHANGE PLANS | ( ) | CONVERT TO INJECTION | ( ) | PULL OR ALTER CASING | ( ) |
| SITE AND ROAD CONSTRUCTION | ( ) | FRACTURE TEST | ( ) | MULTIPLE COMPLETE | ( ) |
| CONSTRUCT NEW PRODUCTION FACILITIES | ( ) | SHOOT OR ACIDIZE | ( ) | ABANDON | ( ) |
| ALTER EXISTING PRODUCTION FACILITIES | ( ) | REPAIR WELL | ( ) | OTHER Temporarily Abandon | XX |

15. DESCRIBE PROPOSED OPERATIONS (Use this space for well activities only. See instructions for current well conditions on reverse)

~~We propose to temporarily abandon~~ deep temperature gradient core hole MZI-11A by removing the existing BOE and bolting a blind flange onto the casing head flange. Access to the well bore can be achieved either by removing the blind flange or opening a wing valve.

Well MZI-11A is currently being cored. Because of problems in maintaining circulation, it is deemed advisable to temporarily abandon (suspend casing operations and place the hole and location in a safe condition preparatory to resuming coring operations in Spring 1987).

The hole is currently completed with 575 feet of 4-1/2 inch casing cemented to surface and HQ (3-3/4 inch) hole drilled to 1354 feet.

16. DESCRIBE PROPOSED OPERATIONS (Use this space for all activities other than well work)

Sumps will be pumped and barricades erected, until the site is reopened in the Spring of 1987, in accordance with direction of the surface manager, Winema National Forest.

(Use reverse side if needed)

17. I hereby certify that the foregoing is true and correct

SIGNED James L. Moore TITLE Sr. Vice President Exploration DATE 10/29/86
James L. Moore

(This space for Federal use)

APPROVED BY Dennis L Olmstead TITLE Petroleum Engr. DATE 11-4-86
CONDITIONS OF APPROVAL, IF ANY:

This permit is required by Law (30 U.S.C. 1023); regulations: 30 CFR 270.34, 30 CFR 270.35, 30 CFR 270.45, 30 CFR 270.71-1, 30 CFR 270.72; Federal Geothermal Lease Terms and Stipulations and other regulatory requirements. The United States Criminal Code (18 U.S.C. 1001) makes it a criminal offense to make a willfully false statement or representation to any Department or Agency of the United States as to any matter within its jurisdiction.

(See instructions on reverse side)

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 11/12/86 This transmission 1 pages.

TO: Susan Prestwich Telecopier No: (208) 526-0524
U. S. Deptartment of Energy, ID Confirmation Service: 526-1503

TO: Mike Wright Telecopier No: (801) 524-3453
University of Utah Research Institute Confirmation Seth: 524-3422

Transmitted By: Sonja Rath Telecopier No: (707) 526-0504
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000

---

MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: 11/12/86 Bill Jensen of the Chemult Forest Service wants more work on sump lid, for abandonment for the winter.

JLP:sr:42

cc: CTC, HHR, GV, RT, DW

TOTAL ESTIMATED COST TO DATE:

By: ____________________

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/24/86 This transmission 2 pages.

TO: Susan Prestwich
U. S. Deptartment of Energy, ID
Telecopier No: (208) 526-0524
Confirmation Service: 526-1503

TO: Mike Wright
University of Utah Research Institute
Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

Transmitted By: Sonja Reth
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000
Telecopier No: (707) 526-0504

---

MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: 10/23/86 DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: 10/23/86 Drilled hole from 1259' - 1334'. Had one temperature check " 1297'. Temperature was 106°F.
19 hrs. drilling core partial to no returns.
4 hrs. handling rods.
1 hr. temperature check.

JLP:sr:42

TOTAL ESTIMATED COST TO DATE:

By: $92,581.00

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/24/86 This transmission 2 pages.

TO: Susan Prestwich Telecopier No: (208) 526-0524
U. S. Deptartment of Energy, ID Confirmation Service: 526-1503

TO: Mike Wright Telecopier No: (801) 524-3453
University of Utah Research Institute Confirmation Beth: 524-3422

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3333 Mendocino Avenue, Suite 100
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(707) 526-1000

---

MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: 10/22/86 DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: 10/22/86 Drilled hole from 1225' - 1259'.
7 hrs. drilling core.
5 hrs. handling rods.
12 hrs. fighting lost circulation while adding LCM to hole.

JLF:sr;42

TOTAL ESTIMATED COST TO DATE:

By: 688,533.00

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/22/86 This transmission 1 pages.

TO: Susan Prestwich
U. S. Deptartment of Energy, ID
Telecopier No: (208) 526-0524
Confirmation Bernice: 526-1503

TO: Mike Wright
University of Utah Research Institute
Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

Transmitted By: Sonja Rath
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000
Telecopier No: (707) 526-0504

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MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: 10-22/86 DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: 10/22/86 63' to TD of 1225' as of 7:00 a.m.
Temperature @ 1204' 110°F, Bit change @ 1223'.
Currently @ 1234' 11:00 a.m. 10/22/86.

JLF:sr:42

TOTAL ESTIMATED COST TO DATE: $86,500.00

By: Dave Workman

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/21/86 | This transmission 1 pages.

TO: Susan Prestwich
U. S. Department of Energy, ID

Telecopier No: (208) 526-0524
Confirmation Service: 526-1503

TO: Mike Wright
University of Utah Research Institute

Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

Transmitted By: Sonia Rath
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000

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MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE:

DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS:
10/20/86 Working stuck pipe, drilled through bit.
10/21/86 Drilled 13' as of late last night. New driller on at shift change. New driller trying to remove last of bit. Dragging up hole and lodged in side. Catching on stabilizer above core barrel. Got bit out of way, rods spinning free--drilling ahead. As of noon, drilling at 1162'.

JLF:sr:42

cc: CTC, HHR, GV, RT, DW

TOTAL ESTIMATED COST TO DATE: $83,000

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/20/86 This transmission 1 pages.

TO: Susan Prestwich
U. S. Deptartment of Energy, ID

Telecopier No: (208) 526-0524
Confirmation Bernice: 526-1503

TO: Mike Wright
University of Utah Research Institute

Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

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3333 Mendocino Avenue, Suite 100
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(707) 526-1000

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MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: 10/17/86 Shut down by BLM for lost circulation. Fought lost circulation all day.
10/18/86 Circulated down to bottom and began drilling @ 0330 a.m. Cut 3' of core. Inner core barrel stuck in rods because of lost circulation material. Tripped out to free inner core barrel. Tripped back in, reached bottom @ 1000 hrs. Total time loss due to fighting lost circulation is 61 hrs. At 2300 hrs., reported 50% returns. Had reported temperature of 144°F (BHT) @ 1106'. At 12:00 a.m. stuck rods @ 1149'.
10/19/86 Spent whole day trying to free rods. Retrieved inner core barrel using NQ rod and brought back out. Rods still stuck this a.m. (10/20/86).

TOTAL ESTIMATED COST TO DATE: $78,000.00

JLF:sr:42

By: Dave Workman

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/17/86 This transmission 1 pages.

TO: Susan Prestwich
U. S. Deptartment of Energy, ID
Telecopier No: (208) 526-0524
Confirmation Service: 526-1563

TO: Mike Wright
University of Utah Research Institute
Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

Transmitted By: Sonja Rath
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000
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MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: Total 36 hrs. mixing mud for lost circulation. Have returns now.

JLF:sr:42

TOTAL ESTIMATED COST TO DATE: $77,000.00

By: Dave Workman

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/16/86 — This transmission 1 pages.

TO: Susan Prestwich
U. S. Deptartment of Energy, ID
Telecopier No: (208) 526-0524
Confirmation Bernice: 526-1503

TO: Mike Wright
University of Utah Research Institute
Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

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3333 Mendocino Avenue, Suite 100
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MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: 10/15/86 — DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: @ 1084'. Mixing mud and LCM for lost circulation.
BLM has required we shut down drilling until circulation is regained.

JLP:er:42

TOTAL ESTIMATED COST TO DATE: $73,000.00

By: Dave Workman

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/15/86 This transmission 1 pages.

TO: Susan Prestwich
U. S. Deptartment of Energy, ID
Telecopier No: (208) 526-0524
Confirmation Service: 526-1503

TO: Mike Wright
University of Utah Research Institute
Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

Transmitted By: Sonja Rath
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3333 Mendocino Avenue, Suite 100
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(707) 526-1000
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MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: 10/15/86 DAYS SINCE SPUD:

TIME: 11:45 a.m.

DEPTH: 1042'

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: Last temperature taken @ 1006' (BHT) and it was 110°F.

TOTAL ESTIMATED COST TO DATE: $70,000.00

By: Dave Workman

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/14/86 — This transmission 1 pages.

TO: Susan Prestwich
U. S. Deptartment of Energy, ID
Telecopier No: (208) 526-0524
Confirmation Bernice: 526-1503

TO: Mike Wright
University of Utah Research Institute
Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

Transmitted By: Sonja Rath
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000
Telecopier No: (707) 526-0504

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MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE:

DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: Correction: On 10/11/86 which was telecopied on 10/13/86, mud temp. was not 132°--it was BHT that was 132°F unstabilized.

10/14/86. Currently drilling @ 954'. Last temperature was @ 890' and was 98°F unstabilized. Drilling w/o circulation. Lost circulation @ 600' - 850'.

JLF:sr:42

TOTAL ESTIMATED COST TO DATE:

By: ______________________

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/13/86 This transmission 1 pages.

TO: Susan Prestwich
U. S. Deptartment of Energy, ID
Telecopier No: (208) 526-0524
Confirmation Bernice: 526-1503

TO: Mike Wright
University of Utah Research Institute
Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

Transmitted By: Sonia Rath
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000
Telecopier No: (707) 526-0504

---

MAZAMA I CORE HOLE MBI-11A

DAILY REPORT

DATE: DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: 10/11/86 Drilling ahead and @ 640' mud temperature @ 132°F.

10/12/86 Drilling ahead @ 856'.

10/13/86 @ 10:40 a.m. drilling @ 870' and reoccurring lost circulation.

JLF:sr:43

TOTAL ESTIMATED COST TO DATE: $63,000.00

By: Dave Workman

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/10/86 This transmission 1 pages.

TO: Susan Prestwich
U. S. Deptartment of Energy, ID

Telecopier No: (208) 526-0524
Confirmation Bernice: 526-1503

TO: Mike Wright
University of Utah Research Institute

Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

Transmitted By: Sonja Rath
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000

Telecopier No: (707) 526-0504

---

MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: 10/9/86 Replaced transmission motor assembly.
10/10/86 Started drilling about midnight.
Drilled out cement on bottom, began coring,
14' cored by 2:00 p.m.

JLF:sr:42

cc: CTC, HHR, GV, RT

TOTAL ESTIMATED COST TO DATE:

By: ______________________

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/8/86 This transmission 1 pages.

TO: Susan Prestwich
U. S. Deptartment of Energy, ID
Telecopier No: (208) 526-0524
Confirmation Bernice: 526-1503

TO: Mike Wright
University of Utah Research Institute
Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

Transmitted By: Sonja Rath
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000
Telecopier No: (707) 526-0504

---

MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: 10/7/86 Replaced valves in preparation for BOP test.
10/8/86 BOP's tested and held. Witnessed by Dennis Simontacchi of BLM. Waiting for new transmssion for rig and should be drilling ahead on 10/9/86.

JLF:sr:42

cc: CTC, HHR, GV, RT

TOTAL ESTIMATED COST TO DATE:

By: ____________________

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/6/86 This transmission 1 pages.

TO: Susan Prestwich Telecopier No: (208) 526-0524
U. S. Deptartment of Energy, ID Confirmation Bernice: 526-1503

TO: Mike Wright Telecopier No: (801) 524-3453
University of Utah Research Institute Confirmation Beth: 524-3422

Transmitted By: Sonja Rath Telecopier No: (707) 526-0504
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000

---

MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS:

10/4/86 Hole pressure bled off slowly and did not pass BOP test. Dennis Davis and Dennis Simontacchi of BLM were both present

10/5/86 Hole still did not hold pressure. Dennis Simontacchi was again present.

10/6/86 Drilling out plug on bottom and setting new cement plug on bottom. Will possibly run BOP test again tomorrow.

JLF:sr:42

TOTAL ESTIMATED COST TO DATE: $50,000

By: Dave Workman

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/3/86 — This transmission 1 pages.

TO: Susan Prestwich
U. S. Deptartment of Energy, ID
Telecopier No: (208) 526-0524
Confirmation Bernice: 526-1503

TO: Mike Wright
University of Utah Research Institute
Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

Transmitted By: Sonja Rath
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000
Telecopier No: (707) 526-0504

---

MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: 10/2/86 Completed rigging up. Tried to test BOP's early afternoon. Did not hold pressure. Dennis Davis and Dennis Simontacchi of BLM were both witnesses.

10/3/86 Entering into hole to put drill string down. Push plug on botton and put another cement plug on top of that. Wait till it sets up and test BOP's on 10/4/86, midday. BLM will again be present.

JLP:ar:42

TOTAL ESTIMATED COST TO DATE: $45,000.00

By: Dave Workman

cc: CTC, HHR, GV, RT

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 10/1/86 — This transmission 1 pages.

TO: Susan Prestwich, U. S. Deptartment of Energy, ID — Telecopier No: (208) 526-0524; Confirmation Bernice: 526-1503

TO: Mike Wright, University of Utah Research Institute — Telecopier No: (801) 524-3453; Confirmation Beth: 524-3422

Transmitted By: Sonja Rath — Telecopier No: (707) 526-0504

California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000

---

MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: BOP's installed 9/30/86. Will be moving rig on today 10/1/86.

JLP:er:42

TOTAL ESTIMATED COST TO DATE:

By: ____________________

cc: CTC, RHR, GV, RT

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 9/30/86 — This transmission 1 pages.

TO: Susan Prestwich, U. S. Deptartment of Energy, ID — Telecopier No: (208) 526-0524; Confirmation Service: 526-1503

TO: Mike Wright, University of Utah Research Institute — Telecopier No: (801) 524-3453; Confirmation Beth: 524-3422

Transmitted By: Sonja Rath — Telecopier No: (707) 526-0504
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000

---

MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: 9/29/86 completed cellar, welded on flange, moved doghouse on site w/installed radio. RTC sent wrong spool. Will be corrected by noon today 9/30/86.

TOTAL ESTIMATED COST TO DATE: $35,000.00

By: Dave Workman

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 9/29/86 This transmission 1 pages.

TO: Susan Prestwich — Telecopier No: (208) 526-0524
U. S. Deptartment of Energy, ID — Confirmation Bernice: 526-1503

TO: Mike Wright — Telecopier No: (801) 524-3453
University of Utah Research Institute — Confirmation Beth: 524-3422

Transmitted By: Sonja Rath — Telecopier No: (707) 526-0504
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000

---

MAZAMA I CORE HOLE MEI-11A

DAILY REPORT

DATE: 9/29/86 DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: Dug out cellar and offloaded BOP's on 9/28/86.
Moving rig in and rigging up today and tomorrow, 9/29/86 and 9/30/86.

JLF:sr:42

cc: CTC, HHR, GV, RT

TOTAL ESTIMATED COST TO DATE:

By: ______________________

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 9/23/86 — This transmission 1 pages.

TO: Susan Prestwich
U. S. Deptartment of Energy, ID
Telecopier No: (208) 526-0524
Confirmation Bernice: 526-1503

TO: Mike Wright
University of Utah Research Institute
Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

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Santa Rosa, CA 95401
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Telecopier No: (707) 526-0504

---

MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: 9/23/86 — DAYS SINCE SPUD:

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: Temporarily suspended till core rig mvoes on as of 9/16/86.

RAP:sr:42

cc: CTC, HHR, GV, RT

TOTAL ESTIMATED COST TO DATE:

By: ______________________

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 9/19/86 This transmission 1 pages.

TO: Susan Prestwich Telecopier No: (208) 526-0524
U. S. Deptartment of Energy, ID Confirmation Bernice: 526-1503

TO: Mike Wright Telecopier No: (801) 524-3453
University of Utah Research Confirmation Beth: 524-3422
Institute

Transmitted By: Sonja Rath Telecopier No: (707) 526-0504
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000

---

MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: 9/18/86 DAYS SINCE SPUD: 6

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: Back filled w/16 feet cement. Put in from surface.
Witnessed by Dennis Simontacchi.

JLF:sr:42

TOTAL ESTIMATED COST TO DATE:

By: ______________________

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 9/19/86 | This transmission 1 pages.

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U. S. Deptartment of Energy, ID

Telecopier No: (208) 526-0524
Confirmation Bernice: 526-1503

TO: Mike Wright
University of Utah Research Institute

Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

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MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: 9/17/86 (Revised) DAYS SINCE SPUD: 5

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: Rig up and run 18 jts. 575', 4-1/2" 11.6# N80, 8 Rd. LT & C casing. Landed @ 575' and circulate with mud. Cement with Halliburton 3 bbls. $H_2O$ ahead of 275 cu. ft. Class G Cement w/1:1 Perlite, 3% Gel. Displaced top plug to 545' w/8.4 bbls $H_2O$. Plug in place 3:00 p.m. 9/17/86. Good cement returns. Approximately 100 cu. ft. Witnessed by Steve Henderson and Dennis Simontacchi of BLM.

RAP:sr:42

TOTAL ESTIMATED COST TO DATE:

By: ______________________

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 9/18/86 (REVISED)-9/17/86 | This transmission 1 pages.

TO: Susan Prestwich
U. S. Deptartment of Energy, ID
Telecopier No: (208) 526-0524
Confirmation Bernice: 526-1503

TO: Mike Wright
University of Utah Research Institute
Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

Transmitted By: Sonja Rath
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000
Telecopier No: (707) 526-0504

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MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: 9/17/86 REVISED! DAYS SINCE SPUD: 5

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: Ran 18 jts. casing to 576' 11.6# 4-1/2" LTC N-80 landed @ 575'. Cemented w/275 ft.$^3$ Class G 1:1 Perlite and 3% Gel, good returns, over 100 ft.$^3$, finished 3:00 p.m.

TOTAL ESTIMATED COST TO DATE:

By: ______________________

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 9/17/86 | This transmission 1 pages.

TO: Susan Prestwich
U. S. Deptartment of Energy, ID

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Telecopier No: (707) 526-0504

---

MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: 9/17/86 DAYS SINCE SPUD: 5

TIME:

DEPTH:

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: Ran 4-1/2" surface casing cemented w/Halliburton w/100% excess. Full returns.

Daily reports suspended until arrival of core rig.

TOTAL ESTIMATED COST TO DATE:

By: ______________________

CALIFORNIA ENERGY COMPANY, INC.

TELECOPY TRANSMITTAL

Date: 9/15/86 This transmission 1 pages.

TO: Susan Prestwich
U. S. Department of Energy, ID
Telecopier No: (208) 526-0524
Confirmation Bernice: 526-1503

TO: Mike Wright
University of Utah Research Institute
Telecopier No: (801) 524-3453
Confirmation Beth: 524-3422

Transmitted By: Sonja Rath
California Energy Co., Inc.
3333 Mendocino Avenue, Suite 100
Santa Rosa, CA 95401
(707) 526-1000
Telecopier No: (707) 526-0504

---

MAZAMA I CORE HOLE MZI-11A

DAILY REPORT

DATE: 9/16/86 DAYS SINCE SPUD: 4

TIME:

DEPTH: 550'

FOOTAGE DRILLED SINCE LAST REPORT:

PERCENT RECOVERY:

COMMENTS: Drill 7-7/8" hole to 550'. Conditioning hole preparatory to running 4-1/2" surface casing.

PB:sr:42

cc: CTC, RHR, GV, BT

TOTAL ESTIMATED COST TO DATE:

By: ______________________

Wright

EG&G Idaho

# NOTEGRAM

FORM EG&G-460
(Rev. 9-76)

Date 1/9/87

To E H Bowhan Dept. Address Moose CECI Ltr 1/7/87

From SMP Dept. Address

1. We will go along with temporary suspension
2. BLM's current schedule is EA Supplement not approved until May. So ok. If this continues to slip schedule (ie summer 88 say) then we should take another look at continuing work
3. I would approve partial milestone payment for drilling contingent on ~~temp~~ receipt of temperature data — which has conviently been omitted mention of!
4. Cost-share of second hole doesn't appear feasible with current 60% funding reduction

PUT IT IN WRITING — WRITTEN MESSAGES SAVE TIME, PREVENT ANNOYING INTERRUPTIONS AND ERRORS

(over)

things could change in FY88 but mark still low. Stall on this if possible

SMP
1/9/87

January 7, 1987

Mrs. Elizabeth M. Bowhan
Chairman
Source Evaluation Board
Department of Energy
Idaho Operations Office
785 DOE Place
Idaho Falls, Idaho 83402

Dear Elizabeth:

As per our earlier telephone conversations, it became necessary to suspend operations on our cost shared Mazama Deep Temperature Core Hole MZI-11A located in Klamath County Oregon. This action was necessitated by drilling conditions which precluded the Company from complying with stipulations mandated under our drilling permits. A more detailed explanation of the technical situation is contained within the attached relevant correspondence between California Energy Company and the Bureau of Land Management.

We intend to resume work on MZI-11A in the summer of 1987 and request your concurrence with that as well as already accomplished actions.

In view of the fact that California Energy Company has spent a substantial amount of funds in addition to those submitted to DOE for cost share at milestone one and because we have not yet reached milestone two because of factors beyond our control (1500 feet depth) and will be unable to proceed to reach that milestone until the summer field season, we respectfully request that California Energy Company, Inc. will be permitted to submit to DOE all well costs incurred to date that were not submitted under milestone one.

In regards a secord matter, you may be aware that we have already drilled hole and cemented approximately 450 feet of surface casing for our MZII-1 Deep Temperature Core Hole located within the Klamath graben and immediately adjacent to Mt. Mazama. As we discussed earlier, we would be interested in cost sharing the remainder of that operation (i.e., core to ±4000 feet) with DOE if you are so interested.

Very truly yours,

James L. Moore

James L. Moore
Senior Vice President
Exploration

JLM:sr:42

Encs.

cc: Susan Prestwich

CALIFORNIA ENERGY COMPANY
3333 MENDOCINO AVENUE, SANTA ROSA, CA 95401 (707)526-1000 TELEX II 510-744-2038

bcc: RAP PS
JLF AKC
DMcC
JLM F.C.
PE
DW
GG

November 12, 1986

Mr. Bob Fujimoto
Division of Mineral Resources
Oregon State Office
Bureau of Land Management
825 N.E. Multnomah St.
Portland, OR 97201

Re: Sundry Notice Request for Modification of Drilling Stipulations

Dear Bob:

California Energy Company, Inc. (CECI) submits the attached Sundry Notice for BLM approval and requests the following changes be incorporated into our Mazama I and Mazama II exploration permits:

1) Maximum allowed hole depths be extended from 4000 feet to 5500 feet.

2) Drilling (coring) be allowed without fluid returns (circulation) to surface.

We feel these changes are necessary in order for us to proceed with a prudent and scientifically valid exploration and data recovery program. The following discussion explains our request in further detail.

Background

The following quotation is taken from California Energy Company: Geothermal Exploration Briefing Paper attached to modified Plan of Exploration dated February 21, 1985.

CALIFORNIA ENERGY COMPANY
3333 MENDOCINO AVENUE SANTA ROSA, CA 95401 (707) 523-1000 TELEX II 510-744-2083

Drilling Concerns

Two drilling uncertainties are associated with any drilling alternative: the potential for water flowing within a hole between aquifers with different pressure heads; and the potential for a blowout (uncontrolled emissions of fluids and/or gases from a well).

There are no guarantees that either event would not occur; however, standard design features that would be incorporated into any drilling permit minimizes the potential for either of these two occurrences. In addition, it would be prudent to incorporate the mitigation measure regarding intermingling of ground water (see discussion in the environmental uncertainties section above) as contained in the letter from the Director, USGS, to the State Director, even though this measure is a standard design feature. Reiteration of the USGS mitigation measure would: acknowledge the consultation and cooperation of the USGS; notify those parties concerned about the hydrology of Crater Lake that the BLM has treated those concerns with high regard; and single out this standard design feature as being more important than some other standard design features.

CECI believes the stated concerns of preserving ground and surface water quality, as contained within the modified POE and its attendant EA is of critical concern to all parties. However, CECI believes that the GRO's more than amply address drilling/coring/abandonment procedures which adequately achieve those objectives. We are not aware of any exploratory core holes within the Cascades which have even remotely presented any substantive pollution threat to either ground or surface waters.

In the MZA I-11A core hole, 4-1/2 inch surface casing was run to approximately 550 feet and cemented back to surface. The shoe of this surface casing was set well below the contact between the Mazama ash and the underlying fractured crystallic basement. In the process of coring out from beneath the 4-1/2 inch surface casing, circulation was lost within the first 100 feet (drilled depth of 650 feet). The standard definition of loss of circulation is that drilling fluids do not return back to the surface through the annulus. Under typical coring operating conditions, the drilling fluids instead of returning to the surface flow into the formation because the hydrostatic head of the annular column of drilling fluid exerts a greater pressure on the formation then it is able to contain. In the Mazama I-11A hole, the process of pumping drilling fluid into the hole through drill rods at the normal rate while coring of ten to twelve gallons per minute resulted in the establishment of a "false fluid level" at approximately 600 feet. It was at that level where the hydrostatic head of the drilling fluid column exceeded the containment ability of the formation. At that approximate depth, the fluid level remained essentially static regardless of whether fluid was being pumped into the hole at the normal circulation rate of ten to twelve gallons per minute or left to stand without pumping. The drilling records show there is no indication of formation fluid entering the hole and hence we have not yet encountered any water-bearing portion of an aquifer system. Our evaluation of the recovered core shows no evidence that distinct horizontal or subhorizontal lithological or structural features ( i.e., inter flow boundaries or the like) are present in the immediate area.

It is our considered opinion that there are no substantive technical reasons to require circulation of drilling fluids as a condition precedent to continued coring operation at Mazama. In fact one of the primary reasons we elected the coring process as a means of gathering subsurface data in the Cascades is that we expected to lose circulation in the fractured crystalline rocks postulated to be found there. Coring was selected over drilling because even with a continued loss of drill fluids during the coring process (which is a standard operating condition for coring operations) less drilling fluid would be introduced into the formation by the total coring process than could be lost in a single lost circulation episode utilizing containment cementing which is a standard procedure with a conventional drilling rig.

We are aware of the political sensitivity to any geothermal operations proximate to the Park boundary. Hopefully, such political problems can be answered through a reasonable technical analysis of the potential aquifer systems and what constitutes a "real" potential pollution threat to them. Since no substantive data have yet been collected defining parameters of potential aquifer systems, CECI recommends that until data has been collected establishing existence of any aquifer systems and some knowledge has been gained regarding the subsurface geometry, CECI be allowed to continue to gather subsurface data through coring. We believe that the CECI coring program will be of infinite value to the scientific community as it seeks to further understand the geology of the Cascades in general and Mazama in particular.

If it is necessary to establish a geological/hydrological technical review team to evaluate this matter, we requested the opportunity to provide at least one outside expert member for that group. Please contact me if you have any comments concerning this request and its attendant issues.

Very truly yours,

James L. Moore

James L. Moore
Senior Vice President Exploration

JLM:sr:42
Encs.
cc: Steve Henderson, BLM Portland
Dennis Simontacchi, BLM Lakeview

Art Dufault, Winema NF
Marv Stump, Winema, NF

Dennis Olmstead, DOGAMI

Susan Prestwich, DOE

BLM: Geothermal Drilling
Perm. No. OR 920-85-WN-001
DOGAMI: 116

Form [illegible] 9-1958 | [illegible] | Form Approved [illegible]

[illegible]

[illegible]

| Field | Entry |
|---|---|
| 1a. [illegible] | Temperature Gradient Core Hole |
| 1b. [illegible] | Temporarily Abandon |
| 2. [illegible] | California Energy Company, Inc. |
| 3. [illegible] | 3333 Mendocino Ave., Ste. 100, Santa Rosa, CA 95401 |
| 11. [illegible] | Approx. 2225' E and 725' N of SW Corner Sec. 10 T31S R7½E |
| 4. [illegible] | OR 34669 |
| 5. [illegible] | Winema NF |
| 6. [illegible] | Mazama I |
| 7. [illegible] | MZI-11A |
| 8. [illegible] | See Above |
| 9. [illegible] | Winema Nat'l Forest |
| 10. [illegible] | Sec. 10 T31S R7½E |
| 12. [illegible] | Klamath |
| 13. [illegible] | Oregon |

14. [illegible]

| | | | | | |
|---|---|---|---|---|---|
| [illegible] | KX | [illegible] | ( ) | [illegible] | ( ) |
| [illegible] | ( ) | [illegible] | ( ) | [illegible] | ( ) |
| [illegible] | ( ) | [illegible] | ( ) | [illegible] | ( ) |
| [illegible] | ( ) | [illegible] | ( ) | [illegible] | ( ) |

15. [illegible]

a) Change permitted total depth from 4000' to 5500'±.

b) Modify stipulations of Geothermal Drilling Permit to allow temperature gradient core hole drilling to proceed without fluid returns (circulation), as is standard safe and prudent procedure for coring operations.

Core hole MZI-11A is currently completed with 575 feet of 4-1/2" casing cemented back to surface and HQ (3-3/4") open hole to 1354 feet. There have been indications of no groundwater produced into the hole and an artificial fluid level of approximately 600 feet has been established through use of circulating pumps.

We request these modifications be made applicable to all deep temperature gradient core holes defined within CECI's Mazama I and Mazama II exploration permits.

16. [illegible]

[illegible]

17. [illegible]

Signed: [signature] James L. Moore | Title: Sr. Vice President Exploration | Date: 10/29/86

[illegible]

Approved by ______ Title ______ Date ______

[illegible]



[illegible]

JLM Chron

December 16, 1986

Mr. Robert Fujimoto
Division of Mineral Resources
U.S. Dept. of the Interior
Bureau of Land Management
825 N.E. Multnomah St.
P.O. Box 2965
Portland, OR 97232

Dear Bob:

The rather long winded explanation that accompanied my written request of 12 November 1986 to allow us to continue coring operations at Mazama without circulation could be simply summarized by the statement:

> Maintaining circulation of drilling fluids in the drilling environment encountered at Mazama (i.e., intensely fractured crystalline rocks) is technically infeasible for a core type of operation.

Very truly yours,

James L. Moore
Senior Vice President
Exploration

JLM:sr:42

cc: Steve Henderson, BLM Portland
Dennis Simontacchi, BLM Lakeview

Art DuFault, Winema NF
Marv Stump, Winema NF

Dennis Olmstead, DOGAMI

Susan Prestwich, DOE

January 9, 1987

Ms. Susan Prestwich
Project Office
U.S. Department of Energy
Idaho Operations Office
785 DOE Place
Idaho Falls, ID 94302

Re: MZI-11A Interim Data - Resubmitted

Dear Susan:

In accordance with your request, we are resubmitting the interim data. Our previous submittals on December 30, 1986 were inadvertently marked "Proprietary".

Also enclosed are temperature data, not previously submitted as follows:

Temperature Gradient Survey, Data and Profile (Al Waibel/ Dave Blackwell)

Temperature Gradient Survey, Data and Profile (LaFleur, CECI)

Please feel free to call me or Jim Moore should you need anything further.

Very truly yours,

Anna K. Carter
Administrative Manager
Compliance

AKC:sr:42

RECEIVED
JAN 13 1987
ADVANCED TECHNOLOGY BRANCH

cc: Elizabeth Bowhan, Contracts Specialist, DOE
Robert Fujimoto, BLM

CALIFORNIA ENERGY COMPANY
3333 MENDOCINO AVENUE, SANTA ROSA, CA 95401 (707)526-1000 TELEX II: 510-744-2083

MZI-11A

WELL HISTORY/DRILLER'S LOG SUMMARY

MAZAMA I-11A
Crater Lake, Oregon

| | |
|---|---|
| 9/12/86 | Move in and rig up Buckner Drilling rotary rig. Drill 8" hole to 24' with air foam. |
| 9/13/86 | Drilling 8" hole from 24' to 370' with air and foam. |
| 9/14/86 | Drill 8" hole from 370' to 575' with air and foam. |
| 9/15/86 | Mix mud and condition hole. |
| 9/16/86 | Circulate and condition mud for casing job. |
| 9/17/86 to 9/28/86 | Run in hole to 575' and circulate--pull out of hole. Rig up and run 18 joints (575') 4-1/2" - 11.6# N-80 casing with 8 round LF & C threads. Land casing at 575' and circulated with mud. Cemented with Halliburton, ran 3 bbls. of $H_2O$ ahead of 272 cubic feet Class G cement with 1:1 Perlite, 3% gel. Displaced top plug to 545' with 8 bbls. of $H_2O$. Plug in place at 1500 hours 9/17/86. Good returns (100+ cubic feet). Job witnessed by Steve Henderson and Dennis Simontacchi. |
| 9/29/86 to 10/7/86 | Weld 6" - 900 series slip on casing head to 4-1/2" casing. Install hydraulic operated annular and blind rams BOP's with dual controls. Install Hydrogen Sulfide detectors and alarm system. Rig up Longyear core rig and work on BOP's. |
| 10/8/86 | Tested BOP's 1/2 hr. each at 700 psi, test ok. Witnessed by Dennis Simontacchi. |
| 10/9/86 | Drilled cement from 545' to 575'. |
| 10/10/86 to 10/24/86 | Coring HQ size (3.50" OD) hole F/575' to 1354'. Fighting lost circulation. |
| 10/25/86 | Run temperature survey. |
| 10/26/86 to 10/29/86 | Rig down and move off Longyear. |

GG:sr:20
Z6132:A5

POSSIBLE LOST CIRCULATION ZONES AND/OR WATER ENTRIES

MZI-11a

It is very difficult to determine exact locations of fluid loss or water entries in the hole during drilling operations. There was no fluid loss reported during the drilling of the surface (0'-575'); however, this was drilled with an air hammer using water and foam mix. There were no water entries in the surface hole which was dry to bottom prior to running casing. There was no observable loss of cement to formation during cementing of the surface casing.

During core drilling (575'-1354') with light mud, a lost circulation zone was reported by the driller at approximately 640'. Upon review of the core, it appears more likely that the fluid loss was between 690' and 693' depth and the standing fluid level while drilling was about 640'.

The attached temperature gradient profile shows a linear gradient in the top 550' of the hole and the bottom 100' or so of the surveyed hole. The thermally perturbed portion of the profile (approximately 550' to 1230') does <u>not</u> suggest cold water entries because the temperature reversals are too minor. These minor reversals probably are reflective of zones where cold drilling fluid was lost to the formation. Since this temperature profile was recorded after only about 20 hours of stabilization, the minor reversals may be the best means of trying to determine where fluid loss actually occurred. Inspection of the core <u>suggests</u> fluid loss zones may occur at the following intervals: significant 690'-693'; major 966'-971'; diffuse 966'-971'; minor 1149'-1152'; minor 1160'-1162'; minor 1263'-1266'; minor 1308'-1314'. These observations on the core do not correspond well to the minor reversals on the temperature log.

There is no evidence to suggest that there were any water entries at all in the hole. The regional water table was not encountered but lies within 200' below the bottom of the hole. The bottom hole elevation is approximately 4700' above sea level and Klamath Marsh is about 4500' above sea level. A cold regional groundwater table, as normally conceptualized, may not be present beneath the site as evidenced by the high heat flow observed in the lower portion of the hole.

Attachment

JLF:sm:42:12:19:86:6138

CALIFORNIA ENERGY COMPANY INC.

MAZAMA PROSPECT

KLAMATH COUNTY, OREGON

# LITHOLOGY
# of CUTTINGS and CORE
# to 1354 feet

November 1986

Columbia Geoscience

CALIFORNIA ENERGY COMPANY INC.

MAZAMA PROSPECT

KLAMATH COUNTY, OREGON

LITHOLOGY of CUTTINGS

from 0 to 570 feet

November 1986

Columbia Geoscience

Hole MZI-11A

Cuttings Review

0-10 ft.
- 75% Beige, variably devitrified, pumice.
- 25% Subrounded to rounded mixed lithic igneous fragments.
- Tr. sub-mm fragments of feldspar, hornblende and pyroxene are present.

10-20 ft.
a/a.

20-30 ft.
100% Light brown volcanic pebble congleromate. Matrix consists of devitrified pumice, sand size lithic fragments, and feldspar, hornblende, and pyroxene crystal fragments. The coarser fraction consists of angular to subrounded volcanic lithic fragments (rhyodacite?) and rounded devitrified pumice fragments. Note: Traces of dark red to orange red in matrix maybe cinnabar or hematite.

30-40 ft.
a/a

40-50 ft.
100% Mixed volcanic fragments, including angular to subrounded gray rhyodacite (?) and red to orange-brown tuff.

50-60 ft.
90% Gray to dark gray, scoriaceous to dense, hypocrystalline basaltic andesite. The more dense fragments show loss of orignal texture due to metasomatic alteration. The pyroxene crystals are generally fresh with minor hematite alteration around the edges.
10% Mixed tuffaceous fragments.

60-70 ft.
a/a with minor light colored clay alteration and black hydrous Fe oxide precipitation along occassional fracture surfaces.

70-80 ft. Unwashed Sample
This sample consists of abundant red and gray clay and sand size crystal and lithic fragments. Coarser pebble sized fragments consist of lava and pumice clasts. It is difficult to determine how much of the coarser fraction is slough from up hole or how much of the clay and sand fraction is recycled drilling fluid.

80-90 ft. "Fine mud, driller couldn't catch sample."
Predominantly reddish clay and silt, sand size crystal and lithic fragments, and pebble size mixed volcanic fragments.

90-100 ft.

2% Dark gray scoriaceous basaltic andesite.

98% Red to gray, strongly hematite stained, locally vesicular andesite. Mafic minerals are strongly oxidized, with much of the orignal crystal morphology lost. The feldspar phenocrysts are variably altered to clay and possibly zeolite, and are often stained red from secondary hematite.

100-110 ft.

20% a/a.

80% Poorly lithified and strongly clay-altered scoriaceous to tuffaceous fragments with abundant secondary reddish hematite.

110-120 ft.

a/a

120-130 ft.

a/a

130-140 ft.

a/a. Note: Possible pipe dope in sample.

140-150 ft.

a/a

150-160 ft.

55% Brown to red devitrified basaltic tephra.

45% Red to gray strongly hematite and clay-altered basaltic lithic fragments.

160-170 ft.

60% red to gray strongly hematite- and clay-altered basaltic lithic fragments.

40% Brown to red devitrified basaltic tephra.

170-180 ft.

100% Red, locally gray, strongly hematite- and clay-altered basaltic lithic fragments.

180-190 ft.

100% Red-brown to gray strongly hematite- and clay-altered basaltic lithic fragments.

190-200 ft.

a/a

200-210 ft.

100% Red to dark gray, locally light green-gray, strongly clay altered basalt(?). Reddish color is due to secondary hematite staining. The green color is due to reduced Fe-bearing secondary clay (smectite?).

210-220 ft.

100% Light green-gray to dark green-gray clay altered dacite(?) with minor local red to orange hematite staining. Fresh sub-mm secondary pyrite crystals are common throughout the green-gray clay-altered rock.

220-230 ft.

100% Light green-gray, locally dark gray, strongly clay-altered dacite(?). Clear to milky precipitated cryptocrystalline silicia is common throughout the fragments. Sub-mm black magnetite crystals are present, possibly as a surviving relic of the host rock. Sub-mm secondary pyrite is irregularly distributed through rock fractures, occasionally occurring as mm-size clusters. Minor clear tabular zeolite clusters are present in occasional vesicles and open fractures. Locally fine-crystalline veins of secondary calcite are observed.

230-240 ft.

a/a

240-250 ft.

Similar to above, though the degree of clay alteration in the rock is decreasing. Relict hematite alteration has been preserved in many fragments which have subsequently undergone silicification. Secondary alteration of mafic minerals to pyrite is common. No secondary calcite is observed.

250-260 ft.

a/a

260-270 ft.

a/a with rare traces of white acicular zeolite (natrolite series ?). A marked reduction in secondary silicification is observed in this sample.

270-280 ft.

a/a with a continued decrease in the amount of silicification and secondary pyrite. No acicular zeolite observed.

280-290 ft.

40% Gray to very dark gray, locally red-gray dacite.

60% Very light gray, locally red-gray, strongly altered dacite. Mafic minerals are occasionally altered to magnetite, though more commonly to hematite. Alteration of plagioclase to clay ranges from moderate to extreme, occasionally with only casts of plagioclase crystals surviving. The groundmass is altered to white clay, clear tabular zeolite and rare traces of secondary sub-mm pyrite.

290-300 ft.

a/a with a vary few soft light green-gray fragments. The texture and degree of alteration is characteristic of a strongly sheared or faulted rock.

300-310 ft.
Similar to above with a general decrease in the degree of alteration. The mafic minerals continue to be strongly altered to hematite. Occasinal fracture surfaces contain a light coating of green clay and sub-mm pyrite crystals.

310-320 ft.
a/a with a slight increase in the white clay-zeolite alteration. A few light green-gray fragments have a texture suggesting protomylonite.

320-330 ft.
5% Very dark gray fresh glassy dacite.
85% Gray to light green-gray, locally red-gray, strongly altered dacite.
10% Green-gray cataclastized dacite with many fragments having a mylonite to protomylonite texture.
Vein filling quartz and botryoidal cryptocrystalline silica are present in some of the dacite fragments. A few of the dacite fragments have been indurated with silica, often associated with secondary precipipated sub-mm pyrite crystals. Secondary zeolite alteration is associated with the more strongly altered and brecciated dacite fragments.
This sample consists of fresh glassy subvolcanic dacite, cataclastized rock associated with subvolcanic emplacement, contact metamorphosed rock and hydrothermally altered rock.

330-340 ft.
a/a

340-350 ft.
a/a with only rare traces of fresh glass.

350-360 ft.
30% Light green to green-gray brecciated and sheared dacite. The brecciated fragments contain cryptocrystalline silica and minor pyrite.
70% Gray to light gray altered dacite with variable amounts of secondary hematite.
Tr. dark gray fresh glassy dacite.

360-370 ft.
a/a

370-380 ft.
a/a with a decrease in brecciated fragments to 10%.

380-390 ft.
a/a

390-400 ft.
80% Gray to red-gray variably altered glassy dacite with secondary green-gray clay and pyrite along fracture surfaces.

390-400 ft. (cont.)
20% Light gray to green-gray, strongly sheared, brecciated and clay altered dacite with secondary sub-mm pyrite crystals.
Tr. orange oxidized mylonite fragments.

400-410 ft.
a/a with a marked increase in secondary clear tabular zeolite occurring along fracture surfaces.

410-420 ft.
a/a with 5% orange oxidized mylonite.

420-430 ft.
a/a

430-440 ft.
a/a with 20% orange oxidized mylonite. Note, all Fe appears to occur as hydrous Fe oxides in orange fragments.

440-450 ft.
90% Gray fresh to slighty altered dacite. Very localized reddish zones in the groundmass are the result of hematite alteration. Rare traces of secondary pyrite occur along fracture surfaces has formed subsquent to the hematite alteration.
5% Light green to light green-gray mylonite with secondary sub-mm pyrite and minor clear tabular zeolites.
5% Orange hydrous Fe oxide bearing mylonite. Hydrous oxidation of Fe appears to be the most recent alteration event.

450-460 ft.
a/a

460-470 ft.
a/a with an increase in the amount of clear tabular zeolite along fracture surfaces; continued tr. of orange mylonite.

470-480 ft.
10% Orange mylonite, the result of Fe oxidation in the light green-gray mylonite.
10% Light green-gray mylonite a/a.
80% Gray to dark gray variably altered dacite a/a.

480-490 ft.
a/a with only a trace of the orange oxidized mylonite.

490-500 ft.
a/a with occasional calcite crystals occurring with clear tabular zeolite crystals in fractures.

500-510 ft.

100% Gray to light red-gray hematite altered dacite with up to 5% of rock fragments showing the effect of shearing. Minor sub-mm crystals of pyrite occur along fracture surfaces and disseminated in the dacite, in part forming at the expense of hematite. Minor vein filling quartz and calcite are observed.

510-520 ft.

85% Gray to light gray clay and zeolite altered dacite with variable hematite alteration. Occasional sub-mm fractures are observed to be filled with calcite and zeolite.
15% Light green-gray, rarely orange, protomylonite and brecciated dacite. Secondary fine grained pyrite is observed to be present in unoxidized cataclastic fragments.

520-530 ft.

a/a

530-540 ft.

60% Dacite a/a.
30% Light gray to light green-gray protomylonite and fine breccia
10% Orange oxidized protomylonite.

540-550 ft.

a/a with 10% very dark gray fresh glassy dacite and 1% orange oxidized protomylonite.

550-560 ft.

60% Gray to light gray clay and zeolite altered dacite with variable amounts of hematite alteration. Occasional fractures are observed to be filled with calcite and zeolite.
30% Light green-gray pyrite-bearing protomylonite and brecciated dacite with zeolite and calcite veining.
10% Orange oxidize protomylonite.

560-570 ft.

Note: Many fragments are in excess of 2 cm; this sample may contain slough from up hole.
95% Dark gray to gray altered dacite with local secondary hematite. White secondary clay and pyrite occur along occasional fracture surfaces.
5% Light green-gray, locally orange, protomylonite and brecciated dacite a/a.

End of Rotary Drilled Section.

CALIFORNIA ENERGY COMPANY INC.

MAZAMA PROSPECT

KLAMATH COUNTY, OREGON

# LITHOLOGY of CORE

from 575 to 1354 feet

November 1986

Columbia Geoscience

| DEPTH FT | LITHOLOGIC DESCRIPTION | | RECOVERY % 90 80 70 60 50 | FRACTURE ANGLE / FRACTURE DENSITY | COMMENTS |
|---|---|---|---|---|---|

575

Rhyodacite: Gray, locally purple-gray, rhyodacite with a macro-texture resembling a very dense welded autobreccia. The rock shows no flow banding, fractures, or vesiculation features that would suggest surface flow dynamics. Occasional irregularly shaped cm-sized vugs are present, lined with a clear tabular zeolite (sub-mm sized crystals, possibly chabazite). Occasional larger irregular cavities and associated fractures are partially to completely filled with calcite and quartz (i.e. at 675 ft.). Calcite also fills irregularly shaped vugs associated with a few of the autobreccia-like fragments. Rarely sub-cm size irregular vugs are observed to be filled with cryptocrystalline silicia. Note that in some vugs a clear plyable material (silicon-like cement ??) has been added; clearly a drilling artifact.
The degree and type of rock alteration is somewhat variable. The Fe-bearing minerals are moderately to completely altered to hematite. The groundmass is generally altered to a light green-gray clay, probably smectite. Local hematite alteration has also taken place in the groundmass.

629 ft. The fractures are largely filled with calcite. Fracture surfaces show the same patterns of secondary minerals as observed in the overall rock alteration (mafic minerals altered to reddish hematite, groundmass altered to green-gray clay and trace calcite, clear feldspar (sandine ?) appears to be fresh).

666 ft. Green-gray sheared and brecciated zone approximately 8 inches thick. Platy fracture surfaces show dark green slickensides and precipitated calcite. The host rock has a strongly welded crystal-lithic silicic tuff microtexture that grades into a more typical rhyodacite subvolcanic texture within 5 ft. above and below the noted depth.

Depth marks: 580, 590, 600, 610, 620, 630, 640, 650, 660

Fracture angle / fracture density
- ~578–580 ft: 30°, 60° — <1, >10, <1
- ~584 ft: 0-10°
- ~587 ft: 0-10° — 3
- ~590 ft: <1
- ~594 ft: 0°, 30° — 2, <1
- ~600 ft: 30°, 5° — 2, 1
- ~610 ft: 40°, 5° — <1
- ~622 ft: 20° — 2, <1
- ~650 ft: 2, 1
- ~660 ft: 5°, 60° — 4, 2, 1
- ~666 ft: 0°, 60° — 3, 2

COMMENTS

577-579 ft. Fractured and broken rock.

585-586 ft. a/a
586-760 ft. Autobreccia-like texture with generally subrounded to subangular fragments 1-15 cm in size. Matrix and fragments are made up of the same compostion. Fractures occasionally follow fragment boundaries, though more often they cut across such boundaries.

627-628 ft. Predominantly sealed fractures with occasional open cavities.

658 ft. Partially sealed fractures with open cavities.

| DEPTH FT | | LITHOLOGIC DESCRIPTION | | RECOVERY % (90 80 70 60 50) | FRACTURE ANGLE | FRACTURE DENSITY | COMMENTS |
|---|---|---|---|---|---|---|---|
| | | | | | 30° / 0° | 1 2 1 | 675 ft. Calcite lines vesicles and fractures. |
| | | | 680 | | | 2 1 | |
| | | | | | 10° / 40° | 2 >10 3 | 682-684 ft. Broken and fractured rock. |
| | | 691-693 ft. Brecciated rhyodacite with calcite partially filling fractures. Both the pervasive rock alteration and brecciated surfaces show fresh clear feldspar (sandine ?) and mottled red hematite alteration in a greenish groundmass. The groundmass is generally harder than the metal probe point and shows no clear texture with the hand lens. Local small cavities of calcite are present in varying density throughout this section of rock. | 690 | | 80° / 10° | >10 | 692-694 ft. Brecciated with poor fracture cementing. |
| | | | | | | 2 | |
| | | | 700 | | 30° / 10° / 5° | 3 | |
| | | | 710 | | 30° / 45° / 0° | 5 3 2 | |
| | | | 720 | | 30° / 10° / 5° | 3 | |
| | | | 730 | | 5° | 1 | |
| | | | 740 | | 70° / 10° | 6 | |
| | | | | | | 1 | |
| | | 756-764 ft. Fractured purple-gray to green-gray rhyodacite. The rock contains variable amounts of red hematite alteration mottled with the a green-gray groundmass. Small irregular vesicles are filled with calcite and silica. The clear feldspar crystals appear to be fresh. Near fracture surfaces the groundmass and feldspar show clay alteration. | 750 | | 30° / 5° | 3 <1 1 | 756-764 ft. The texture suggests silica metasomatization. The fractures are filled with calcite and pyrite. Occasional fracture surfaces have a red-orange staining, associated with partial oxidation of secondary pyrite. Secondary pyrite is present locally in the rock, usually away from fractures. |
| 764 | 850 | Rhyodacite to Dacite: Gray to purple gray, massive. The groundmass conatains variable hematite alteration. Sub-mm feldspars and hornblende crystals are recongnizable. | 760 | | 0° / 85° / 15° | 7 >10 4 | 758-770 ft. Moderately to strongly fractured, including some vertical fracturing. |

| DEPTH FT | | LITHOLOGIC DESCRIPTION | | RECOVERY % 90 80 70 60 50 | FRACTURE ANGLE | FRACTURE DENSITY | COMMENTS |
|---|---|---|---|---|---|---|---|

775-780 ft. Broken or crushed zone poorly cemented with a soft white clay, contains many open cavities.

817-821 ft. Strongly fractured and sheared rock.

827-828 ft.Strongly fractured and sheared rock.

848-850 ft. Cataclastized zone which is poorly cemented. The fracture surfaces are coated with a white clay-like mineral while the center of the fractures are partially filled with coarse calcite crystals.

850 | 1036

Rhyodacite-Dacite: gray, locally purple gray, massive. The texture varies from a welded autobreccia to a welded crystal-lithic tuff. No flow features or vesiculation are observed. The autobreccia fragments are sub-angular to rounded and range from 1-20 cm.
862-875 ft. Fractures, horizontal to high angle, with no slickensides. No secondary precipitation or alteration minerals are observed.

Depth scale: 780, 790, 800, 810, 820, 830, 840, 850, 860

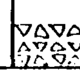
Fracture angle / density: 10° – 4; 45° – 8; 4; 3; 8; 10-30° – 2; 80°; 30°; 30°; 80°, 15°, 10° – >10, 4, 2; 5-15°, 10° – 4, >10, <1; 35°, 0-10°, 10° – 4; >10; 85° – 4; 0°, 30°; >10; 85°, 60°, 0° – 4

**COMMENTS**

770-784 ft. Fractures lined with thin film of calcite and trace pyrite.

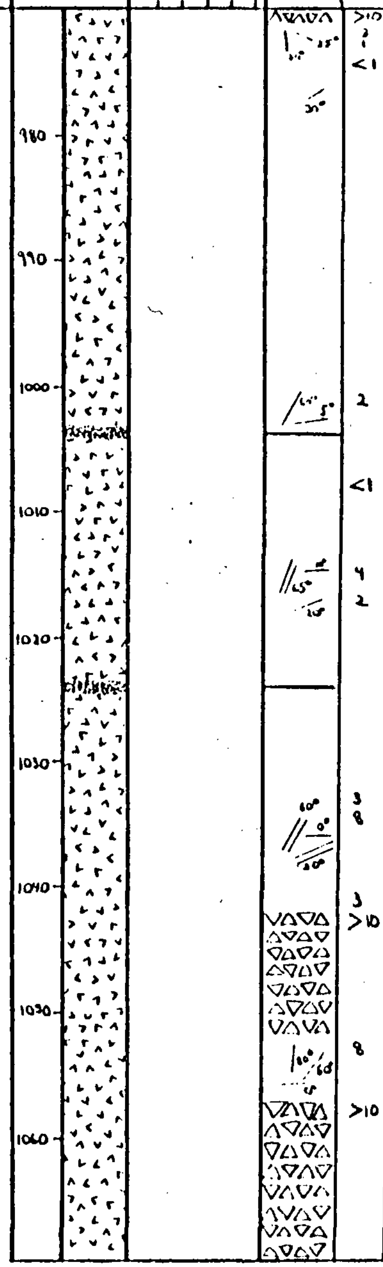
792-843 ft. Fractures filled with calcite and varying amounts of pyrite. Pyrite precipitation both preceded and is cogenetic with calcite. Reddish stained fractures both cross-cut and are cross-cut by some calcite veinlets.

843.5-844 ft. Single vein of quartz with sub-mm calcite lining.
848-850 ft. Brecciated and poorly cemented.
850-903 ft. Calcite seams and veins up to 3 mm wide. The groundmass of the rock-both adjacent to and away from fractures, has been pervasively altered to a gray-green clay with local small areas of orange hematite and secondary calcite.

| LITHOLOGIC DESCRIPTION | DEPTH FT | FRACTURE ANGLE | FRACTURE DENSITY | COMMENTS |
|---|---|---|---|---|
| | | 5° | 1, 8, >10 | ** 871 ft. The core contains an 8 inch thick section of soft dark gray clay-like material with sharp upper and lower boundaries. This appears to be an artifact of drilling. When viewed through a microscope it appears to be made up of finely ground rock containing fine fresh feldspar fragments. |
| 875-882 ft. Predominately vertical fractures coated with thin dark green sheared clay. The fractures cross-cut calcite veins. | 880 | 80°, 45° | 3, 5 | |
| | | 70°, 10° | 3, 2 | |
| 890-892.5 ft. Fractured and brecciated zone containing minor white clay, calcite, and clear tabular zeolite (chabazite ?). These fractures cross-cut earlier formed veins of calcite and pyrite. The rock surrounding this brecciated zone is strongly altered to clay. | 890 | 10°, 60°, 10° | >10, <1 | |
| 900-967 ft. Calcite bearing fractures. A few fracture surfaces contain a very thin zone of slickenside-like sheared rock. Occasional calcite bearing fractures show a dark green clay alteration adjacent to the rock. | 900 | | | 897 ft. Probable drilling artifact, see comment at 871 ft. |
| | 910 | | 1 | |
| | | | 3, <1 | 910-1002 ft. General increase in pervasive alteration of dacite to light green-gray clay and dark green clay, chlorite, and calcite. |
| | 920 | 5°, 50° | 5 | |
| | | 5°, 50° | 2 | |
| | 930 | | 1 | |
| | 940 | 5° | <1 | |
| | 950 | | | |
| 967-971 ft. Brecciated zone with a pervasive light green-gray clay alteration of the rock. Minor white clay and traces of a clear tabular zeolite (chabazite ?) have formed on some of the fracture surfaces. | 960 | 5°, 60° | 2, 1 | |
| | |  | >10 | |

RECOVERY % (90 80 70 60 50)

| DEPTH FT | LITHOLOGIC DESCRIPTION | | RECOVERY % 90 80 70 60 50 | FRACTURE ANGLE / FRACTURE DENSITY | COMMENTS |
|---|---|---|---|---|---|
| | 971-983 ft. Generally unfractured rock with only occasional vesicles filled with calcite. | | | | 984 ft. Fractures and vesicles are filled with calcite.<br>986 ft. a/a<br>989 ft. a/a |
| | | | | | 995-1039 ft. Vein and vesicle filling calcite is common. |
| | | | | | 1004 ft. Probable drilling artifact, see comment at 871 ft. |
| | 1003-1039 ft. Dacite autobreccia showing variable secondary hematite alteration in the groundmass. Often the variations in the intensity of secondary hematite accent the autobreccia-like fragments. | | | | 1024 ft. Probable drilling artifact, see comment at 871 ft. |
| | 1035-1086 ft. The rock is strongly brecciated and variably, but generally strongly, altered to clay. Many of the breccia fragment surfaces have a sheared slickenside texture. No obvious secondary precipitation minerals are observed in this zone. | | | | 1039-1042 ft. Secondary pyrite is associated both with dark green slickensides and with traces of calcite and clay.<br>1042-1059 ft. Rare traces of pyrite are present. |
| | | | | | 1059-1062 ft. An older fracture event has resulted in a fracture and breccia zone with veins of a soft clear mineral with boxwork morphology. Replacement pyrite is present in the the brecciated fragments. |



| DEPTH FT | | LITHOLOGIC DESCRIPTION | | RECOVERY % 90 80 70 60 50 | FRACTURE ANGLE / FRACTURE DENSITY | COMMENTS |
|---|---|---|---|---|---|---|
| | | | | | >10, 6, >10, 8, >10 | 1074-1079 ft. Minor to trace of pyrite occurs. Note that the pyrite occurrence may predate the intense brecciation of this zone. |
| | | | 1080 | | | |
| 1096 | 1125 | Dacite: Gray to purple-gray dacite with pronounced autobreccia-like features. The secondary hematite alteration accounting for the purple color is most pronouced in the matrix of the autobreccia. The stable Fe mineral in much of the rock is secondary clay/chlorite. Minor veins and vesicles of secondary quartz and white clay are usually under 5 mm thick. Near vertical fractures with pronounced sheared faces postdate the mineral filled fractures and vesicles. | 1090 | | 8, 3, 8, 2, 1 | |
| | | | 1100 | | | 1106 ft. Probable drilling artifact, see comment at 871 ft. |
| | | | 1110 | | >10, 8, 1 | |
| | | | 1120 | | | |
| 1125 | 1190 | Dacite: Gradual decrease in the autobreccia-like features. | | | | 1128 ft. Probable drilling artifact, see comment at 871 ft. |
| | | 1131-1135 ft. Coarsely brecciated dacite with minor mm-thick veins of calcite. The brecciation appeare to postdate the calcite seams. | 1130 | | 5, >10, 4, >10, <1 | |
| | | 1141-1151 ft. Brecciated dacite with abundant vertical fractures. No pronounced secondary alteration is observed. No precipitation minerals appear to be associated with the brecciation. Minor calcite veins appear to predate the brecciation. | 1140 | | | 1149 ft. Probable drilling artifact, see comment at 871 ft. |
| | | | 1150 | | 4, <1 | |
| | | 1159.5-1162 ft. A/a, with some of the fractures following earlier calcite veins. 1164 ft. The dacite contains abundant microcrystalline vesicles. Background alteration appears to include green clay or chlorite, preferentially located around vesicles. Secondary hematite occurs in the groundmass away from the vesicles. The only recognizable primary minerals are mm to sub-mm sized plagioclase laths. | 1160 | | >10, <1, 4, 3, 1 | 1164 ft. Local sub-mm zones of hematite which may be possible pseudomorphs of mafic minerals. Secondary calcite is common, occurring both in vesicles and plagioclase sites. Green clay alteration appears to be subsequent to hematite alteration. |

| DEPTH FT. | LITHOLOGIC DESCRIPTION | | RECOVERY % (90 80 70 60 50) | FRACTURE ANGLE | FRACTURE DENSITY | COMMENTS |
|---|---|---|---|---|---|---|

## LITHOLOGIC DESCRIPTION

1169-1178 ft. Only minor vesicle and fracture filling minerals are present, mainly calcite. Background rock alteration suggests a partial oxidation of iron minerals followed by secondary green clay or chlorite. The rock contains abundant microvesicles in a crystal-rich groundmass. Minor secondary calcite is ubiquitous throughout the rock.

Dacite: Gray to light gray, pervasive though variable clay altered dacite. A few sub-mm clear feldspar crystals appear to be fresh. Many feldspar phenocrysts appear to be altered to clay and calcite. The groundmass contains variable zones of secondary dark green clay/chlorite and minor zones of secondary purple hematite.

1200 ft. The rock is becoming increasingly altered to clay, causing the rock to become softer.

1208 ft. The rock is more brittle due to a decrease in clay alteration. Many of the fracture surfaces show slickenside effects suggesting vertical to oblique high angle movement. Vein filling minerals include calcite and unidentified soft white mineral which does not effervesce in HCl. Traces of mordenite needles may be present as a vein filling mineral.

1211-1217 ft. Highly fractured rock with veins a/a. The background alteration of early stage hematite followed by subsequent green clay or chlorite continues.

1229-1232 ft. Fractures and vesicles show linings of green clay or chlorite followed by massive calcite. At a hand lens scale no phenocrysts are readily identifiable in the rock. The rock appears to have undergone a mild but pervasive hematite alteration followed by a clay or chlorite alteration. The latter is preferentially located near vesicles and plagioclase sites. Minor secondary calcite commonly occurs in feldspar sites.

1263-1266 ft. A brecciated zone. The rock shows a pervasive background clay alteration. A clear zeolite with a tabular morphology (chabazite ?) and pervasive purple to orange hematite alteration of the rock is present. Very minor secondary calcite is present along fracture surfaces.

## FRACTURE ANGLE / FRACTURE DENSITY

| Depth (approx.) | Fracture angle | Fracture density |
|---|---|---|
| 1170 | | <1 |
| 1177 | 0-10° | |
| 1184 | 5° | |
| 1187 | 45° | |
| 1190 | 15° 10° | 4 |
| 1192 | | <1 |
| 1196 | 0-10° | |
| 1207 | 85° 10° | >10 |
| 1210 | | <1 |
| 1212 | 75° | 8 |
| 1217 | 0° | <1 |
| 1226 | 20° | |
| 1233 | 70° 10° | 3 |
| 1238 | 55° | 1 |
| 1240 | 10° | 3 |
| 1250 | 70° | 2 |
| 1263 | (breccia) | >10 |
| 1267 | | 1 |

## COMMENTS

1174 ft. Occasional vesicles show green clay or chlorite alteration along the edges, followed by calcite, and rarely with quartz following calcite. More commonly vesicles and fractures are filled with calcite, and occasionally with calcite and mordenite. A few of the the vesicles contain only an acicular zeolite (mordenite ?). One vesicle contains massive calcite, followed by mordenite, which in turn is followed by bladed calcite. Pervasive rock alteration includes green clay or chlorite and secondary calcite. Plagioclase laths have altered to clay, possible zeolite, and calcite.

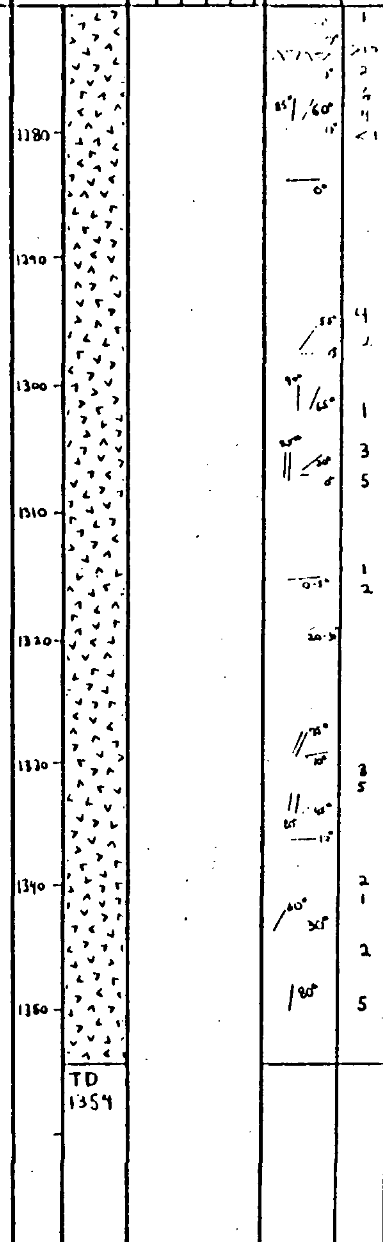
1187 ft. Rock alteration shows an early episode of hematite alteration of Fe minerals, both phenocrysts and groundmass, to hematite, followed by a later stage green clay or chlorite, preferentially occurring near vesicles and fractures. Larger vesicles and fractures contain secondary calcite and mordenite.

1217-1218 ft. Only minor amounts of calcite in fractures and vesicles.

1232-1254 ft. The intensity of fracture and vesicle filling is variable.

1259 ft. Late stage calcite is present in a few of the vesicles. Mordenite also occurs with the calcite. The latest stage of calcite, formed subsequent to the mordenite, has a bladed morphology.

| DEPTH FT | LITHOLOGIC DESCRIPTION | | RECOVERY % 90 80 70 60 50 | FRACTURE ANGLE / FRACTURE DENSITY | COMMENTS |
|---|---|---|---|---|---|




## LITHOLOGIC DESCRIPTION

1267-1276 ft. Dacite with secondary hematite occurring in the groundmass, followed by subsequent secondary green clay or chlorite. Vesicle-filling minerals include green clay followed by massive calcite.

***1294 ft. A strongly fractured zone. The fractures are partially*** filled with chlorite (or green clay), minor calcite, mordenite, and sub-mm Fe sulfide (pyrite ?). Soft white areas probably include other unidentified secondary minerals. Mordenite appears to make up the bulk of secondary mineralization in these fractures.

1296 ft. Occasional fractures containing minor secondary quartz, followed by calcite and mordenite. The rock shows somewhat less alteration than up-hole, with only minor early stage hematite alteration. Small sub-mm fractures are predominately filled with silica. Minor localized secondary calcite is limited to the groundmass.

By 1298 ft. The secondary mineralization associated with fractures appears to be limited to calcite and a zeolite. Sealed fractures are filled with calcite. Open fracture surfaces have a fine coating of a crystalline zeolite (mordenite ?). Rare sub-mm silica veins may be the result of nothing more than localized metasomatic alteration.

1301-TD (1354 ft.) The dominant fracture filling minerals are calcite and mordenite with the most recent morphology consisting of calcite blades forming on mordenite needles. The most intensely fractured zones occur at 1331 ft., 1334-1340 ft., and 1347-TD ft. Many of these fractures show a lining of green clay or chlorite. Much of the more recent alteration is dominated by light green clay or chlorite which tends to obscure earlier hematite alteration. The earlier hematite alteration is best preserved in those areas away from intense fracturing. Microscopic sized Fe sulfide occurs as a trace vein mineral and as an alteration mineral below 1319 ft. It occurs most commonly in the intensely fractured areas.

## COMMENTS

1276-1277 ft. Fractures show both massive calcite and quartz filling.

1278-1280 ft. The fracture surfaces show very minor calcite mainly in open fractures. No secondary quartz is observed.

1280-1294 ft. Generally unfractured rock with minor calcite filled vesicles.

A clear to white zeolite with a tablet-like morphology occurs in fractures, associated with a rare trace of pyrite (?), 1319 ft. (see 1322 ft. away from main fracture veining). The degree of secondary green clay-chlorite increases below 1315 ft., especially in areas of fracturing. In addition to an increase of clay-chlorite, a rare trace of drusy quartz occurs, cogenetic with mordenite. Minor secondary pyrite also occurs as a vein-filling mineral. The precipitation of quartz appears to represent the most recent, perhaps ongoing, activity.

1350 ft. Thick calcite-mordenite veins observed.

1351 ft. A very fine clear white vein filling zeolite, possibly mordenite with a more tabular morphology is observed.

1352 ft. Veining of calcite-mordenite-quartz-pyrite.

MZI-11A
CORE RECOVERY

| Depth Interval | Cut | Recovered | % Recovered |
|---|---|---|---|
| 575'-579' | 4 | 4 | 100% |
| 579'-585' | 6 | 6 | " |
| 585'-589' | 4 | 4 | " |
| 589'-594' | 5 | 5 | " |
| 594'-596' | 2 | 2 | " |
| 596'-604' | 8 | 8 | " |
| 604'-614' | 10 | 10 | " |
| 614'-624' | 10 | 10 | " |
| 624'-634' | 10 | 10 | " |
| 634'-644' | 10 | 10 | " |
| 644'-654' | 10 | 10 | " |
| 654'-663' | 9 | 9 | " |
| 663'-673' | 10 | 10 | " |
| 673'-683' | 10 | 10 | " |
| 683'-693' | 10 | 10 | " |
| 693'-694' | 1 | 1 | " |
| 694'-704' | 10 | 10 | " |
| 704'-714' | 10 | 10 | " |
| 714'-724' | 10 | 10 | " |
| 724'-734' | 10 | 10 | " |
| 734'-744' | 10 | 10 | " |
| 744'-754' | 10 | 10 | " |
| 754'-764' | 10 | 10 | " |
| 764'-772' | 8 | 8 | " |
| 772'-782' | 10 | 10 | " |
| 782'-792' | 10 | 10 | " |
| 792'-801' | 9 | 9 | " |
| 801'-811' | 10 | 10 | " |
| 811'-820' | 9 | 9 | " |
| 820'-830' | 10 | 10 | " |
| 830'-840' | 10 | 10 | " |
| 840'-850' | 10 | 10 | " |
| 850'-856' | 6 | 6 | " |
| 856'-861' | 5 | 5 | " |
| 861'-871' | 10 | 10 | " |
| 871'-873' | 3 | 2 | 67% |
| 873'-882' | 9 | 9 | 100% |
| 882'-892' | 10 | 10 | " |
| 892'-897' | 5 | 5 | " |
| 897'-907' | 10 | 10 | " |
| 907'-914' | 7 | 7 | " |
| 914'-924' | 10 | 10 | " |
| 924'-934' | 10 | 10 | " |
| 934'-944' | 10 | 10 | " |
| 944'-954' | 10 | 10 | " |
| 954'-964' | 10 | 10 | " |

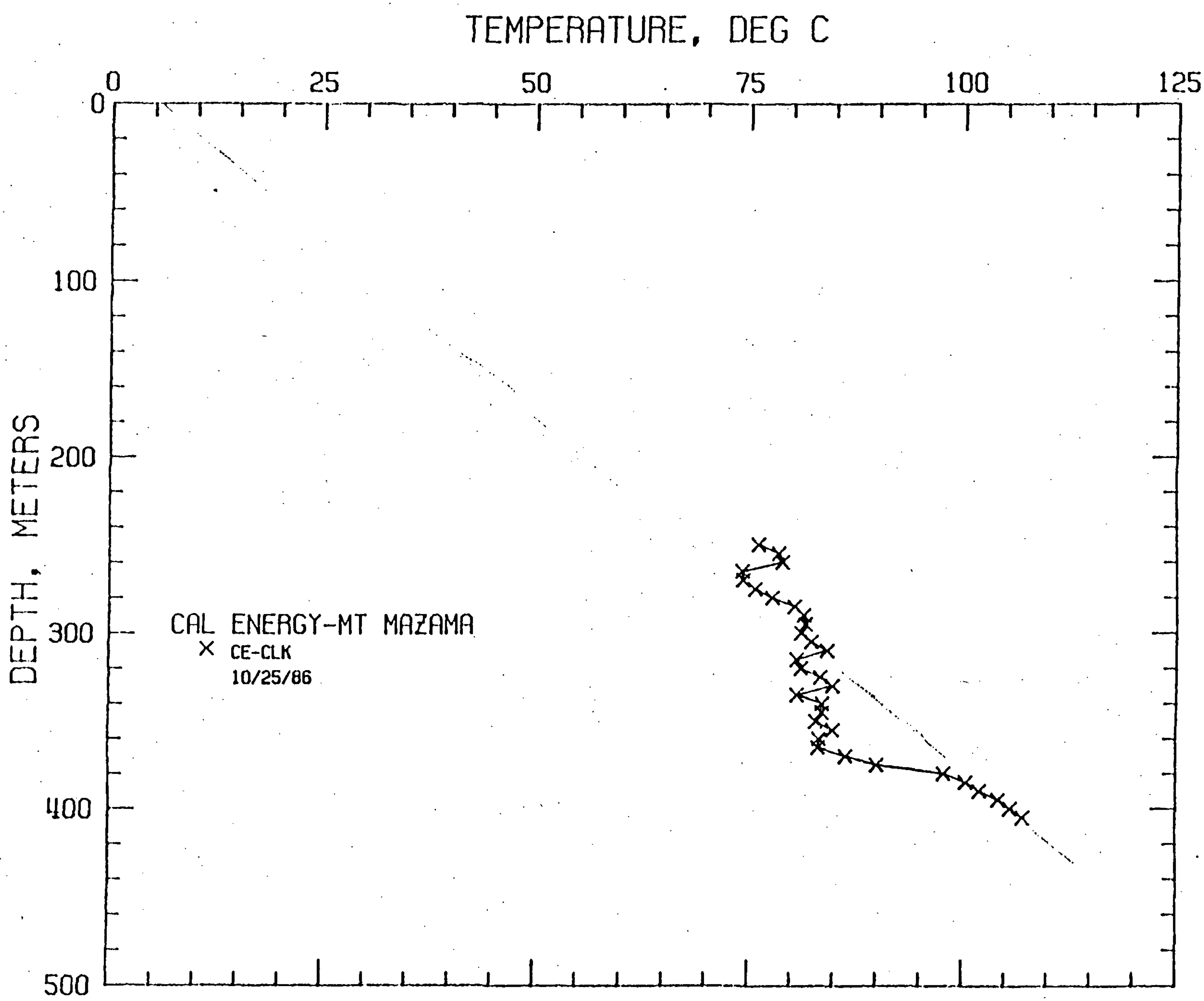
| Depth Interval | Cut | Recovered | % Recovered |
|---|---|---|---|
| 964'-974' | 10 | 10 | 100% |
| 974'-984' | 10 | 10 | " |
| 984'-994' | 10 | 10 | " |
| 994'-1004' | 10 | 10 | " |
| 1004'-1006' | 2 | 2 | " |
| 1006'-1014' | 8 | 8 | " |
| 1014'-1024' | 10 | 10 | " |
| 1024'-1032' | 8 | 8 | " |
| 1032'-1042' | 10 | 10 | " |
| 1042'-1052' | 10 | 10 | " |
| 1052'-1058' | 6 | 6 | " |
| 1058'-1061' | 3 | 3 | " |
| 1061'-1069' | 8 | 8 | " |
| 1069'-1079' | 10 | 10 | " |
| 1079'-1084' | 5 | 5 | " |
| 1084'-1086' | 2 | 2 | " |
| 1086'-1096' | 10 | 10 | " |
| 1096'-1106' | 10 | 10 | " |
| 1106'-1108' | 2 | 2 | " |
| 1108'-1118' | 10 | 10 | " |
| 1118'-1128' | 10 | 10 | " |
| 1128'-1138' | 10 | 10 | " |
| 1138'-1147 | 9 | 9 | " |
| 1147'-1150' | 3 | 3 | " |
| 1150'-1154' | 4 | 4 | " |
| 1154'-1162' | 8 | 8 | " |
| 1162'-1164 | 2 | 2 | " |
| 1164'-1174' | 10 | 10 | " |
| 1174'-1184' | 10 | 10 | " |
| 1184'-1194' | 10 | 10 | " |
| 1194'-1204' | 10 | 10 | " |
| 1204'-1209 | 5 | 5 | " |
| 1209'-1219' | 10 | 10 | " |
| 1219'-1225' | 6 | 6 | " |
| 1225'-1234' | 9 | 9 | " |
| 1234'-1244' | 10 | 10 | " |
| 1244'-1250' | 6 | 6 | " |
| 1250'-1259' | 9 | 9 | " |
| 1259'-1263' | 4 | 3 | 75% |
| 1263'-1268' | 5 | 4 | 80% |
| 1268'-1278' | 10 | 10 | 100% |
| 1278'-1287' | 9 | 9 | " |
| 1287'-1297' | 10 | 10 | " |
| 1297'-1307 | 10 | 10 | " |
| 1307'-1315' | 8 | 8 | " |
| 1315'-1324' | 9 | 9 | " |
| 1324'-1334' | 10 | 10 | " |
| 1334'-1344' | 10 | 10 | " |
| 1344'-1354' | 10 | 10 | " |

JLF:sr:42:12-19-86:6232/B2

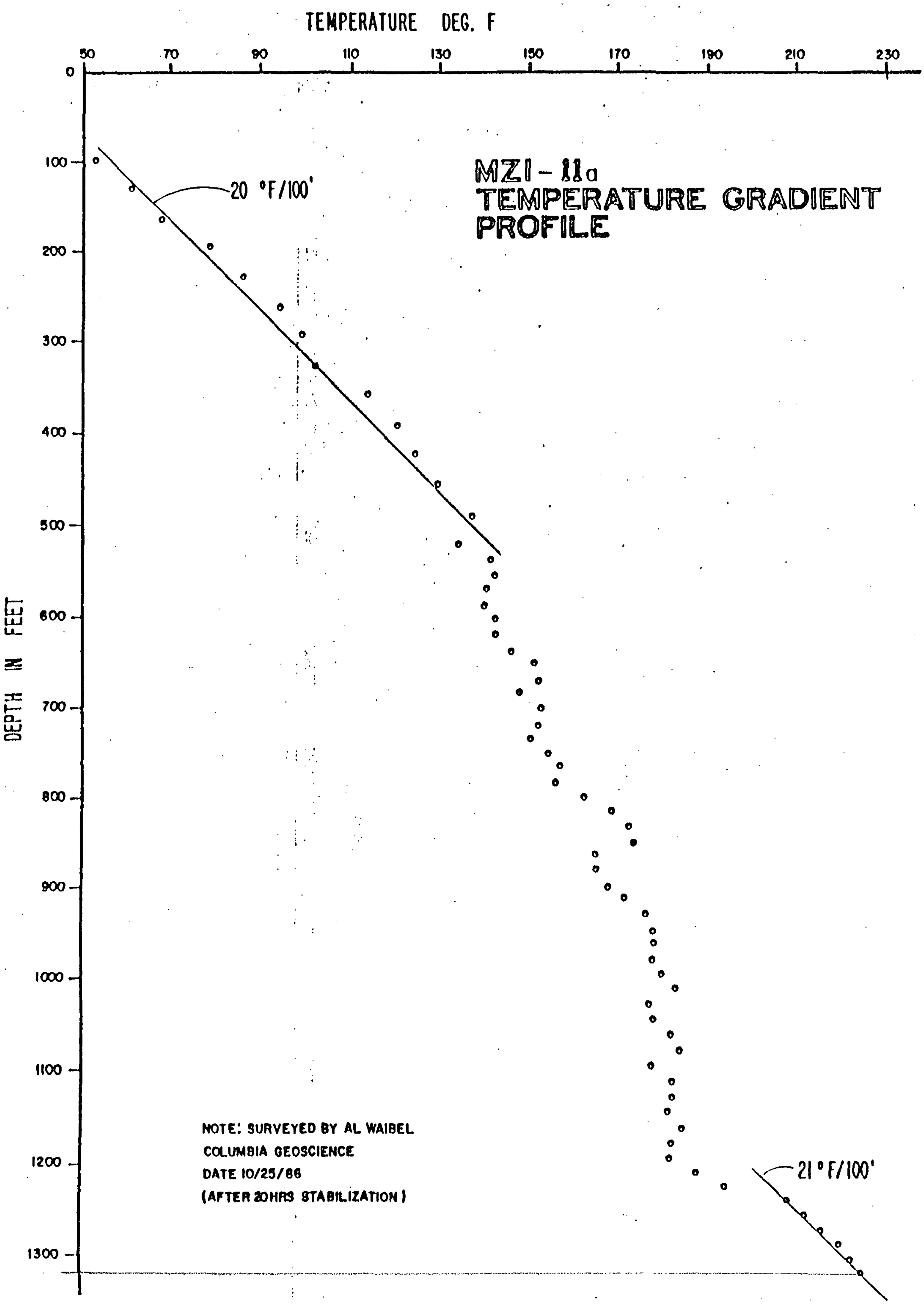
LOCATION: KLAMATH FALLS AMS, ORE
T/R-S:
HOLE NAME: MZI-11A
DATE MEASURED: 10/25/86

| DEPTH | DEPTH | TEMPERATURE | | GEOTHERMAL GRADIENT | |
|---|---|---|---|---|---|
| METERS | FEET | DEG C | DEG F | DEG C/KM | DEG. F/100 FT |
| 250.0 | 820.2 | 76.100 | 168.98 | 0.0 | 0.0 |
| 255.0 | 836.6 | 78.500 | 173.30 | 480.0 | 26.3 |
| 260.0 | 853.0 | 78.900 | 174.02 | 80.0 | 4.4 |
| 265.0 | 869.4 | 74.200 | 165.56 | -940.0 | -51.6 |
| 270.0 | 885.8 | 74.300 | 165.74 | 20.0 | 1.1 |
| 275.0 | 902.2 | 75.700 | 168.26 | 280.0 | 15.4 |
| 280.0 | 918.6 | 77.700 | 171.86 | 400.0 | 22.0 |
| 285.0 | 935.0 | 80.300 | 176.54 | 520.0 | 28.5 |
| 290.0 | 951.4 | 81.400 | 178.52 | 220.0 | 12.1 |
| 295.0 | 967.8 | 81.600 | 178.88 | 40.0 | 2.2 |
| 300.0 | 984.3 | 81.100 | 177.98 | -100.0 | -5.5 |
| 305.0 | 1000.7 | 82.300 | 180.14 | 240.0 | 13.2 |
| 310.0 | 1017.1 | 84.200 | 183.56 | 380.0 | 20.9 |
| 315.0 | 1033.5 | 80.600 | 177.08 | -720.0 | -39.5 |
| 320.0 | 1049.9 | 81.100 | 177.98 | 100.0 | 5.5 |
| 325.0 | 1066.3 | 83.400 | 182.12 | 460.0 | 25.2 |
| 330.0 | 1082.7 | 84.800 | 184.64 | 280.0 | 15.4 |
| 335.0 | 1099.1 | 80.600 | 177.08 | -840.0 | -46.1 |
| 340.0 | 1115.5 | 83.600 | 182.48 | 600.0 | 32.9 |
| 345.0 | 1131.9 | 83.600 | 182.48 | 0.0 | 0.0 |
| 350.0 | 1148.3 | 82.900 | 181.22 | -140.0 | -7.7 |
| 355.0 | 1164.7 | 84.900 | 184.82 | 400.0 | 22.0 |
| 360.0 | 1181.1 | 83.300 | 181.94 | -320.0 | -17.6 |
| 365.0 | 1197.5 | 83.200 | 181.76 | -20.0 | -1.1 |
| 370.0 | 1213.9 | 86.400 | 187.52 | 640.0 | 35.1 |
| 375.0 | 1230.3 | 90.000 | 194.00 | 720.0 | 39.5 |
| 380.0 | 1246.7 | 97.800 | 208.04 | 1560.0 | 85.6 |
| 385.0 | 1263.1 | 100.400 | 212.72 | 520.0 | 28.5 |
| 390.0 | 1279.5 | 102.000 | 215.60 | 320.0 | 17.6 |
| 395.0 | 1295.9 | 104.200 | 219.56 | 440.0 | 24.1 |
| 400.0 | 1312.3 | 105.600 | 222.08 | 280.0 | 15.4 |
| 405.0 | 1328.7 | 107.100 | 224.78 | 300.0 | 16.5 |

Data from Dave Blackwell's Computer Program.




Data Plot From
Dave Blackwell

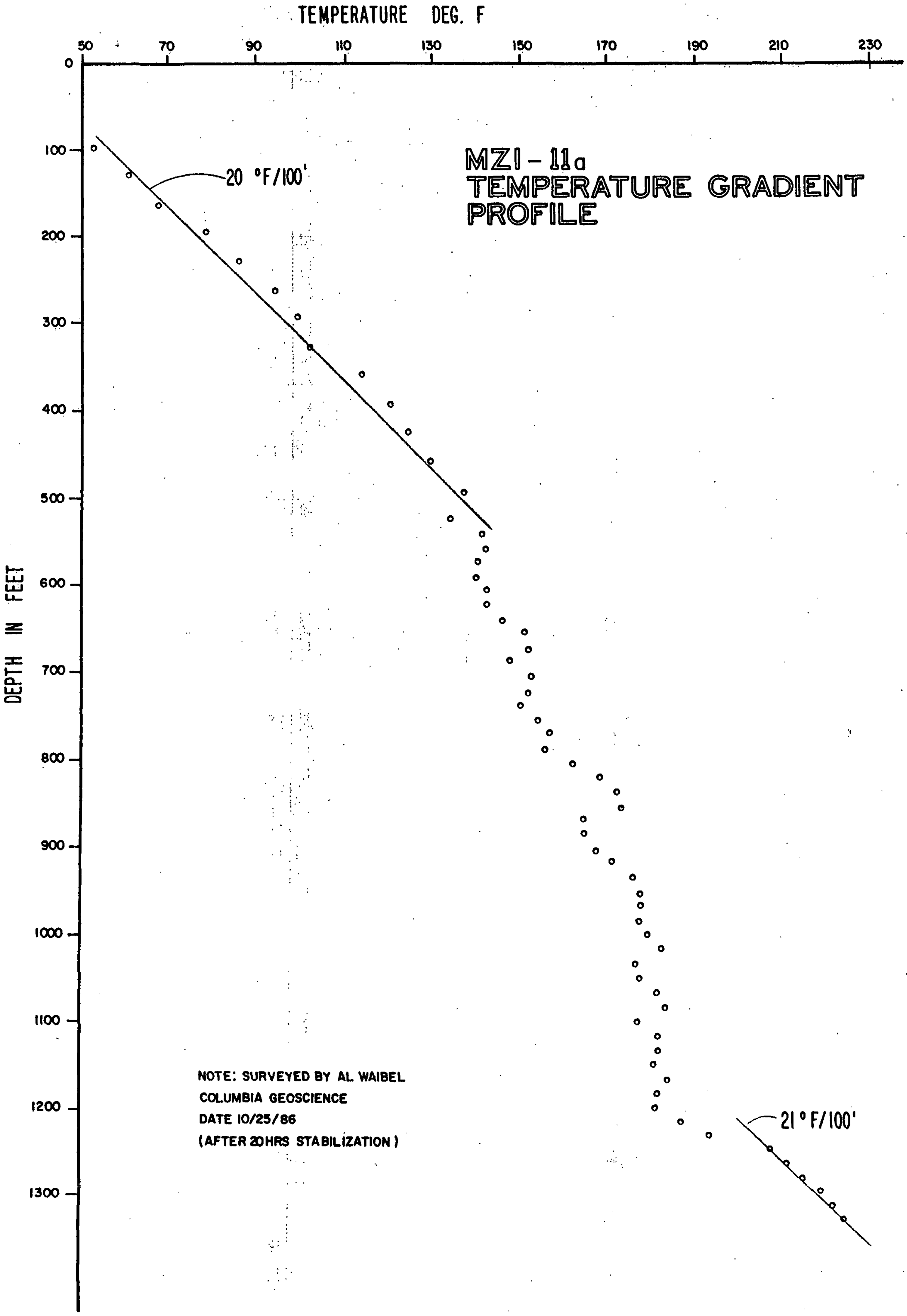

TEMPERATURE DEG. F
50
70
90
110
130
150
170
190
210
230
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
DEPTH IN FEET
20 °F/100'
21 °F/100'
MZI - 11a
TEMPERATURE GRADIENT
PROFILE
NOTE: SURVEYED BY AL WAIBEL
COLUMBIA GEOSCIENCE
DATE 10/25/86
(AFTER 20HRS STABILIZATION)

MZI-11A Temperature Gradient Data

This data was recorded by Al Waibel, Columbia Geoscience, on 10/25/86, after about 20 hours of stabilization.

| Depth in Feet | Temperature °F |
|---|---|
| 98 | 53.5 |
| 131 | 61.5 |
| 164 | 68.25 |
| 197 | 79.75 |
| 230 | 86.4 |
| 262.5 | 94.8 |
| 295 | 99.95 |
| 328 | 102.5 |
| 361 | 114.3 |
| 394 | 121.15 |
| 426.5 | 125.7 |
| 459 | 130.3 |
| 492 | 137.8 |
| 525 | 134.8 |
| 541 | 141.9 |
| 558 | 142.9 |
| 574 | 141.2 |
| 591 | 140.25 |
| 607 | 142.8 |
| 623 | 143.1 |
| 640 | 146.7 |
| 656 | 152.1 |
| 673 | 152.85 |
| 689 | 148.2 |
| 705 | 153 |
| 722 | 152.5 |
| 738 | 150.5 |
| 755 | 154.5 |
| 771 | 157.5 |
| 787 | 156.4 |
| 804 | 162.7 |
| 820 | 169.0 |
| 837 | 173.0 |
| 853 | 174.0 |
| 869 | 165.6 |
| 886 | 165.7 |
| 902 | 168.3 |
| 919 | 171.9 |
| 935 | 176.5 |
| 951 | 178.6 |
| 968 | 178.9 |
| 984 | 178.0 |
| 1001 | 180.1 |
| 1017 | 183.6 |
| 1033.5 | 177.1 |
| 1050 | 178.0 |
| 1066 | 182.1 |
| 1083 | 184.6 |
| 1099 | 177.1 |
| 1115.5 | 182.5 |
| 1132 | 182.5 |
| 1148 | 181.2 |
| 1165 | 184.8 |
| 1181 | 181.9 |
| 1197.5 | 181.8 |
| 1214 | 187.5 |
| 1230 | 194.0 |
| 1247 | 208.0 |
| 1263 | 212.7 |
| 1279.5 | 215.6 |
| 1295.9 | 219.6 |
| 1312 | 222.1 |
| 1329 | 224.8 |

JLF:sr:42


TEMPERATURE DEG. F
50
70
90
110
130
150
170
190
210
230
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
DEPTH IN FEET
20 °F/100'
21 °F/100'
MZI - 11a
TEMPERATURE GRADIENT
PROFILE
NOTE: SURVEYED BY AL WAIBEL
COLUMBIA GEOSCIENCE
DATE 10/25/86
(AFTER 20HRS STABILIZATION)

MZI-11A Temperature Gradient Data

This data was recorded by Al Waibel, Columbia Geoscience, on 10/25/86, after about 20 hours of stabilization.

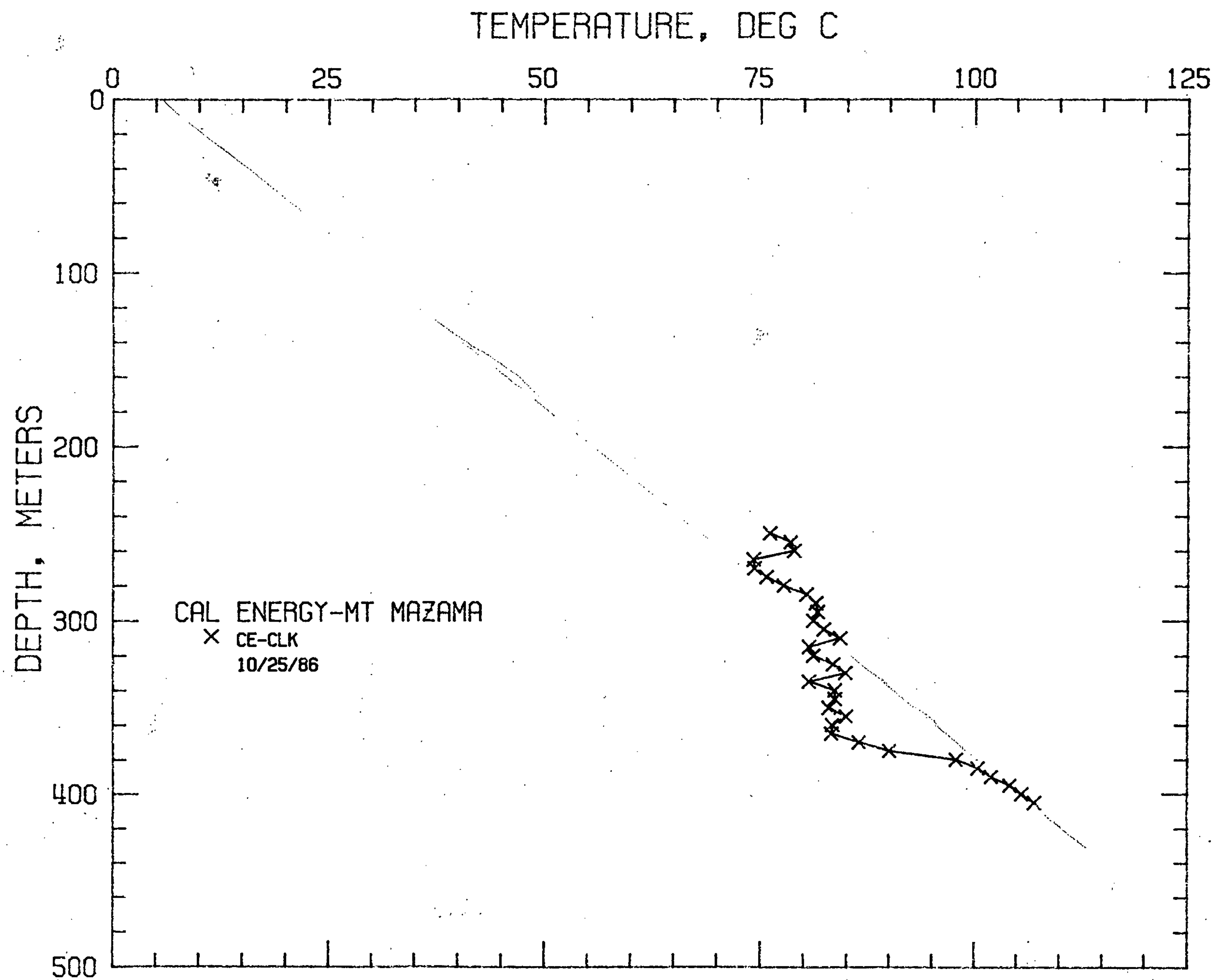
| Depth in Feet | Temperature °F |
|---|---|
| 98 | 53.5 |
| 131 | 61.5 |
| 164 | 68.25 |
| 197 | 79.75 |
| 230 | 86.4 |
| 262.5 | 94.8 |
| 295 | 99.95 |
| 328 | 102.5 |
| 361 | 114.3 |
| 394 | 121.15 |
| 426.5 | 125.7 |
| 459 | 130.3 |
| 492 | 137.8 |
| 525 | 134.8 |
| 541 | 141.9 |
| 558 | 142.9 |
| 574 | 141.2 |
| 591 | 140.25 |
| 607 | 142.8 |
| 623 | 143.1 |
| 640 | 146.7 |
| 656 | 152.1 |
| 673 | 152.85 |
| 689 | 148.2 |
| 705 | 153 |
| 722 | 152.5 |
| 738 | 150.5 |
| 755 | 154.5 |
| 771 | 157.5 |
| 787 | 156.4 |
| 804 | 162.7 |
| 820 | 169.0 |
| 837 | 173.0 |
| 853 | 174.0 |
| 869 | 165.6 |
| 886 | 165.7 |
| 902 | 168.3 |
| 919 | 171.9 |
| 935 | 176.5 |
| 951 | 178.6 |
| 968 | 178.9 |
| 984 | 178.0 |
| 1001 | 180.1 |
| 1017 | 183.6 |
| 1033.5 | 177.1 |
| 1050 | 178.0 |
| 1066 | 182.1 |
| 1083 | 184.6 |
| 1099 | 177.1 |
| 1115.5 | 182.5 |
| 1132 | 182.5 |
| 1148 | 181.2 |
| 1165 | 184.8 |
| 1181 | 181.9 |
| 1197.5 | 181.8 |
| 1214 | 187.5 |
| 1230 | 194.0 |
| 1247 | 208.0 |
| 1263 | 212.7 |
| 1279.5 | 215.6 |
| 1295.9 | 219.6 |
| 1312 | 222.1 |
| 1329 | 224.8 |

JLF:sr:42

LOCATION: KLAMATH FALLS AMS, ORE
T/R-S:
HOLE NAME: MZI-11A
DATE MEASURED: 10/25/86

| DEPTH | DEPTH | TEMPERATURE | | GEOTHERMAL GRADIENT | |
|---|---|---|---|---|---|
| METERS | FEET | DEG C | DEG F | DEG C/KM | DEG F/100 FT |
| 250.0 | 820.2 | 76.100 | 168.98 | 0.0 | 0.0 |
| 255.0 | 836.6 | 78.500 | 173.30 | 480.0 | 26.3 |
| 260.0 | 853.0 | 78.900 | 174.02 | 80.0 | 4.4 |
| 265.0 | 869.4 | 74.200 | 165.56 | -940.0 | -51.6 |
| 270.0 | 885.8 | 74.300 | 165.74 | 20.0 | 1.1 |
| 275.0 | 902.2 | 75.700 | 168.26 | 280.0 | 15.4 |
| 280.0 | 918.6 | 77.700 | 171.86 | 400.0 | 22.0 |
| 285.0 | 935.0 | 80.300 | 176.54 | 520.0 | 28.5 |
| 290.0 | 951.4 | 81.400 | 178.52 | 220.0 | 12.1 |
| 295.0 | 967.8 | 81.600 | 178.88 | 40.0 | 2.2 |
| 300.0 | 984.3 | 81.100 | 177.98 | -100.0 | -5.5 |
| 305.0 | 1000.7 | 82.300 | 180.14 | 240.0 | 13.2 |
| 310.0 | 1017.1 | 84.200 | 183.56 | 380.0 | 20.9 |
| 315.0 | 1033.5 | 80.600 | 177.08 | -720.0 | -39.5 |
| 320.0 | 1049.9 | 81.100 | 177.98 | 100.0 | 5.5 |
| 325.0 | 1066.3 | 83.400 | 182.12 | 460.0 | 25.2 |
| 330.0 | 1082.7 | 84.800 | 184.64 | 280.0 | 15.4 |
| 335.0 | 1099.1 | 80.600 | 177.08 | -840.0 | -46.1 |
| 340.0 | 1115.5 | 83.600 | 182.48 | 600.0 | 32.9 |
| 345.0 | 1131.9 | 83.600 | 182.48 | 0.0 | 0.0 |
| 350.0 | 1148.3 | 82.900 | 181.22 | -140.0 | -7.7 |
| 355.0 | 1164.7 | 84.900 | 184.82 | 400.0 | 22.0 |
| 360.0 | 1181.1 | 83.300 | 181.94 | -320.0 | -17.6 |
| 365.0 | 1197.5 | 83.200 | 181.76 | -20.0 | -1.1 |
| 370.0 | 1213.9 | 86.400 | 187.52 | 640.0 | 35.1 |
| 375.0 | 1230.3 | 90.000 | 194.00 | 720.0 | 39.5 |
| 380.0 | 1246.7 | 97.800 | 208.04 | 1560.0 | 85.6 |
| 385.0 | 1263.1 | 100.400 | 212.72 | 520.0 | 28.5 |
| 390.0 | 1279.5 | 102.000 | 215.60 | 320.0 | 17.6 |
| 395.0 | 1295.9 | 104.200 | 219.56 | 440.0 | 24.1 |
| 400.0 | 1312.3 | 105.600 | 222.08 | 280.0 | 15.4 |
| 405.0 | 1328.7 | 107.100 | 224.78 | 300.0 | 16.5 |

Data from Dave Blackwell's Computer Program.




Data Plot From
Dave Blackwell

MAZAMA I-11A
Crater Lake, Oregon

| | |
|---|---|
| 9/12/86 | Move in and rig up Buckner Drilling rotary rig. Drill 8" hole to 24' with air foam. |
| 9/13/86 | Drilling 8" hole from 24' to 370' with air and foam. |
| 9/14/86 | Drill 8" hole from 370' to 575' with air and foam. |
| 9/15/86 | Mix mud and condition hole. |
| 9/16/86 | Circulate and condition mud for casing job. |
| 9/17/86 to 9/28/86 | Run in hole to 575' and circulate--pull out of hole. Rig up and run 18 joints (575') 4-1/2" - 11.6# N-80 casing with 8 round LF & C threads. Land casing at 575' and circulated with mud. Cemented with Halliburton, ran 3 bbls. of $H_2O$ ahead of 272 cubic feet Class G cement with 1:1 Perlite, 3% gel. Displaced top plug to 545' with 8 bbls. of $H_2O$. Plug in place at 1500 hours 9/17/86. Good returns (100+ cubic feet). Job witnessed by Steve Henderson and Dennis Simontacchi. |
| 9/29/86 to 10/7/86 | Weld 6" - 900 series slip on casing head to 4-1/2" casing. Install hydraulic operated annular and blind rams BOP's with dual controls. Install Hydrogen Sulfide detectors and alarm system. Rig up Longyear core rig and work on BOP's. |
| 10/8/86 | Tested BOP's 1/2 hr. each at 700 psi, test ok. Witnessed by Dennis Simontacchi. |
| 10/9/86 | Drilled cement from 545' to 575'. |
| 10/10/86 to 10/24/86 | Coring HQ size (3.50" OD) hole F/575' to 1354'. Fighting lost circulation. |
| 10/25/86 | Run temperature survey. |
| 10/26/86 to 10/29/86 | Rig down and move off Longyear. |

GG:sr:20
Z6132:A5

United States Department of the Interior

GEOLOGICAL SURVEY

Branch of Igneous and Geothermal Processes, MS-910
345 Middlefield Road, Menlo Park, California 94025

March 10, 1987

Mr. Joe LaFleur
California Energy Co., Inc.
3333 Mendocino Avenue #100
Santa Rosa, CA 95401

Dear Joe:

I have looked at the thin sections from the core samples that you sent me. The sample from 579 feet looks to be rhyodacite of the general sort that makes up most of the hills east of the park. All of the samples from deeper in the hole appear to once have been hornblende andesites or dacites more akin to Dry Butte rock, but possibly more silicic. So, the major contact is somewhere between about 580 and 680 feet. From my notes on the photos, I can't pinpoint the lithologic break more precisely. I'm no alteration expert, so I hesitate to comment at this time on what secondary minerals are in the sections.

Thanks again for the rocks. The information from the hole certainly does provide a new perspective on what's down there. I admit surprise at finding all those hornblende-bearing rocks.

The Portland meeting was a stimulating exercise. At the very least, it gave all of us an opportunity to hear what's being studied.

Sincerely,

Charlie

Charles R. Bacon
Geologist

# MZI-11a

## Core Recovery

| Depth Interval | Cut | Rec. | % Rec |
|---|---|---|---|
| 575'-579' | 4 | 4 | 100 |
| 579-585 | 6 | 6 | |
| 585-589 | 4 | 4 | |
| 589-594 | 5 | 5 | |
| 594-596 | 2 | 2 | |
| 596-604 | 8 | 8 | |
| 604-614 | 10 | 10 | |
| 614-624 | 10 | 10 | |
| 624-634 | 10 | 10 | |
| 634-644 | 10 | 10 | |
| 644-654 | 10 | 10 | |
| 654-663 | 9 | 9 | |
| 663-673 | 10 | 10 | |
| 673-683 | 10 | 10 | |
| 683-693 | 10 | 10 | |
| 693-694 | 1 | 1 | |
| 694-704 | 10 | 10 | |
| 704-714 | 10 | 10 | |
| 714-724 | 10 | 10 | |
| 724-734 | 10 | 10 | |
| 734-744 | 10 | 10 | |
| 744-754 | 10 | 10 | |
| 754-764 | 10 | 10 | |
| 764-772 | 8 | 8 | |
| 772-782 | 10 | 10 | |
| 782-792 | 10 | 10 | |

| Interval | Cut | Rec | % Rec |
| --- | --- | --- | --- |
| 792 - 801 | 9 | 9 | 100 |
| 801 - 811 | 10 | 10 | " |
| 811 - 820 | 9 | 9 | " |
| 820 830 | 10 | 10 | |
| 830 - 840 | 10 | 10 | |
| 840 - 850 | 10 | 10 | |
| 850 - 856 | 6 | 6 | |
| 856 - 861 | 5 | 5 | |
| 861 - 871 | 10 | 10 | " |
| 871 - 873 | 3 | 2 | 67% |
| 873 - 882 | 9 | 9 | 100 |
| 882 - 892 | 10 | 10 | " |
| 892 - 897 | 5 | 5 | |
| 897 - 907 | 10 | 10 | |
| 907 - 914 | 7 | 7 | |
| 914 - 924 | 10 | 10 | |
| 924 - 934 | 10 | 10 | |
| 934 - 944 | 10 | 10 | |
| 944 - 954 | 10 | 10 | |
| 954 - 964 | 10 | 10 | |
| 964 - 974 | 10 | 10 | |
| 974 - 984 | 10 | 10 | |
| 984 - 994 | 10 | 10 | |
| 994 - 1004 | 10 | 10 | |
| 1004 - 1006 | 2 | 2 | |
| 1006 - 1014 | 8 | 8 | |

| Interval | Cut | Rec | % Rec |
|---|---|---|---|
| 1014 - 1024 | 10 | 10 | 100 % |
| 1024 - 1032 | 8 | 8 | 100 |
| 1032 - 1042 | 10 | 10 | |
| 1042 - 1052 | 10 | 10 | |
| 1052 - 1058 | 6 | 6 | |
| 1058 - 1061 | 3 | 3 | |
| 1061 - 1069 | 8 | 8 | |
| 1069 - 1079 | 10 | 10 | |
| 1079 - 1084 | 5 | 5 | |
| 1084 - 1086 | 2 | 2 | |
| 1086 - 1096 | 10 | 10 | |
| 1096 - 1106 | 10 | 10 | |
| 1106 - 1108 | 2 | 2 | |
| 1108 - 1118 | 10 | 10 | |
| 1118 - 1128 | 10 | 10 | |
| 1128 - 1138 | 10 | 10 | |
| 1138 - 1147 | 9 | 9 | |
| 1147 - 1150 | 3 | 3 | |
| 1150 - 1154 | 4 | 4 | |
| 1154 - 1162 | 8 | 8 | |
| 1162 - 1174 | 10 | 10 | |
| 1174 - 1184 | 10 | 10 | |
| 1184 - 1194 | 10 | 10 | |
| 1194 - 1204 | 10 | 10 | |
| 1204 - 1209 | 5 | 5 | |
| 1209 - 1219 | 10 | 10 | |

| Interval | Cut | Rec | Rec % |
|---|---|---|---|
| 1219-1225 | 6 | 6 | 100 |
| 1225-1234 | 9 | 9 | |
| 1234-1244 | 10 | 10 | |
| 1244-1250 | 6 | 6 | |
| 1250-1259 | 9 | 9 | 〃 〃 |
| 1259-1263 | 4 | 3 | 75 % |
| 1263-1268 | 5 | 4 | 80 % |
| 1268-1278 | 10 | 10 | 100 % |
| 1278-1287 | 9 | 9 | 100 % |
| 1287-1297 | 10 | 10 | |
| 1297-1307 | 10 | 10 | |
| 1307-1315 | 8 | 8 | |
| 1315-1324 | 9 | 9 | |
| 1324-1334 | 10 | 10 | |
| 1334-1344 | 10 | 10 | |
| 1344-1354 | 10 | 10 | |

March 14, 1987

Director, NPS
Attn: Energy, Mining and Minerals Division
(WASO 480, Room 3223
Main Interior Building)
National Park Service
P. O. Box 37127
Washington, DC 20013-7127

RE: Comment on Criteria in Support of Listing of Crater Lake National Park as a Significant Thermal Feature and Request to Delete From List Public Law 99-591, Sec. 115 ("The Act")

Dear Sir:

We submit that the "thermal features" of Crater Lake National Park are not of a nature requiring additional protection under this Act and therefore should be deleted from the Final List. The analyses of the significant thermal features of the Park, as prepared by the National Park Service and summarized in the 2-13-87 Federal Register, is erroneous and misleading.

There is no evidence for "hot spring" activity existing on the floor of Crater Lake. The identified thermal features on the lake floor are two areas of moderately anomalous heat flow. These areas of slightly warmer rock (albeit still quite cold at 39°F) cannot be affected by the activities of man.

The identified temperature anomalies are five miles distant from the nearest possible geothermal development.

Crater Lake and Crater Lake National Park <u>in its entirety</u>, is protected from adverse affects under a myriad of existing laws, including the Geothermal Steam Act, the National Environmental Policy Act, and legislation specific to the Park.

Attached for your consideration are the following:

<u>Exhibit 1</u>: Critical review and <u>Response</u> to criteria data relied on by the National Park Service in support of listing Crater Lake as a significant thermal feature. By Joseph LaFleur, Senior Exploration Geologist, California Energy Company, Inc.

<u>Exhibit 2</u>: Notice of Conference and tapes of proceedings of a scientific conference on the geochemistry and hydrology of Crater Lake, held on February 24-25, 1987 in Portland, Oregon to "provide a forum for evaluation and discussion of relevant research and its implications." Representatives of the U.S. Geological Survey, Army Corp of Engineers, Oregon State University, other researchers and industry reviewed the data.

CALIFORNIA ENERGY COMPANY
3333 MENDOCINO AVENUE, SANTA ROSA, CA 95401 (707)526-1000 TELEX II: 510-744-2088

A conclusion of the conference was that there was insufficient evidence to conclude that thermal springs exist on the bottom of Crater Lake . A major conclusion of the conference was that any thermal features which may exist would be unaffected by geothermal development outside of the Park on National Forest lands.

We would appreciate notice of any opportunities to participate further in any congressional hearings or other opportunities to comment.

Respectfully submitted,

James L. Moore

James L. Moore
Senior Vice President Exploration

California Registered Geologist
#980

JLF/PE/AKC:42

Enclosures

<u>EXHIBIT 1</u>

**Feature: Crater Lake**

**Significance Criteria: 1.**

**"Size--48 square kilometers"**

<u>**Response**</u>--This is the approximate surface area of the lake and is not the size of the thermal features. The thermal features identified were two areas of slightly warmer lake floor. (Williams, D.L. and Von Herzen, 1983 P. 1097). These two areas of warmer rock have a combined area of approximately 2.5 sq. kilometers (See Attachment 1). The anomalous heat emanating from these slightly warmer areas would not be discernible to the touch. These heat flow anomalies are over five miles from the nearest possible geothermal development.

**"Extent--Hydrothermal vents are located on the south central floor of the basin of Crater Lake at approximately 1500 feet depth - 30-150 liters per second inflow of thermal water is estimated to enter Crater Lake."**

<u>**Response**</u>--This statement is misleading. Hydrothermal vents were never identified or "located." The highest temperature measured in 62 soundings was 3.64°C (38.6°F), which is less than 0.15°C (0.27°F) above normal lake floor temperatures (Williams, D.L. and Von Herzen, 1983). (Note that water freezes at 0°C). The basis for the 30-150 L/sec "estimate" was never published but it is based on the erroneous assumptions that all the chloride in the lake comes from currently active hot springs and that the chloride level remains constant at this time. There is no data to support these contentions. In fact, the scant available data suggests the contrary. The published literature suggests a declining chloride concentration. Phillips and Van Denburgh, 1968 reported chloride concentrations of 11 ppm in 1912, 10 ppm in 1961 and 9.5 in 1964 (Phillips, K.N. and Van Denburgh 1968, Table 13, Page E57). The average of 14 samples taken in 1984 was about 9.1 mg/L (approximately 9.1 ppm). (Salinas, White, and Thompson, 1984). This apparent decline rate is in good agreement with what the decline rate would be if no chloride were entering the lake (see attached Calculation Sheet 1). Therefore, the 30-150 L/sec rate is not a valid estimate but an unfounded guess. This guess also ignores the highly probable and logical conclusion that other sources of chloride would also contribute to the chloride concentration of the lake. Salts deposited on the original caldera floor may well contribute to the current lake chemistry. Salts left from evaporation would also contribute. Crater Lake evaporates about 2 ft. per year (Phillips & Van Denburgh, 1968). A continuing source of chloride may be hydrogen chloride gas. Hydrogen chloride ($HCl$) gas is a volatile common to degassing volcanic edifices such as Mount Mazama. Stoiber and Williams recorded <u>830 tons per day</u> of $HCl$ emanating from a volcanic crater in Nicaragua (Stoiber, R.E. and Williams, S.N., 1984). To ignore this highly probable source of chloride is highly inappropriate, especially since other noncondensable gases such as helium and radon have been recorded in the lake. Isotopes of helium and radon are common to degassing volcanic edifices and provide <u>no evidence</u> for a <u>hydro</u>thermal system.

The "estimate" of 30-150 L/sec was obtained by comparing the chloride content of a lake situated above a degassing major volcanic edifice (6,800 years old), with hot springs issuing from convection cells in 5-40 million year old volcanic rocks of the western Cascades. There is no reasonable geological basis for this comparison. If the author of the "estimate" had compared the chloride content of the lake with the chloride content of cold mineral springs, common throughout the Cascades, similar flow rates would probably have been "estimated." Chloride is not an element necessarily indicative of heat and is not unique to hot spring activity.

Even if one were to accept the totally unfounded and illogical guess that all the chloride in the lake comes from currently active "hot springs," the resulting "guesstimated" flowrate of 30-150 L/sec would be infinitesimal compared to the total lake volume. Annually, the flow rate 30-150 L/sec would constitute a volume equivalent to 0.000055 to 0.00027 of the total lake volume (see attached Calculation Sheet 2). Compared to the volume of the lake, the midpoint of this 30-150 L/sec is equivalent to putting one and a half drops per day of thermal water into a 44 gallon bath tub of ice water (see attached Calculation Sheet 3). Although there is no evidence that this 1-1/2 drops per day is being added, it would have undetectable affect on the physical properties of the total volume. The two areas of slightly warmer rock identified by Williams and Von Herzen could generate local convection cells that could facilitiate vertical mixing to the mid depth range. These two areas of warmer rock are the significant thermal features on the lake floor and cannot be affected by the activites of man. Therefore, additional legislation to protect them is unnecessary.

> **"Uniqueness--Crater Lake is among the highest, largest and deepest caldera lakes in the world. It is known for its blue color nearly pure optical properties and extreme water clarity."**

**Response**--These statements address the lake not the thermal features. The deep blue color is a result of the clarity. The apparent 25-30% loss of clarity in a 15 year period reported by Dr. Larson (Larson, Douglas W., 1984) will cause a change in color if allowed to continue. Any thermal vents, if they were present, would add to that loss of clarity by providing nutrients to the lake.

**Significance Criteria: 2.**

> **"Scientific and geologic significance--Studies indicate that thermal springs feed the lake from the vents located on the floor of the basin. Bathymetric and temperature surveys are needed to characterize the contribution of these vents to the lake's water quality. Crater Lake resembles the primitive ocean. It is ideal for limnological studies and is a prime example of a caldera lake. It is an isolated system which approximates a closed system and provides a laboratory to investigate environmental disturbances from outside influences such as atmospheric fallout."**

**Response**--The statement that thermal springs feed the lake is misleading. The only data that may suggest the ascension of thermal waters is the 0.15°C above ambient lake floor temperatures that Dr. Williams recorded. This slightly thermal (3.64°C) water was interpreted to be lake water convecting downward and back upward within the lake subfloor (Williams, D.L., 1983). Therefore, the term "feed the lake" is incorrect, since no extraneous water source was suggested by Dr. Williams. That is why Dr. Williams has repeatedly stated that activity outside of the lake cannot effect the thermal features in the lake. The less than 0.15°C anomalous temperature could have been just as reasonably interpreted to be conductive heating of lake water from warmer rocks below the lake floor, without convection of lake water in the subfloor.

Crater Lake bears no resemblance to a primitive ocean. The lake had initially higher salinity due to fumarolic activity at the time of caldera collapse and has become fresher with time. The lake is now fresher than any primitive ocean could have been. The oceans became saltier with time and, therefore, the comparison is unfounded and illogical.

Thermal vents occur on the ocean floors where the oceanic crust is being rifted away from the spreading centers at about 10cm/yr and active faulting is commonplace. The floor of Crater Lake Caldera is tectonically quiescent. Hot springs are relatively short-lived features due to self sealing by mineral precipitation. The cold lake temperatures and tectonic quiescence of Crater Lake make it an unlikely place for hot springs to persist.

Although Crater Lake is definitely not appropriate for comparison to oceanic settings, it does lend itself to interesting limnological studies. However, the purpose of the Crater Lake National Park unit was not to provide a laboratory for research, it was intended to protect the quality of the lake water. Research vessels with outboard motors and water cooled engines do not enhance the lake's water quality.

**Significance Criteria: 3.**

> **"The extent to which the feature remains in a natural, undisturbed condition - The feature is in a natural, undisturbed condition."**

**Response**--The thermal features, two areas of warmer rock on the lake floor are in natural undisturbed condition. This legislation, however, contends that the whole lake is a thermal feature. The lake is not in a natural undisturbed condition. Fish have been planted in the lake and there are current research results that strongly suggest sewage infiltration from Rim Village may be affecting the apparent loss of clarity. (Dahm, Dr. Clifford, 1986).

Significance Criteria: 4.

> **"Significance of the feature to the authorized purposes for which the unit was created - Crater Lake National Park was established in 1902 to preserve the caldera lake and to assure the retention of the lake's superb water quality (16 U.S.C. 121)."**

Response--Any thermal vents in the lake would have to be deleterious to the quality of the pure lake water. Why is legislation being proposed to protect hypothetical thermal vents which, if present, would have effects on water quality contrary to the purpose for which the park was established?

ATTACHMENT 1



NOTE: Shading added by LaFleur.

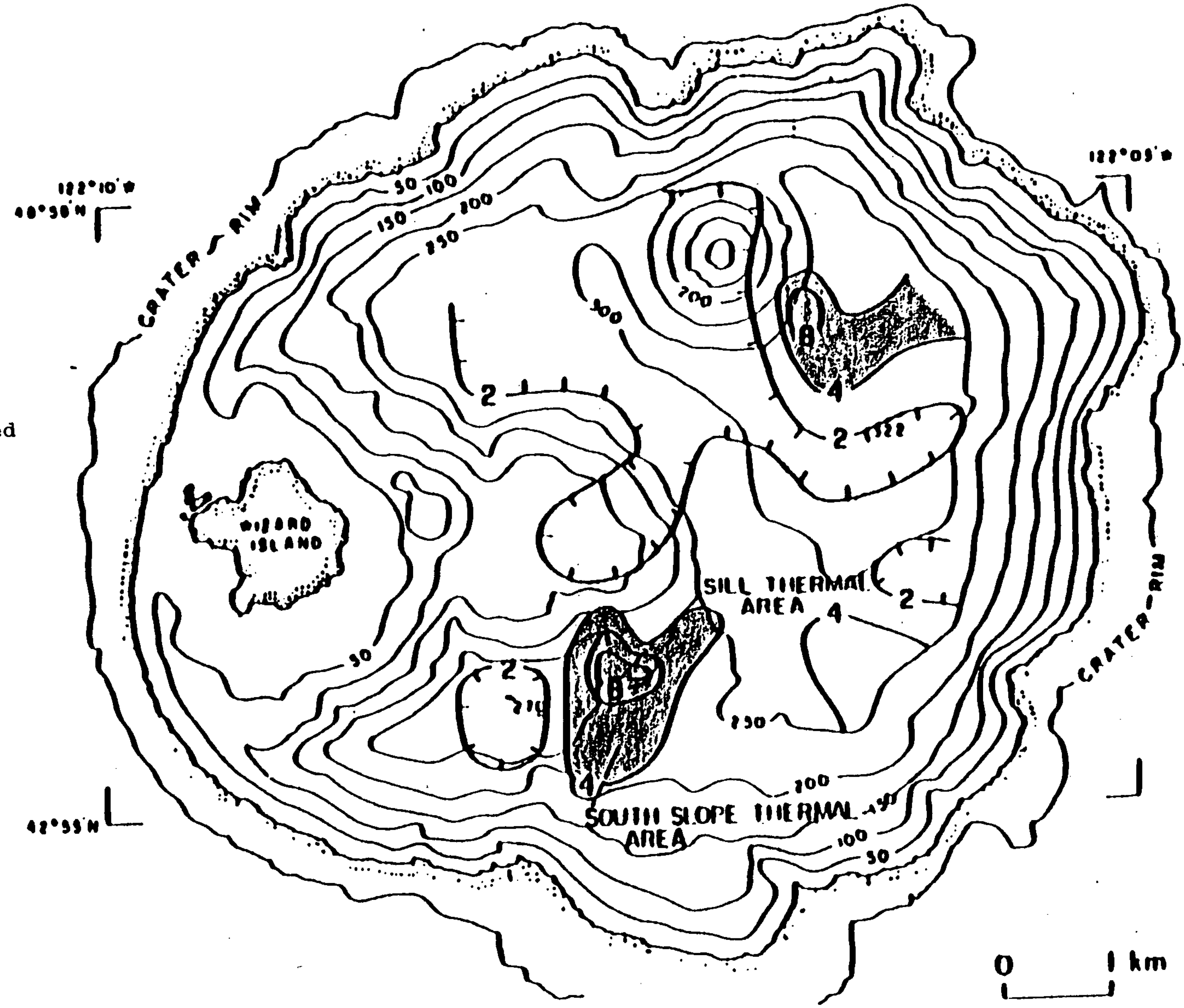



Fig. 3. Heat flow contours at a 2 HFU (84 mW/m²) contour interval. Contours above 8 HFU (334 mW/m²) are omitted for clarity.

## CALCULATION SHEET 1

Reported Chloride Concentrations, Crater Lake, Oregon

| Data Points: | Date | Concentration | Source |
|---|---|---|---|
| | 1912 | 11 ppm | Phillips & Van Denburgh, 1968 |
| | 1961 | 10 ppm | " " " " " " |
| | 1964 | 9.5 ppm | " " " " " " " |
| | 1984 | 9.13 ppm | Salinas, White, & Thompson, 1984 (Average of 14 determinations) |

Matrix for Comparison of Apparent Decline Rates

| | 1912 11 ppm | 1961 10 ppm | 1964 9.5 ppm |
|---|---|---|---|
| 1961 10 ppm | 1 ppm/ 49 Yrs. | X | X |
| 1964 9.5 ppm | 1.5 ppm/ 52 Yrs. | .5 ppm/ 3 Yrs. | X |
| 1984 9.13 ppm | 1.87 ppm/ 72 Yrs. | .87 ppm/ 23 Yrs. | .37 ppm/ 20 Yrs. |

The Average Rate of Apparent Decline between any Two Data Points

| | 1912 | 1961 | 1964 |
|---|---|---|---|
| 1961 | .020 ppm/Yr. | X | X |
| 1964 | .029 ppm/Yr. | .167 ppm/Yr. | X |
| 1984 | .026 ppm/Yr. | .038 ppm/Yr. | .0185 ppm/Yr. |

The average of these six calculated rates of apparent decline is <u>.04975 ppm/Yr.</u>

If no additional chloride were entering the lake, the chloride decline rate could be estimated by determining what the rate of change would be (assuming the lake to be thoroughly mixed annually).

Annual Seepage Loss: 64,400 Acre Ft.

Phillips & Van Denburgh, 1968

Total Lake Volume: 14,000,000 Acre Ft.

$$\frac{6.44 \times 10^4 \text{ Acre Ft.}}{14 \times 10^6 \text{ Acre Ft.}} = .0046$$

This ratio would be the rate of decline for any given year if no chloride were being added.

.0046/Yr. X 9.13 ppm* = .042 ppm/Yr.

*Averaged 1984 chloride concentration (Salinas, White & Thompson, 1984)

This would be the rate at which the chloride content would currently be declining if no chloride were being added. This agrees well with the .04975 ppm/Yr. calculated for the apparent decline rate from data reported in the published literature.

NOTE: Because the accuracy of analysis for chloride determinations is about plus or minus 1 ppm, it is actually impossible to say whether the chloride content of the lake is or is not really changing. The apparent decline since 1912 is just that - apparent. However, it is illogical to ignore this apparent decline and assume no decline.

CALCULATION SHEET NO. 2

The "estimated" flow rate of 30-150 L/sec:

1 L/sec = 15.85 gal/min. = $8.33 \times 10^6$ gal/Yr.

30 L/sec = $.25 \times 10^9$ gal/Yr.

150 L/sec = $1.25 \times 10^9$ gal/Yr.

Total lake volume = 14,000,000 Acre Ft. (Phillips & Van Denburgh, 1968)

1 Acre Ft. = 325851.40764 gallon liquid U.S.

14,000,000 Acre Ft. = $4.57 \times 10^{12}$ gallons = Total Lake Volume

The "estimated" annual flow rate compared to the total lake volume would be:

$$\frac{.25 \times 10^9 \text{ gal.}}{4.57 \times 10^{12} \text{ gal.}} = 0.000055$$

$$\frac{1.25 \times 10^9 \text{ gal.}}{4.57 \times 10^{12} \text{ gal.}} = 0.00027$$

Thus the "estimated" annual flow rates would amount to .0055 to .027 percent of the total lake volume.

## CALCULATION SHEET NO. 3

From Calculation Sheet No. 2: the "estimated" flow rate of 30-150 L/sec can be expressed as an annual flow rate of $.25 \times 10^9$ to $1.25 \times 10^9$ gallons per year, the midpoint of this range is $.75 \times 10^9$ gal/Yr.

The total lake volume of 14,000,000 Acre Ft. can be expressed as $4.57 \times 10^{12}$ gallons

The ratio of the midpoint "estimated" annual flow rate to the total lake volume is:

$$\frac{.75 \times 10^9 \text{ gal.}}{4.57 \times 10^{12} \text{ gal.}} = .000164$$

---

1 gallon = 256 tablespoons
1 tablespoon $\simeq$ .50 Oz. $\simeq$ 14.8 mililiters
1 mililiter $\simeq$ 20 drops

The ratio of .000164 is the same as 2 tablespoons per year in a 47.64 gallon bath tub

$$\frac{2 \text{ Tablespoons}}{256 \text{ Tbl/gal} \times 47.64 \text{ gal.}} = .000164$$

2 Tablespoons per year $\simeq$ 592 drops per year = 1.62 drops per day

1.62 drops per day into a 47.64 gallon bath tub is equivalent to = 1.5 drops per day in a 44.1 gallon bath tub.

| NOTE: You guys sure have me doing some goofy things! |
|---|

## BIBLIOGRAPHY

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Larson, Douglas W., 1984, The Crater Lake Study: Detection of Possible Optical Deterioration of a rare, unusually deep caldera lake in Oregon, U.S.A., Verh Internat. Verein. Limual., Bd. 22, P. 513-517

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Williams, D.L. and Von Herzen, R.P., 1983. On terrestrial heat flow and physical limnology of Crater lake, Oregon. Journal of Geophysical Research, v. 88, p. 1094-1104.

I Joseph G. LaFluer, do hereby testify to the following:

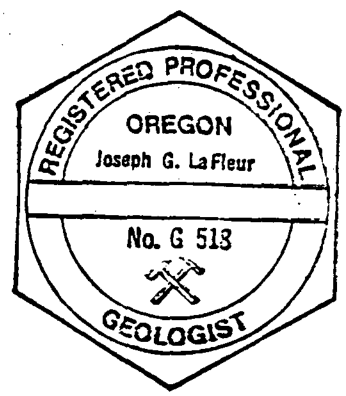
I am a professional geologist of 20 years experience and have been a registered geologist in the state of Oregon since 1977, when registration requirements were implemented. I have been working in geothermal exploration for 12 years and have been employed as the Senior Exploration Geologist for California Energy Company, Inc. for 6 1/2 years. I grew up in the western Cascades of Oregon and have been conducting geothermal exploration in Oregon for the past five years. Much of the last five year's work has focused on Mt. Mazama and Crater Lake. My background includes a working knowledge of heat flow, hydrology, geochemistry, and volcanology. I have been investigating hydrothermal systems around the world for 12 years and claim a professional overview perspective.

I have carefully reviewed most of the data on Crater Lake available to the public and have discussed this matter with all the researchers involved. I believe the attached response to be accurate and scientifically unbiased to the best of my ability.

Dated this 13th day of March, 1987

Joseph G. La Fleur

Joseph G. LaFleur,
Senior Exploration Geologist



March 20, 1987

Director, NPS
Attn: Energy, Mining and Minerals Division
(WASO 480, Room 3223
Main Interior Building)
National Park Service
P.O. Box 37127
Washington, DC 20013-7127

Attn: Pamela A. Matthes
Environmental Protection Specialist
Land Resources Division

Dear Sirs:

The statements California Energy Company submitted to the National Park Service on March 14, 1987 in response to the February 13, 1987 Federal Register listing of "thermal features" focused exclusively on Crater Lake. We would like now to provide further comment on the broader issue of what the Section 115 bill addresses. We regret that this letter was not forwarded during the brief two week response period designated by the National Park Service, but we hope its content will be evaluated in the final decision making process.

In point-of-fact all features within the National Parks are already protected by a myriad of legislation. The intent of Section 115 was to identify significant thermal features which are "likely" to be affected by geothermal development outside of the parks. It is unfortunate that the objective of Section 115 is lost in the ambiguous and expansive National Park Service definition of "thermal feature." The NPS listing of "thermal features" includes a variety of volcanic landforms such as craters, calderas, ash deposits and volcanoes. To suggest that these landforms could benefit from additional bureaucracy boarders strongly on the absurd. It appears equally unnecessary for the NPS to list parks in places that are of no geothermal interest or development potential. To suggest that remote springs in Gates of the Arctic National Park or huge volcanoes in the Wrangell Range of Alaska require added legislative "protection" is grossly incorrect.

If Section 115 is to have any relevant credibility, it should focus on hydrothermal surface manifestations that are viewed by the tourists and that are "likely" to be affected by geothermal development. Surface manifestations including geysers, hot springs, mud pots and fumaroles are of public interest and could be affected if tapped directly. Few, if any, of these types of features in the Parks could be affected by any "worst case" development scenario. The hydrothermal features of Yellowstone and Mt. Lassen are the only ones that may be applicable to such worst case consideration. Under the consideration of "likely" to be affected, there are no such features in the National Parks that are being threatened by geothermal development. The geothermal lease applications in Island Park Caldera, southwest of Yellowstone, are highly unlikely to be in hydraulic communication with the Yellowstone features.

C A L I F O R N I A E N E R G Y C O M P A N Y
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If the USGS interpretation of the Lassen system is correct, geothermal development outside the southern park boundary would have to rely on limited outflow from the park. This would make commercial exploitation for power development impractical and, therefore, unlikely to transpire. The data from the Walker "0" well, 8 miles south of Lassen Peak, supports the proposed USGS model.

The objectives of Section 115 can best be administered through existing BLM leasing and permitting procedures.

Very truly yours,

Joseph G. LaFleur

Joseph G. LaFleur
Senior Exploration Geologist

JLF:sr:42