GL01878

CASCADES THERMAL GRADIENT DRILLING PROGRAM

GeoNewberry N-1
Logs by Dresser Atlas -- 2, 3 Nov. 1985

Log	Interval(s) (ft)
1. Caliper Log - 4 Arm	454 - 1249 1788 - 3430
2. Geothermal Temperature Log	0 - 4000
3. Induction Electrolog	491 - 1250
4. Gamma Ray Log	0 - 4000
5. BHC Acoustilog	1788 - 4000
6. BHC Acoustic Fraclog	1788 - 4000

IN REPLY REFER TO:
3260 (920)
OR 11987
OR 12004
OR 12442

United States Department of the Interior

BUREAU OF LAND MANAGEMENT

OREGON STATE OFFICE
P.O. Box 2965 (825 NE Multnomah Street)
Portland, Oregon 97208

AUG 25 1987

Jody Spooner
Environmental Coordinator
GEO-Operator Corporation
1330 North Dutton Avenue, Suite A
Santa Rosa, California 95401

Dear Ms. Spooner:

We have received and reviewed your letter of August 6, 1987. We have considered your comments concerning Shur-Gel as a final abandonment fluid and our comments and re-stated requirements are as indicated below.

During the permitting process we (BLM) gave approval of Shur-Gel as an abandonment fluid during the temperature monitoring (temporary abandonment) phase. However at the time of final (permanent) abandonment the presence of Shur-Gel in the hole complicates and makes more difficult the placement of cement plugs as defined by our regulations and GRO No. 3. We are now in the process of re-evaluating our approval or non-approval of the use of Shur-Gel during the permitting process of future wells.

In the case of wells N-1, N-2, and N-3, we approved the use of Shur-Gel. Therefore we will consider it as an acceptable plugging medium if its presence and plugging adequacy can be demonstrated for all zones to be plugged off in wells N-1 and N-2, as specified in our letter dated July 16, 1987. We don't however consider the presence of Shur-Gel at the surface as proof of its down-hole presence and adequacy for plugging the zones specified in our letter.

The presence of Shur-Gel may be demonstrated by shooting-off or perforating the 1.9 in. OD tubing at the appropriate depth below the shoe, i.e., 500 ft or 550 ft. etc, filling the tubing with water and applying appropriate pressure (estimated 150 psi) at the surface. If there is a considerable amount of flow the presence and adequacy of Shur-Gel is very questionable and the zone will have to be cemented. If the water doesn't flow when pressured up to 150 psi, we will accept that the Shur-Gel is present and is an adequate barrier for fluid flow.

With regard to N-3, it is apparent to us that the Sur-Gel, if it is present in the acquifer zone, is not sealing off the flow of water up the well bore. Our requirements remain as stated in our previous letter, that the acquifer zone (below 3750 ft) has to be isolated with a 200 ft cement plug in the area of approximately 3650 ft to 3850 ft. The N-3 casing shoe and surface plugging may be accomplished in the same manner as specified for wells N-1 and N-2.

We prefer 200 ft. plugs (100 ft in 100 ft out) across the surface casing shoe especially for wells N-1 and N-3, where the integrity of the surface casing cementing is questionable. We also prefer 200 ft plugs because it gives added insurance of good cement in the middle area of the plug even though the top and bottom ends of the plug may be weakened, by intermixing with water, drilling muds, etc. The additional cement cost for this added insurance is very small. For the plug at the surface, we require that the top 50 ft of the tubing and annulus be cemented.

The final abandonment of wells N-1, N-2, and N-3 is to be accomplished in accordance with GRO No. 3 and our letter of July 16, 1987, except where clarified and changed by this letter.

We hope this letter has explained our rationale and smoothes out some of your concerns. If you have any further questions please call Steve Henderson, Petroleum Engineer, at (503) 231-2048.

Sincerely,

Leroy M. Mohorich

Leroy M. Mohorich
Acting Deputy State Director
for Mineral Resources

cc: Dennis Davis, Prineville DO
Dennis Simontacchi, Lakeview DO
Supervisor, Deschutes NF

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Aug. 21, 1985

TIME: 2:00 PM

Rig on location. Pits dug, Tonto rigging up. Mud pit reveals 7 feet of cinder underlain by a horizon presumed to be Mazama Ash.

Total est. cost to date: $3,000

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Aug. 27, 1985

TIME: 12 noon

DEPTH: 305'

Drill rods parted, 9 drill rods + sub & bit left in hole. RIH with 4½" bit to clean hole above fish, before attempting to retrieve fish with tap.

Total est. cost to date = $26,286.

8. A.M. Aug. 28th. Phone call to Mike Johnson: at Motel
Tapped into fish - 2 rods out, then back in and got the rest out. Change to 20' rods to reduce bending, as of last night (27-28th).

I reported this to Sue P.

Bruce.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Sept. 24, 1985 DAYS SINCE SPUD: 32

TIME: 12:00 noon

DEPTH: 2,294'

FOOTAGE DRILLED SINCE LAST REPORT: 117

PERCENT RECOVERY: 97

Changing O-ring on hydraulic ram. Fluid level at 1,600'. BHT at 2,207' is less than 100°F. Last Lithology: Basalt.

Total est. cost to date: $147,724.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Sept. 25, 1985 DAYS SINCE SPUD: 33

TIME: 11:00 AM

DEPTH: 2,398'

FOOTAGE DRILLED SINCE LAST REPORT: 104

PERCENT RECOVERY: 95

Drilling 5'/hr. in basalt. Fluid level at 1,600'. BHT at 2,308' is less than 100°F. Attempted to run fluid sampling tool; would not function.

Total est. cost to date: $153,231.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Sept. 26, 1985 DAYS SINCE SPUD: 34

TIME: 1:30 PM

DEPTH: 2,452'

FOOTAGE DRILLED SINCE LAST REPORT: 54

PERCENT RECOVERY: 96

POH, change bit, RIH. Drilling 5'/hr. in basalt to basaltic andesite. BHT at 2,398' is less than 100°F. Fluid sample taken from core barrel at 2,412'. Fluid level at 1,600'.

Total est. cost to date: $158,430.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Sept. 27, 1985 DAYS SINCE SPUD: 35

TIME: 1:00 PM

DEPTH: 2,564'

FOOTAGE DRILLED SINCE LAST REPORT: 112

PERCENT RECOVERY: 98

Drilling 5'/hr. in basalt. Fluid level at 1,600'. BHT at 2,502' is less than 100°F.

Total est. cost to date: $164,483.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Sept. 28, 1985 DAYS SINCE SPUD: 36

TIME: 9:30 AM

DEPTH: 2,668'

FOOTAGE DRILLED SINCE LAST REPORT: 104

PERCENT RECOVERY: 97

Drilling 7'/hr. in basalt. BHT at 2,602' is less than 100°F.

Total est. cost to date: $170,107.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Sept. 29, 1985 DAYS SINCE SPUD: 37

TIME: 1:00 PM

DEPTH: 2,724'

FOOTAGE DRILLED SINCE LAST REPORT: 56

PERCENT RECOVERY: 95

Wireline broke: POH, repair, RIH, drill ahead. Drilling 5'/hr. in basalt to basaltic andesite. BHT at 2,712' is less than 60°F. Fluid samples taken from core barrel at 2,707'.

Total est. cost to date: $175,538.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Sept. 30, 1985 DAYS SINCE SPUD: 38

TIME: 1:00 PM

DEPTH: 2,800'

FOOTAGE DRILLED SINCE LAST REPORT: 76

PERCENT RECOVERY: 91

Repaired hydraulic ram. Drilling ahead 2-5'/hr. in basalt to basaltic andesite. Fluid level at 1,600'.

Total est. cost to date: $180,819.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 1, 1985 DAYS SINCE SPUD: 39

TIME: 1:00 PM

DEPTH: 2,891'

FOOTAGE DRILLED SINCE LAST REPORT: 91

PERCENT RECOVERY: 96

Repaired hydraulic ram. Drilling ahead 5'/hr in basaltic tuff. BHT at 2,820' was less than 60°f. BHT at 2,891'=64°F after allowing 1.5 hours to elapse without pumping mud down hole.

total est. cost to date: $186,763.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 2, 1985 DAYS SINCE SPUD: 40

TIME: 12:30 PM

DEPTH: 2,923'

FOOTAGE DRILLED SINCE LAST REPORT: 32

PERCENT RECOVERY: 97

Core tube stuck, wireline snapped, POH, repair wireline, free core tube, RIH. Drilling ahead 5'/hr. in basalt to basaltic andesite. Fluid sample collected from core barrel at 2,923'.

Total est. cost to date: $190,838.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 3, 1985 DAYS SINCE SPUD: 41

TIME: 11:00 AM

DEPTH: 2,996'

FOOTAGE DRILLED SINCE LAST REPORT: 73

PERCENT RECOVERY: 94

Drilling ahead at 4'/hr. in basalt.

total est. cost to date: $196,111.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 4, 1985 DAYS SINCE SPUD: 42

TIME: 11:00 AM

DEPTH: 3,102'

FOOTAGE DRILLED SINCE LAST REPORT: 106

PERCENT RECOVERY: 95

Drilling 3-5'/hr. in basaltic andesite. BHT at 3,098' is less than 60°F.

TOTAL EST. COST TO DATE: $202,813.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 5, 1985 DAYS SINCE SPUD: 43

TIME: 11:30 AM

DEPTH: 3,167'

FOOTAGE DRILLED SINCE LAST REPORT: 65

PERCENT RECOVERY: 97

POH, change bit, RIH, drilling 4-5'/hr. in fault breccia and basaltic dikes.

TOTAL EST. COST TO DATE: $208,239

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 6, 1985 DAYS SINCE SPUD: 44

TIME: 1:30 Pm

DEPTH: 3,263'

FOOTAGE DRILLED SINCE LAST REPORT: 96

PERCENT RECOVERY: 93

Drilling 3-5'/hr in basaltic andesite. BHT at 3,208' is less than 60°F.

TOTAL EST. COST TO DATE: $215,479.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 7, 1985 DAYS SINCE SPUD: 45

TIME: 10:30 AM

DEPTH: 3,332'

FOOTAGE DRILLED SINCE LAST REPORT: 69

PERCENT RECOVERY: 96

Drilling 3-4'/hr. in fault breccia. BHT at 3,312' is 82°F.

TOTAL EST. COST TO DATE: $220,994.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 8, 1985 DAYS SINCE SPUD: 46

TIME: 10:30 AM

DEPTH: 3,412'

FOOTAGE DRILLED SINCE LAST REPORT: 80

PERCENT RECOVERY: 88

Drilling 5'/hr. in basaltic andesite. BHT at 3,412' is below 60°F.

TOTAL EST. COST TO DATE: $226,926.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 9, 1985 DAYS SINCE SPUD: 47

TIME: 11:00 AM

DEPTH: 3,468'

FOOTAGE DRILLED SINCE LAST REPORT: 56

PERCENT RECOVERY: 95

Drilling 4'/hr. in basaltic andesite. Fluid sample collected from core barrel at 3,424'.

TOTAL EST. COST TO DATE: $231,986.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 10, 1985 DAYS SINCE SPUD: 48

TIME: 12:00 noon

DEPTH: 3,545'

FOOTAGE DRILLED SINCE LAST REPORT: 78

PERCENT RECOVER: 88

POH, change bit. Last lithology drilled was basalt. BHT at 3,518'=95°F. Fluid sample taken from core barrel at 3,545'.

TOTAL EST. COST TO DATE: $238,098.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

Chan (Chewe)
415-321-5662

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 11, 1985 DAYS SINCE SPUD: 49

TIME: 11:00 AM

DEPTH: 3,605'

FOOTAGE DRILLED SINCE LAST REPORT: 59

PERCENT RECOVERY: 97

Run rod into hole to 3,540' after bit change. Temperature at 3,540'=117°F. Wash and ream to T. D. Drilling ahead 5-6'/hr. in basaltic andesite.

A tentative decision has been made by GEO-Operator to deepen the core hole to 4,650 feet. The estimated cost for this extension is $82,500-$135,000; the higher figure to include the possibility of hole completion problems. The Department of Energy has been requested to telecopy by Monday morning, Oct.14, 1985, their decision as to whether or not to participate in the additional costs and the additional data. Over the weekend, a water sample will be collected and a temperature build up test (Horner plot) will be conducted to give the best possible estimate of current down hole conditions.

TOTAL EST. COST TO DATE: $244,502.

3672'
med 149 BHT

0 50°F – mean Annual Air Temp –
3672 149°F
= 0.027°F/ft = 49°C/km.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 12, 1985 DAYS SINCE SPUD: 50

TIME: 10:30 AM

DEPTH: 3,635'

FOOTAGE DRILLED SINCE LAST REPORT: 30

PERCENT RECOVERY: 86

Mislatched, POH, clean tube, bit, RIH. Last lithology =basaltic andesite. BHT at 3,615'=97°F.

TOTAL EST. COST TO DATE: $248,500.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 13, 1985 DAYS SINCE SPUD: 51

TIME: 4:00 PM

DEPTH: 3,672'

FOOTAGE DRILLED SINCE LAST REPORT: 37

PERCENT RECOVERY: 99

Conduct time-temperature build-up test, wireline snaps during testing. Fish for wireline, unsuccessfully, rig up new set-up to continue test. Rough estimate of equilibrated BHT=151°F, gradient=2.75°F/100' Last lithology drilled was basaltic andesite.

TOTAL EST. COST TO DATE: $254,305.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 14, 1985 DAYS SINCE SPUD: 52

TIME: 11:00 AM

DEPTH: 3,736'

FOOTAGE DRILLED SINCE LAST REPORT: 64

PERCENT RECOVERY: 96

Drilling 5'/hr. in basaltic andesite, which underlies 14' of clay-rich tuff. BHT at 3,732' after one hour pump shutdown=114°F.

TOTAL EST. COST TO DATE: $259,734.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 15, 1985 DAYS SINCE SPUD: 53

TIME: 9:30 AM

DEPTH: 3,762'

FOOTAGE DRILLED SINCE LAST REPORT: 26

PERCENT RECOVERY: 100

Last drilling 4'/hr. in basaltic andesite. Changed bit, drilled through caved zone at 1,300'.

TOTAL EST. COST TO DATE: $264,914

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 16, 1985 DAYS SINCE SPUD: 54

TIME: 9:30 AM

DEPTH: 3,784'

FOOTAGE DRILLED SINCE LAST REPORT: 22

PERCENT RECOVERY: 96

Last drilling 4'/hr. in basaltic andesite. POH to change bad bit at 1 PM yesterday. Got back on bottom at 1 AM this morning.

TOTAL EST. COST TO DATE: $268,570.

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 17, 1985 DAYS SINCE SPUD: 55

TIME: 11:30 AM

DEPTH: 3,857'

FOOTAGE DRILLED SINCE LAST REPORT: 73

PERCENT RECOVERY: 96

Drilling 4-5'/hr. in andesite. BHT at 3,802'=128°F.
BHT at 3,854'=124°F.

TOTAL EST. COST TO DATE: $274,461.

6100 South Highway 97, Suite A, Bend, OR 97701 (503) 389-6681

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 18,1985 DAYS SINCE SPUD: 56

TIME: 10:00 AM

DEPTH: 3,918'

FOOTAGE DRILLED SINCE LAST REPORT: 61

PERCENT RECOVERY: 98

Drilling 4'/hr. in andesite. BHT at 3,864'=138°F.
BHT at 3,914'=140°F.

TOTAL EST. COST TO DATE: $279,781.

[illegible] OR 97701 (503) 389-6681

GEO Newberry Crater, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 19, 1985 DAYS SINCE SPUD: 57

TIME: 10:30 AM

DEPTH: 3,990'

FOOTAGE DRILLED SINCE LAST REPORT: 72

PERCENT RECOVERY: 99

Drilling 4-5'/hr. in andesite. BHT at 3,964' is 142°F.

TOTAL EST. COST TO DATE: $285,654.

$71.59/ft average cost to here

GEO-Newberry Crater, Inc.

GEO-NEWBERRY CORE HOLE N-1

DAILY REPORT

DATE: Oct. 20, 1985 DAYS SINCE SPUD: 58

TIME: 10:00 AM

DEPTH: 4,059'

FOOTAGE DRILLED SINCE LAST REPORT: 69

PERCENT RECOVERY: 100

Drilling 4-5' hr. in andesite. BHT at 4,014=140°F. total est. cost to 4,000'= $286,559.

TOTAL EST. COST TO DATE: $291,717.

DEPARTMENT OF ENERGY
CASCADES DEEP GEOTHERMAL GRADIENT DRILLING PROGRAM

OBJECTIVE:

Sponsor research to characterize the deep hydrothermal regime of the Cascades in order to define its geothermal potential.

PROGRAM MANAGEMENT:

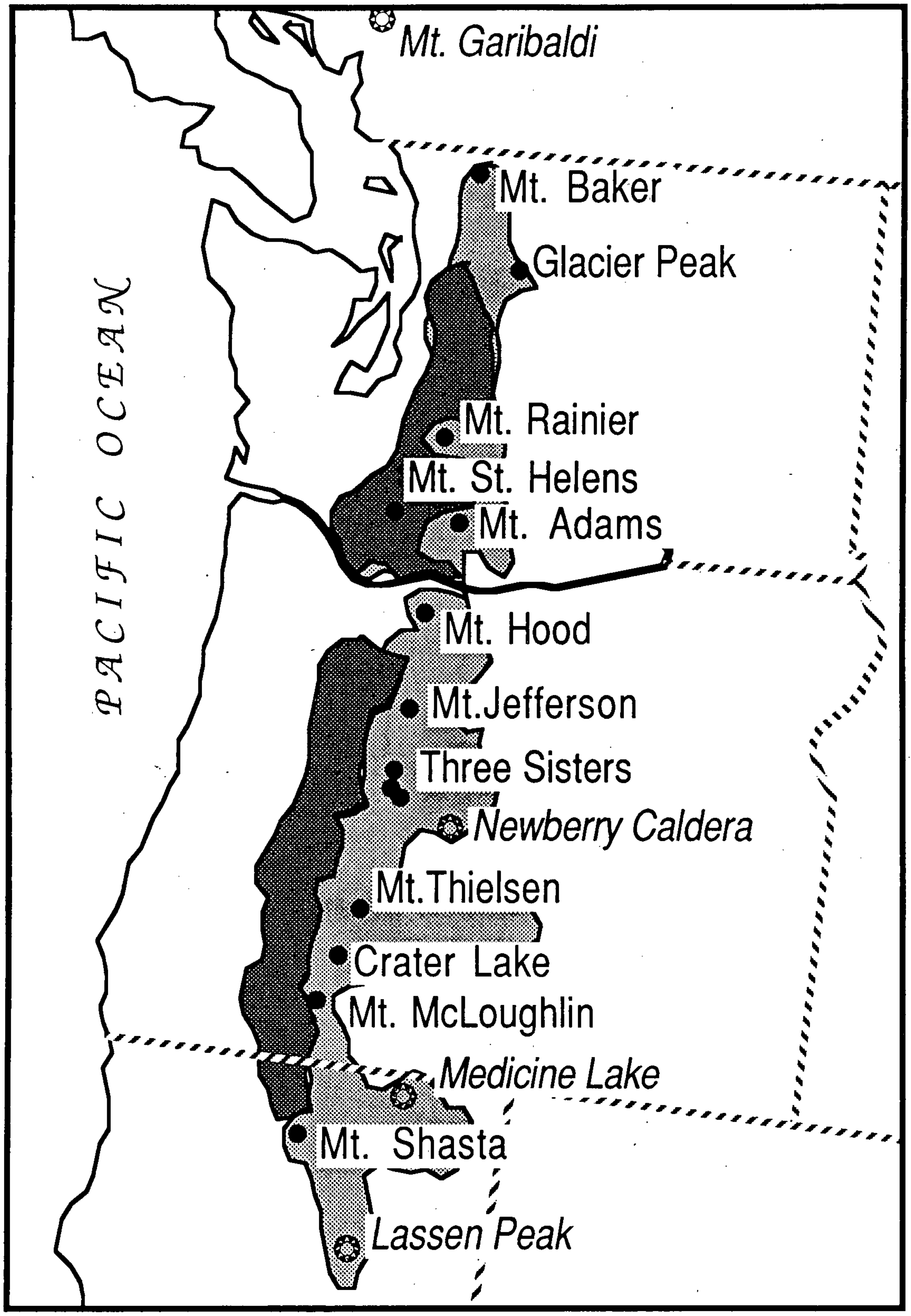
DOE/Idaho Operations Office

TECHNICAL COORDINATION:

University of Utah Research Institute

MECHANISM:

Solicitations for Cost-Shared Drilling



High Temperature Hydrothermal System

CASCADES DEEP GEOTHERMAL GRADIENT DRILLING PROGRAM

PROGRAM ELEMENTS

Thermal Gradient Drilling

Data Acquisition

- Lithology
- Geophysical Well Logs
- Hydrology
- Surface Studies

Data Integration and Interpretation

Technology Transfer

- Open File Release of Data and Core
- Case Studies

CASCADES DEEP GEOTHERMAL GRADIENT DRILLING PROGRAM

STATUS

First Solicitation (closing date 4-29-85)

GEO Operator Corp.

Two Coreholes at Newberry

N-1	4000 ft. (public data)
N-3	4002 ft.

Thermal Power Company

One Corehole near Mt. Jefferson

CTGH-1	4800 ft.

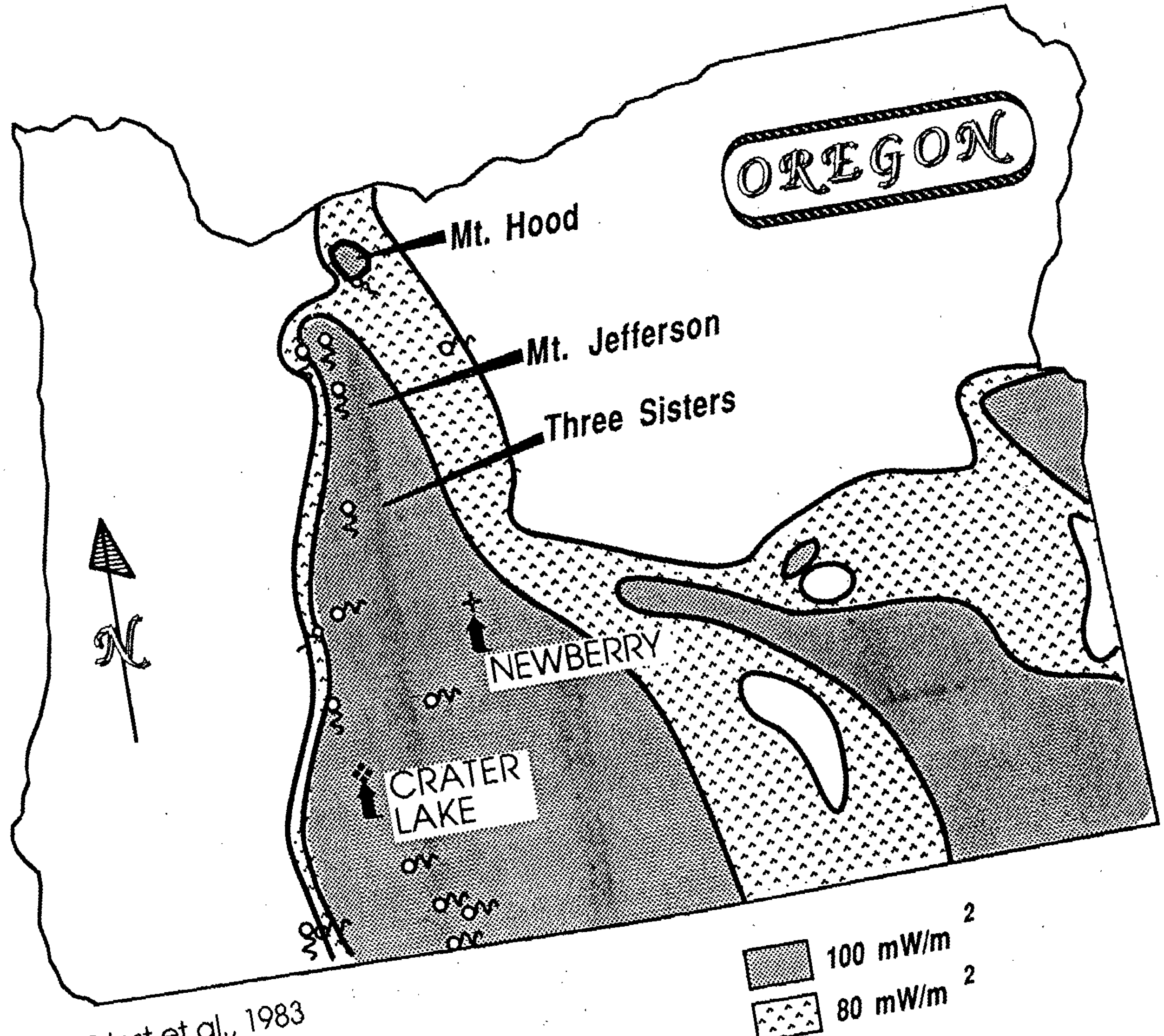
Blue Lake Geothermal

Proposer Unable to Arrange Financing
◊◊Project Cancelled◊◊

Second Solicitation (closing date 5-30-86)

California Energy Company, Inc.

One Corehole (MZI-11A) Now Drilling
Near Crater Lake (Mazama)



Priest et al., 1983

CASCADES DEEP GEOTHERMAL GRADIENT DRILLING PROGRAM

SCIENTIFIC STUDIES

* NEWBERRY

Heat Flow - GEO and Southern Methodist

Downhole Hg - GEO

Alteration - USGS

Volcanic Stratigraphy - U of Wyoming / NSF

Correlation of Electric Logs with Alteration - UURI

Analysis of Well Logs - UURI

* CLAKAMAS

Heat Flow - Southern Methodist

Alteration - USGS

Volcanic Stratigraphy - DOGAMI

Analysis of Well Logs - UURI

* MAZAMA

Heat Flow - Southern Methodist

Alteration - USGS

Volcanic Stratigraphy - UURI

Analysis of Well Logs - UURI

CASCADES DEEP GEOTHERMAL GRADIENT DRILLING PROGRAM

OPPORTUNITIES

* Holes available for down-hole experiments for one year

* Core stored at UURI; available for study

* Geophysical well logs and other acquired data available for study

* Correlation of surface studies with down-hole data

CASCADES DEEP GEOTHERMAL GRADIENT DRILLING PROGRAM

STATUS

✡ GEO Operator Corp.

N-1	(4000')	Completed 10/20/85 Data and samples open filed by UURI Feb 86
N-3	(4000')	Spud 6/1/86 – update

✡ Thermal Power Company

Clackamas	(5000')	Spud 6/1/86 - update

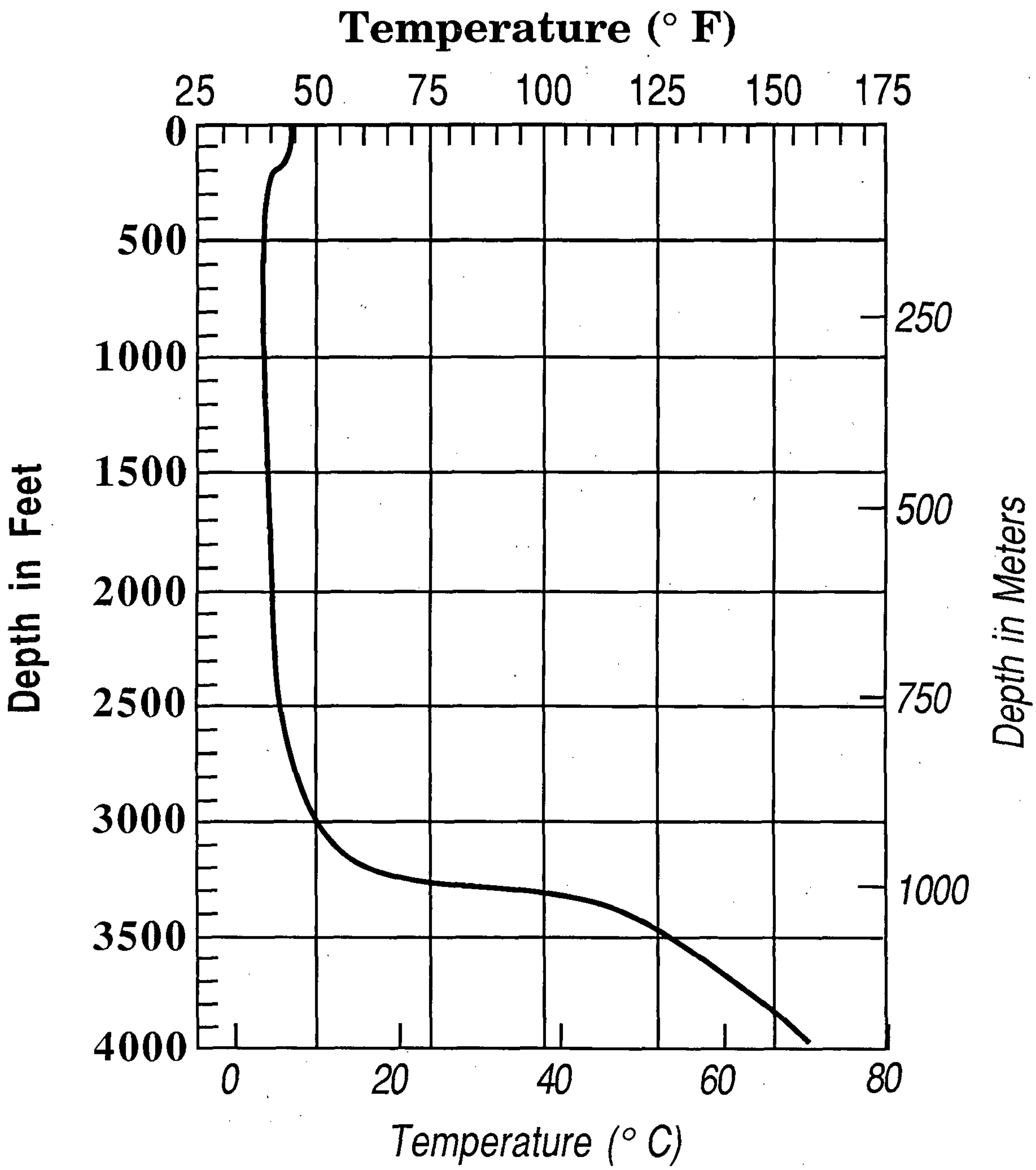
✡ Blue Lake Geothermal

Blue Lake	(4000')	Spud ?

✡ New Solicitation: May 30, 1986

Two additional holes anticipated Calif Energy

TEMPERATURE - DEPTH LOG
GEO N-1



CASCADES DEEP GEOTHERMAL GRADIENT DRILLING PROGRAM

STATUS OF GEO-NEWBERRY N-3

Spud Date	6/2/86
Expected Completion (4000')	8/1-4/86
Drilling Contractor	Tonto
Core Recovery	50 - 95%
Planned Completion	1-1/2" Iron Pipe
Geophysical Well Logs Planned	Temperature, Resistivity, Caliper SP, Sonic, Gamma-Ray, Induction, Fraclog

CASCADES DEEP GEOTHERMAL GRADIENT DRILLING PROGRAM

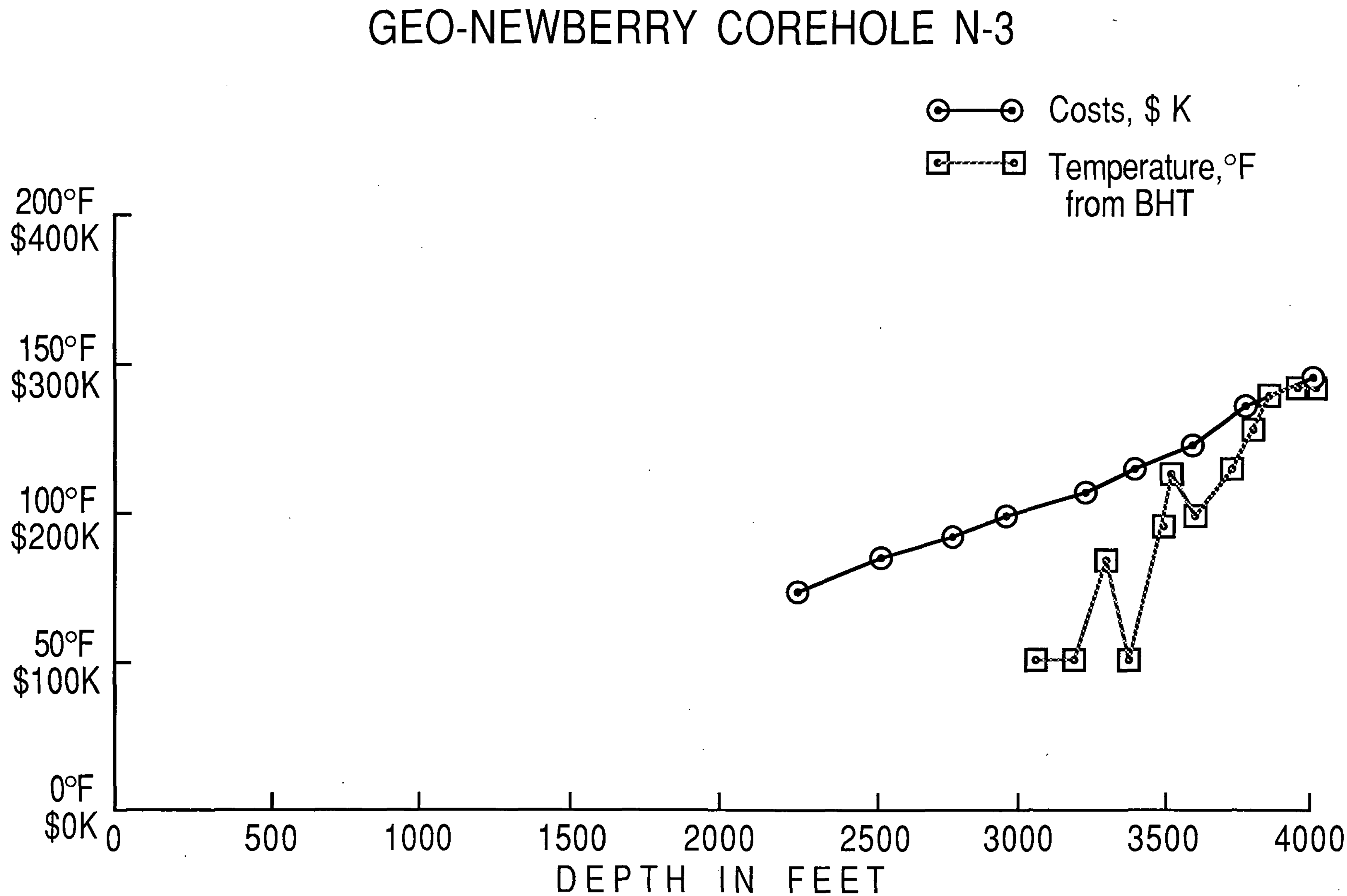
STATUS OF THERMAL POWER CTGH-1

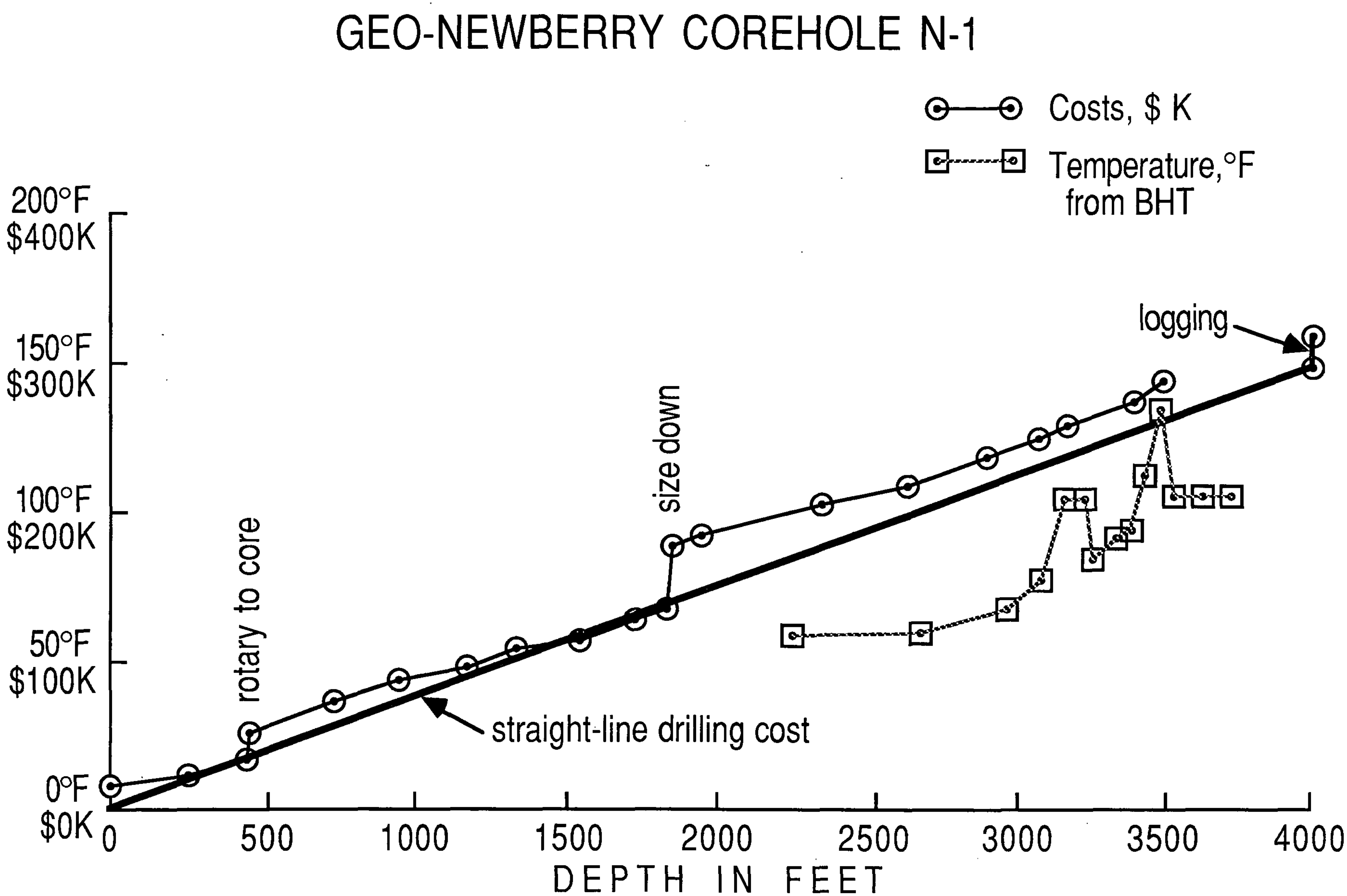
Spud Date	6/8/86
Expected Completion	8/12-16/86
Drilling Contractor	Boyles Brothers
Core Recovery	90 - 100%
Planned Completion	Iron Pipe
Geophysical Well Logs Planned	Temperature, Resistivity, Caliper, SP, Sonic, Gamma-Ray, Density

CASCADES DEEP GEOTHERMAL GRADIENT DRILLING PROGRAM

STATUS OF GEO-NEWBERRY N-3

Spud Date	6/2/86
Expected Completion (4000')	8/1-4/86
Drilling Contractor	Tonto
Core Recovery	50 - 95%
Planned Completion	1-1/2" Iron Pipe
Geophysical Well Logs Planned	Temperature, Resistivity, Caliper SP, Sonic, Gamma-Ray, Induction, Fraclog


GEO-NEWBERRY COREHOLE N-3
Costs, $ K
Temperature,°F
from BHT
200°F
$400K
150°F
$300K
100°F
$200K
50°F
$100K
0°F
$0K
0
500
1000
1500
2000
2500
3000
3500
4000
DEPTH IN FEET



GEO-NEWBERRY COREHOLE N-1
Costs, $ K
Temperature,°F from BHT
200°F $400K
150°F $300K
100°F $200K
50°F $100K
0°F $0K
0
500
1000
1500
2000
2500
3000
3500
4000
DEPTH IN FEET
rotary to core
size down
logging
straight-line drilling cost

8 729 at spud   Start core 66,362   35000
385,300 @ end drill   4059   72300
6000

	GEO N-1	GEO N-3	Thermal CTGH-1	CECI MZI-11A
Spud Date	8/24/85	6/2/86	6/7/86	9/12/86
Completion Date	10/20/85	8/1/86	9/2/86	—
Drilling Contractor	Tonto	Tonto	Boyles	Longyear
Core Recovery	≥90%	>90%	>90%	—
Cost				
rotary	0-487 $96/ft	0-453 $58/ft	0-517 $60/ft	0-575 $61/ft
core	487-4000 $66/ft	453-4002 $83/ft	517-4800 $73/ft	—
total	$286K	$360K	$439K	—
Drilling Rate	69 ft/day	67 ft/day	66 ft/day	—
Total Depth	4550±	4002 ft	4800 ft	—
Public Domain Data	0-4000	0-4002 ft	0-4800 ft	—
Completion	1½" iron pipe to TD	1½" iron pipe to TD	[illegible] rods to 4203 ft open to TD	—

291   286

CASCADES DEEP GEOTHERMAL GRADIENT DRILLING PROGRAM

GEOPHYSICAL WELL LOGS

		GEO N-1	GEO N-3	Thermal CTGH-1	CECI MZI-11A
(1)	Temperature	X	X	X	–
(2)	Caliper	X	X	4100–4800	–
(3)	Gamma Ray	X	X	X	–
(6)	Spontaneous Potential	X	–	4200–4798	–
(7)	Resistivity	X	–	4200–4799	–
(10)	Induction	X	–	–	–
(11)	Acoustic	X	X	4225–4425	–
(12)	Acoustic Fraclog	X	X	–	–
(4)	Neutron	–	–	X	–
(5)	Gamma - Gamma Density	–	–	775–900	–
(8)	Induced Polarization	–	–	4200–4799	–
(9)	Lateralog	–	–	4200–4798	–

X logged 0 – TD
– not logged

GEO-Newberry Core Hole No 1 Costs

1.) 4½" rotary drilled hole to 470' 10 days, $112/ft. total
Costs without mob & casing $96/ft.

2.) To 4000 ft. $71.60/ft overall ave. not including mob-
Averaged 69 ft/day drilling rate

3. Coreing only $66.23/ft

4. Costs from 3,545' to 4059' ave. $104/ft., rate 51.4 ft/day

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

MAIL ME 'GEOLOGS'

NOTES ON GEO N-1 GEOPHYSICAL WELL LOGS

CALIPER LOG

The caliper log shows a highly uniform hole diameter and shape over most of the length of the hole. There are a few areas of enlargement that correspond for the most part to flow boundaries or to suspected fractures. The interval immediately adjacent to the bottom of the rain curtain at 3260 is enlarged to 5 in, and the largest washout occurs at 3429, where the hole diameter is 9.7 in.

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There were two temperature logs run in the well. The first was run on 2 Nov 85 during the course of the Dresser Atlas logging. The second temperature log was run on 9 Nov 85 by Geotech Data od Poway, Ca. This second log used a tool having an apparent sensitivity of about 0.01 C, which is believed to be considerably better than the sensitivity of the usual logging tool temperature probe. In addition, the second tool is likely to be better calibrated. The last fluid circulation is estimated to have occurred when the black iron pipe was set, which was completed on 8 Nov 85, one day earlier. Neither of the temperature logs is an equilibrium log. Nevertheless, they do yield date of significance.

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ELECTRIC LOGS

The electric logs comprise an SP log, a 16-in short normal resistivity log and an induction log. The SP log was off scale for much of the upper part of the hole and appears to be of limited use for quantative interpretation in any case. It will not be discussed further. The resistivity of the borehole fluid at the time of the logging was not measured, and so the interpretations that can be placed of the resistivity and induction logs are somewhat compromised. The induction log is the more useful of the two remaining logs in yielding representative values of resistivity for the formations because of its greater depth penetration.

Both the resistivity and induction logs indicate the presence of conductive horizons below a depth of about 2800 ft. The conductors become more numerous and of higher conductivity down hole. The average resistivity of the upper 2000 ft of the hole is 50-70 ohm-m. Below this there is a systematic decrease in resistivity with depth. Below 2800 ft, there are at lease 15 separately identifiable horizons having resistivities below 10 ohm-m, and one horizon has a resistivity value of 1.2 ohm-m. The thickness of these horizons varies from a few feet to a few tens of feet. These conductive horizons correspond, for the most part, to clay-altered basaltic ash and felsic tuff units. The chief alteration type is smectite which has apparently developed at low temperature.

The conductive horizons observed on the electric logs are believed to be responsible for the occurrence of anomalies in interpreted conductivity on surface TDEM surveys reported by Dave Fitterman of the USGS. The surface surveys indicate a widespread area underlain by conductive horizons around the Newberry volcano. Part of the anomaly must correspond to the high-temperature hydrothermal system found in USGS Newberry-2 corehole which was drilled in the caldera. However, part of the anomaly must also correspond to the conductors found in GEO N-1.

ACOUSTIC LOGS

Two acoustic logs were run in the well--an acoustic velocity log and an acoustic fraclog. Both of these logs are useful in detecting flow boundaries and differentiating areas of uniform, probably low porosity/permeability from porous/permeable horizons that correspond for the most part to flow boundaries and, to a lesser extent, to fractures.

INTERPRETATION OF THE LOGS

These logs will be very useful when correlated with the core in calibrating log response in this sequence of basalt and basaltic-andesite flows with separate ash and tuff units. UURI is involved with this work at the present time. We plan to make detailed log correlations with the core, make such measurements as resistivity and perhaps IP effect on selected core specimens, and study cross plots.

.S
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1

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✓ Waxman and Smits, electrical conductivities in oil-bearing Shaly Sands, see Petr Eng J, Trans AIME vol 243, June 1968 pp 107-122 Reprinted in Well Logging, SPE, 1971

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Proc Annu Conv Indonesian Pet Assoc 6(2) p023
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1978 ~~Voigt, H.J. cation exch in chem gw~~
cer

~~Pratchett, J.G CEC - shale cond~~ not in dup

Eberl, D hydrolic reactivity smect
Am Mineral vol 63 N 3-4 p 400-09

Grimm TA 45T G55 G7 1963?

Van Olphen QD 549 V27 1977
Velde QE 389.625 V40

Logs

Run 1 Trip 1 logs 4 arm caliper] caliper log
gamma ray says
temp

Run 1 Trip 1 temp, CCL] temp log says

Run 1 Trip 1 IEL, GR, CAL, TEMP] GR Log says

Run 1 Trip 1 IEL, GR, CAL, TEMP] IEL log says

173.8

0.063°F/100ft

95

95 / 25-30

40-50

Electric Logs

1. Induction + 16" SN

2. – Resistivity above ±2800' averages > 50 Ω-m
– Below 2800', conductors begin to appear, largely coincident with altered beds of latitic tuff (clay alt) and basaltic ash

3. Systematic decrease in resistivity w/ depth

4. Induction Log gives reliable formation resistivities --
SN ~~seems to be~~ tracks well in good conductors but ~~to~~ reads too high in higher resistivity rocks -- this could be an effect of flushed zone w/ fresh mud

5. Mud ρ not measured -- a major shortcoming

6. SN log pegs @ 460 Ω-m

7. SN lacks detail of conductivity log, but is useful in picking boundaries

8. Induct useful in boundaries

Acoustic Logs

1. Sonic velocity and "Fraclog"
both are borehole compensated.

2. Acoustic log shows ~~formation~~ contacts very clearly -- one would expect main permeability to be along the contacts and fractures in this type of log.

3. Acoustic Fraclog shows contacts clearly also -- tracks sonic very well

4. Fraclog
- first arrivals are P wave
- attenuation or amplitude given as variable density
- later arrivals are S waves
- same type of log is used in cement bond log -- this hole is uncased, so we are seeing true formation parameters

5. Acoustic log shows integrated travel time ticks

Gamma Log

1. shows γ counts in std API units 0-100

2. Basalt and andesite flows are fairly uniform, some individual flows can be differentiated
   - typical value in basalt flaws
     = 20-40 API

3. Dacite ash @ 1982 clearly delineated

4. Several thin clay-altered units below about 3100 ft show high γ -- prob due to alteration

5. Dacite flows 3211-3330 high γ
   Dacite flows 3708 - ~~3810~~ to td
   average 130 API.

Caliper Log = 4-arm
Scale 2" per 100 ft

FR = first recording
BIT 1 & 2 – bit dia settings

1. What are C24 and C13 ?
2. What are logs on the two tracks ?
3. Are scales different ?

Areas of hole enlargement — bit size = 3.8"

598 – 611	to 7.1
655 – 684	to 6.9"
789 – 796	to 6.2"
813 – 827	to 6.2"
852 – 870	to 4.8"
998 – 1042	to 5.7"
no log 1243 – 1786	—
1930 – 1960	to 6.1"
2615 – 2617	to 5.0"
3264 – 3267	to 5.0"
3351 – 3354	to 8.7"
3429 – 3430 log FR	to 9.7"

TEMPERATURE LOG

1. What does DTEM stand for?
what are scales

2. what logs were run together?

TEMP LOG	°F
0 – 1950	42.5 °F
2300	43.5
2500	45.5
2700	49.5
2900	54.5
3000	57.5
3260	74.0
3300	91.0
3400	113
3500	126
3600	133
3700	138.5
3800	145.5
3900	157
4000	157

3. Shows constant temp down to ±2300, slow increase to 3260, then much higher gradient. This is a manifestation of the rain curtain effect, prob due to mineralogic effects.

INDUCTION ELECTROLOG

1. was mud or mud filtrate resistivity not measured?

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

June 20, 1986

Mr. Dennis Olmstead
Dept. of Geology & Mineral Ind.
1005 State Office Bldg.
Portland, Ore. 97201

Dear Dennis:

We have recently submitted to your office the GEO N-1 core splits you requested in your letter of June 6, 1986. I trust UURI will also be sending you the splits that you have requested from them. As far as GEO is concerned, the splits you receive from UURI are part of the public record and you may use them in any capacity you deem appropriate. The splits that you are receiving from GEO however, are part of our corporate assets and we request that they be kept proprietary in a fashion similar to what would be the case if there were no public involvement in the corehole.

As you know, we are currently drilling our second corehole (GEO N-3) on the north flank of Newberry and at present, we are coring below 1,050 feet. We will continue to work with DOE/UURI in order to provide your office the core that you require in a timely fashion and with as few restrictions as is compatible with our various interests.

Thank you very much.

Very truly yours,

Chandler Swanberg, President

CAS/rs
cc: M. Cale, GEO
J. Combs, GEO
R. King, DOE
P. Wright, UURI

6449 South Highway 97, Suite A, Bend, OR 97701 (503) 389-6681

VICTOR ATIYEH
GOVERNOR

Department of Geology and Mineral Industries

ADMINISTRATIVE OFFICE
1005 STATE OFFICE BLDG., PORTLAND, OREGON 97201 PHONE (503) 229-5580

June 6, 1986

Mr. Bruce Sibbett
University of Utah
Research Institute
391 Chipeta Way, Suite 8
Salt Lake City, UT 84108

Mr. Chan Swanberg
GEO Operator Corporation
2300 County Center Dr., Suite 250
Santa Rosa, CA 95401

Dear Bruce and Chan:

I understand you have each agreed to supply for our sample repository half of the 1985 samples from well N-1 at Newberry Crater. This sounds like a good answer to the problem and below I propose how this should be done. I don't know the availability of cuttings from the rotary drilled portion of the well (0' to 470'), but these samples are included in the proposed list.

The core samples to be submitted should be approximately 6 inches in lenth (or a split 6 inches in length) from the named depths.

DOE/UURI to submit:
(1) cuttings samples at 30 ft intervals 0' to 450'
(2) core samples from:

500'	900'	1180'	1350'	1600'
695'	960'	1230'	1375'	1750'
750'	1100'	1275'	1460'	1870'

GEO Operator to submit:
(1) core samples from:

2000'	2530'	3100'	3600'	4000'
2230'	2600'	3200'	3700'	4100'
2400'	2750'	3300'	3800'	4300'
2500'	2930'	3430'	3900'	4500'

I hope this works as an equitable method of dividing the task of supplying us with the cuttings and cores. Thank you both for your efforts.

Sincerely,

Dennis L. Olmstead
Petroleum Engineer

DLO:ak
cc: Phillip M. Wright, UURI
Michael J. Cale, GEO Operator

VICTOR ATIYEH
GOVERNOR

Department of Geology and Mineral Industries

ADMINISTRATIVE OFFICE

910 STATE OFFICE BLDG., 1400 SW 5th AVE., PORTLAND, OR 97201-5528 PHONE (503) 229-5580

August 12, 1986

Mike Wright
UURI, Earth Science Lab
391 Chipeta Way, Suite C
Salt Lake City, UT 84108

Dear Mr. Wright:

On August 10, 1986, we received the core samples from the Geo-Newberry corehole N-1. I would like to thank you for supplying this material to us.

I would like to request a cut from the surface portion of the hole which was rotary drilled. This would be a cut every 30' from the surface to a 465' depth.

Your handling of this matter is appreciated.

Best regards,

Dan E. Wermiel
Petroleum Geologist

DEW:rm

VICTOR ATIYEH
GOVERNOR

Department of Geology and Mineral Industries
ADMINISTRATIVE OFFICE
910 STATE OFFICE BLDG., 1400 SW 5th AVE., PORTLAND, OR 97201-5528 PHONE (503) 229-5580

October 22, 1986

Mr. Mike Wright
URRI, Earth Science Lab
391 Chipeta Way, Suite C
Salt Lake City, Utah 84108

Dear Mr. Wright:

In August, 1986, I wrote you requesting a cut from the surface portion of the Geo-Newberry N-1, Deschutes Co., Oregon. This would be a cut every 30' from the surface to a 465' depth.

This has not arrived to date, and would you please provide a cut at this time.

Your handling of this matter is appreciated.

Sincerely,

Dan E. Wermiel

Dan E. Wermiel
Petroleum Geologist

DEW/sf
AT1/wermiel/wright

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

Sept. 11, 1986

Mike Wright
University of Utah Research Institute
Research Park
391 Chipeta Way, Suite C
Salt Lake City, UT 84108

Dear Mike:

I have attached a copy of an abstract which we have submitted to the Fall AGU Meeting. Happy Reading.

Very truly yours,

Chandler A. Swanberg, President

CAS/rs
enclosure

61419 South Highway 97, Suite A, Bend, OR 97701 (503) 389-6681

CORE HOLE DRILLING TO DEFINE THE THERMAL REGIME AT NEWBERRY VOLCANO, CENTRAL OREGON

CHANDLER A. SWANBERG & JIM COMBS, (GEO OPERATOR CORP., 1825 S. Grant, Suite 900, San Mateo, CA 94402)

Geo Operator Corp., in conjunction with U.S. DOE, has drilled two core holes on the flanks of Newberry Volcano in central Oregon. GEO N-1 was cored to a depth of 1387 m roughly 9 km south and GEO N-3 was cored to a depth of 1220 m roughly 12 km north of the caldera center.

GEO N-1, completed on 11/9/85, penetrated interbedded pyroclastic lava flows and lithic tuffs ranging from basalt through rhyolite in composition. The surface cinders have been dated at 5835±195 yr B.P. my (C^{14}). Thirteen K-Ar age dates range from 0.027±0.009 my(478m) to 1.63±0.13 my (1082 m) with the ages increasing systematically with depth. Five samples selected for Fission Track age dating were either too young and/or too impoverished in uranium to be dated. Two other age dates (K-Ar [953 m] and Fission Track-apatite [495 m] gave spurious (?) ages of 20-30 my. These ages are comparable to pre-Newberry units thus leaving open the possibility that magmatic and/or hydrothermal heating may be effecting age dates throughout much of the volcanic pile. A detailed temperature log (±0.01°C) measured 7 months after completion shows GEO N-1 to be nearly isothermal at 6°C throughout most of its upper 900 m. Temperatures increase very rapidly between 990 m and 1020 m and then take on a conductive character reaching 73.36°C at 1220 m. Twelve thermal conductivity measurements representing one rhyolite and two dacite flows yield a heat flow of 181 mWm^{-2}.

GEO N-3 was completed on 7/31/86 and a detailed temperature log was completed on 8/18/86. GEO N-3 is nearly isothermal @ 6°C throughout the upper 580 m and nearly isothermal @ 52°C over the interval 610 m - 1192 m. The conductive gradient below 1192 m is 51°C/km and a preliminary estimate of heat flow is 90 mWm^{-2}. Additional core holes are planned to more accurately define the thermal regime.

Submittal information:

1. 1986 Fall Meeting
2. 001374080
3. a)Chandler A. Swanberg
   GEO OPERATOR CORP.
   1825 S. Grant, Suite 900
   San Mateo, CA 94402

   b) 415 349 8181
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UNITED STATES DEPARTMENT OF THE INTERI

GEOLOGICAL SURVEY

Hydrothermal Mineralization in GEO N-1 Drill Hole, Newberry Volcano, Oregon

by

Keith E. Bargar and Terry E. C. Keith[1]

Open-File Report 86-440

[1]Menlo Park, CA

Mike
Here is a copy of
our report on the
GEO N-1 drill hole.
Keith

ABSTRACT

GEO N-1 was drilled in November, 1985 by GEO-Newberry Crater, Inc., under a cost-sharing agreement with DOE, at a surface altitude of 1783 m on the south flank of Newberry Volcano, Oregon. Drill core, drilling data, and geophysical data from the upper 1219 m of GEO N-1 are available to the public; maximum measured temperature for the released interval is 71°C at 1219 m. The drill core intercepted mostly andesitic to basaltic lava flows with interlayers of ash-flow tuffs, lithic tuffs, cinders, and flow breccias; core recovery was about 95 percent. Twelve basalt dikes intrude the flows between 622 and 719 m but there is little alteration at the contacts. Intense fracturing and vesiculation are common in the basal and upper portions of most flows whereas the flow interiors are generally very dense with few fractures.

Very little evidence for hydrothermal alteration was found in the upper 500 m of drill core; however, pre-hydrothermal, low temperature, amorphous clay-like material and amorphous silica occur as fracture or vug fillings. Below 500 m, most ash-flow tuffs contain smectite, and, although the lavas generally show little alteration, many fractures and vesicles are lined with secondary minerals: hematite, smectite, and carbonates (siderite, kutnohorite, dolomite, rhodochrosite, calcite, and aragonite). Locally, small amounts of ß-cristobalite, chalcedony(?), chabazite, phillipsite, okenite, illite(?), and pyrite were identified. The hydrothermal minerals were probably deposited at the <71°C temperatures measured following drilling of GEO N-1.

INTRODUCTION

Geothermal drill hole GEO N-1, located on the southern flank of Newberry Volcano about 4.5 km outside the caldera rim at an elevation of about 1783 m, was completed by GEO-Newberry Crater, Inc. (subsidiary of GEO Operator Corporation) in November, 1985. This 1219+ m drill hole is the first Cascade geothermal drill hole to be finished under a new program of the U. S. Department of Energy (DOE). In this program, the U.S. government shares geothermal exploration drilling costs with industry at approved drill sites.

A brief summary of data from the GEO N-1 drill hole by the University of Utah Research Institute (UURI) Earth Science Laboratory, including abbreviated descriptions of temperature and selected geophysical logs, is given in a newsletter (UURI, 1986). GEO N-1 was rotary drilled to about 148 m, and then was cored to 1219 m with about 95 percent core recovery. Below 1219 m, information from this drill hole is proprietary, and has not been released by GEO-Newberry Crater, Inc. Swanberg and Combs (1986) present preliminary lithologic and temperature logs for the GEO N-1 drill hole; they also discuss the results of several geophysical tests conducted in GEO N-1 and indicate that such geophysical data may be of great importance to future geothermal exploration in the Cascades.

The drill core was logged and photographed upon recovery by GEO-Newberry

Crater, Inc. and a split of the core was sent to UURI. A selection of the UURI core (222 samples) including vein fillings, vug fillings, or representative samples of stratigraphic intervals was studied by us for hydrothermal alteration mineralogy. In addition, GEO-Newberry Crater, Inc., provided 49 hydrothermal mineral samples, geophysical logs, and a color photo log of the entire drill core. Altogether, 271 samples of the GEO N-1 drill core were studied by binocular microscope, petrographic microscope (15 thin sections), and X-ray diffraction methods (more than 300 X-ray diffractograms).

LITHOLOGY

A lithologic log of the GEO N-1 drill core was compiled by GEO-Newberry Crater, Inc., and made available through UURI. The log contains detailed lithology notes and tentative rock identifications (pending receipt of thin sections and chemical analyses). The GEO-Newberry terminology will be followed in this report, modified only slightly on the basis of our observations of the entire split of UURI core. Age data are not available for any of the rocks recovered from the drill hole. The majority of core samples consist of basaltic to andesitic lava flows and associated flow breccia, pyroclastic, and ash-flow material (Fig. 1). Primary minerals in the lavas vary with the chemical composition of the lava but are predominantly plagioclase with varying amounts of olivine, clinopyroxene, orthopyroxene, magnetite, and α-cristobalite; minerals such as hornblende or biotite are noteably absent. Several lava flows contain vapor-phase tridymite, alkali-feldspar(?), and magnetite that has altered to hematite. The deepest lava flow available for study (1170.4-1219.2 m depth) is probably dacitic and contains trace amounts of primary quartz. Textures of the lava flows may be perlitic, massive, flow-banded, diktytaxitic, vesicular, or scoriaceous. Between 622 and 719 m depth, 12 moderate to steeply dipping basaltic dikes (up to about 12 m apparent core thickness) intrude the lava flows.

The lava flows are commonly vesicular at the top and bottom, dense in the interior and have intervening fractured intervals consisting of steeply dipping tight fractures. Ash and cinder layers and lithic tuffs appear to have good permeability where unaltered; one layer (567-572 m) retained significant water in the pore spaces several months after recovery of the drill core. At deeper intervals, below 830 m, ash-flow tuffs are pervasively altered to smectite and the present permeability is presumably quite low.

PRE-HYDROTHERMAL ALTERATION

Many secondary minerals, not hydrothermal in origin, were deposited along narrow fractures and in vesicles throughout the upper 610 m of the drill core, especially above about 520 m. The deposits consist of thin coatings of reddish iron oxide (mostly amorphous iron hydroxide but some hematite), yellow, green, and pale blue soft amorphous material (which may be, in part, a precursor to smectite), and scattered small amounts of amorphous silica. Hematite was deposited at high temperatures during cooling of the lava flows and ejecta; amorphous silica, amorphous iron hydroxide, and at least some of the amorphous clay-like deposits are probably deuteric and formed at low temperatures. Below 520 m depth some of these pre-hydrothermal minerals, especially hematite, persist intermingled with hydrothermal deposits. Amorphous clay-like material coating fractures and vesicles is similar in appearance to hydrothermal clay coatings but lacks the smectite structure. The abundant iron oxides, including some hematite in ash-flow tuffs, may have formed by oxidation of primary magnetite during deuteric alteration.

HYDROTHERMAL ALTERATION

The lava flows are mostly very little altered. Below about 670 m depth, thin fracture fillings or vesicles contain hydrothermal deposits, dominantly carbonates (aragonite, calcite, dolomite, kutnohorite, rhodochrosite, and siderite), smectite, and hematite with local minor amounts of silica minerals (ß-cristobalite and chalcedony?), zeolites (chabazite, and phillipsite), okenite (one occurrence of the calcium silicate hydrate mineral), illite(?), and pyrite (Fig. 2).

Fractures frequently have a smectite coating and may also contain one or more of the several carbonate minerals. Most vesicles do not contain any secondary minerals, but thin clay coatings and clusters of carbonate crystals are sporadically abundant.

Hydrothermal alteration of the pyroclastic layers and flow breccias is somewhat irregular. The flow breccias, ash-flow tuffs, and other pyroclastic layers are not altered above 567 m (but do contain deuteric minerals). From 567 to 820 m minor clay alteration is present in three layers of ash and cinders but one ash-flow tuff (659 to 664 m) and two layers of ash and cinders (797 to 800 m and 816 to 820 m) are unaltered. Below 830 m, the pyroclastic deposits are extensively altered to smectite; however, layers of ash and cinders at 860 to 869 m, 897 to 901 m, 949 to 979 m, and 1125 to 1132 m have only minor smectite alteration. Iron oxide is abundant in many of the pyroclastic layers and usually stains the layers an earthy brick-red color. Some of the iron oxides are amorphous but most were identified as hematite by X-ray diffraction.

Silica Minerals

Several cavities in samples from 1124 and 1172 m are partly coated by bluish botryoidal ß-cristobalite along with smectite, calcite, and siderite. X-ray diffraction analysis of a massive green fracture filling deposit at 1178 m shows the presence of ß-cristobalite and minor smectite, siderite, hematite, and kutnohorite. ß-cristobalite, smectite, and siderite were also identified on an X-ray trace of a clayey fracture filling at 1185 m. The only other hydrothermal(?) silica mineral in drill core GEO N-1 is yellowish botryoidal chalcedony which coats flow breccia fragments at 555 m. Several samples of white to clear amorphous silica deposits in the upper half of the drill core may be of deuteric origin.

Carbonate Minerals

Several carbonate minerals (aragonite, calcite, dolomite, kutnohorite, rhodochrosite, and siderite) occur as vesicle or fracture fillings in the lower half of the drill core; and calcite appears to replace plagioclase at about 1200 m depth. Aragonite can generally be distinguished from the other carbonates by its typical clear acicular crystals (as much as 1 cm long). However, white powdery, clear massive, or white cauliflower-like aragonite deposits were also verified by X-ray diffraction analyses.

Siderite, a fairly abundant carbonate mineral in the drill core, usually occurs as distinctive light to dark caramel-colored or rarely greenish discoidal, hemispherical, or spherical aggregates of rhombic crystals. 'Towery' stacked rhombic crystal clusters occur at 1090 and 1121 m. The color of GEO N-1 siderite probably reflects its composition. Lighter caramel or pale yellow siderite crystals have their most intense X-ray diffraction peak at about 2.82 Å corresponding to a manganese siderite (X-ray diffraction identification of carbonate minerals is based on data of the Joint Committee on Powder Diffraction Standards. No internal standard was used in any of the X-ray diffraction measurements; however, accuracy of the measurements is within about ±0.02Å.). In darker caramel-colored siderite crystals (Fe-rich), the most intense X-ray peak occurs between 2.78 - 2.80 Å.

The remaining four carbonate minerals (calcite, dolomite, kutnohorite, and rhodochrosite) have no distinctive color or crystal habit. These open-space deposits may be clear, white, pink, or yellowish in color; and they may consist of powdery or massive deposits, blocky or acicular crystals, or spherical to hemispherical crystalline aggregates. Most carbonate mineral identifications in this study (including siderite) are based on the position of the most intense X-ray diffraction peak as follows: siderite (2.78 - 2.80 Å), Mn-siderite (2.82 Å), rhodochrosite (2.84 - 2.86 Å), dolomite (or possibly ankerite) (2.88 - 2.90 Å), kutnohorite (2.91 - 2.98 Å), and calcite (3.02 - 3.05 Å). Only a few samples of rhodochrosite or dolomite (ankerite?) were identified in the GEO N-1 drill core (Fig. 2). Characteristic X-ray peaks for these two minerals are fairly distinctive. However some difficulty was found in distinguishing between calcite and kutnohorite because the presence of manganese in the calcite structure expands the range of positions of the most intense X-ray peak from typical calcite (3.02 - 3.05 Å) to at least the upper border of the kutnohorite range (2.94 - 2.98 Å) (Krieger, 1930). A further complication is that although kutnohorite has a dolomitic structure, the X-ray peaks which are characteristic of dolomitic structure may be too weak to detect, at least in Ca-kutnohorite (Gabrielson and Sundius, 1965). In this study, the mineral was identified as kutnohorite if the highest X-ray peak ranged between 2.94 and 2.98 Å and calcite if the peak occurred at 2.99 to 3.05 Å; even though data in Krieger (1930) indicate that the most intense X-ray peak in calcite with high manganese content may extend to 2.95 Å.

In the GEO N-1 drill core, kutnohorite and calcite were not deposited in distinctive zones; instead they overlap in their distribution throughout the lower half of the drill hole (Fig. 2). In some fractures or vugs, the two minerals are found together or are closely associated with up to three other carbonate minerals. This suggests that the fluids that deposited the carbonate minerals may have varied somewhat in cation composition with time.

Zeolite and Related Minerals

Chabazite and phillipsite are the only zeolite minerals found in the GEO N-1 drill core. Flow rock between 801 and 802 m depth contain trace amounts of clear to white, twinned, pseudorhombic chabazite crystals. Tiny, clear, prismatic crystals from a lava flow at 756 m and three samples of open-space fillings in a lava flow between 801 and 804 m were identified as phillipsite by X-ray diffraction. The two zeolite minerals occur together in two of the samples; calcite and smectite are the only other associated hydrothermal minerals.

Okenite, a hydrous calcium silicate mineral, occurs as a soft white vug filling in a lava flow at 857 m. Okenite typically is found in basalt cavities in association with zeolite minerals (Heller and Taylor, 1956).

Clay Minerals

Smectite is the most abundant hydrothermal mineral found in the GEO N-1 drill core (Fig. 1). This white, yellow, green, brown, blue, or black clay mineral ranges from poorly crystalline (low, broad X-ray peaks) to well-crystallized with sharp (001) X-ray diffraction peaks that generally fall within the range from about 15.2 - 16.7 Å and expand to between about 17.0 and 18.3 Å with glycolation (average values for 91 samples are 15.7 Å untreated and 17.6 Å glycollated). No correlation was found between poor or well-developed crystallinity, or position of the (001) X-ray peak, with depth of smectite formation in the GEO N-1 drill core. In the GEO N-1 drill core, smectite occurs as whole rock (glass) alteration in pyroclastic samples and as open-space (fracture and vug fillings) in the lava flows and flow breccias. Smectite was deposited at several different times, occurring both earlier than (beneath) and later than (above) some carbonate cavity and vein fillings.

Illite is provisionally identified (based on a low, usually broad, approximately 10 Å X-ray diffraction peak that showed no significant change with glycolation) in a few X-ray diffraction analyses of whole-rock, vesicle, and fracture filling samples from lava flows and pyroclastic deposits at 310-362 m, 568 m, 789 m, and 1217 m depth. The 10 Å illite(?) mineral formed later than calcite in one vesicle filling and is associated with calcite, dolomite, and smectite in other samples.

Iron Oxide and Sulfide Minerals

Small patches of disseminated, very minute ($\approx$ 0.02 mm), yellow, metallic, cubic pyrite crystals were identified only at 943, 945, and 1068 m in the GEO N-1 drill core. At 1068 m a pyrite veinlet crosscuts iron oxide deposits, and pyrite crystals formed later than smectite in vesicles. Associated minerals are smectite, calcite, siderite, and hematite.

Red deuteric amorphous iron oxide stains flow breccias, ash, and tuffaceous layers and coats fractures in lava flows in the upper part of the drill core. In contrast, crystalline hematite (identification based on X-ray diffraction analyses) occurs below about 300 m in red-stained tuffs, altered vapor-phase magnetite grains, and fracture coatings.

PARAGENETIC SEQUENCE

Deposition of the major secondary minerals began with vapor-phase hematite, which formed during cooling of the lava flows and pyroclastic intervals. During late-stage cooling and pre-hydrothermal circulation of meteoric waters, amorphous iron hydroxides, and amorphous clay-like deposits were precipitated. Hydrothermal smectite and carbonate minerals were deposited later than vapor-phase minerals. Smectite alteration of the pyroclastic layers occurred prior to carbonate deposition. Most open-space smectite formed earlier than the carbonates; however, smectite is also found locally deposited later than carbonate minerals. The several carbonate minerals appear to have been deposited from fluids that varied greatly in cation content with respect to time. Aragonite, however, formed later than the other carbonates. Silica minerals, zeolite minerals, and okenite all formed later than most smectite but their sequence relative to carbonates and to each other are unknown. Pyrite formed later than hydrothermal hematite in the single vein occurrence, and it formed later than smectite but earlier than carbonate in the disseminated occurrences.

DISCUSSION

A maximum temperature of about 71°C was reported following drilling of the GEO N-1 drill hole at 1219 m depth (UURI, 1986). Hydrothermal alteration minerals identified from the drill core are consistent with these low temperatures. The minerals form a nearly identical hydrothermal mineral suite to that found at temperatures of less than 100°C in the upper 650 m of the U.S.G.S. Newberry 2 drill core (Bargar and Keith, 1984; Keith and others, 1984) from a site about 7.5 km NNE of the GEO N-1 drill site. In both drill holes hydrothermal silica, zeolite, carbonate, and clay minerals were deposited from migrating fluids, mostly in open-spaces of vugs, fractures, and voids in flow breccias. Permeable ash-flow tuff and lithic tuff locally display more intense alteration of glass to smectite. Some replacement of plagioclase by calcite appears to have occurred in the vicinity of 1200 m in the drill core from GEO N-1.

In drill core GEO N-1, the numerous carbonate phases are not confined to discrete zones. Instead, the minerals may vary from fracture to fracture. Such abrupt changes are especially true for calcite and kutnohorite; a sequence of three fractures can have fracture #1 coated by calcite, fracture #2 by kutnohorite, and fracture #3 by calcite. The fluids from which the minerals were deposited must have varied somewhat in chemical composition between at least two of the three adjacent fractures, and, consequently, the fracture fillings probably resulted from at least two separate fluid pulses. In fact, it is likely that fluctuations in fluid cation (Mg, Ca, Mn, and Fe) composition occur over a period of time because as many as four different carbonate minerals (aragonite, siderite, calcite, and dolomite) were identified in a single open-space filling. Aragonite is always the last carbonate phase to be deposited, but, locally, it appears to have been partly reordered to the more stable calcite phase.

The presence of 12 basaltic dikes between 622 and 719 m show that a transient heat source was introduced near the area when the dikes intruded the volcanic pile. Some of the dikes have chilled margins preserved, but there is no evidence of significant alteration directly adjacent to the contacts. The dikes occur near the upper limit of the occurrence of hydrothermal alteration minerals in the drill core.

Although the temperature gradient begins to increase at about 1000 m, there are no changes in hydrothermal mineralogy at that depth. The existence of smectite and amorphous clay-like material rather than mixed-layer clays indicates that temperatures probably were never hotter than the present measured temperature of about 71°C at 1219 m.

ACKNOWLEDGMENTS

We would like to thank GEO-Newberry Crater, Inc. and in particular M. J. Johnson and C. A. Swanberg for providing us with complete sets of lithologic, temperature, and geophysical logs for the GEO N-1 drill hole. P. M. Wright and D. L. Nielson at UURI provided access to their split of the GEO N-1 core and facilities for observing and sampling the core. The assistance of M. H. Price with X-ray diffraction analyses is gratefully acknowledged.

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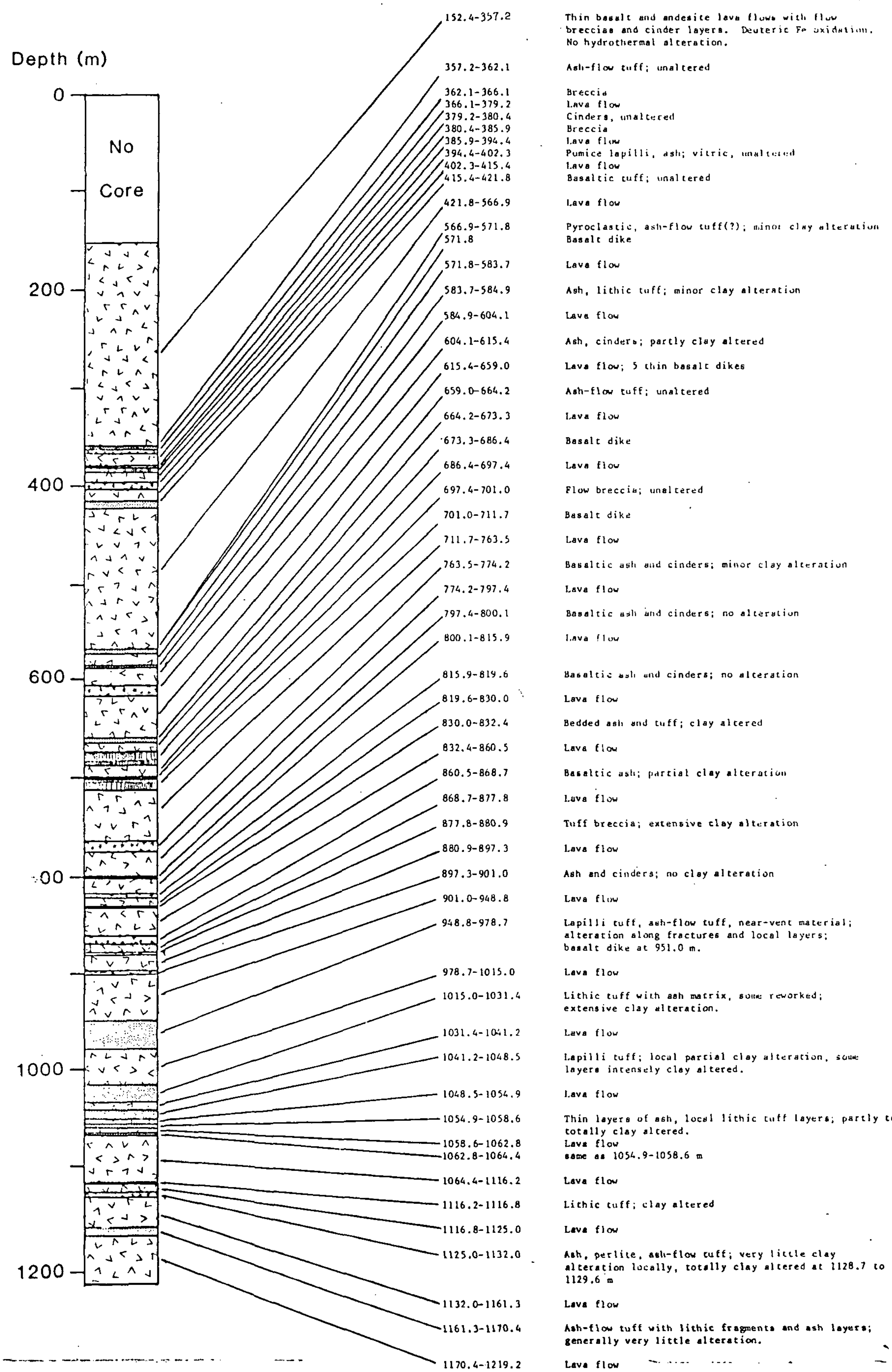
UURI, 1986, Announcement of open file data release: Cascades Newsletter, no. 2, 2 p.

FIGURE CAPTIONS

Figure 1. Preliminary lithologic log of core from drill hole GEO N-1, based on stratigraphic data made available by GEO-Newberry Crater, Inc.

Figure 2. Distribution of selected secondary minerals with depth in geothermal drill hole GEO N-1. Left column shows a generalized stratigraphic section of rock units encountered in the drill hole including: basaltic or andesitic lava flows (star pattern), tuffaceous or pyroclastic material (solid), basaltic dikes (diagonal lines), and dacitic lava flow (horizontal lines). The column is blank above 148 m where no core was recovered. Filled circles are temperatures measured during drilling from the log provided by GEO-Newberry Crater, Inc. The temperature curve is dashed where measurements were imprecise. The maximum measured temperature was 61.1°C at 1208.2 m; however, maximum temperatures of 68.3°C and 71.1°C were recorded at 1219.2 m on subsequent temperature logs (Swanberg and Combs, 1986; UURI, 1986).

GEO N1 Annotated Lithologic Log



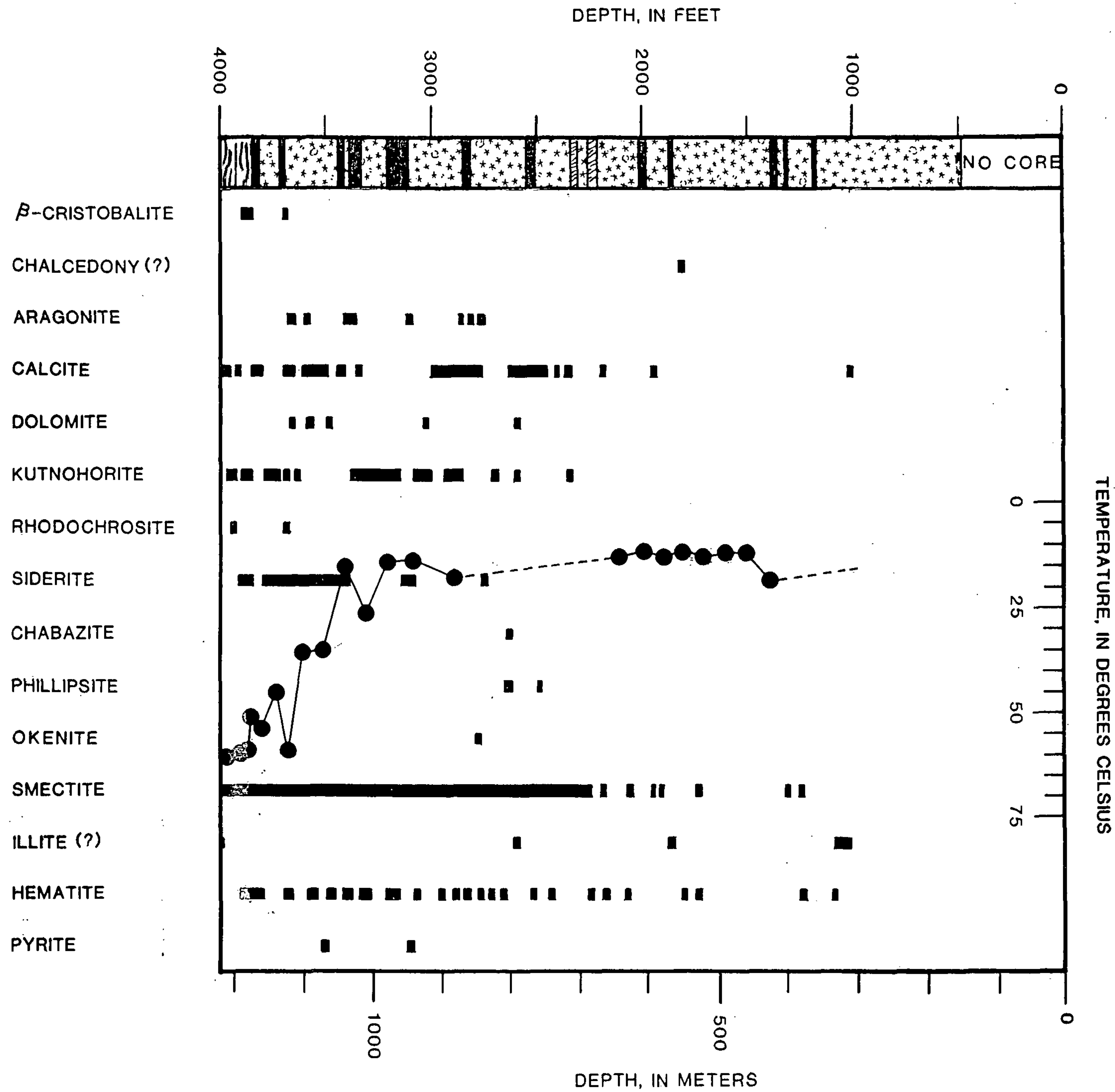

DEPTH, IN FEET
4000
3000
2000
1000
0
NO CORE
β-CRISTOBALITE
CHALCEDONY (?)
ARAGONITE
CALCITE
DOLOMITE
KUTNOHORITE
RHODOCHROSITE
SIDERITE
CHABAZITE
PHILLIPSITE
OKENITE
SMECTITE
ILLITE (?)
HEMATITE
PYRITE
TEMPERATURE, IN DEGREES CELSIUS
0
25
50
75
1000
500
0
DEPTH, IN METERS

Fig. 2

VICTOR ATIYEH
GOVERNOR

Department of Geology and Mineral Industries

ADMINISTRATIVE OFFICE

910 STATE OFFICE BLDG., 1400 SW 5th AVE., PORTLAND, OR 97201-5528 PHONE (503) 229-5580

July 8, 1986

Mr. Mike Wright
UURI, Earth Science Lab
391 Chipeta Way, Suite C
Salt Lake City, Utah 84108

Dear Mr. Wright:

In April, 1986, Dennis Olmstead wrote you regarding the GEO Operator Corporation N-1 well, Deschutes Co., Oregon. Certain material was requested from you, which has not yet been received.

Please send the following material to my attention:

a) Representative samples of cores. GEO Operator Corp. has supplied samples from 2000' to total depth. Per our agreement, you are to provide samples from surface down to 2000'. The core samples you are to submit are: 500', 695', 750', 900', 960', 1100', 1180', 1230', 1275', 1350', 1375', 1460', 1600', 1750' and 1870'. The core samples should be approximately 6" in length or a split 6" in length from the named depths.

b) Amounts of rods left in the hole.

c) Depth to water.

d) Continuous lithology descriptions.

You are required to submit this material to us, and your prompt attention to this matter is appreciated.

Best regards,

Dan E. Wermiel

Dan E. Wermiel
Petroleum Geologist

DEW:ab

7-18-86

Geo Newberry N-1

This Core were Remove for

Dennis Olmstead Dept. of Geol & Mineral. Portland

500'	5½"
695'	4"
750'	4"
900'	4½"
960'	3½"
1100'	6"
1180'	3"
1230'	4"
1275'	4"
1350'	5"
1375'	3"
1460'	5"
1600'	7"
1750'	4½"
1870	4"

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

GEO-NEWBERRY CORE HOLE N-1

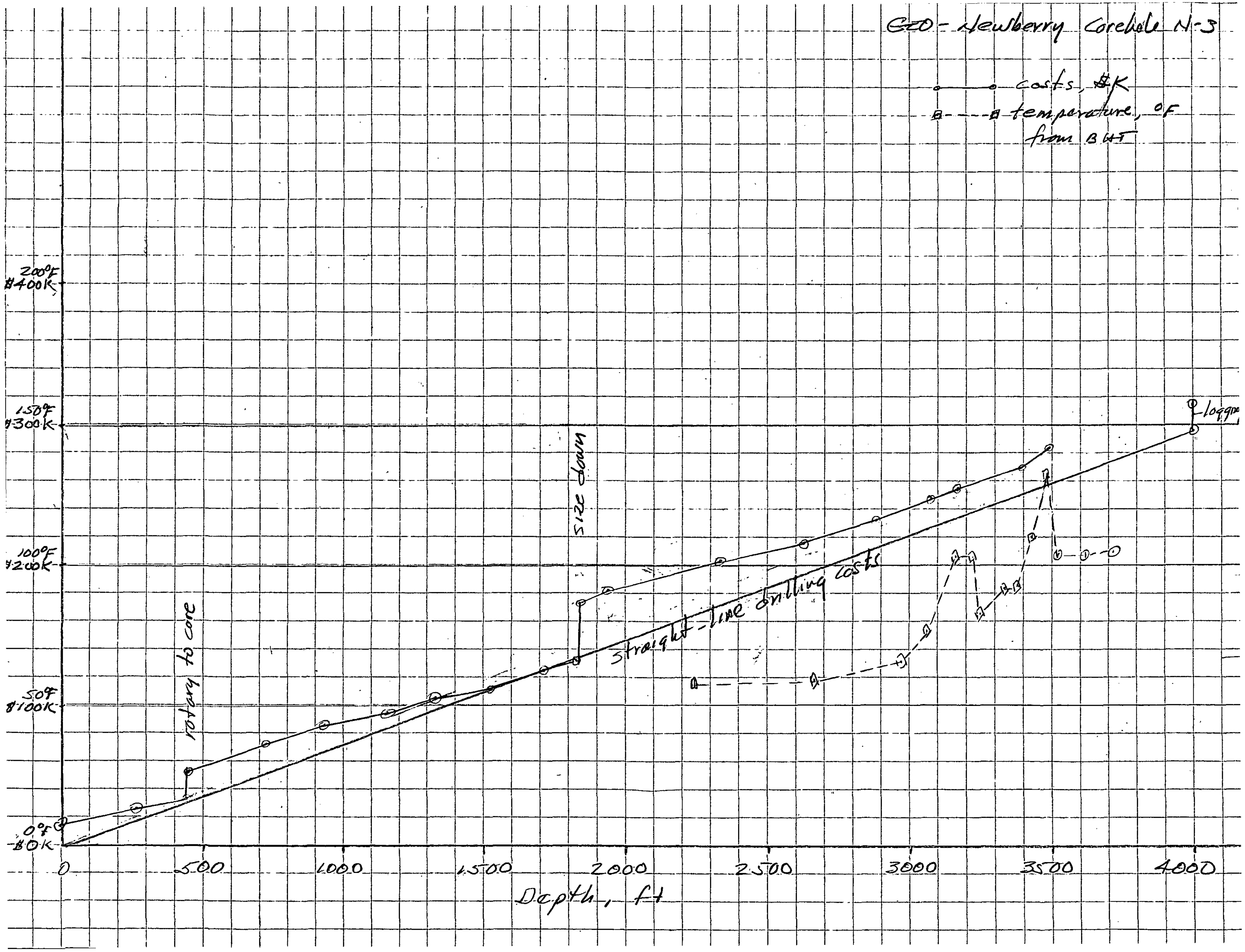
DAILY REPORT

DATE: August 22, 1985

TIME: 3:00 PM

Pit lined, Tonto rigging up. Begin hauling water late afternoon.

Total est. cost to date: $3,000



GEO - Newberry Corehole N-3
costs, $K
temperature, °F from BHT
200°F
$400K
150°F
$300K
100°F
$200K
50°F
$100K
0°F
$0K
logging
size down
rotary to core
straight-line drilling costs
0
500
1000
1500
2000
2500
3000
3500
4000
Depth, ft

VICTOR ATIYEH
GOVERNOR

Department of Geology and Mineral Industries

ADMINISTRATIVE OFFICE

910 STATE OFFICE BLDG., 1400 SW 5th AVE., PORTLAND, OR 97201-5528 PHONE (503) 229-5580

July 8, 1986

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UURI, Earth Science Lab
391 Chipeta Way, Suite C
Salt Lake City, Utah 84108

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d) Continuous lithology descriptions.

You are required to submit this material to us, and your prompt attention to this matter is appreciated.

Best regards,

Dan E. Wermiel

Dan E. Wermiel
Petroleum Geologist

DEW:ab

Geo Newberry N-1 7-18-86

This Core were Remove for
Dennis Olmstead Dept. of Geol & Minerals
Portland

500' 5½"
695' 4"
750' 4"
900' 4½"
960' 3½"
1100' 6"
1180' 3"
1230' 4"
1275' 4"
1350' 5"
1375' 3"
1460' 5"
1600' 7"
1750' 4½"
1870 4"

STATE OF OREGON 1859

VICTOR ATIYEH
GOVERNOR

Department of Geology and Mineral Industries
ADMINISTRATIVE OFFICE
1005 STATE OFFICE BLDG., PORTLAND, OREGON 97201 PHONE (503) 229-5580

June 6, 1986

Mr. Bruce Sibbett
University of Utah
Research Institute
391 Chipeta Way, Suite 8
Salt Lake City, UT 84108

Mr. Chan Swanberg
GEO Operator Corporation
2300 County Center Dr., Suite 250
Santa Rosa, CA 95401

Dear Bruce and Chan:

I understand you have each agreed to supply for our sample repository half of the 1985 samples from well N-1 at Newberry Crater. This sounds like a good answer to the problem and below I propose how this should be done. I don't know the availability of cuttings from the rotary drilled portion of the well (0' to 470'), but these samples are included in the proposed list.

The core samples to be submitted should be approximately 6 inches in lenth (or a split 6 inches in length) from the named depths.

DOE/UURI to submit:
(1) cuttings samples at 30 ft intervals 0' to 450'
(2) core samples from:

500'	900'	1180'	1350'	1600'
695'	960'	1230'	1375'	1750'
750'	1100'	1275'	1460'	1870'

GEO Operator to submit:
(1) core samples from:

2000'	2530'	3100'	3600'	4000'
2230'	2600'	3200'	3700'	4100'
2400'	2750'	3300'	3800'	4300'
2500'	2930'	3430'	3900'	4500'

I hope this works as an equitable method of dividing the task of supplying us with the cuttings and cores. Thank you both for your efforts.

Sincerely,

Dennis L. Olmstead
Petroleum Engineer

DLO:ak
cc: Phillip M. Wright, UURI
Michael J. Cale, GEO Operator

THE UNIVERSITY OF WYOMING
DEPARTMENT OF GEOLOGY AND GEOPHYSICS
P.O. BOX 3006
LARAMIE, WYOMING 82071
(307) 766-3386

[redacted] 29 July 1986

Mike Wright
Earth Science Laboratory [redacted]
UURI
391 Chipeta Way, Suite C
Salt Lake City, UT 84108

Dear Mike:

For your information, a copy of the NSF proposal describing our work at Newberry is enclosed. Blanks from the samples we took from the core have been cut and sent off for thin sections. As soon as we have any preliminary results we will send you them. Again, thanks very much for your assistance.

Sincerely,

James D. Myers
Assistant Professor

JM/nf

APPENDIX II

PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION
Cover Page

FOR CONSIDERATION BY NSF ORGANIZATIONAL UNIT (Indicate the most specific unit known, i.e. program, division, etc.)

Mantle Geochemistry & Volcanology

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? Yes ___ No _X_ ; IF YES, LIST ACRONYM(S):

PROGRAM ANNOUNCEMENT/SOLICITATION NO.:

CLOSING DATE (IF ANY):

NAME OF SUBMITTING ORGANIZATION TO WHICH AWARD SHOULD BE MADE (INCLUDE BRANCH/CAMPUS/OTHER COMPONENTS)

Department of Geology & Geophysics, University of Wyoming

ADDRESS OF ORGANIZATION (INCLUDE ZIP CODE)

P.O. Box 3006, University Station
Laramie, WY 82071

TITLE OF PROPOSED PROJECT A detailed petrologic study of Newberry volcano, Oregon: a quantitative attempt to assess the relative importance of fractionation, crustal assimilation and magma mixing in the evolution of continental volcanic suites.

REQUESTED AMOUNT	PROPOSED DURATION	DESIRED STARTING DATE
$95,729	2 years	May 1, 1987

PI/PD NAME AND SOCIAL SECURITY NO. (SSN)*	PI/PD PHONE NO.
James D. Myers 008-34-3651	307-766-2203

PI/PD DEPARTMENT	PI/PD ORGANIZATION
Department of Geology & Geophysics	University of Wyoming

ADDITIONAL PI/PD AND SSN*	ADDITIONAL PI/PD AND SSN*
Carol D. Frost 574-50-5619	

ADDITIONAL PI/PD AND SSN*	ADDITIONAL PI/PD AND SSN*

FOR RENEWAL OR CONTINUING AWARD REQUEST, LIST PREVIOUS AWARD NO.: N/A

SUBMITTING ORGANIZATION IS ___ IS NOT _X_ A SMALL BUSINESS CONCERN (see CFR Title 13, Part 121 for definitions).

*Submission of social security numbers is voluntary and will not affect the organization's eligibility for an award. However, they are an integral part of the NSF information system and assist in processing the proposal. SSN solicited under NSF Act of 1950, as amended.

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- ☐ Human Subjects
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- ☐ Research Involving Recombinant DNA Molecules
- ☐ Historical Sites
- ☐ Pollution Control
- ☐ Proprietary and Privileged Information

	PRINCIPAL INVESTIGATOR/ PROJECT DIRECTOR	AUTHORIZED ORGANIZATIONAL REP.	OTHER ENDORSEMENT (optional)
NAME	James D. Myers	James E. Todd	James E. McClurg
SIGNATURE	James D. Myers	James E. Todd	James E. McClurg
TITLE	Assistant Professor	Vice President, Finance	Department Head
DATE	7/20/86		

APPENDIX IV

NATIONAL SCIENCE FOUNDATION

PROJECT SUMMARY

FOR NSF USE ONLY			
DIRECTORATE/DIVISION	PROGRAM OR SECTION	PROPOSAL NO.	F.Y.

NAME OF INSTITUTION (INCLUDE BRANCH/CAMPUS AND SCHOOL OR DIVISION)

University of Wyoming
Department of Geology and Geophysics
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PRINCIPAL INVESTIGATOR(S)

James D. Myers and Carol D. Frost

TITLE OF PROJECT A detailed petrologic study of Newberry volcano, Oregon: a quantitative attempt to assess the relative importance of fractionation, crustal assimilation and magma mixing in the evolution of continental volcanic suites.

TECHNICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

Newberry Volcano, which lies 60 km east of the crest of the Cascade Range, is one of the largest Quaternary volcanoes in the conterminous U.S. Recent mapping by MacLeod et al. (1981, 1982) and unpublished $^{87}Sr/^{86}Sr$ data have necessitated a re-interpretation of the evolutionary history of this volcanic center. To determine the relative roles of fractionation, assimilation and hybridization in the evolution of the volcanics, we propose a detailed petrologic investigation of the Newberry suite. Field work, guided by the geologic and stratigraphic framework of MacLeod et al. (1982), will document the temporal and spatial relations of the principal eruptive products. At the same time, samples from DOE cores will provide information on the vertical nature of the volcanic pile. Petrographic study will determine phenocryst phases, their modes, textural relationships, crystallization sequences as well as other important petrographic characteristics. The geochemical nature of the volcanics will be established by major, trace and RE element and neodymium and strontium isotopic analysis. Using this extensive database, we will employ a variety of quantitative models to unravel the evolution of the Newberry suite. Our proposed study has three basic petrologic objectives: 1) to evaluate the relative importance of fractionation, assimilation and magma mixing in the evolution of this continental volcanic suite; 2) to ascertain through comparison of our results with other well-studied continental centers if contamination/assimilation in similar tectonic and geologic environments follows a general petrologic pattern or if each example of basalt magma-crust interaction is a completely unique event; and 3) to establish whether Newberry is part of the Cascade volcanic chain or associated with the intersection of the Basin and Range with the Columbia Plateau.

NSF Form 4 (7-83)

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Introduction

The origin of compositionally diverse igneous suites has remained a prominent topic in the geologic literature most of this century. The convincing arguments of Bowen (1928) persuaded many petrologists that crystal fractionation was the dominant process in the generation of basalt-andesite-dacite-rhyolite volcanic suites. Recent studies have, however, revealed the importance of basalt magma-crust interaction in generating such suites (Myers and Marsh, 1981; Grove et al., 1982; Bacon et al., 1984; Wiebe, 1980). Since basaltic magmas encounter considerable thicknesses (20-50 km) of crust compositionally different from themselves, continental volcanic centers are ideally suited for the study of basalt magma-crust interaction.

Newberry Volcano, which lies 60 km east of the crest of the Cascade Range (Fig. 1), is one of the largest Quaternary volcanoes (>1300 km^2) in the conterminous United States. A composite summit caldera, associated rhyolitic flows and domes, andesitic to rhyolitic pyroclastic deposits, and more than 400 cinder cones rest on a broad basalt/basaltic andesite shield. The entire volcanic system appears to be less than one million years old with numerous Holocene eruptions occurring as recently as 1,400 years ago (MacLeod et al., 1981). While several geologists have studied various aspects of the Newberry Volcano (Higgins, 1973; Beyer, 1973; Williams, 1935, 1957), no comprehensive petrologic study has been made of this compositionally diverse volcanic center. In the light of the reinterpretation of the volcanic history by MacLeod et al. (1981, 1982) and the evidence of basalt magma-crust interaction (see below), a new modern petrologic study of this important Cascade volcano is warranted.

Geologic and geochemical data presently available suggest that some combination of crystal fractionation, crustal assimilation, and hybridization are responsible for the wide range of compositions observed. To evaluate the relative roles of the aforementioned processes, we propose to carry out an extensive petrographic, geochemical, and isotopic study of the Newberry volcanic rocks. If crustal assimilation has been important at Newberry, we will be in a position to evaluate basalt magma-crust interaction, in a general context, by comparing the Newberry system to other volcanic centers such as Edgecumbe (Myers and Marsh, 1981), Medicine Lake (Grove and Donnelly-Nolan, 1986; Grove et al., 1982), and South Sister (Clark, 1983) where assimilation has been demonstrated. By such a comparison, we hope to determine if

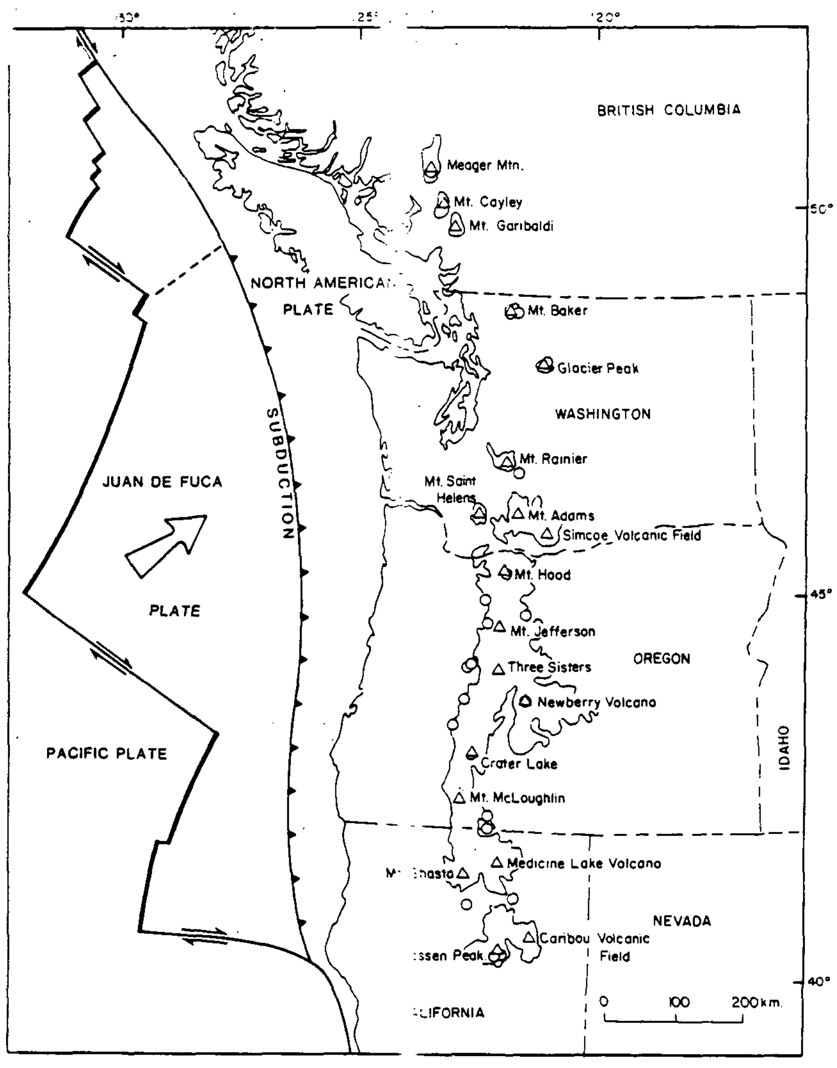

Fig. 1: Map showing plate tectonic setting of Cascade Range. Large arrow indicates direction of convergence between Juan de Fuca and North American plates. Area of Pliocene and Quaternary volcanic rocks is outlined. Triangles mark major volcanoes; circles indicate hydrothermal systems. (From Guffanti and Muffler, 1985).

contamination/assimilation in similar tectonic and geologic environments follows a general petrologic pattern with only minor local variations or if each example of basalt magma-crust interaction is a completely unique event.

Our proposed study is timely not only in regard to the renewed interest in the petrologic development of continental volcanic suites but also in light of the ongoing drilling program at this volcanic center. At the present time, a 900 m deep hole in the caldera and a 1,219 m DOE-funded well on the southern flank of the volcano have been completed. By fall 1986, a second deep core from the northern flank will also be available. These cores provide a rare opportunity to examine a very thick volcanic stratigraphic section and provide an important complement to surface geologic data. Due to the limited core volumes relative to the entire volcanic pile, understanding the recovered sections will require a sound petrologic model of the volcanic center as a whole.

Newberry Volcano

Previous Studies

In a remarkable study, Williams (1935) mapped, in reconnaissance, the flanks of Newberry Volcano and studied the caldera in greater detail. Most subsequent investigations, guided by the work of Williams, have focused on the geology of the caldera or the young flank basalts (Bestland, 1985; Friedmann, 1977; Beyer, 1973; Higgins, 1969, 1973; Higgins and Waters, 1968, 1970; Peterson and Groh, 1969). Recent studies by the Geothermal Research Program of the U.S. Geological Survey have provided substantial new data on the basic geology and stratigraphy of the Newberry system. Foremost among these contributions are a new geologic map and new K-Ar dates (MacLeod et al., 1981, 1982). These data require considerable reinterpretation of the history of the volcano including caldera formation and subsequent volcanic activity. Recent and ongoing investigations of Newberry also include: (1) a U.S. Geol. Sur. geothermal drilling program (Sammel, 1981); (2) an interpretation of magnetic and gravity data (Griscom and Roberts, 1983); (3) a P-wave velocity investigation of the upper crust below the volcano (Stauber et al., 1985); and (4) a DOE funded deep (1200 m) drilling program on the flanks of the volcano.

Regional Setting

Newberry Volcano is a Quaternary shield volcano located in central Oregon about 60 km east of the axis of the High Cascade volcanic chain (Fig. 1). In a regional sense, Newberry lies at the west end of the High Lava Plains. This terrain consists of Miocene to Quaternary basalt flows and vents and associated rhyolitic complexes (Walker, 1974). Analysis of the ages of the rhyolitic rocks shows that Newberry lies at the western end of a well-defined monotonic westward-younging age progression (Fig. 2; MacLeod et al., 1975). Intersecting fault zones appear to have played an important role in controlling vent locations.

General Geology

The following description of Newberry geology is summarized from MacLeod et al. (1981, 1982). The shield underlying the Newberry caldera is about 1 km thick, elliptical in map view (40 km in the north-south direction and 30 km in the east-west direction), and topped by a 6 km wide caldera. The oldest exposed rocks consist of flank basalts and basaltic andesites, rhyolitic domes, and basaltic andesite to rhyodacitic tuffs (Fig. 3). These units yield K-Ar ages of up to 600,000 years. Younger basalt and basaltic andesite cinder cones and associated flows occur in arcuate zones on the flanks and are as young as 5,800 years (carbon-14 age). In contrast to the recent, dominantly mafic eruptions from the flanks, volcanism associated with the summit caldera has been predominantly rhyolitic during the last 6,000 years. The most recent eruption of Newberry Volcano was a rhyolitic extrusion occurring 1,350 years ago.

Considered as a whole, the volcano is made up of greater than 95 percent basalt/basaltic andesite. Published geochemical data indicates that these mafic rocks consist of two divergent compositions - one is calc-alkaline and very similar to High Cascade basalts whereas the other is high-iron tholeiite (Fig. 4; Beyer, 1973). Although the calc-alkaline lavas lie along the major element trends for most oxides, the high-Fe basalts are significantly displaced from these arrays. Figure 4 also shows only minor variation in major element compositions for the silicic rocks at Newberry. Based on trace element abundances, the rhyolitic rocks can, however, be divided into two

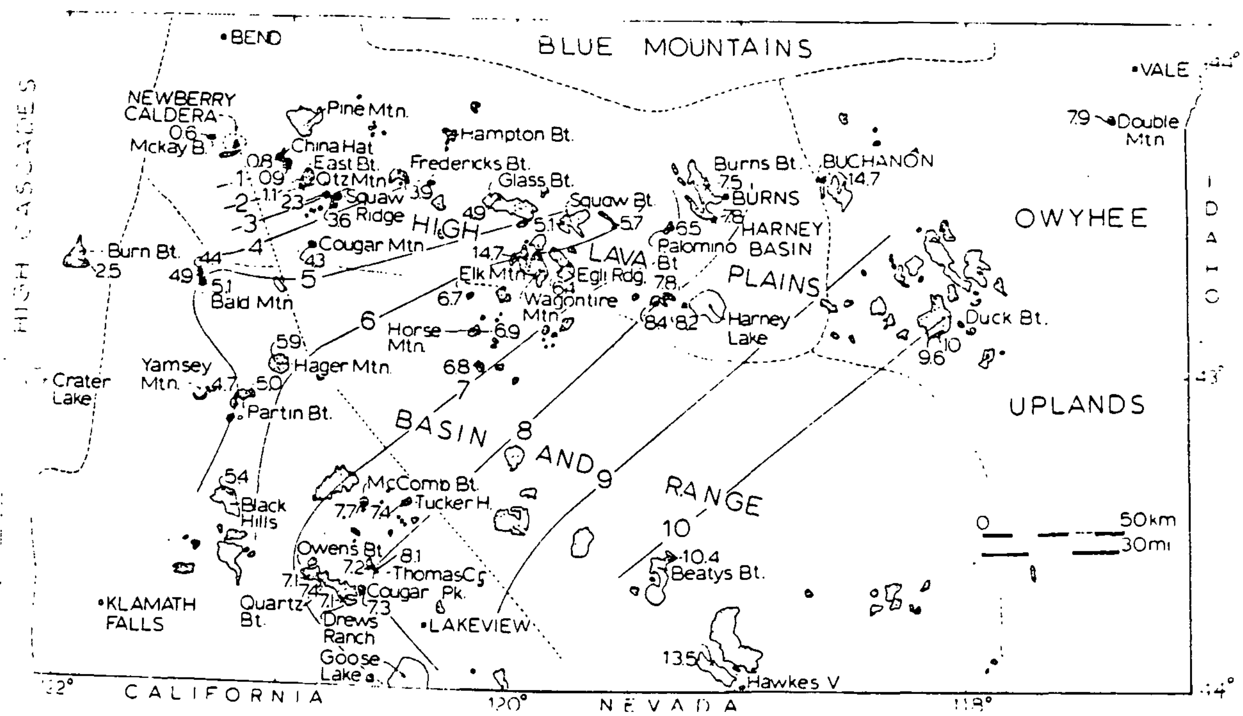

Fig. 2: Map of southeastern Oregon showing radiometric ages of domal rocks (stippled pattern). Isochrons separating ages of domes in 1 m.y. increments are approximate, particularly in the eastern part of the area. From MacLeod et al., 1975.

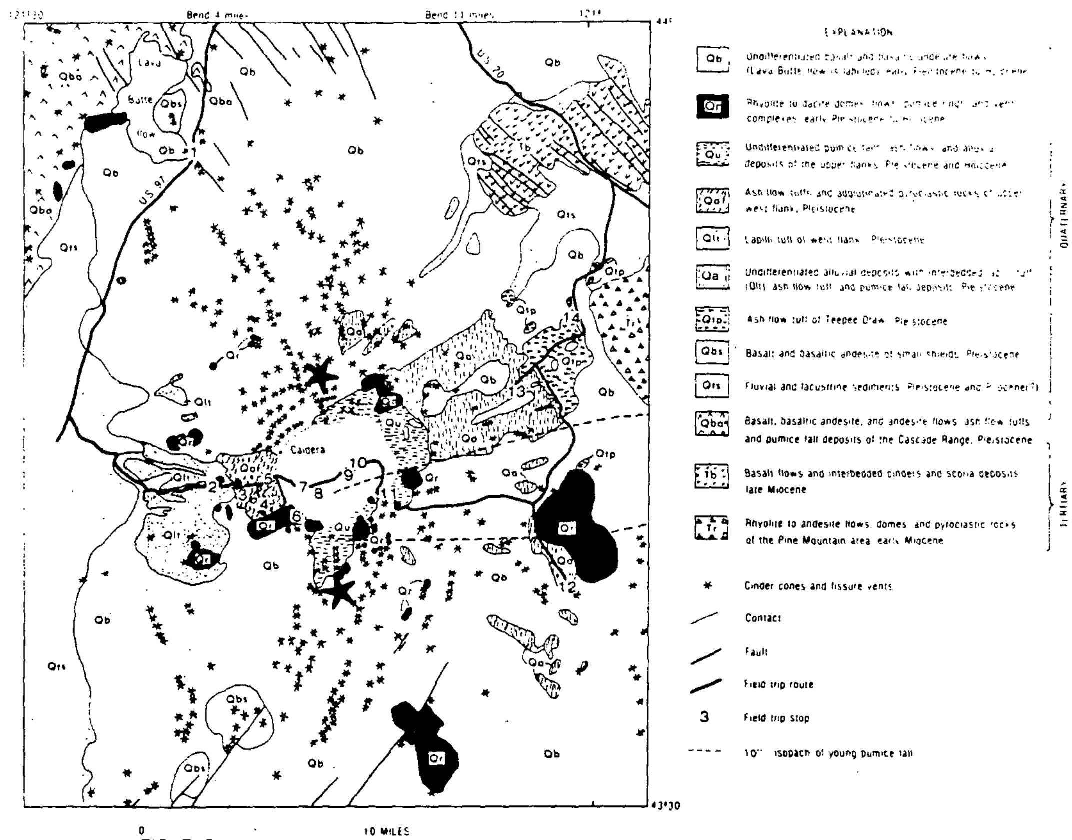

Fig. 3. Geologic sketch map of Newberry volcano. Large stars show locations of DOE core holes N-1 and N-3. North is to the top of the map. From MacLeod et al. (1981).

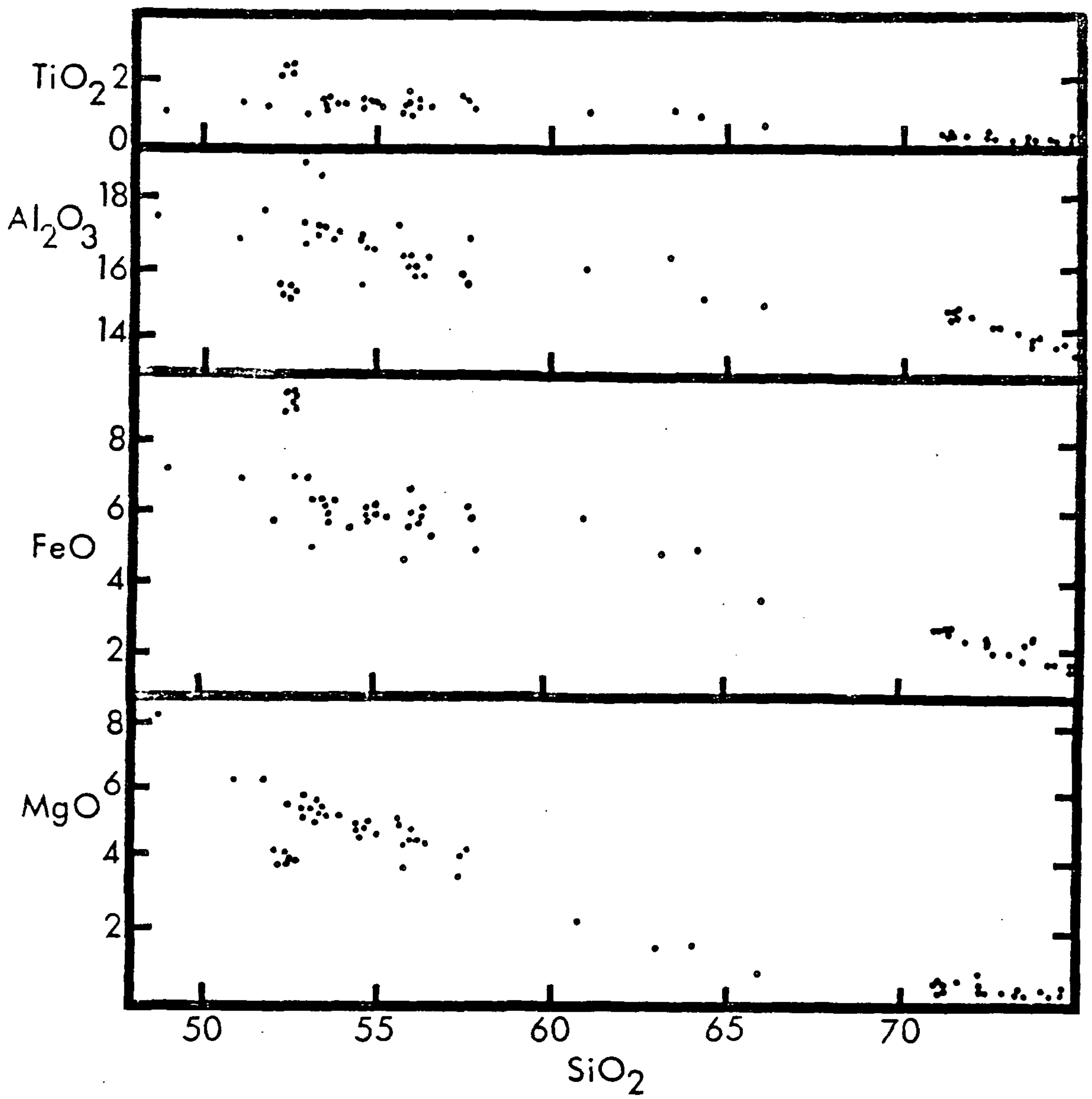

Fig. 4: Major element Harker diagram for Newberry volcanics. Two mafic lava types can be distinguished. The calc-alkaline basalts fall along the trends for the more evolved volcanics whereas the high-Fe tholeiites are significantly displaced from these trends. Data sources: Beyer, 1973; Higgins, 1973.

distinct groups (Fig. 5). One group is characterized by very high Rb/Sr and Ba/Sr ratios whereas the other has much lower ratios. Unlike the mafic and siliceous rocks, volcanics with 53 to 60% SiO_2 define fairly systematic compositional trends (Fig. 4). Several large ash flows, mapped by MacLeod et al. (1982), are variable in composition (andesite to rhyodacite) and include abundant fused xenoliths. Mixed magma textures and phenocryst disequilibrium features are also common in lavas near the caldera (Higgins, 1973). Unpublished strontium isotopic analyses display significant variation (Fig. 6; Sinha, 1985, personal communication).

DOE Drilling Program

The U.S. Department of Energy (DOE) Division of Geothermal and Hydropower Technologies is currently conducting a program to support geothermal industry efforts in the Cascades volcanic region. As part of this cost sharing program, GEO-Newberry Crater, Inc. completed one geothermal gradient hole at Newberry in November, 1985. The hole, corehole N-1, is located 1,067 m (3500 ft) west and 747 m (2450 ft) north of the SE corner of Section 25, T225, R12E in Deschutes County, Oregon (Fig. 3, approximately 8 km south of the southern caldera rim). The 9.65 cm (3.8 in) hole was drilled to a depth greater than 1200 m with 95% core recovery. A second deep (1200 m) hole is being drilled by GEO during the summer of 1986. Scheduled to be completed August, 1986 (the well is at 762 m at this writing - July, 1986), this hole, corehole N-3, is located approximately 7 km north of the northern caldera rim (Fig. 3). A third hole is tentatively scheduled for 1987. The public split of these cores is administered by the Earth Sciences Laboratory of the University of Utah Research Institute (UURI). No petrologic studies of these cores are planned by UURI.

Petrologic Objectives

Previous studies of the Newberry system concluded that the suite was generated entirely through crystal fractionation (Beyer, 1973) controlled in part by the presence of a caldera lake (Higgins, 1973). The significant $^{87}Sr/^{86}Sr$ variation precludes generation of the entire suite by such a process and suggests some of the compositional diversity must result from contamination. The presence of fused xenoliths as well as disequilibrium phenocryst assemblages may also be evidence of basalt magma-crust

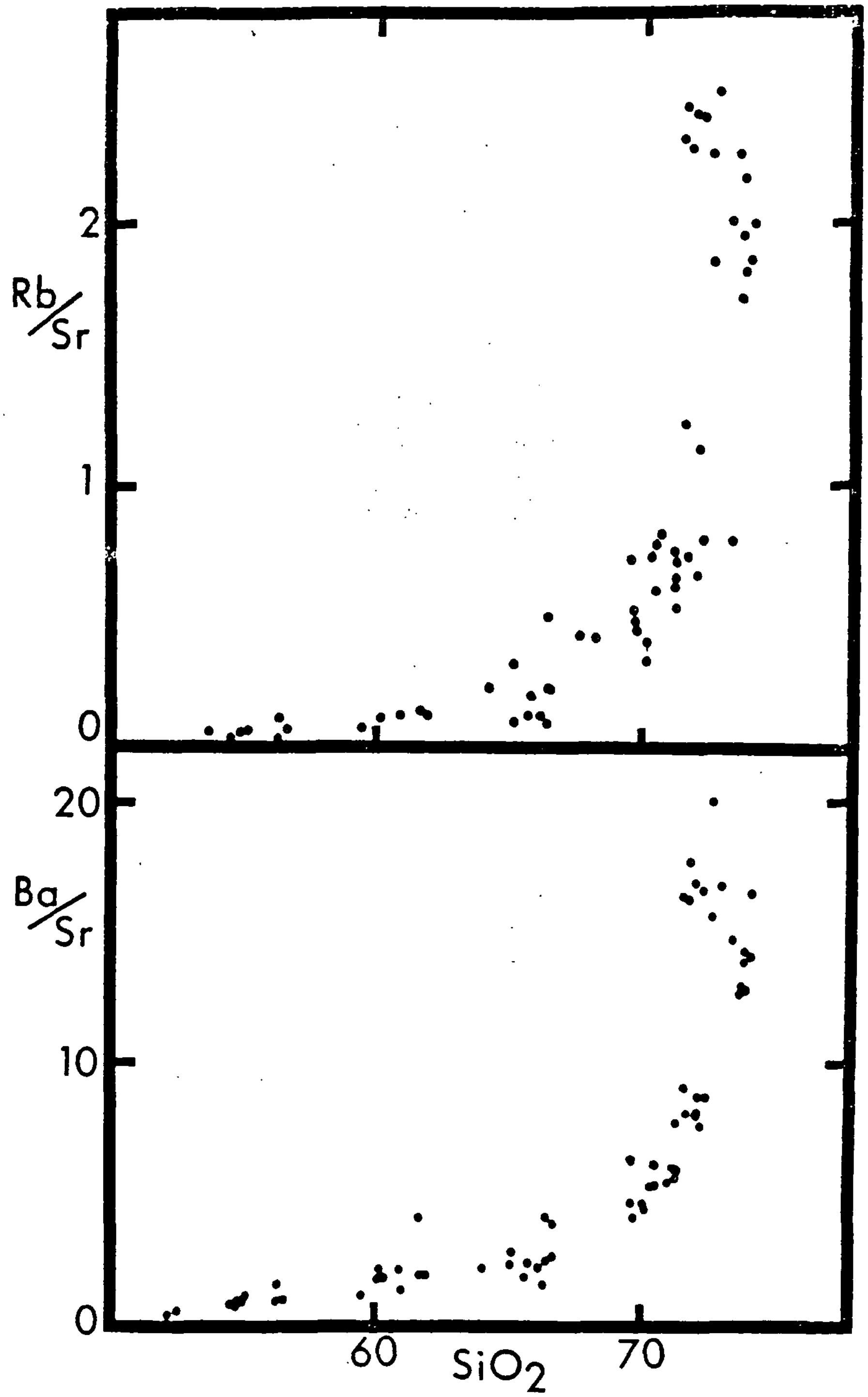

Fig. 5: Rb/Sr and Ba/Sr ratios plotted against silica. At high SiO_2 contents ($\geq$70%), a group of high as well as low ratio lavas exist. Data source: N.S. MacLeod, 1985, unpublished data.

interaction. At the same time, the mixed volcanics may be indicative of magma mixing. Clearly, these results require a reinterpretation of the magmatic evolution of this volcanic center. In particular, some of the questions that must be addressed include:

(1) The nature of the voluminous basalt/basaltic andesite lavas of the shield. Are they related through a long lived fractionating and replenished system or are they magmatic hybrids of some sort? Can we discern a parental magma type for these basic volcanics or has hybridization erased such evidence?

(2) The relationship of the early silicic rocks to the contemporaneous basaltic volcanics of the flanks. Are these rhyolites residual liquids from the basaltic magmas or partial melts of crustal rocks? Was there a single, compositionally stratified magma chamber or did the rhyolitic system evolve independently?

(3) The origin of the andesitic to rhyodacitic pyroclastic rocks. Do they represent explosive interaction of basaltic and rhyolitic magmas?

(4) The relation of the young basalt-rhyolite comagmatic suite to the older volcanics. Was their evolution a continuation of an earlier episode of volcanism or independent yet analogous?

(5) The petrologic connection of the late rhyolitic activity to the mafic volcanism of the cinder cones on the flanks of the basal shield.

Answering these questions requires data that are presently unavailable.

<u>Planned Work</u>

Our work at Newberry is divided into two distinct but closely related phases. One phase involves extensive geologic mapping designed to document temporal and spatial relations of the principal eruptive products. This fieldwork, based on the geologic and temporal framework of MacLeod et al. (1982), will include supplemental mapping at a scale of 1:24,000 and estimation of the variability and volume of individual volcanic units. The other phase involves a petrologic examination of the available DOE cores. Eighty samples, representing all major flow units, have been selected for study from core N-1 (Fig. 7). Similar samples will be obtained from core N-3 when it becomes available in the fall of 1986. Samples taken from the core are sufficient for both thin section and analytical work. Consequently, the proposed work described in the following paragraph refers to core samples as well as surface material.

Extensive petrographic and geochemical analyses will be performed on the Newberry volcanics. Thin section study will determine phenocryst phases, their modes, textural relationships, crystallization sequences as well as other important petrographic characteristics (e.g. presence/absence of xenocrysts and/or xenoliths, zoning patterns, etc.). To determine the geochemical characteristics of the volcanic suite, each sample will be analyzed for major and trace element compositions. A subset of these samples will also be analyzed for REE. Based on the petrographic and bulk rock data, a representative suite of samples will be chosen for extensive microprobe study. For each phenocryst phase, microprobe analysis will determine compositional ranges, zoning, as well as minor element abundances (e.g. Ca in olivine, Al in orthopyroxene). Groundmass mineral compositions will also be determined. In conjunction with petrographic observations and published phase diagrams, the microprobe data will be used to infer the intensive parameters of crystallization (T, P, fH_2O, fO_2). Using field relations, we should be able to detect any changes in these parameters as well as bulk rock characteristics with time. Geochemical models consistent with our analytical data must also be compatible with field relations. Bulk rock strontium and neodymium isotopic analyses from important representative samples, as defined by the first phase of our study, will be used to verify (or negate) the relative roles of the proposed petrologic processes. If deemed useful, we will also attempt to document phenocryst-groundmass isotopic disequilibrium.

Quantitative Modelling

An essential aspect of this project is the formulation of quantitative geochemical models. This modelling can be divided into two parts. First, identification of a parental magma(s) and the determination of its source(s). Recognition of the parental magma must be based as much on geologic as geochemical data. For example, lavas containing abundant

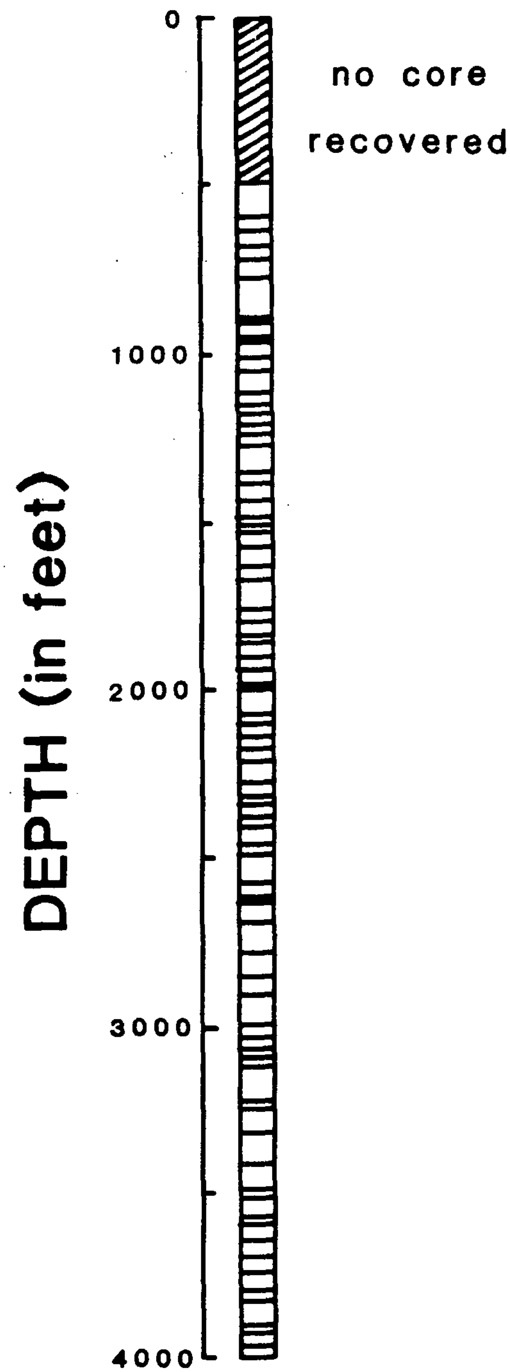

Fig. 7: Schematic representation of DOE Newberry Core N-1 showing locations (horizontal lines) of UW samples.

xenocrysts or xenoliths are unlikely to approximate true liquid compositions. Having identified the parental magma(s), the nature of the source(s) capable of yielding such a liquid(s) must be discerned. Given the tectonic setting, likely magma sources include: 1) the subducted oceanic plate; or 2) the mantle wedge. Using phase projections (O'Hara, 1976; Walker et al., 1979) and the thermodynamic procedure of Carmichael et al. (1977), the capability of each source to yield such liquids will be tested. Employing the equations of Shaw (1970) and Hertogen and Gijbels (1976), we will calculate the trace element abundances of partial melts of these sources and compare them to those of the parental magmas. Strontium and neodymium isotopic data should also be useful in determining the source region of the parental magmas, e.g. the plate-wedge region or perhaps the lower crust.

The second part of this work involves modelling the processes that produced the compositionally diverse volcanic suite. This work can be divided into three interrelated components, i.e. major elements, trace and RE elements, and isotopic compositions. The relative importance of crystal fractionation, contamination/assimilation and magma mixing will be evaluated using various pseudo-ternary phase projections (O'Hara, 1976; Walker et al., 1979; Grove et al., 1982). Possible crystal fractionation trends defined in this manner will be examined in detail using measured phenocryst compositions and mass balance programs (Wright and Doherty, 1970; Stormer and Nicholls, 1978). These results will, in turn, be tested using trace and RE element data (Greenland, 1970; Arth, 1976). Because they are not affected by crystal fractionation, isotopic data can be used qualitatively to test proposed fractionation schemes. On a more quantitative basis, they provide a means of evaluating assimilation and magma mixing. Provided the magmatic end members are not characterized by significant compositional variability, models exist to evaluate simple two component mixing (Vollmer, 1976; Langmuir et al., 1978), combined AFC (DePaolo, 1981), systems with variable contaminant compositions (Myers et al., 1984) and AFC combined with replenishment (DePaolo, 1985). If the proposed end members are compositionally variable, these effects can be accomodated by a new mathematical procedure developed by Myers and Angevine (1986) and Myers et al. (1986a). This technique has proved very useful in examining Aleutian arc magma petrogenesis (Myers et al., 1986b). Because they behave differently in magmas crystallizing plagioclase (i.e. Nd is an incompatible element and Sr compatible), combined Nd and Sr isotopic data will be useful in assessing the details of magma evolution (DePaolo, 1985). The variation in strontium and neodymium isotopic ratios for Newberry materials is expected to be small but significant. The range in $^{87}Sr/^{86}Sr$ measured by Sinha (unpublished data) is from 0.7033 to 0.7038. No neodymium isotopic data are yet available from Newberry but at Mount St. Helens, ε_{Nd} for measured samples varied from +4.1 to +7.7 (Halliday et al., 1983). Ranges in isotopic ratios of this magnitude were sufficient for quantitative petrogenetic modeling at Mount St. Helens (Halliday et al., 1983) and Edgecumbe, Alaska (Myers et al., 1984; Myers and Sinha, 1985). Thus, isotopic data should prove useful for quantitative modelling of Newberry parental magma sources and subsequent processes. These data will also be complemented by extensive geologic, petrographic and geochemical information. Clearly, our extensive database will enable us to employ a variety of quantitative models in our attempt to determine the evolution of the Newberry volcanic suite. This multi-faceted approach offers the best opportunity to distinguish between petrogenetic processes that could have been operative in the Newberry magmatic system.

Petrologic Significance

Recent studies of Quaternary High Cascade volcanoes suggest similar processes are responsible for other compositionally diverse volcanic suites. Grove et al. (1982) and Grove and Donnelly-Nolan (1986) have presented petrographic, geochemical and experimental evidence indicating that fractionation, assimilation and magma mixing combined to produce the lavas at Medicine Lake Volcano. In addition, Eichelberger (1981) has shown physical evidence of mixing between basaltic and rhyolitic magmas in relation to the eruption of the Glass Mountain lava flow. Clark (1983) concluded that the basalt to rhyodacite suite at South Sister Volcano developed from extensive interaction between ascending basaltic magma and silicic crustal rocks at shallow depths. Similar mechanisms of assimilation and magma mixing have been proposed for Mount Adams (Hildreth and Fierstein, 1983), Mount Mazama (Bacon, 1983; Richey, 1980), and Mount St. Helens (Halliday et al., 1983). Knowledge of the relative importance of crystal fractionation, assimilation/contamination and magma mixing is important in understanding the evolution of Cascade volcanic centers.

The Newberry volcanic system has been chosen for this extensive petrologic study for several reasons. The lavas at Newberry display tremendous compositional variation. Contemporaneous silicic to mafic volcanism has occurred until the last few thousand years providing fresh samples necessary for such a study. There is excellent control on the eruptive history of the system from both surficial mapping (MacLeod et al., 1982) and deep drilling. Complementary geophysical studies offer additional data about subsurface magma chamber configuration.

With the completion of our study, extensive databases will be available for at least four continental volcanic centers (i.e. Edgecumbe, Medicine Lake, Mount St. Helens and Newberry). Using these data, we will be able to compare and contrast the evolutionary trends of four centers with similar geologic settings. In particular, comparisons can be made between intercenter spatial and temporal relationships as well as petrographic, geochemical and isotopic characteristics. A detailed comparison of this nature will serve two purposes. First, examination of the intercenter temporal and spatial relationships may shed light on the <u>physical</u> development of continental magma chambers. For example, are continental magma chambers composed of a single, compositionally stratified chamber (Hildreth, 1979, 1981), a large mafic chamber topped by individual magmatic cupolas (Myers and Sinha, 1985) or some other configuration? The physical arrangement of a magma chamber has direct bearing on the geochemical evolution of its magmas as well as on the nature and timing of volcanic eruptions. Secondly, an intercenter comparison may suggest the factors that control the evolution of hybrid liquids. Such variables may include: a) parental magma composition; b) wallrock composition; c) tectonic setting; or 3) the intensive parameters of crystallization and assimilation (i.e. T, P, f_{H2O}, etc.). Determining the relative importance of these factors will be useful in understanding magmatic evolution and planning future petrologic studies. For example, if tectonic setting is of prime importance, specific models could be derived for different settings and used to examine volcanic centers in such settings. In a similar manner, models could be derived for intensive variable controlled evolution. Local control of magmatic evolution (e.g. wallrock and/or parent magma composition) implies, however, that each example of basalt magma-crust interaction is a unique event. In this context, only the most general framework can be derived to guide future studies. Recent regional studies in

Central America (Carr, 1984) and the Andes (Thorpe et al., 1984) conclude that a variety of these factors have combined to produce continental volcanic suites in these arcs. Clearly, knowledge of the factors controlling magmatic evolution at a number of continental volcanic centers is very important.

Additional complexity is added to the Newberry problem when the tectonic setting of the volcano is considered. Spatial association and geophysical data indicate that the High Cascade volcanic chain is related to the subduction of the Juan de Fuca plate beneath North America, though geochemical evidence is not conclusive (McBirney and White, 1982). Although Newberry Volcano is often included as part of the Cascade Range (Fig. 1), it is also located on the westernmost edge of the Basin and Range volcanic province. Some workers have identified Newberry as the youngest in a series of extension related magmatic systems initiated at the intersection of the Basin and Range with the Columbia Plateau (Christiansen and McKee, 1978). Identification of parental magmas at Newberry could aid in resolving these tectono-magmatic questions. If the parental magmas are compatible with a subduction origin, we can contrast the magmatic evolution of the Newberry system with that of other subduction-related volcanoes. For example, comparison of Newberry with island arc volcanoes (e.g. the Aleutians) can be made in terms of mineralogy, eruptive volumes, geochemical and isotopic variability. Differences in these factors must be explained by models of continental volcanism.

Summary

Newberry volcano, which lies 60 km east of the crest of the Cascade Range, is one of the largest Quaternary volcanoes in the conterminous U.S. A composite summit caldera, associated rhyolite flows and domes, andesitic to rhyolitic pyroclastic deposits and more than 400 cinder cones rest on a basalt/basaltic andesite shield. Recent mapping by MacLeod et al. (1981, 1982) has necessitated a re-interpretation of the evolutionary history of this volcanic center. At the same time, unpublished $^{87}Sr/^{86}Sr$ data suggest some component of contamination must have played a role in the generation of the volcanic suite. Consequently, we propose to conduct a detailed petrologic investigation of the compositionally diverse Newberry volcanic suite. In particular, we are interested in determining the relative importance of crystal fractionation, crustal assimilation and hybridization. To accomplish these goals, we plan a combined field and analytical study. Field work, guided by the geologic and stratigraphic framework of MacLeod et al. (1982), will document the temporal and spatial relations of the principal eruptive products. At the same time, the two DOE-cores will provide unique vertical sections through the volcanic pile. Petrographic study will determine phenocryst phases, their modes, textural relationships, crystallization sequences as well as other important characteristics. The geochemical nature of the volcanics will be established by major, trace, and RE element and neodymium and strontium isotopic analysis. Using this extensive analytical database, we will be able to employ a variety of quantitative models to unravel the evolution of the Newberry suite. In particular, we will use major element phase projections and mass-balance calculations to define likely petrogenetic schemes. These models will be tested quantitatively with trace and RE element and isotopic data. Our proposed study has three basic petrologic objectives. First, we wish to evaluate the relative importance of crystal fractionation, crustal assimilation and magma mixing in the evolution of continental volcanic suites. In a larger context, comparison of our Newberry results with data from other well-studied continental centers may allow us to ascertain if contamination/assimilation in similar tectonic and geologic environments follow a general petrologic pattern or if each example of basalt magma-crust interaction is a completely unique event. Finally, identification of the character of Newberry parental magmas may aid in establishing if Newberry is part of the Cascade chain or associated with the intersection of the Basin and Range with the Columbia Plateau.

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Budget	1987	1988	Total
PERSONNEL			
J.D. Myers (1 1/2 mo)	5,990	-	5,990
C.D. Frost (1 mo)	-	3,402	3,402
Scott Linneman, R.A.			
academic year	6,000	6,000	12,000
summer	3,000	3,000	6,000
Secretarial and Clerical	2,500	2,500	5,000
Total Salaries	17,490	14,902	32,392
Fringe Benefits (20% less academic year for RA)	2,298	1,780	4,078
Total Salaries and Fringe	19,788	16,682	36,470
FIELD SUPPORT			
Travel (Laramie-Oregon)	500	500	1,000
Food and supplies (for 2 for 3 months)	2,200	2,200	4,400
ANALYTICAL SUPPLIES			
Thin sections and probe mounts ($10/ea)	2,000	2,000	4,000
Microprobe time ($25/hr)	2,500	2,500	5,000
ICP supplies[1]	2,000	1,000	3,000
Reagent supplies for isotopic analyses (acids, beakers, filaments, etc.)	-	2,000	2,000
Mass spec time ($25/hr)	-	4,500	4,500
REE analysis (reactor time, vials, transportation costs, etc.)	1,000	1,500	2,500
TRAVEL	1,000	1,500	2,500
PUBLICATION (page charges, drafting)	1,500	2,000	3,500
TOTAL DIRECT COSTS	32,488	36,382	68,870
INDIRECT COSTS (39% MTDC)	12,670	14,189	26,859
TOTAL REQUEST	45,158	50,571	95,729

[1]The larger request for 1987 reflects the cost of setting up the sample preparation at UW.

Appendix A: Work Plan and Analytical Procedures

A proposed research project such as this in which both geochemical and petrologic approaches are used requires careful planning and cooperation to obtain the most information from each aspect of the study. We enjoy close contact with Dr. N. S. MacLeod of the U.S. Geol. Sur. Cascade Volcanic Observatory, who oversaw much of the recent work at Newberry Volcano. Our cooperation with Dr. MacLeod allows us access to many U.S. Geol. Sur. samples (including core of the 1981 caldera drillhole) and unpublished analyses of Newberry volcanic rocks. We plan to work closely with Dr. MacLeod throughout the duration of this study.

Due to the magnitude of this project, we have carefully divided responsibilities for the petrographic and geochemical work. As his PhD thesis, Mr. Scott Linneman will be responsible for the geologic field mapping and the petrographic and geochemical analysis of associated samples. The examination of the cores will be largely the responsibility of Dr. James Myers. In all aspects of this part of the project, he will work closely with Mr. Linneman. Thin sections of the N-1 core samples are presently being made and extensive petrographic work will begin in September with probe and geochemical analyses soon after. To facilitate study of our core samples, we will return to UURI in the fall to make a detailed description of the N-1 core. Samples from N-3 will also be obtained sometime this fall.

Field work will begin in August, 1986 and last for at least two months each season. The field work will be detailed (not simply a sampling exercise) as it comprises a critical aspect of the study. No meaningful interpretation of petrographic, geochemical, or isotopic data can be made without sound geologic foundations. Our field work will include: (1) additional detailed mapping in conjunction with that of MacLeod et al. (1982); (2) volume estimates of all key extrusive units; (3) special observation for evidence of physical processes operating (e.g. fused xenoliths and mixed lavas); and (4) collection of an extensive suite of samples for petrography and analytical work. To evaluate their compositional variability, our sample collection will include multiple samples of certain flows.

Extensive petrographic examinations of the samples (core and surficial) collected from Newberry will be made at the University of Wyoming. This work will determine the phenocryst mineralogy and textural relations. The abundances of each phenocryst phase will be determined by point counts using a Swift automated point counter. These data are necessary to evaluate crystallization sequences as well as determine crystallization conditions by comparison with experimental studies.

Whole rock geochemical analyses will be performed by inductively coupled plasma (ICP) spectrometry. Sample solutions will be prepared at the University of Wyoming using the technique of Feigenson and Carr (1985). Spectrometry will be performed at Indiana University (where two ICP spectrometers are run by a full-time technician) with the cooperation of Dr. James Brophy. All samples will be analyzed for major and trace elements (Ba, Sr, V, Cr, Ni, Zr, Sc, Cu). Results from these analyses will define the variability and geochemical trends between and within the lavas. Selected samples will be analyzed for REE abundances by INAA. Samples will be irradiated at the U.S. Geol. Sur. reactor facility in Denver and activities counted using an ultra-pure Ge detector and Canberra MCA both housed in the Chemistry Department at UW. Reduction of spectra will be performed using a

PDP 11/23+ computer and the modified TEABAGS Software (Lindstrom and Korotev, 1982). We obtained our software from Dr. James Hoover of UTEP and are currently performing INAA on a variety of samples including Aleutian and Galapagos volcanic rocks.

Probe work will define the phenocryst compositional ranges, their zoning profiles as well as the abundance of important trace constituents. Computer automated line scans will be made from rim to rim on all phases to determine zoning patterns. These data will be acquired using the University of Wyoming's three channel Cameca microprobe. Using these data, estimates of crystallization temperatures for the andesites and dacites can be obtained from the two pyroxene geothermometer of Lindsley and Anderson (1983). Two oxide geothermometry will also be used whenever possible. Differences in composition between phenocryst and groundmass phases of the same mineral, e.g. the Ca content of olivine as well as pyroxene Al content, will provide qualitative estimates of crystallization pressure.

During the second year of the project after the above petrologic foundations have been laid, select samples will be analyzed for strontium and neodymium isotopes. The work will be performed in the chemical preparation lab and on the VG Sector single collector mass spectrometer at the University of Wyoming under the direction of Dr. Carol Frost. Blanks for Nd, Sm, Rb and Sr at the UW facility are less than 0.15 ng. The mean value for La Jolla Nd on the UW VG Sector is $^{143}Nd/^{144}Nd = 0.511834$ with external precision of 15 ppm, whereas the mean value for NBS-987 Sr is $^{87}Sr/^{86}Sr = 0.710254$ with external precision of 7 ppm. The isotopic data obtained at UW will be used to test the fractionation, assimilation, and variable source models for the Newberry suite.

Appendix B: Personnel

Dr. James D. Myers will be the principal investigator on this project. His recent and ongoing work on the Edgecumbe Volcanic Field and in the Aleutian arc will be strongly complementary to this study of the Newberry system. He will oversee all aspects (geologic, petrographic, geochemical and petrologic) of this project.

Dr. Carol D. Frost will be co-investigator on this project. She has experience using geochemical and oxygen and Sm-Nd, Rb-Sr, and U-Pb isotopic techniques to solve petrologic problems. Her interest in the petrogenesis of continental margin igneous suites dates from her Ph.D. research on Caledonian plutonism. She will oversee the isotopic aspects of this project.

Working with the principal investigators will be a graduate student, Scott Linneman. Before enrolling at the University of Wyoming, this student spent several years in various volcanic terrains including the Cascades for the U.S. Geol. Sur., University of California, Berkeley, and Union Geothermal (UNOCAL). As a result, he is already quite familiar with Cascade geology. Mr. Linneman will be involved in all phases of this study as part of his Ph.D. work.

VITA
JAMES D. MYERS

DEGREES

B.S., Geology, University of Rhode Island, 1973
M.A., Geology, Johns Hopkins University, 1977
Ph.D., Geology, Johns Hopkins University, 1979
Dissertation: Geology and Petrology of the Edgecumbe volcanic field, southeastern Alaska: transform fault volcanism and magma mixing.

PROFESSIONAL EXPERIENCE

1974-1979, Research Assistant, Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, MD 21218

1979-1980, Research Associate, Department of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

1980-1981, Research Geologist, Minerals Research Group, Chevron Oil Field Research, La Habra, CA 90631

1981-present, Assistant Professor, Department of Geology and Geophysics, University of Wyoming, Laramie, WY 82071

PROFESSIONAL AFFILIATIONS:

American Geophysical Union
Geochemical Society
American Mineralogical Society
International Association of Volcanology and Chemistry of the Earth's Interior

GRANT SUPPORT

National Science Foundation EAR-8207063 "Magma Interaction and Mixing: a new model for basalt-andesite-dacite-rhyolite generation" ($54,000) 1982-1985.

National Science Foundation EAR-8419550 "Proposal to upgrade an electron microprobe" ($25,000) 1985.

National Science Foundation EAR-8508118 "The Precambrian Lake Owens Mafic Complex, SE Wyoming: a detailed petrologic investigation of an oxide-rich, unusual layered mafic complex" ($47,500) 1985-1987.

National Science Foundation EAR-8607324 "A detailed petrologic study of Kanaga and Seguam: an attempt to confirm the temporal evolution of Aleutian arc centers" ($62,174) 1987-1989.

James D. Myers

National Science Foundation "A detailed petrologic study of Newberry volcano, Oregon: a quantitative attempt to assess the relative importance of fractionation, crustal assimilation and magma mixing in the evolution of continental volcanic suites." ($95,729) 1987-1989 pending.

ABSTRACTS

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PUBLICATIONS:

Furlong, K.P., and J.D. Myers, 1985, Thermal-mechanical modeling of the role of thermal stresses and stoping in magma contamination: J. Volcanol. Geotherm. Res., vol. 24, pp. 179-191.

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CURRICULUM VITAE

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EDUCATION:	1980-1983	Ph.D. Earth Sciences, University of Cambridge Thesis: Isotopic evolution of continental crust: granite petrogenesis and sediment recycling Supervisor: Prof. R. K. O'Nions
	1979-1980	Diploma (M.Phil), Polar Studies, University of Cambridge Thesis: Geochronology of Svalbard Supervisor: W. B. Harland
	1975-1979	B.A., magna cum laude, Dartmouth College Major: Earth Sciences Thesis: Geochronology and depositional environment of a Late Pliocene age Siwalik sequence enclosing several volcanic tuff horizons, Pind Savikka area, Eastern Salt Range, Pakistan Advisor: Dr. G. D. Johnson
AWARDS AND FELLOWSHIPS:	1980-1983	NSF Graduate Fellowship, University of Cambridge
	1979-1982	Winston Churchill Foundation Scholar, Churchill College, University of Cambridge
	1979-1982	Andrew King Mellon Fellow, Churchill College, University of Cambridge
	1979	Sigma Xi Award for Excellence in Undergraduate Research, Dartmouth College
	1975-1979	Daniel Webster Scholar, Dartmouth College
	1975	National Merit Scholar
	1975	Presidential Scholar
PROFESSIONAL EXPERIENCE:	1983-present	Assistant Professor, Department of Geology and Geophysics, University of Wyoming, Laramie, Wyoming 82071
	1980-1983	Teaching assistant, Department of Earth Sciences, University of Cambridge

SOCIETIES:

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European Union of Geosciences
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Geochemical Society

PUBLICATIONS: Frost, C.D. and Winston, D., Nd isotope systematics of clastic sediments: sedimentary fractionation processes and implications for provenance studies and models of crustal evolution. Journal of Geology, in revision.

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Johnson, G.D., Zeitler, P., Naiser, C.W., Johnson, N.M., Summers, D.M., Frost, C.D., Opdyke, N.D., Tahirkheli, R.A.K., 1982. THe occurrence and fission-track ages of late Neogene and Quaternary volcanic sediments, Siwalik Group, Northern Pakistan. Paleogeography, Paleoclimatology, Paleoecology, 37: 63-93.

Frost, C.D., 1982. A radiogenic and stable isotope investigation of petrogenesis of the Etive Complex. Institute of Geological Sciences, London, Geochemistry and Petrology Division, Stable Isosope Report No. 82. 10 pp.

Frost, C.D., Gray, J., Williams, C., and Teggin, D., 1980. Work on 13 samples sets collected from Svalbard in 1974 for Rb-Sr age determinations. Cambridge Arctic Scientific Programme Internal Report 33. 29 pp.

Frost, C.D. and Marston, B.W., 1978, Wroxton: An Abbey, A History. Cake and Cockhorse, Journal of the North Oxfordshire Historical Society, 7: 137-146.

ABSTRACTS: Frost, C.D., 1986. Interpretation of Sm-Nd isotopic data for coarse-grained clastic sediments. Terra cognita, 6, 217.

Frost, C.D., Myers, J.D., and Angevine, C.L., 1986. A unified major element, trace element and isotopic mass balance approach to Aleutian magma genesis. EOS, 67, 404.

Frost, C.D., Frost, B.R., Koesterer, M.E., Hulseboch, T.P., 1986. Development of Archean crust in the Wind River Mountains, Wyoming. Workshop on early crustal genesis: the world's oldest rocks. LPI technical report number 86-04, 40-45.

Koesterer, M.E., Frost, C.D., and Frost, B.R., 1985. Evidence for the presence of two supracrustal sequences in the central Wind River Mountains, Wyoming. GSA Abstracts with Programs, 17: 632.

Frost, C.D. and Myers, J.D., 1985. The Sr, Nd and Pb isotope systematics of the Aleutian arc: I. Observations. GSA Abstracts with Programs, 17: 587.

Myers, J.D. and Frost, C.D., 1985. The Sr, Nd and Pb isotope systematics of the Aleutian Arc: II. A unified petrologic model. GSA Abstracts with Programs, 17: 672.

Frost, C.D., 1985. A Sm-Nd investigation of Sediment Provenance. EOS, 66: 420.

Frost, C.D. and O'Nions, R.K., 1984. Nd isotopic mass balance in the Mediterranean Sea. GSA Abstracts with Programs, 16: 513.

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Frost, C. D., and O'Nions, R. K., 1983. Nd-isotope study of a major Proterozoic sedimentary succession. Terra cognita, 3: 130.

Frost, C. D., and O'Nions, R. K., 1982. Isotopic constraints from O, Sr, Nd, Pb, on granite petrogenesis. EOS, 63: 461.

Frost, C. D., 1982. Systematic O, Sr, and Nd isotopic study of the Caledonian Etive Complex, Scotland. Colloque International "Geochimie et Petrologie des Granitoides", C. Allegre and J. Didier, organizers, Clermont-Ferrand, France. (Invited paper).

CURRICULUM VITAE

Scott R. Linneman
615 E. Bradley
Laramie, WY 82070
Tel. 307-745-4805

EDUCATION

1985 — Ph.D. graduate student in geology, University of Wyoming Thesis: Petrologic and isotopic evolution of Newberry Volcano, Oregon
Advisor: Prof. J.D. Myers

1983-1985 — Graduate student in geology, University of California, Berkeley
Advisor: Prof. I.S.E. Carmichael

1979-1983 — B.A., magna cum laude, Carleton College.
Major: Geology
Thesis: Quaternary volcanics of the Erzincan Basin, Eastern Turkey: an example of pull-apart basin volcanism

HONORS AND AWARDS:

CARLETON COLLEGE:

Phi Beta Kappa, Sigma Xi, Magna Cum Laude, graduated with Honors from Geology Department, honors in independent research, and honors in comprehensive exercises, Dean's List, Duncan Stewart Fellow (geology fellowship with support), William Carleton Scholar. Salutorian of high school class.

RESEARCH AND WORK EXPERIENCE:

1985-1986 — Teaching assistant, Department of Geology and Geophysics, University of Wyoming

May-August 1985 — Assistant geologist, Union Geothermal Division, Union Oil Company of California.

1983-1985 — Research and teaching assistant, Department of Geology and Geophysics, University of California, Berkeley.

June-August 1983 — Geologic Field Assistant/Assistant Geologist of U.S.G.S. Worked with Peter Lipman at the Questa caldera in N. New Mexico mapping and sampling a complex igneous system.

June-August 1982 — Summer field camp in the British Isles, Dennis S. Wood, Director.

Jan.-June 1982	Undergraduate research in Costa Rica studying lava flow morphology at Arenal Volcano.
August 1981	Geology Field Assistant for Dr. Shelby Boardman in his research on Precambrian sequence near Salida, Colorado.
June-July 1981	Mineral Collection Curator, Carleton College. Identified and classified additions to collection.
Mar. 1981-June 1983	Laboratory Assistant and Teaching Aide, Carleton College Geology Department.

SOCIETIES:

American Geophysical Union
Mineralogical Society of America
Sigma Xi
Geological Society of America

GRANT SUPPORT:

1986	Geological Society of America Research Grant ($1200)
1986	Sigma Xi Research Award ($500)
	Both for 1986 field work at Newberry Volcano, Oregon

PUBLICATIONS:

Heller, P.L., Linneman, S.R. and Angevine, C.L. (1986) "Sea-level cycles in response to supercontinent breakup." EOS, v. 67, p. 372.

Hempton, M.R., and Linneman, S.R. (1984) "Volcanism in the Erzincan Pull-Apart Basin: Age, Composition and Tectonic Significance." EOS, v. 65, p. 1084.

Borgia, A., S. Linneman, D. Spencer, L.D. Morales and J.B. Andre. (1983) "Dynamics of lava flow fronts, Arenal Volcano, Costa Rica." Journal of Volcanology and Geothermal Research, v. 18, p. 303-329.

Linneman, S.R. and Borgia, A. (1983) "Dynamics and kinematics of lava flows, Arenal Volcano, Costa Rica." GSA Abstracts with Programs, v. 15, p. 530.

"Evolution of lava flows and growth of volcanoes: Arenal, Costa Rica" (with A. Borgia in preparation).

Appendix C: Summary of all current and pending research support

	Source of Support	Project Title	Award Amount	Period Covered	% Effort	Research Location
I. James D. Myers						
A. Current Support	NSF	1	23,000	6/86-5/87	10	UW
	NSF	2	30,296	10/86-10/87	15	UW
B. Pending Support						
1. Present Proposal	NSF	3	95,729	5/87-5/89	10	UW
2. Continuing	NSF	2	31,878	10/87-10/88	15	UW
3. Planned	------------------------------			NONE-------------------------		
II. Carol Frost						
A. Current Support	NSF	4	48,750	11/85-11/86	15	UW
	NSF	5	50,000	1/86-1/87	10	UW
B. Pending Support						
1. Present Proposal	NSF	3	95,729	5/87-5/89	10	UW
2. Continuing	NSF	5	50,000	1/87-1/88	10	UW
3. Planned	------------------------------			NONE-------------------------		

1. The Precambrian Lake Owens Mafic Complex, SE Wyoming: a detailed petrologic investigation of an oxide-rich, unusual layered mafic complex.

2. A detailed petrographic study of Kanaga and Seguam: an attempt to confirm the temporal evolution of Aleutian arc centers.

3. A detailed petrologic study of Newberry volcano, Oregon: a quantitative attempt to assess the relative importance of fractionation, crustal assimilation and magma mixing on the evolution of continental volcanic suites.

4. Geochemical and petrologic studies of the amphibolite-granulite transition in Archean rocks of the Wind River Mountains, Wyoming (with B. R. Frost).

5. Petrotectonic evolution of Tobago, West Indies (with A. W. Snoke).

Appendix D: Results from prior NSF support

James D. Myers

NSF award number: EAR-8207063
amount of award: $ 54,000
period of award: 1982-1985

Project title: Magma interaction and mixing: a new model for basalt-andesite-dacite-rhyolite generation.

Using the Edgecumbe volcanics, SE Alaska, we attempted to detail the process of crustal contamination. Earlier work (Myers and Marsh, 1981, CMP) had indicated that the volcanic suite was produced by the interaction of basaltic magma with crustal melts of varying composition. The present study was undertaken to: 1) investigate phenocryst-groundmass isotopic relationships; 2) examine inter-lava isotopic (Sr, Pb) and trace element variations; 3) provide additional petrographic, chemical and isotopic constraints on crustal contaminant; and 4) test the general applicability of our contamination model. Our results have shown that crustal assimilation is an extremely complex process that can only be studied by an integrated field, analytical and theoretical approach. Strontium isotopic results revealed that the strontium content of partial melts varied significantly and had an important effect on hybrid lava isotopic composition. Because of this effect, lavas with low $^{87}Sr/^{86}Sr$ still recorded significant amounts (70% or greater) of crustal contamination. Later Pb isotopic data on the same samples showed that the assumed parent was, in fact, a hybrid magma itself. This secondary contamination was recognized because of the differences in mixing line slopes between the two isotopic systems. In general, Pb isotopic results are similar to Sr and can be explained by the same petrologic process but required a significant revision of the physical model for the magma chamber. The new model envisions the development of the hybrid magmas in individual cupolas above a main basaltic magma chamber. In this manner, hybrid liquids are derived independently of each other thereby allowing extremely complex evolutionary cycles. Because of the difficulty of identifying possible crustal end members at most continental volcanic centers, quantitatively testing this contamination model at other volcanic centers may prove impossible.

Abstracts:

Furlong, K.P., and J.D. Myers, 1982, Magma contamination: role of thermal stresses: EOS, v. 63, p. 458.

Furlong, K.P., and J.D. Myers, 1983, The role of thermal stresses in magma contamination: theoretical aspects: IUGG XVIII General Assembly, IACVEI Symposia, Hamburg, Germany, p. 6.

Myers, J.D., and K.P. Furlong, 1983, The role of thermal stresses in magma contamination: petrologic consequences: IUGG XVIII General Assembly, IACVEI Symposia, Hamburg, Germany,p. 7.

Myers, J.D., and A.K. Sinha, 1984, Pb systematics of crustal assimilation: Geol. Soc. Am. Abstracts with Programs, v. 16, p. 606.

Myers, J.D., B.D. Marsh and A.K. Sinha, 1982, Intra- and inter-volcanic center isotopic variations: Adak and Atka, Aleutian Islands, Alaska: Geol. Soc. Am. Abstracts with Programs, v. 14, p. 573.

Myers, J.D., B.D. Marsh and A.K. Sinha, 1984, Pb isotopic data from two Aleutian volcanic centers: additional evidence for the evolution of lithospheric plumbing systems: EOS, v. 65, p. 1135-1136.

Publications:

Furlong, K.P., and J.D. Myers, 1985, Thermal-mechanical modeling of the role of thermal stresses and stoping in magma contamination: J. Volcanol. Geotherm. Res., v. 24, pp. 179-191.

Myers, J.D., and A.K. Sinha, 1985, A detailed Pb isotopic study of crustal contamination/assimilation: the Edgecumbe volcanic field, SE Alaska: Geochim. Cosmochim. Acta., v. 49, pp. 1343-1355.

Myers, J.D., B.D. Marsh and A.K. Sinha, 1986, Geochemical and strontium isotopic characteristics of parental Aleutian arc magmas: evidence from the basaltic lavas of Atka: Contrib. Mineral. Petrol., in press.

Myers, J.D., B.D. Marsh and A.K. Sinha, 1985, Strontium isotopic and selected trace element variation between two Aleutian volcanic centers, Adak and Atka: implications for the development of volcanic plubming systems: Contrib. Mineral. Petrol., v. 91, pp. 221-234.

Myers, J.D., A.K. Sinha and B.D. Marsh, 1984, Assimilation of crustal material by basaltic magma: strontium isotopic and trace element data from the Edgecumbe volcanic field, SE Alaska: J. Petrol., v. 25, pp. 1-26.

Carol D. Frost

NSF award number: EAR-840844
Amount of award: $ 40,000
Period of award: 1984-1985

Project title: Acquisition of a low-cost thermal ionization mass spectrometer

The purpose of this project was to help fund the purchase of a new microprocessor-bound, easily upgradeable but initially low-cost thermal ionization mass spectrometer. Working with engineers at VG Isotopes, Ltd in Cheshire, U.K., the P.I. helped design what has now become the VG Sector production line, which is operated entirely through an IBM PC/XT and includes new electronics units positioned for easy access during repair. The instrument is supplied so that Daly collector and extra Faraday collectors may be added relatively easily, as may be filament preheat and automated barrel attachments. The instrument, equipped with prototype electronics, was delivered in June, 1985. During the past year we have been evaluting the reliability of the electronics. A second generation of electronic units were installed in February and have proved to be quite robust. The precision obtained both on standards and rocks samples is routinely 15 ppm or better (2 S.E.) for both Sr and Nd isotope ratio measurements.

No publications have yet resulted from this grant.

OMB No. 3145-0058
Exp. Date 12/31/85

APPENDIX V 1987

SUMMARY PROPOSAL BUDGET

ORGANIZATION	FOR NSF USE ONLY		
University of Wyoming	PROPOSAL NO.	DURATION (MONTHS) Proposed	Granted
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR James D. Myers	AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	NSF FUNDED PERSON-MOS. CAL.	ACAD	SUMR	FUNDS REQUESTED BY PROPOSER	FUNDS GRANTED BY NSF (IF DIFFERENT)
1. James D. Myers			1.5	$ 5990	$
2. Carol D. Frost			–	–	
3.					
4.					
5. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
6. (2) TOTAL SENIOR PERSONNEL (1-5)			1.5	5990	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (1) GRADUATE STUDENTS				6000	
4. ( ) UNDERGRADUATE STUDENTS					
5. (1) SECRETARIAL-CLERICAL				2500	
6. (1) OTHER summer support for RA				3000	
TOTAL SALARIES AND WAGES (A+B)				17490	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				2298	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				19788	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $1,000:)					
TOTAL PERMANENT EQUIPMENT				–	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				1500	
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 2. TRAVEL 3. SUBSISTENCE 4. OTHER					
TOTAL PARTICIPANT COSTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				9700	
2. PUBLICATION COSTS/PAGE CHARGES				1500	
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)				32488	
I. INDIRECT COSTS (SPECIFY) 39% of MTDC					
TOTAL INDIRECT COSTS				12670	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				45158	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS GPM 252 AND 253)					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 45158	$

PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
		INDIRECT COST RATE VERIFICATION		
INST. REP. TYPED NAME & SIGNATURE* James E. Todd [signature]	DATE 7/21/86	Date Checked	Date of Rate Sheet	Initials - DGC Program

NSF Form 1030 (4-83) *Supersedes All Previous Editions*

*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPM 233)

OMB No. 3145-0058
Exp. Date 12/31/85

APPENDIX V 1988 SUMMARY PROPOSAL BUDGET

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (MONTHS)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Wyoming

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR
James D. Myers

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	NSF FUNDED PERSON-MOS. CAL.	ACAD	SUMR	FUNDS REQUESTED BY PROPOSER	FUNDS GRANTED BY NSF (IF DIFFERENT)
1. James D. Myers			–	$ –	$
2. Carol D. Frost			1	3402	
3.					
4.					
5. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
6. (2) TOTAL SENIOR PERSONNEL (1-5)			1	3402	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (1) GRADUATE STUDENTS Scott Linneman				6000	
4. ( ) UNDERGRADUATE STUDENTS					
5. (1) SECRETARIAL-CLERICAL				2500	
6. (1) OTHER summer support for RA				3000	
TOTAL SALARIES AND WAGES (A+B)				14902	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) 20% less acad. yr. for RA				1780	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				16682	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $1,000:)					
TOTAL PERMANENT EQUIPMENT				–	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2000	
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 2. TRAVEL 3. SUBSISTENCE 4. OTHER					
TOTAL PARTICIPANT COSTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				15700	
2. PUBLICATION COSTS/PAGE CHARGES				2000	
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)				36382	
I. INDIRECT COSTS (SPECIFY) TOTAL INDIRECT COSTS 39% of MTDC				14189	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				50571	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS GPM 252 AND 253)					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 50571	$

PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
		INDIRECT COST RATE VERIFICATION		
INST. REP. TYPED NAME & SIGNATURE* James E. Todd [signature]	DATE 7/21/86	Date Checked	Date of Rate Sheet	Initials - DGC Program

NSF Form 1030 (4-83) *Supersedes All Previous Editions*

*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPM 233)

OMB No. 3145-0058
Exp. Date 12/31/85

APPENDIX V TOTAL 1987-1988 SUMMARY PROPOSAL BUDGET

ORGANIZATION	FOR NSF USE ONLY		
University of Wyoming	PROPOSAL NO.	DURATION (MONTHS) Proposed	Granted
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: James D. Myers	AWARD NO.		

A. SENIOR PERSONNEL. PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.6. show number in brackets)	NSF FUNDED PERSON-MOS. CAL.	ACAD	SUMR	FUNDS REQUESTED BY PROPOSER	FUNDS GRANTED BY NSF (IF DIFFERENT)
1. James D. Myers			1.5	$ 5990	$
2. Carol D. Frost			1	3402	
3.					
4.					
5. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
6. (2) TOTAL SENIOR PERSONNEL (1-5)			2.5	9392	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (1) GRADUATE STUDENTS Scott Linneman				12000	
4. ( ) UNDERGRADUATE STUDENTS					
5. (1) SECRETARIAL-CLERICAL				5000	
6. (1) OTHER summer support for RA				6000	
TOTAL SALARIES AND WAGES (A+B)				32392	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) 20% less acad. yr. for RA				4078	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				36470	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $1,000:)					
TOTAL PERMANENT EQUIPMENT				–	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				3500	
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $					
2. TRAVEL					
3. SUBSISTENCE					
4. OTHER					
TOTAL PARTICIPANT COSTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				25400	
2. PUBLICATION COSTS/PAGE CHARGES				3500	
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)				68870	
I. INDIRECT COSTS (SPECIFY) 39% of MTDC					
TOTAL INDIRECT COSTS				26859	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				95729	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS GPM 252 AND 253)					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$95729	$

PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
		INDIRECT COST RATE VERIFICATION		
INST. REP. TYPED NAME & SIGNATURE* James E. Todd [signature]	DATE 7/21/86	Date Checked	Date of Rate Sheet	Initials - DGC Program

*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPM 233)

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108—1295
TELEPHONE 801-524-3422

August 4, 1986

Mr. Dennis Olmstead
Department of Geology
and Mineral Industries
910 State Office Building
1400 SW 5th Avenue
Portland, Oregon 97201-5528

Dear Dennis:

We are sending under separate cover the samples from Geo-Newberry Corehole N-1 which we agreed to provide. Also enclosed in the package is a copy of the lithology log for N-1. Regarding rods left in the hole, we understand that there is a 1-1/2 inch iron pipe to TD, which I believe is about 4550 ft. You would have to check with Geo-Operator about the TD because the data below 4000 ft. are not part of the DOE package and have not been delivered to us. We understand that the fluid level was about 1600 ft. below surface at the conclusion of drilling. As far as I know, no static fluid level measurement has been made since drilling ended about November, 1985.

I hope that this completes our obligation to you, but if not, please let me know.

Sincerely,

Mike

Phillip M. Wright
Technical Vice-President

PMW:leo

Encl.

cc: Dan E. Wermiel

VICTOR ATIYEH
GOVERNOR

Department of Geology and Mineral Industries
ADMINISTRATIVE OFFICE
910 STATE OFFICE BLDG., 1400 SW 5th AVE., PORTLAND, OR 97201-5528 PHONE (503) 229-5580

July 8, 1986

Mr. Mike Wright
UURI, Earth Science Lab
391 Chipeta Way, Suite C
Salt Lake City, Utah 84108

Dear Mr. Wright:

In April, 1986, Dennis Olmstead wrote you regarding the GEO Operator Corporation N-1 well, Deschutes Co., Oregon. Certain material was requested from you, which has not yet been received.

Please send the following material to my attention:

a) Representative samples of cores. GEO Operator Corp. has supplied samples from 2000' to total depth. Per our agreement, you are to provide samples from surface down to 2000'. The core samples you are to submit are: 500', 695', 750', 900', 960', 1100', 1180', 1230', 1275', 1350', 1375', 1460', 1600', 1750' and 1870'. The core samples should be approximately 6" in length or a split 6" in length from the named depths.

b) Amounts of rods left in the hole.

c) Depth to water.

d) Continuous lithology descriptions.

You are required to submit this material to us, and your prompt attention to this matter is appreciated.

Best regards,

Dan E. Wermiel

Dan E. Wermiel
Petroleum Geologist

DEW:ab

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108—1295
TELEPHONE 801-524-3422

MEMORANDUM

TO: Susan Prestwich, DOE/ID

FROM: Mike Wright, UURI

SUBJECT: Sampling of GEO Newberry N-1 Core by University of Wyoming

DATE: July 9, 1986

On July 9, 1986, I was visited by Dr. James Myers, professor of geology at the University of Wyoming and by Scott Linneman, his graduate student. The purpose of their visit was to discuss data from the GEO Newberry N-1 corehole and to examine the core and take selected samples of it. Myers has available funding for work on the core and he expects further funding from the NSF. Linneman will be doing a field geologic mapping project at Newberry as part of his PhD work, and will also work on the core. They plan to do petrologic, isotope, probe and bulk chemical analyses of the core samples. The results of this work should start to be available as abstracts and talks by next spring.

I emphasized the need that DOE has to get the maximum amount of scientific results from study of the samples and that they should restrict their sampling to the minimum necessary. I also asked that before they took a one of a kind sample they get this okayed by UURI. They have agreed to these stipulations.

Attached is a list of the samples that they took and for which we can expect research results.

cc: J. Myers
M. Reed
D. Nielson
B. Sibbett

UNIVERSITY OF UTAH RESEARCH INSTITUTE
UURI
EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108—1295
TELEPHONE 801-524-3422

MEMORANDUM

TO: Dr. J. Myers
University of Wyoming
Dept. of Geology
Laramie, Wyoming 82071

FROM: P. M. Wright

RE: Samples taken for study at the University of Wyoming (sample number refers to feet) pieces taken average 4" in length.

DATE: July 10, 1986

3992	2690	1574
3957	2628	1532
3922	2602	1503
3893	2572	1491
3825	2489	1441
3788	2450	1392
3739	2402	1348
3685	2377	1277
3643	2333	1239
3590	2306	1206
3564	2274	1180
3511	2206	1151
3485	2168	1122
3407	2142	1055
3324	2096	1011
3248	2065	976
3220	1997	949
3120	1979	912
3085	1940	897
3063	1904	893
3035	1859	888
3028	1825	775
2993	1798	721
2908	1759	683
2854	1672	626
2778	1631	595
		492

Nov. 22.

To: Mike Wright:

From: Bruce Sibbett

Subject: GEO-Newberry N-1 logs.

After talking with Chan Swanberg and Mike Johnson on Nov. 21 the following estimates on the arrival of data are given.

Data set	Approx. Date Expected
Nov. 9th T° & Gamma log (by Barry Williams)	Dec. 3, '85
Photo set of core 465-4000'	Dec. 3,
Tape logs & transparencies (11/2/85 Dresser Atlas)	Dec 16, '85
Final Report with Drilling History (GEO Rept.)	Dec 16, '85
Publications submitted to Journals	~July to Sept, 1986

I will keep you advised as soon as any of this data comes in.

Mike Bullett and Davie left Bend about noon on thursday, on their way to Boise, Id. They should arrive in SLC today (Nov. 22) with the core.

Bruce.

Bruce

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108—1295
TELEPHONE 801-524-3422

November 13, 1985

MEMORANDUM

TO: Susan Prestwich

FROM: Bruce Sibbett

SUBJECT: GEO-Newberry N-1 Logs

Enclosed is one copy of each log from the Newberry N-1 hole. The temperature increase at 3260' occurs within a 120 foot thick, massive lava flow which is underlain by an ash-flow tuff. The upper few feet of the tuff at 3349 feet is clay altered and impermeable. The combination of the massive lava flow and the clay seal below appears to control the base of the rain curtain. The temperature gradient within the lower part of the rain curtain, 2300 to 3240 is 2.8°F/100' (51°C/km). Within the zone of pyroclastic units and lava flows, 3260 to 3440 ft the gradient is 24.7°F/100' (450°C/km). From 3440 to 4000 ft the gradient is 6.5°F/100' (118.7°C/km). These apparent gradients will change somewhat as the hole temperature equilibrates but I don't expect the overall pattern to change.

Bruce S. Sibbett

BSS/jp

enclosures

03/18/86 10:08 EG&G WCB IF NO.006 001

EG&G Idaho, Inc.
FORM EG&G-1421A
(Rev. 12-84)

Willow Creek Building
Mini-Message Center

RECEIVED
1986 MAR 18 AM 10 09

	FTS	Commercial
3M 9165 auto	583-1898	208-526-1898
3M 9600 auto	583-0726	208-526-0726
3M manual	583-9243	208-526-9243
Confirm	583-1771	208-526-1771

008213

TELECOPIER TRANSMITTAL REQUEST

3-18
Date

MIKE WRIGHT
To

UURI SLC
Organization/Location

SUSAN STIGER
From

EG&G
Organization/Location

Total Pages
Excluding Cover Page 4

Return Original - Yes ______ No X

Name S.J. Stiger Ext. 0457

Location ______

APPENDIX A

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
1069 State Office Building
Portland, Oregon 97201

LAWS AND ADMINISTRATIVE RULES RELATING TO GEOTHERMAL EXPLORATION AND DEVELOPMENT IN OREGON

MISCELLANEOUS PAPER NO. 4

PART 2

REVISED 1981

-36-

Chapter 522

1981 REPLACEMENT PART

Geothermal Resources

CROSS REFERENCES

Air and water pollution control permit for geothermal well drillings and operation, 468.380
Assessment of lands subject to geothermal resource exploration lease for ad valorem taxation, 308.370
Exploration, mining and processing of geothermal resources in areas zoned for farm use, 215.213
Geothermal resource rights on state lands, 273.780

ent may be present during any abandonment operation. If the representative determines that the abandonment is satisfactory, e representative shall approve the abandonment of the well.

(2) Within 30 days after the completion of andonment of any geothermal well, the erator of the well shall make a written port of all work done with respect to the andonment. Within 10 days after the receipt of such report, the department shall nish the operator with a written final proval of abandonment, or a written disapproval of abandonment setting forth the conditions upon which the disapproval is based.

(3) Failure to abandon in accordance with approved method of abandonment, failure submit to the department any notice or ort required by this chapter, or failure to nish the department with any required rmation shall constitute sufficient unds for disapproval of the abandonment uch well.

(4) When the department has issued a tten disapproval of abandonment, the rd may proceed against the operator and surety of the operator as provided for in ORS 522.145 or may bring suit pursuant to ORS 522.810. [1975 c.552 §19; 1981 c.684 §10]

522.250 [1971 c.776 §10; repealed by 1975 c.552 §55]

522.255 Resolution of conflicts between geothermal and water uses. If interference between an existing geothermal well itted under this chapter and an existing r appropriation permitted under ORS ter 537 is found by either the State Geologist or the Water Resources Director, the State Geologist and the Water Resources Director shall work cooperatively to resolve conflict and develop a cooperative management program for the area. In determining action should be taken, they shall consider the following goals:

(1) Achieving the most beneficial use of water and heat resources;

(2) Allowing all existing users of the resources to continue to use those resources to greatest extent possible; and

(3) Insuring that the public interest in ent use of water and heat resources is cted. [1981 c.589 §8]

522.260 [1971 c.776 §30; repealed by 1975 c.552 §55]

ADMINISTRATION

522.275 Administration by State Geologist. Subject to policy direction by the board, the State Geologist shall administer this chapter, the rules and orders made pursuant thereto, and supervise the department in carrying out the provisions of this chapter. [1975 c.552 §20]

522.305 Rules. In accordance with applicable provisions of ORS 183.310 to 183.550, the board may make reasonable rules necessary for the administration of this chapter. [1975 c.552 §22]

522.310 [1971 c.776 §24; repealed by 1975 c.552 §55]

522.315 Final order of department; delivery to operator. Whenever the department gives any written direction concerning any geothermal well and the operator requests in writing that a final order for purposes of ORS 183.310 to 183.550 be made, the department shall, within 15 days after receipt of the notice, deliver such final written order to the operator. [1975 c.552 §24]

522.320 [1971 c.776 §§25, 26; repealed by 1975 c.552 §55]

522.325 Compliance with final order; appeal. (1) The operator of any geothermal well shall within 15 days from the date of the service of any order, either comply with the order or file with the department a written statement that the order is not acceptable, and the reasons therefor, and the statement shall constitute an appeal from such order to the board.

(2) Any final written order of the board may be appealed in the manner provided in ORS 183.310 to 183.550 for appeals from final orders in contested cases. [1975 c.552 §25]

522.330 [1971 c.776 §27; repealed by 1975 c.552 §55]

WELL RECORDS

522.355 Records of well; contents; drill cutting and core samples. (1) The operator of any geothermal well shall keep, or cause to be kept, a careful and accurate log, core record and history of the drilling of the well.

(2) The log referred to in subsection (1) of this section shall show the character and depth of each formation encountered in the drilling of the well; the amount, size and weight of casing used; and the location, depth

and temperature of water-bearing strata, including the temperature, chemical composition and other chemical and physical characteristics of fluid encountered from time to time, so far as determined.

(3) The core record referred to in subsection (1) of this section shall show the depth, character and fluid content of cores obtained, so far as determined from the study and analysis thereof.

(4) The history referred to in subsection (1) of this section shall show the location and amount of sidetracked casings, tools or other material; the depth and quantity of cement in cement plugs; the shots of dynamite or other explosives used; the results of production and other tests during drilling operations; and completion data.

(5) The log referred to in subsections (1) and (2) of this section shall be kept in the local office of the operator and, together with the tour reports of the operator, shall be subject, during business hours, to inspection by the board, or department.

(6) The operator of any geothermal well shall, in addition to furnishing the log, records, and tests required by this section, collect representative drill cuttings. The operator shall additionally, in the event cores are taken, collect representative core samples. The drill cuttings and core samples shall be filed with the department promptly upon completion or upon its written request, and upon the abandonment or upon suspension of operations for a period of at least six months. [1975 c.552 §26; 1977 c.87 §4]

522.355 Filing record with department; exemption from disclosure. (1) Each operator of any geothermal well or his designated agent shall file with the department a copy of the log, history and core record, or any portion thereof, promptly upon completion, or upon the written request of the department at any time after the commencement of the work of drilling any geothermal well, and upon the abandonment or upon suspension of operations for a period of at least six months.

(2) For a period of four years after the receipt of any log, history, core record, or any portion thereof, such record shall be exempt from disclosure as a trade secret pursuant to ORS 192.500 (1) unless the operator gives approval to release the data. [1975 c.552 §27]

UNITIZATION OF GEOTHERMAL RESOURCE AREA

522.405 Unitization; development of unit agreement. (1) When two or more separately owned tracts of land are within an area under which a reservoir is located or reasonably believed to be located, or when there are separately owned interests in all or part of such an area, the board, upon its own motion may or upon the application of an interested person or state or local governmental governing body, special district or agency, shall review the need for unitization of the area. The board by rule or order may require the development of a unit agreement for the geothermal resource area if it finds:

(a) Unitized management, operation and development of the geothermal resources in a reservoir is necessary to increase the ultimate recovery of the resources;

(b) The application of unitized methods of operation will prevent waste and aid efficient production and utilization of the resource; or

(c) Unitization and the unitized method of operation are in the public interest and reasonably necessary to protect the correlative rights of owners.

(2) When the board requires the development of a unit agreement under this section, it shall encourage the development of a voluntary agreement between the affected parties. In the absence of a voluntary agreement, the board shall itself develop or cause to be developed a unit agreement that satisfies the provisions of ORS 273.775, 308.370, 522.005, 522.015, 522.405 to 522.545, 522.815 and 522.990. In adopting a rule or entering an order for a unit agreement, the board shall consider any plant dedicated area agreement in effect and shall not contravene or interfere with that agreement unless it finds that a term or condition of that agreement violates the policies stated in ORS 522.015. The board shall require the development of the resource in accordance with a proposed unit agreement if it finds that the agreement conforms with the provisions of ORS 273.775, 308.370, 522.005, 522.015, 522.405 to 522.545, 522.815 and 522.990.

(3) The development of a unit agreement under subsections (1) and (2) of this section shall be conducted as a rulemaking proceeding in accordance with ORS 183.310 to 183.550 unless an interested party requests that it be conducted as a contested case in accordance

GEO Operator Corporation
A Subsidiary of Geothermal Resources International, Inc.

March 25, 1986

Ronald A. King
U.S. Department of Energy
Idaho Operations Office
550 Second Street, Room 119
Idaho Falls, Idaho 83401

Dear Ron:

The attached letter from the BLM has some complimentary things to say about our last summer's joint drilling program so I thought I would pass it along for your files.

Given the relatively mild winter and warm spring, we could be on the ground by mid-May with our N-3 operations. I will be in further contact with you as soon as we are able to make some definite plans.

Very truly yours,

Chandler A. Swanberg
Vice President
Non-Geysers Project Manager

CAS:yts
Attachment

cc: J. Combs - GEO
S. Prestwich - DOE
P. Wright - UURI

1825 South Grant Street, Suite 900, San Mateo, CA 94402 (415) 349-8181

IN REPLY REFER TO:
3260 (920)

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
OREGON STATE OFFICE
P.O. Box 2965 (825 NE Multnomah Street)
Portland, Oregon 97208

MAR 11 1986

Mr. Mike Cale,
Senior Environmental Coordinator
GEO-Operator Corporation
1330 North Dutton Avenue, Suite A
Santa Rosa, California 95401

Dear Mr. Cale:

We received your letter with Geothermal Drilling Permit (GDP) applications for core holes N-2 and N-3 on your Newberry Flank Unit on March 5, 1986. We appreciate your early communication as well as the previous early notice of a change of the N-2 location.

We do not anticipate any significant problems in processing the applications and expect to complete approval of the N-3 core hole GDP well in advance of drilling time. Issuance of the GDP for core hole N-2 will be subsequent to on-the-ground siting and completion of core hole N-3. To facilitate approval, we would appreciate notice as early as possible on the date you expect to start on-the-ground operation for N-2.

Based on feedback from our own staff and that of the U. S. Forest Service and the Oregon Department of Geology and Mineral Industries, we commend and compliment you and your contractor for the excellent cooperation, professionalism, and efforts to meet regulatory requirements for core hole N-1 operations. In short, it was a job well done. We hope for continued work in that mutually beneficial spirit throughout future operations. Thank you for making the operation so trouble-free.

Sincerely,

Patrick H. Geehan

Patrick H. Geehan
Deputy State Director
for Mineral Resources

RECEIVED
MAR 1? 1986
SAN MATEO

Department of Energy

Idaho Operations Office
550 Second Street
Idaho Falls, Idaho 83401

August 23, 1985

Dr. Chandler Swanberg
GEO Operator Corporation
2300 County Center Drive, Suite 250
Santa Rosa, CA 95401

SUBJECT: Newberry N-1 Corehole Plans Required by Cooperative Agreement

Dear Dr. Swanberg:

The plans transmitted to DOE as required by the cooperative agreement are not formated nor definitive as DOE anticipated. There is no problem with the incorporation of the four specified plans within a single document. However, a clear and concise section for each of the plans should be presented explaining what will be done and how it will be accomplished with a schedule, if applicable. Most of the necessary information for the plans are contained in the submitted materials, but better structure and detail would be preferable. The majority of the issues addressed within the 4.3. Drilling Section appear to be institutional and/or environmental.

The major points of concern are listed below by Plan:

Management Plan - All that has been given are key personnel. No schedule management controls nor responsibility structure are given. A formal submittal of the management structure and controls as described in the GEO proposal and letter response for clarifications would be adequate.

Institutional Plan - The major issues appear to be addressed in the 4.2. Permitting and Environmental Reporting and 4.3. Drilling. Putting that information together in one section would be acceptable. However, the issue not addressed is that DOE must meet its own environmental and institutional requirements independent of those imposed by BLM or Forest Service. We have established a MOU agreement with both agencies to lessen as much duplication as possible for the environmental assessment. But DOE is still responsible as an agency to document environmental actions as the cognizant agency funding the project. Therefore, we will require copies of correspondence, etc. regarding GEO compliance to the Special Lease Stipulations and Plan of Exploration.

Drilling Plan - The plan submitted is a copy of the plan submitted to BLM and is generic to a 4-well situation. This will be acceptable if amended with detail and changes specific to corehole N-1, such as completion with a knock-out plug on the bottom of the 2-3/4" tubing string as stated in the cooperative agreement scope of work. Also a drilling schedule should be submitted describing anticipated major drilling activities and estimated durations.

Data - Collection Plan - This is fairly adequate. However, provisions and schedule data to DOE (UURI) are not covered. Nor has the schedule for data analysis and reports required under the cooperative agreement been incorporated. A description for obtaining and handling artesian fluid samples should be included.

In the interest of expediting this cooperative agreement, DOE wishes to see how the project proceeds, but more formal documentation shall be required under the cooperative agreement.

DOE anticipates approval of the plans when above deliverables are received. DOE Approval of the Plans shall be required prior to any payments under the cooperative agreement.

Very truly yours,

Susan

Susan M. Prestwich
Project Manager
Advanced Technology Division

GEO-Newberry Crater, Inc.
A Subsidiary of Geothermal Resources International, Inc.

4153

August 15, 1985

Mr. Ronald A. King
R & D Contracts Division
Contracts Management Division
U.S. Dept Energy
550 Second St.
Idaho Falls, Idaho 83401

RE: Solicitation # DE SC07-85ID12580

Dear Ron:

Pursuant to your communication of July 18, 1985, GEO Operator Corporation submits the attached data collection Plan for your review and approval. The information is submitted in accordance with section 4.0 (Technical Tasks) subsection 4.4 (Data Collection). Subsections 4.1 (Project Management) 4.2 (Permitting and Environmental Reporting) and 4.3 (Drilling) have been transmitted to your office by Mike Cale dated 8/7/85 and Federal Expressed from our Bend office on 8/14/85. Please let me know ASAP if you need additional documentation from us.

Very truly yours,

Mr. Chandler A. Swanberg

CAS/rs
cc: M. Cale, w/encl.
J. Combs, w/encl.

61419 South Highway 97, Suite A, Bend, OR 97701 (503) 389-6681

4.4 DATA COLLECTION

The purpose of the Core Hole Program is the development of baseline geological and geochemical data to assist in evaluating the presence of and recovery potential of a geothermal resource in a virtually unexplored region. The following paragraphs describe the types of data to be collected and the methodology, including depths, timing/frequency, instrumentations, etc.

Rock sampling-cuttings: The first 400 feet of the hole will be rotary drilled. During this period, roughly 4 lbs of cuttings will be collected at 10 feet intervals, rinsed, logged, divided into two equal splits, bagged, labeled, and placed in temporary storage in Bend, Oregon.

Rock sampling-core: The remainder of the hole will be continuously cored. The core will be handled according to accepted industry standards. These standards are described in the drilling contract between Tonto Drilling and GEO Operator Corporation dated 8/14/85 and transmitted under separate cover to DOE on 8/14/85. The core will be logged daily on site with emphasis on litiology, fractures, joints, faults, alterations, and other gross features. Subsequently, the core will be split for more detailed description of minerology, texture, secondary mineralization, etc. At this point, small samples (up to 2 lbs) will be selected for mercury analysis, thin section preparation, age dating, or other use. Finally, both splits of the core will be removed from the site for temporary storage in Bend, Oregon.

Drilling Records: The driller will keep accurate records of all information pertaining to the drilling of the corehole including, but not limited to, drilling rate, mud and other additives, fluid entries, lost circulation, drilling conditions and/or problems, hole depth, and possibly lithology.

Temperature: Measurement of bottom hole temperature will be taken every 100' or as follows:

a) every 50' if temperatures exceed 125°F.
b) every 30' if temperatures exceed 175°F.

Hydraulic Head: The driller will attempt to locate the depth to water during each trip into the hole.

Drilling Fluid Samples: A sample of core hole fluid will be taken following each trip for a bit change or more frequently if warranted by geologic conditions. The samples will be taken with a Kuster, clock-operated, 1000 ml wireline sampler. Appropriate geochemical "fluid sampling kit" will be available on site including sample bottles, chemicals for stabilizing unstable species, filteration apparatus, etc. Artesian fluids will also be sampled if so warranted by hole conditions.

I don't believe that this will be productive depending on amount of lost circulation - Should be on "out". Hopefully the sample will fit w/in rods.

Data Collection continued

Geophysical well logging: Temperature, caliper, resistivity, gamma, and self-potential logs will be run in the interval between the surface casing and total depth. Density and sonic velocity logs will also be run if tools are available which can operate in the conditions encountered in the hole. The temperature tool will have a precision of 0.01°C. The corehole will be relogged until equilibrium has been obtained.

GEO Operator Corporation
A Subsidiary of Geothermal Resources International, Inc.

August 7, 1985

Ronald A. King
R & D Contracts Branch
Contracts Management Division

Re: Project Management Plan Geo-Newberry
(Solicitation #DE-SCOF-85ID12580

Dear Sir:

Pursuant to your communication of July 18, 1985, GEO Operator Corporation submits the following Project Management Plan for your review and approval. The following information is submitted in accordance with Section 4.0 (Technical Tasks):

4.1 Project Management

PROJECT LOCATION

The following are the approved locations for the Newberry Flank (GEO-Newberry) core hole program:

- Site N-1; East Lake Quad:
  3500' West and 2450' North of the Southeast corner of Section 25, T22S, R12E.
- Site N-3; Fuzztail Butte Quad:
  4100' North and 500' East of the Southwest corner of Section 24, T20S, R12E.
- Site N-4; East Lake Quad:
  1500' North and 2250' West of the Southwest corner of Section 35, T21S, R13E.

The Lessee/Operator for the project will be:

- GEO Operator Corporation
  545 Middlefield Road Suite 200
  Menlo Park, CA 94025

Project Manager

- Chandler Swanberg
  545 Middlefield Rd. Suite 200
  Menlo Park, CA 94025
  (415) 321-5662

Dr. Swanberg shall be the principal contact on any and all questions pertaining to the operations of the Geo-Newberry Project. Unless otherwise directed, all correspondence will be initially transmitted to Dr. Swanberg for review and disposition.

Environmental Affairs

- Michael J. Cale
  2300 County Center Drive
  Santa Rosa, CA 95401
  (707) 523-4272

Geology/Drilling

- Dr. Walter Randall
  2300 County Center Drive
  Santa Rosa, CA 95401
  (707) 523-4272

Land

- Peter Hansen
  545 Middlefield Rd.
  Menlo Park, CA 94025
  (415) 321-5662

Legal

- Tom Hamilton
  545 Middlefield Rd.
  Menlo Park, CA 94025
  (415) 321-5662

4.2 Permitting and Environmental Reporting

The Geothermal Resources Operational Orders, issued under the Geothermal Steam Act of 1970, states "....the Lessee shall be responsible for the monitoring of readily identifiable localized impacts associated with specific activities that are under the control of the Lessee...." (GRO Order 4. General Environmental Protection Requirements). As the project is a federal unit the Oregon State Office of the Bureau of Land Management acted as lead agency for the project. The Prineville District Office, under the direction of Gerald E. Magnusun, was responsible for preparation of the Environmental Assessment.

The following specific impacts were addressed in the Plan of Exploration (Attachment 1) as a potential consequence of the project:

- Aesthetics
- Land Use & Reclamation
- Public Access & Recreational Opportunities
- Slope Stability & Erosion Control
- BIOTA
- Cultural Resources
- Subsidence & Seismicity

- o Air Quality
- o Pits & Sumps
- o Water Quality
- o Noise

On July 29, 1985, the Prinaville office of the BLM issued a Finding Of No Significant Impact (Attachment 2). In accordance with, and pursuant thereto, the Deputy State Director for Mineral Resources, BLM Oregon State Office, issued a Letter of Approval (Attachment 3) dated July 31, 1985.

Completion of the Environmental Assessment, and issuance of the Letter of Approval and Conditonal Drilling Permit (Attachment 4) satisfied federal requirements for Environmental Review of the GEO-Newberry Project. In addition, permits to drill a geothermal well were issued by the State of Oregon, Department of Geology and Mineral Industries on July 8, 1985 (Attachment 5).

The Environmental Assessment process associated with this project has three major objectives which ultimately dictate an Environmental Management Plan:

1. Identifying specific impacts
2. Magnitude of impact
3. Mitigation of impact

As shown in the Plan of Exploration (Attachment 1) GEO Operator Corporation accomplished objectives #1 & 2, and suggested a direction for objective #3. Our proposal coupled with the BLM assessment, including conditions and stipulations attached thereto, makes the goal of properly addressing institutional concerns a realistic expectation. Therefore, GEOOC believes that the criteria outlined in Section 4.2, paragraphs A, B, and C have been satisfied.

4.3 Drilling

The purpose of the Core Hole Program is the development of baseline geophysical data to assist in evaluating the presence of and recovery potential of a geothermal resource in a virtually unexplored region. Existing surface and subsurface characteristics suggest that the Newberry Area would have geothermal capability.

Access to the sites will be via existing roads (Attachment 6) requiring no surface disturbance. Fugitive dust will be controlled as directed by the BLM, Conditions of Approval For Geothermal Drilling, Surface Protection Requirements (5, C) (Attachment 7).

Site preparation will conform to the requirements specified in the Plan of Exploration, Land Use & Reclamation (Attachment 1). Mitigation will include all measures specified in the Condtions of Approval for Geothermal Drilling, Surface Protection Requirements (Attachment 7).

The hole design will conform to the specifications outlined in the approved drilling permits from the BLM and Oregon Department of Geology & Mineral Industries (Attachments 3 & 4).

The drill rig will be a truck mounted rotary rig with a CP50 drill motor (diesel), exhaust driven turbo charged capable of drilling 4,000' core holes. The rig will be supplied by Tonto Drilling Services, 2701 West 900 South, Salt Lake City, Utah 84104.

Well control will be subject to the Conditions of Approval for Geothermal Drilling, Conditions 6 through 18 (Attachment 7).

Drilling fluids will be regulated in accordance with the Conditons of Approval for Geothermal Drilling, Condtion 5; subparagraphs d and e (Attachment 7).

Hole completion will be accomplished as specified in the Conditions of Approval for Geothermal Drilling (Attachment 7).

Plugging and abandonment shall be accomplished in accordance with the Conditions of Approval For Geothermal Drilling, Condition 18 (Attachment 7).

Site restoration shall be subject to the Conditions of Approval For Geothermal Drilling, Condition 5; subparagraphs a through e (Attachment 7), and the specifications contained in the approved Plan of Exploration (Attachment 1).

GEOOC does not anticipate any unusual problems impeding or preventing completion of the core holes.

All drilling and appurtenant operations shall be conducted in such a fashion that insures complicance with all pertinent federal and state health/safety standards. This will include, but not be limited to, adequate noise protection, safety equipment, traffic control, and regulated access on or near equipment. Environmental considerations will be closely monitored, and strict adherence to the Conditions of Approval For Geothermal Drilling will be mandatory to insure compliance with the approved Plan of Exploration.

No site facilities are anticipated for this phase of the project.

The first core hole (N-1) is proposed to be spudded August 19, 1985, and completion not to exceed 45 days thereafter. Snow fall will preclude the drilling of the second core hole (N-3) until June 1, 1986 (approximate). If this hole can be completed by August 15, 1986, we would be in a position to drill N-4 if necessary. This schedule satisfies the terms and conditions of the GEO-Newberry Unitization Agreement.

The Drilling Supervisor will be assigned by Tonto Drilling Services and will be responsible to the Project Manager or his designate. Geologist(s) associated with the drilling operation will be assigned by GEOOC's Chief Geologist (Dr. Walter Randall) with the concurrance of the Project Manager.

The DOE representative shall receive drilling reports in a timely fashion regarding well status and data recovery. Said reports will be disseminated by the Project Manager or his designate.

The comments contained herein respond to the specific questions contained under Section 4.3 (Drilling); paragraph A, and should meet the DOE criteria for the Approved Project Drilling Plan.

MJC:bc

Constitutes institutional plan.

PLAN OF EXPLORATION

NEWBERRY FLANK

(GEO-NEWBERRY)

DESCHUTES COUNTY, OREGON

Project Location

The following are the proposed locations for the Newberry Flank (GEO-Newberry) Core Hole Program:

- N-1: East Lake Quad

  3500' west and 2450' north of the southeast corner of Section 25, T22S, R12E.

- N-2: Paulina Peak Quad

  950' west and 2600' north of the southeast corner of Sec. 32, T21S, R12E.

- N-3: Fuzztail Butte Quad

  4100' north and 500' east of the southwest corner of Sec. 24, T20S, R12E.

- N-4: East Lake Quad

  1500' north and 2250' west of the southwest corner of Sec. 35, T21S, R13E.

Operations

The lessee/operator for the project will be:

- GEO Operator Corporation for GEO-Newberry
  2300 County Center Drive, #250
  Santa Rosa, CA 95401
  (707) 523-4272

Key personnel assigned to the project are:

- Chandler Swanberg (Project Manager)
  545 Middlefield Road
  Menlo Park, CA 94025
  (415) 321-5662

- Michael Cale (Senior Environmental Coordinator/Regulatory Liaison)
  2300 County Center Drive, #250
  Santa Rosa, CA 95401
  (707) 523-4272

o Michael Johnson (Project Geologist)
2300 County Center Drive, #250
Santa Rosa, CA 95041
(707) 523-4272

Location of a field office will be provided when established.

Project Description

The core hole program is a low-key operation utilized in developing baseline geophysical data. This information is a preliminary step in evaluating resource recovery potential in a virtually unexplored region that suggests the presence of geothermal capability. The project will consist of the following:

- o Preparation of up to four (4) drilling locations and mud pits (total area: 100' x 100'± per site)
- o Utilizing a truck-mounted rotary drill rig, the core holes will be drilled to a maximum depth of 4000'.
- o Log temperatures and collect core samples.
- o Rig down.
- o Continue logging.
- o Abandonment.
- o The project should begin not later than July 1, 1985, and terminate November 1, 1986 (estimates).

Drilling Program

- o Prepare drill location.
- o Rig-up.
- o Spud 5-5/8" diameter hole and drill to 400'.
- o Record mud return temperature and collect core samples.
- o Run 400' of 4-1/2" casing with cementing shoe.
- o Install cementing head and pressure cement to fill annulus to surface.
- o Cut off casing approximately 2' below ground level and install B.O.P.E. flange.
- o Install 2" fill-up line and blowdown line below flange.
- o Install B.O.P.E. equipment.

- Wait 24 hours for cement to set; lower one joint of drill pipe into hole; close preventer and test to 300 psi.
- After completing successful B.O.P.E. test, drill out shoe and continue drilling with mud system to T.D.
- Record temperatures of mud returns and collect cores to T.D.
- When T.D. is reached circulate to clean out cuttings and condition hole.
- Run bull-plugged string of 2-3/4" tubing to T.D. and fill with water.
- Backfill annulus with Sure-Gel or equivalent.
- Remove B.O.P.E. and wellhead.
- Install locking cap on tubing.
- Rig-down and remove drill rig, support vehicles, and materials from site.
- Backfill mud pits and grade to original contour.
- Clean area of debris and restore to (as near) original condition.
- Run temperature and gamma-ray logs at least twice (1 month interval) prior to final abandonment.

Environmental

Pursuant to the Geothermal Resources Operational Orders, issued under the Geothermal Steam Act of 1970, the lessee shall be responsible for the monitoring of readily identifiable localized impacts associated with specific activities that are under the control of the lessee (GRO Order 4. General Environmental Protection Requirements).

Specific impacts that may be associated with this project, and mitigation measures proposed to reduce said impacts to a level of insignificance are as follows:

- Aesthetics

  Compatibility with the existing view shed is a primary goal. The short-term duration of each drilling operation (30-45 days) coupled with the low profile of a truck-mounted rotary drill rig (30'± to top of mast) ensure that visual intrusion will not be significant. Additionally, sites have been selected that are well removed from populated areas and traditional recreation centers in the Deschutes/Newberry region.

- Land Use and Reclamation

  The project has been designed to reduce vegetation impacts to a minimum. Access will be via the existing road network to the pad location. The pad area will require only clearing and grading an area approximately 100' x 100'. When the project terminated, the area will be graded to as near the original contour, and revegetated with similar vegetation species as directed by BLM. Aquatic habitat will not be impacted, and water will only be secured as directed by the State Watermaster. At project termination, all debris, scrap, or other materials imported by the operator shall be removed.

The project proposed by GEO Operator Corporation meets the criteria for exploration and development of a managed resource as defined by the United States Department of the Interior. Additionally, the project is compatible with the Deschutes County Geothermal Element as incorporated into the Deschutes County Comprehensive Plan and Zoning Ordinance.

- Public Access/Recreational Opportunities

  The short duration of each drilling operation, minimal amount of surface area required, and isolated location ensure that public access will be maintained, and that recreational value of the Deschutes/Newberry area will not be adversely impacted.

- Slope Stability/Erosion Control

  The project is so designed that with maximum surface disturbance, slope stability could not be an issue. Mud pits are constructed to a standard that alleviates the potential of encroachment on a natural drainage course, or deposition of sediment/drilling waste into a waterway. As previously described, at project termination, the sites will be regraded to as near the original contour, and revegetated with native species as required by BLM.

- Biota

  A core drilling project does not have the potential (long-term) to adversely impact the associated flora and/or fauna (terrestrial or aquatic). The drilling operation could temporarily inconvenience some species, particularly avian raptors, causing a minor alteration in migration and/or hunting habits. Historically, these types of operations have not produced any noticeable adverse impact to biota.

- Cultural Resources

  In the event a cultural or historic resource is located on or near any of the drill sites. the location will be shifted, under the direction of BLM, to preserve the integrity of the resource. As a core drilling program is designed to incorporate maximum flexibility, at the discretion of the permitting agency, avoidance of any area of significant value is easily accomplished.

- Subsidence and Seismicity

  Concerns regarding geothermal resource production would not be an issue during a core drilling program.

- Air Quality

  The project as proposed does not have the potential to adversely impact ambient air quality.

o **Pits and Sumps**

During the core drilling operation, waste material (cuttings/drilling medium) will be directed to a waste sump for containment. The sumps will be constructed and lined with an impervious material to ensure the integrity of the natural environment, and eliminate the potential of contaminants entering a drainage course or waterway. At the conclusion of the drilling operation, the sumps will be purged as directed by the BLM prior to backfilling. As part of site restoration, the sumps/pads will be regraded to as near the original contour and revegetated per BLM requirements.

o **Water Quality**

The project, as defined, does not have the potential to degrade water quality.

o **Noise**

Due to the isolated locations proposed and the nature of the equipment involved, the project will not impact on any human receptors. Intrusion by humans in a remote area may have the ability to disrupt some wildlife species, particulary avian raptors, which rely on a keen sense of hearing to locate and secure a food source. However, the limited scope of the project adequately mitigates significant short-term, and precludes any long-term impact from occurring.

It is the position of GEO Operator Corporation that the project, as proposed, does not have the potential to produce any significant long-term environmental impacts. Utilizing Best Management Practices and conditions proposed by BLM, short-term effects will be reduced to a level of insignificance.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY, CONSERVATION DIVISION

GEOTHERMAL DRILLING PERMIT

Newberry Flank (GEO Newberry)

Well No.: N-1

Field or Area: Newberry

Sec., T., R.: 25 22S 12E

County: Deschutas

State: Oregon

Approx. starting date: July 85

Acres assigned (well spacing): N/A

Status: Core Hole to be drilled. No existing wells

Operator Corporation (GEO-Newberry)

) County Center Dr. #250 Santa Rosa, CA 95401

3500' West & 2450' North of the Southeast corner of Sec 25, T22S, R12E

N/A

miles south of inner sourthern boudary of unit

5 miles from N-2

)'West & 2500' North of the Southwest corner of Sec 24, T20S, R12E

Proposed depth: 4,000'

Elevation: 5350'

Size of hole	Size of casing	Weight per foot	Coupling (Collars & Threads)	Grade	Setting depth Top	Setting depth Bottom	Quantity of cement
5/8"	4½"	7.7#	Diamond Drill Flush Joint 3 threads/in.	A-120	Surf	400'	25 cu. ft.
/8"	2-3/4"	5.4#	Flush Joint	J-55	Surf	4,000'	14.7 cu. ft. Shur-Gel

fer to attached Drilling Program.

Michael J. Cale (signature)

Title: Senior Environmental Coordinator

Date: 3-26-85

(See instructions on reverse side)

GEOTHERMAL DRILLING PERMIT

...ological Survey requires this form or other Supervisor approved form to be prepared and filed in ... with requisite attachments with the Supervisor. The Supervisor must approve this permit prior to operation.

OF WORK: DRILL NEW WELL ( ) DEEPEN ( ) REDRILL ( ) PLUG BACK ( ) DIRECTIONALLY DRILL ( ) OTHER (X)

TYPE: PRODUCTION ( ) INJECTION ( ) HEAT EXCHANGE ( ) OBSERVATION ( ) WATER SUPPLY ( ) OTHER (X)

STATUS: Core hole to be drilled. No existing wells

OF LESSEE/OPERATOR: Operator Corporation (GEO-Newberry)

ADDRESS OF LESSEE/OPERATOR: 0 County Center Dr.#250 Santa Rosa, CA 95401

LOCATION OF WELL: 4100'North & 500'East of the Southwest corner of Sec 24 T20S, R12E

N/A

DISTANCE FROM PROPOSED LOCATION TO NEAREST PROPERTY OR LEASE LINE: miles south of outer northern boundary of unit

DISTANCE FROM PROPOSED LOCATION TO NEAREST WELL, DRILLING, COMPLETED, OR APPLIED FOR ON THIS LEASE: iles from N-2 (950'West & 2500'North of the Southeast corner of 32, T21S, R12E

LEASE SERIAL NO.:

SURFACE MANAGER: FEDERAL ( ) STATE ( ) OTHER ( )

UNIT AGREEMENT NAME: Newberry Flank(GEO Newberry)

WELL NO.: N-3

PERMIT NO.:

FIELD OR AREA: Newberry

SEC., T., R., B.& M.: 24 20S 12E

COUNTY: Deschutes

STATE: Oregon

APPROX. STARTING DATE: July 1985

N/A

PROPOSED DEPTH: MEASURED: 4000' TRUE VERTICAL:

ELEVATIONS: ... 5750'

PROPOSED CASING AND CEMENTING PROGRAM:

SIZE OF HOLE	SIZE OF CASING	WEIGHT PER FOOT	COUPLING (Vallurec & Threads)	GRADE	SETTING DEPTH TOP	SETTING DEPTH BOTTOM	QUANTITY OF CEMENT
5/8"	4½"	7.7#	Diamond Core Drill Flush Joint 3 threads/in.	A-120	Surf	400'	25 cu.ft.
/8"	2-3/4"	6.4#	Flush Joint	J-55	Surf	4,000'	14.7 cu.ft. Snur-Gel

...er to attached Drilling Program.

(See additional space on reverse side if needed)

Michael J. Cole

Michael J. Cole TITLE Sr. Env. Coordinator DATE 3-26-85

TITLE DATE

(See Instructions on reverse side)

Mike - Bruce + I commented on this for Susan. She wants to "watch this one like a hawk"

Dan.

Pmw ?

4157

wberry Crater, Inc.
ermal Resources International, Inc.

gust 15, 1985

51D12580

Dear Ron:

Pursuant to your communication of July 18, 1985, GEO Operator Corporation submits the attached data collection Plan for your review and approval. The information is submitted in accordance with section 4.0 (Technical Tasks) subsection 4.4 (Data Collection). Subsections 4.1 (Project Management) 4.2 (Permitting and Environmental Reporting) and 4.3 (Drilling) have been transmitted to your office by Mike Cale dated 8/7/85 and Federal Expressed from our Bend office on 8/14/85. Please let me know ASAP if you need additional documentation from us.

Very truly yours,

Chandler A. Swanberg

Mr. Chandler A. Swanberg

CAS/rs
cc: M. Cale, w/encl.
J. Combs, w/encl.

61419 South Highway 97, Suite A, Bend, OR 97701 (503) 389-6681

4.4 DATA COLLECTION

The purpose of the Core Hole Program is the development of baseline geological and geochemical data to assist in evaluating the presence of and recovery potential of a geothermal resource in a virtually unexplored region. The following paragraphs describe the types of data to be collected and the methodology, including depths, timing/frequency, instrumentations, etc.

Rock sampling-cuttings: The first 400 feet of the hole will be rotary drilled. During this period, roughly 4 lbs of cuttings will be collected at 10 feet intervals, rinsed, logged, divided into two equal splits, bagged, labeled, and placed in temporary storage in Bend, Oregon.

Rock sampling-core: The remainder of the hole will be continuously cored. The core will be handled according to accepted industry standards. These standards are described in the drilling contract between Tonto Drilling and GEO Operator Corporation dated 8/14/85 and transmitted under separate cover to DOE on 8/14/85. The core will be logged daily on site with emphasis on litiology, fractures, joints, faults, alterations, and other gross features. Subsequently, the core will be split for more detailed description of minerology, texture, secondary mineralization, etc. At this point, small samples (up to 2 lbs) will be selected for mercury analysis, thin section preparation, age dating, or other use. Finally, both splits of the core will be removed from the site for temporary storage in Bend, Oregon. *Specify Hg analysis intervals.*

split 100%

Drilling Records: The driller will keep accurate records of all information pertaining to the drilling of the corehole including, but not limited to, drilling rate, mud and other additives, fluid entries, lost circulation, drilling conditions and/or problems, hole depth, and possibly lithology.

Temperature: Measurement of bottom hole temperature will be taken every 100' or as follows:

a) every 50' if temperatures exceed 125°F,
b) every 30' if temperatures exceed 175°F.

Hydraulic Head: The driller will attempt to locate the depth to water during each trip into the hole.

Drilling Fluid Samples: A sample of core hole fluid will be taken following each trip for a bit change or more frequently if warranted by geologic conditions. The samples will be taken with a Kuster, clock-operated, 1000 ml wireline sampler. Appropriate geochemical "fluid sampling kit" will be available on site including sample bottles, chemicals for stabilizing unstable species, filteration apparatus, etc. Artesian fluids will also be sampled if so warranted by hole conditions.

— need aquifer fluid samples

I don't believe that this will be productive depending on amount of lost circulation — Should be an "out". Hopefully the sampler will fit w/in rods.

Data Collection continued

Geophysical well logging: Temperature, caliper, resistivity, gamma, and self-potential logs will be run in the interval between the surface casing and total depth. Density and sonic velocity logs will also be run if tools are available which can operate in the conditions encountered in the hole. The temperature tool will have a precision of 0.01°C. The corehole will be relogged until equilibrium has been obtained.

GEO Operator Corporation
A Subsidiary of Geothermal Resources International, Inc.

August 7, 1985

Ronald A. King
R & D Contracts Branch
Contracts Management Division

Re: Project Management Plan Geo-Newberry
(Solicitation #DE-SCOF-85ID12580

Dear Sir:

Pursuant to your communication of July 18, 1985, GEO Operator Corporation submits the following Project Management Plan for your review and approval. The following information is submitted in accordance with Section 4.0 (Technical Tasks):

4.1 Project Management

PROJECT LOCATION

The following are the approved locations for the Newberry Flank (GEO-Newberry) core hole program:

- Site N-1; East Lake Quad:
  3500' West and 2450' North of the Southeast corner of Section 25, T22S, R12E.
- Site N-3; Fuzztail Butte Quad:
  4100' North and 500' East of the Southwest corner of Section 24, T20S, R12E.
- Site N-4; East Lake Quad:
  1500' North and 2250' West of the Southwest corner of Section 35, T21S, R13E.

The Lessee/Operator for the project will be:

- GEO Operator Corporation
  545 Middlefield Road Suite 200
  Menlo Park, CA 94025

Project Manager

- Chandler Swanberg
  545 Middlefield Rd. Suite 200
  Menlo Park, CA 94025
  (415) 321-5662

2300 County Center Dr., Suite 250, Santa Rosa, CA 95401 (707) 523-4272

Dr. Swanberg shall be the principal contact on any and all questions pertaining to the operations of the Geo-Newberry Project. Unless otherwise directed, all correspondence will be initially transmitted to Dr. Swanberg for review and disposition.

Environmental Affairs

- Michael J. Cale
  2300 County Center Drive
  Santa Rosa, CA 95401
  (707) 523-4272

Geology/Drilling

- Dr. Walter Randall
  2300 County Center Drive
  Santa Rosa, CA 95401
  (707) 523-4272

Land

- Peter Hansen
  545 Middlefield Rd.
  Menlo Park, CA 94025
  (415) 321-5662

Legal

- Tom Hamilton
  545 Middlefield Rd.
  Menlo Park, CA 94025
  (415) 321-5662

4.2 Permitting and Environmental Reporting

The Geothermal Resources Operational Orders, issued under the Geothermal Steam Act of 1970, states "....the Lessee shall be responsible for the monitoring of readily identifiable localized impacts associated with specific activities that are under the control of the Lessee...." (GRO Order 4. General Environmental Protection Requirements). As the project is a federal unit the Oregon State Office of the Bureau of Land Management acted as lead agency for the project. The Prineville District Office, under the direction of Gerald E. Magnusun, was responsible for preparation of the Environmental Assessment.

The following specific impacts were addressed in the Plan of Exploration (Attachment 1) as a potential consequence of the project:

- Aesthetics
- Land Use & Reclamation
- Public Access & Recreational Opportunities
- Slope Stability & Erosion Control
- BIOTA
- Cultural Resources
- Subsidence & Seismicity

- o Air Quality
- o Pits & Sumps
- o Water Quality
- o Noise

On July 29, 1985, the Prineville office of the BLM issued a Finding Of No Significant Impact (Attachment 2). In accordance with, and pursuant thereto, the Deputy State Director for Mineral Resources, BLM Oregon State Office, issued a Letter of Approval (Attachment 3) dated July 31, 1985.

Completion of the Environmental Assessment, and issuance of the Letter of Approval and Conditonal Drilling Permit (Attachment 4) satisfied federal requirements for Environmental Review of the GEO-Newberry Project. In addition, permits to drill a geothermal well were issued by the State of Oregon, Department of Geology and Mineral Industries on July 8, 1985 (Attachment 5).

The Environmental Assessment process associated with this project has three major objectives which ultimately dictate an Environmental Management Plan:

1. Identifying specific impacts
2. Magnitude of impact
3. Mitigation of impact

As shown in the Plan of Exploration (Attachment 1) GEO Operator Corporation accomplished objectives #1 & 2, and suggested a direction for objective #3. Our proposal coupled with the BLM assessment, including conditions and stipulations attached thereto, makes the goal of properly addressing institutional concerns a realistic expectation. Therefore, GEOOC believes that the criteria outlined in Section 4.2, paragraphs A, B, and C have been satisfied.

4.3 Drilling

The purpose of the Core Hole Program is the development of baseline geophysical data to assist in evaluating the presence of and recovery potential of a geothermal resource in a virtually unexplored region. Existing surface and subsurface characteristics suggest that the Newberry Area would have geothermal capability.

Access to the sites will be via existing roads (Attachment 6) requiring no surface disturbance. Fugitive dust will be controlled as directed by the BLM, Conditions of Approval For Geothermal Drilling, Surface Protection Requirements (5, C) (Attachment 7).

Site preparation will conform to the requirements specified in the Plan of Exploration, Land Use & Reclamation (Attachment 1). Mitigation will include all measures specified in the Condtions of Approval for Geothermal Drilling, Surface Protection Requirements (Attachment 7).

The hole design will conform to the specifications outlined in the approved drilling permits from the BLM and Oregon Department of Geology & Mineral Industries (Attachments 3 & 4).

The drill rig will be a truck mounted rotary rig with a CP50 drill motor (diesel), exhaust driven turbo charged capable of drilling 4,000' core holes. The rig will be supplied by Tonto Drilling Services, 2701 West 900 South, Salt Lake City, Utah 84104.

Well control will be subject to the Conditions of Approval for Geothermal Drilling, Conditions 6 through 18 (Attachment 7).

Drilling fluids will be regulated in accordance with the Conditons of Approval for Geothermal Drilling, Condtion 5; subparagraphs d and e (Attachment 7).

Hole completion will be accomplished as specified in the Conditions of Approval for Geothermal Drilling (Attachment 7).

Plugging and abandonment shall be accomplished in accordance with the Conditions of Approval For Geothermal Drilling, Condition 18 (Attachment 7).

Site restoration shall be subject to the Conditions of Approval For Geothermal Drilling, Condition 5; subparagraphs a through e (Attachment 7), and the specifications contained in the approved Plan of Exploration (Attachment 1).

GEOOC does not anticipate any unusual problems impeding or preventing completion of the core holes.

All drilling and appurtenant operations shall be conducted in such a fashion that insures complicance with all pertinent federal and state health/safety standards. This will include, but not be limited to, adequate noise protection, safety equipment, traffic control, and regulated access on or near equipment. Environmental considerations will be closely monitored, and strict adherence to the Conditions of Approval For Geothermal Drilling will be mandatory to insure compliance with the approved Plan of Exploration.

No site facilities are anticipated for this phase of the project.

The first core hole (N-1) is proposed to be spudded August 19, 1985, and completion not to exceed 45 days thereafter. Snow fall will preclude the drilling of the second core hole (N-3) until June 1, 1986 (approximate). If this hole can be completed by August 15, 1986, we would be in a position to drill N-4 if necessary. This schedule satisfies the terms and conditions of the GEO-Newberry Unitization Agreement.

The Drilling Supervisor will be assigned by Tonto Drilling Services and will be responsible to the Project Manager or his designate. Geologist(s) associated with the drilling operation will be assigned by GEOOC's Chief Geologist (Dr. Walter Randall) with the concurrance of the Project Manager.

The DOE representative shall receive drilling reports in a timely fashion regarding well status and data recovery. Said reports will be disseminated by the Project Manager or his designate.

The comments contained herein respond to the specific questions contained under Section 4.3 (Drilling); paragraph A, and should meet the DOE criteria for the Approved Project Drilling Plan.

MJC:bc

Constitutes institutional plan.

PLAN OF EXPLORATION

NEWBERRY FLANK

(GEO-NEWBERRY)

DESCHUTES COUNTY, OREGON

Project Location

The following are the proposed locations for the Newberry Flank (GEO-Newberry) Core Hole Program:

- N-1: East Lake Quad

  3500' west and 2450' north of the southeast corner of Section 25, T22S, R12E.

- N-2: Paulina Peak Quad

  950' west and 2600' north of the southeast corner of Sec. 32, T21S, R12E.

- N-3: Fuzztail Butte Quad

  4100' north and 500' east of the southwest corner of Sec. 24, T20S, R12E.

- N-4: East Lake Quad

  1500' north and 2250' west of the southwest corner of Sec. 35, T21S, R13E.

Operations

The lessee/operator for the project will be:

- GEO Operator Corporation for GEO-Newberry
  2300 County Center Drive, #250
  Santa Rosa, CA 95401
  (707) 523-4272

Key personnel assigned to the project are:

- Chandler Swanberg (Project Manager)
  545 Middlefield Road
  Menlo Park, CA 94025
  (415) 321-5662

- Michael Cale (Senior Environmental Coordinator/Regulatory Liaison)
  2300 County Center Drive, #250
  Santa Rosa, CA 95401
  (707) 523-4272

- Michael Johnson (Project Geologist)
  2300 County Center Drive, #250
  Santa Rosa, CA 95041
  (707) 523-4272

Location of a field office will be provided when established.

Project Description

The core hole program is a low-key operation utilized in developing baseline geophysical data. This information is a preliminary step in evaluating resource recovery potential in a virtually unexplored region that suggests the presence of geothermal capability. The project will consist of the following:

- Preparation of up to four (4) drilling locations and mud pits (total area: 100' x 100'± per site)
- Utilizing a truck-mounted rotary drill rig, the core holes will be drilled to a maximum depth of 4000'.
- Log temperatures and collect core samples.
- Rig down.
- Continue logging.
- Abandonment.
- The project should begin not later than July 1, 1985, and terminate November 1, 1986 (estimates).

Drilling Program

- Prepare drill location.
- Rig-up.
- Spud 5-5/8" diameter hole and drill to 400'.
- Record mud return temperature and collect core samples.
- Run 400' of 4-1/2" casing with cementing shoe.
- Install cementing head and pressure cement to fill annulus to surface.
- Cut off casing approximately 2' below ground level and install B.O.P.E. flange.
- Install 2" fill-up line and blowdown line below flange.
- Install B.O.P.E. equipment.

- o Wait 24 hours for cement to set; lower one joint of drill pipe into hole; close preventer and test to 300 psi.
- o After completing successful B.O.P.E. test, drill out shoe and continue drilling with mud system to T.D.
- o Record temperatures of mud returns and collect cores to T.D.
- o When T.D. is reached circulate to clean out cuttings and condition hole.
- o Run bull-plugged string of 2-3/4" tubing to T.D. and fill with water.
- o Backfill annulus with Sure-Gel or equivalent.
- o Remove B.O.P.E. and wellhead.
- o Install locking cap on tubing.
- o Rig-down and remove drill rig, support vehicles, and materials from site.
- o Backfill mud pits and grade to original contour.
- o Clean area of debris and restore to (as near) original condition.
- o Run temperature and gamma-ray logs at least twice (1 month interval) prior to final abandonment.

Environmental

Pursuant to the Geothermal Resources Operational Orders, issued under the Geothermal Steam Act of 1970, the lessee shall be responsible for the monitoring of readily identifiable localized impacts associated with specific activities that are under the control of the lessee (GRO Order 4, General Environmental Protection Requirements).

Specific impacts that may be associated with this project, and mitigration measures proposed to reduce said impacts to a level of insignificance are as follows:

- o Aesthetics

  Compatibility with the existing view shed is a primary goal. The short-term duration of each drilling operation (30-45 days) coupled with the low profile of a truck-mounted rotary drill rig (30'± to top of mast) ensure that visual intrusion will not be significant. Additionally, sites have been selected that are well removed from populated areas and traditional recreation centers in the Deschutes/Newberry region.

- o Land Use and Reclamation

  The project has been designed to reduce vegetation impacts to a minimum. Access will be via the existing road network to the pad location. The pad area will require only clearing and grading an area approximately 100' x 100'. When the project terminated, the area will be graded to as near the original contour, and revegetated with similar vegetation species as directed by BLM. Aquatic habitat will not be impacted, and water will only be secured as directed by the State Watermaster. At project termination, all debris, scrap, or other materials imported by the operator shall be removed.

The project proposed by GEO Operator Corporation meets the criteria for exploration and development of a managed resource as defined by the United States Department of the Interior. Additionally, the project is compatible with the Deschutes County Geothermal Element as incorporated into the Deschutes County Comprehensive Plan and Zoning Ordinance.

- Public Access/Recreational Opportunities

  The short duration of each drilling operation, minimal amount of surface area required, and isolated location ensure that public access will be maintained, and that recreational value of the Deschutes/Newberry area will not be adversely impacted.

- Slope Stability/Erosion Control

  The project is so designed that with maximum surface disturbance, slope stability could not be an issue. Mud pits are constructed to a standard that alleviates the potential of encroachment on a natural drainage course, or deposition of sediment/drilling waste into a waterway. As previously described, at project termination, the sites will be regraded to as near the original contour, and revegetated with native species as required by BLM.

- Biota

  A core drilling project does not have the potential (long-term) to adversely impact the associated flora and/or fauna (terrestrial or aquatic). The drilling operation could temporarily inconvenience some species, particularly avian raptors, causing a minor alteration in migration and/or hunting habits. Historically, these types of operations have not produced any noticeable adverse impact to biota.

- Cultural Resources

  In the event a cultural or historic resource is located on or near any of the drill sites. the location will be shifted, under the direction of BLM, to preserve the integrity of the resource. As a core drilling program is designed to incorporate maximum flexibility, at the discretion of the permitting agency, avoidance of any area of significant value is easily accomplished.

- Subsidence and Seismicity

  Concerns regarding geothermal resource production would not be an issue during a core drilling program.

- Air Quality

  The project as proposed does not have the potential to adversely impact ambient air quality.

- <u>Pits and Sumps</u>

  During the core drilling operation, waste material (cuttings/drilling medium) will be directed to a waste sump for containment. The sumps will be constructed and lined with an impervious material to ensure the integrity of the natural environment, and eliminate the potential of contaminants entering a drainage course or waterway. At the conclusion of the drilling operation, the sumps will be purged as directed by the BLM prior to backfilling. As part of site restoration, the sumps/pads will be regraded to as near the original contour and revegetated per BLM requirements.

- <u>Water Quality</u>

  The project, as defined, does not have the potential to degrade water quality.

- <u>Noise</u>

  Due to the isolated locations proposed and the nature of the equipment involved, the project will not impact on any human receptors. Intrusion by humans in a remote area may have the ability to disrupt some wildlife species, particulary avian raptors, which rely on a keen sense of hearing to locate and secure a food source. However, the limited scope of the project adequately mitigates significant short-term, and precludes any long-term impact from occurring.

It is the position of GEO Operator Corporation that the project, as proposed, does not have the potential to produce any significant long-term environmental impacts. Utilizing Best Management Practices and conditions proposed by BLM, short-term effects will be reduced to a level of insignificance.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY, CONSERVATION DIVISION

GEOTHERMAL DRILLING PERMIT

Newberry Flank (GEO Newberry)

N-1

Newberry

25 22S 12E

Core Hole to be drilled. No existing wells

Operator Corporation (GEO-Newberry)

) County Center Dr. #250 Santa Rosa, CA 95401

3500'West & 2430'North of the Southeast corner of Sec 25, T22S, R12E

N/A

miles south of inner sourthern boudary of unit

Deschutes

Oregon

5 miles from N-2

)'West & 2600'North of the Southwest corner of Sec 24, T20S, R12E

July 85

N/A

4,000'

5850'

5/8"	4½"	7.7#	Diamond Drill Flush Joint 3 threads/in.	A-120	Surf	400'	25 cu.ft.
/8"	2-3/4"	5.4#	Flush Joint	J-55	Surf	4,000'	14.7 cu.ft. Shur-Gel

fer to attached Drilling Program.

Michael J. Cole

Senior Environmental Coordinator

3-26-85

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY, CONSERVATION DIVISION

GEOTHERMAL DRILLING PERMIT

Type of work: Other (X)

Type: Other (X)

Core hole to be drilled. No existing wells

Operator Corporation (GEO-Newberry)

0 County Center Dr.#250 Santa Rosa, CA 95401

4100'North & 500'East of the Southwest corner of Sec 24 T20S, R12E

N/A

miles south of outer northern boundary of unit

iles from N-2 (950'West & 2500'North of the Southeast corner of 32, T21S, R12E

Unit agreement name: Newberry Flank(GEO Newberry)

Well no.: N-3

Field or area: Newberry

Sec., T., R.: 24 20S 12E

County: Deschutes

State: Oregon

Approx. starting date: July 1985

N/A

Proposed depth: 4000'

Elevation: 5750'

Size of hole	Size of casing	Weight per foot	Coupling	Grade	Setting depth (Top)	Setting depth (Bottom)	Quantity of cement
5/8"	4½"	7.7#	Diamond Drill Flush Joint 3 threads/in.	A-120	Surf	400'	25 cu.ft.
/8"	2-3/4"	6.4#	Flush Joint	J-55	Surf	4,000'	14.7 cu.ft. Shur-Gel

er to attached Drilling Program.

Michael J. Cala

Title: Sr. Env. Coordinator Date: 3-26-85

(See Instructions on reverse side)

~~UNITED STATES DEPARTMENT OF ENERGY~~

~~IDAHO OPERATIONS OFFICE~~

CASCADES DRILLING PROGRAM
MEMO OF CONVERSATION

Project: GEO Newberry N-1

Person Calling: Mike Johnson Date: Aug 30, 85

Representing: GEO OC Time: 8:15 AM

Person Called: Bruce Sibbett Phone Number:

Representing: ESL/UURI

City: Bend OR. to SLC Distribution:

Subject: Drilling N-1

DOE-ID

UURI Mike W, Dennis N,

Other

At a depth of 400' the hole was in soft rock, drilling easy. Drilling therefore was continued to find hard rock to set the casing shoe in. The hole entered hard rock again at 465' and rodary drilling was stopped at 470', about midnight, Thursday.

The rest of the mud was pumped down the hole to condition it. Casing was run in the hole to 430' where it encountered caving or tight hole. The casing, with shoe, is being drilled down.

Last temperature check at 430' depth showed less than 100°F. The BOP equipment has arrived at La Pine, OR, a few miles from the site.

Signature

GEO-South

Statement of Work

1.0 Introduction

The Cascade volcanic region has long been suspected to contain considerable geothermal potential, as evidenced by recent volcanism and other thermal expressions. There are few known surface manifestations of geothermal energy in spite of the obvious occurrence of heat sources. One possible explanation is that the downward percolation of the extensive regional cold gound-water system suppresses surface evidence of underlying hydrothermal systems. However, there have been few wells drilled in the Cascades region to a sufficient depth to properly evaluate the temperature and hydrological conditions beneath the cold water zone. There is a great need for characterization identification of the deeper hydrothermal regime in order to more conclusively define the geothermal potential of the Cascades volcanic environment.

DOE's primary objectives for this cost-shared drilling project are to obtain and release to the public subsurface information specifically:

- o rock samples (core and/or drill chips),
- o equilibrium temperature profiles,
- o uncontaminated fluid samples,
- o evidence for the existence and depth of potentially producible aquifers,
- o geophysical well logs, and
- o information on drilling conditions and problems in the Cascades environment.

2.0 Scope

The Participant, GEOOC, will drill a deep thermal gradient hole to a depth of 4000 feet located 3,500 feet north and 2450 feet north of the southeast corner of section 25, T22S, R12E, Deschutes County, Oregon. The Participant will perform data collection both during and subsequent to drilling. The Participant will maintain the hole and allow DOE access to the hole to collect data. The Participant will be responsible for obtaining any permits or approvals required by government regulatory agencies in the performance of this project. The Participant will provide all data and information gathered under this project to DOE.

3.0 Applicable Documents

Work performed by the Participant will be in compliance with all Federal, State, and local laws, rules and regulations, and agency orders and guidelines.

4.0 Technical Tasks

4.1 Project Management

A. Prepare and obtain DOE approval of a Project Management Plan within 30 days after award of this agreement. The plan will include a work breakdown structure and a list of deliverables by task, identify the individuals and subcontractors responsible for each task, discuss the management techniques to be used, and include a schedule that shows the period for performance of each subtask and identifies principal milestones and decision points for each. The plan will also designate an individual or individuals who will act as principal points of contact with DOE on behalf of the Participant.

B. Perform project management in accordance with the approved Project Management Plan. In addition to close general coordination with DOE, immediate and full disclosure of any project problem areas to DOE is required, so that timely corrective action may be taken with DOE support, if necessary.

Deliverable: Approved Project Management Plan

4.2 Permitting and Environmental Reporting

A. Submit and obtain DOE approval of a Project Institutional Plan prior to initiation of site preparation. The plan will identify items required by governmental regulatory agencies for the performance of this work, the agency whose requirement the item fulfills, and the actual or projected submittal and agency approval dates. The plan will also discuss any legal, social or institutional problems anticipated during performance of the project and planned solution.

B. Prepare, submit and obtain approval of any documentation required by governmental regulatory agencies for the performance of this work. A copy of all documentation provided to any governmental agency and pertinent to this project shall be provided to DOE.

C. An approved environmental document is required for this project prior to any ground disturbance. It is anticipated that an environmental assessment will be prepared by the Bureau of Land Management for this project. This environmental assessment may satisfy DOE's environmental reporting requirements. If DOE determines that an

Environmental Evaluation Report is required prior to any ground disruptive activity, DOE will notify the Participant in writing. In that event, the Participant will prepare the Environmental Evaluation Report in accordance with DOE Environmental Guidelines. If a DOE Environmental Assessment is required, the Participant will provide information required by DOE for DOE's preparation of the Environmental Assessment.

Deliverables: Approved Project Institutional Plan, Regulatory Documentation, Approved Environmental Document

4.3 Drilling

A. Prepare and obtain DOE approval of a Project Drilling Plan prior to drilling. The plan shall describe:

- Surface and subsurface conditions anticipated to be encountered during drilling, including configuration of the resource.
- Site access.
- Site preparation.
- Hole design including hole size, casing size, cementing, etc.
- Rig and equipment specifications.
- Well containment during and after drilling (including applicable regulatory requirements).
- Drilling fluids and disposal method.
- Hole completion.

- Plugging and abandonment.
- Site restoration.
- Anticipated hole problems, if any, and proposed solutions.
- Health, safety and environmental considerations.
- Site facilities, if any.
- Drilling schedule including major activities and estimated duration.
- On-site supervision to be used during drilling, including drilling supervisor(s) and geologist(s).

B. Prepare a drill site and drill a deep thermal gradient hole in accordance with the approved Project Drilling Plan. The Participant shall report on drilling status daily to the designated DOE representative, so that decisions concerning the drilling operation can be made in a timely manner.

Deliverable: Approved Project Drilling Plan

4.4 Data Collection

A. Prepare and obtain DOE approval of a Project Data Collection Plan prior to drilling. This plan will address data collection both during drilling and after drilling. The plan will identify the types of data to be collected, the depth(s) at which each type of data will be collected, the timing of collection, and the method by which the Participant plans to collect each type of data (including type of instrument and planned calibration, where appropriate). The plan will specifically identify all logs and samples of rock and fluid that are to be collected.

B. Collect the following data as a minimum in accordance with the approved Project Data Collection Plan. These samples and data shall be provided to DOE as soon as possible after collection.

Rock Sampling. Cuttings will be collected at 15-foot intervals in the section of the hole to be rotary drilled. The remainder of the hole will be continuously cored. The Participant will warehouse the core and cuttings in Bend and make them available to DOE. DOE will provide procedures for identification and splitting of core and cuttings. The Participant will make thin sections of selected core samples and complete a petrographic study of these sections. The Participant will also select core samples for age dating. The results of these studies will be made available to DOE.

Drilling Records. Logs describing primary lithology and secondary mineral content and mud return temperatures will be kept during the tricone drilling and core portion of the hole, copies of which will be provided to DOE. These logs will also include information on lost circulation amounts, times and depths and/or the location of water entries.

Temperature. The bottomhole temperature shall be recorded at a minimum of 100 ft. intervals during drilling and preferably at least at every other change of core barrel. One objective of these measurements will be to obtain a useable temperature profile in the event a subsequent equilibrium temperature profile cannot be obtained. The measurements shall be made using calibrated thermometers.

Hydraulic head. At the start of daily drilling, or whenever the drilling operation will allow, measurements of the hydraulic head or depth to fluid surface in the hole will be made.

Drilling fluid samples. An appropriate number of sets of one-liter samples of drilling fluid will be collected every twelve hours during drilling. One set will be delivered to DOE for possible analysis. If the Participant analyzes samples, copies of the results will be given to DOE.

Aquifer fluid samples. If artesian flow is encountered during drilling, representative samples of uncontaminated aquifer fluid will be collected in accordance with procedures outlined in the approved Data Collection Plan. If no artesian flow is encountered, the Participant will still endeavor to collect samples of uncontaminated aquifer fluids at locations in the hole at which fluid production would be anticipated on the basis of lost circulation, indications of fracturing in the core or chips, geophysical well logs or other standard indicators. Potential methods for collection of these samples include swabbing, bailing, airlift, drill stem tests and pumping. The Participants will examine these and/or other fluid sampling techniques and address collection of these samples in the Project Data Collection Plan.

Geophysical well logging. Temperature, caliper, resistivity and self-potential logs will be run in the interval between the surface pipe and total depth. Density and sonic velocity logs will also be run if tools are available which can operate in the conditions encountered in the hole. The temperature tool capable of 0.01 °F precision in measurement will be used to measure the geothermal gradient. One set of field prints will be sent to DOE as soon as available.

Deliverables: Approved Data Collection Plan, Data and Samples

4.5 Hole Completion and Maintenance

A. Upon satisfactory completion of openhole geophysical logging and sampling, standard black pipe, 2" ID, with a knockout plug at the bottom, will be run from surface to total depth, filled with fresh water and capped. After allowing sufficient time for thermal equilibration to occur, a temperature log will be run from which a geothermal gradient will be derived.

B. Upon completion of the hole, DOE and the Participant shall review and discuss the data. A mutual agreement between DOE and the Participant must be reached prior to releasing the rig.

C. The Participant shall provide to DOE within 15 days of completion of the hole a schematic of the actual completed hole configuration.

D. The hole and site facilities shall be maintained for 12 months after hole completion in accordance with the approved Project Drilling Plan. The hole and site facilities shall be made available to DOE during this period for DOE's scientific use. The Participant may also collect data during this period at its own expense and on a non-interference basis.

Deliverable: Completed Hole Configuration Schematic

4.6 Abandonment

The hole will be plugged and abandoned in accordance with U. S. Bureau of Land Management requirements (Form 3200-9, #5) and other applicable regulations within the 12 months subsequent to the end of the DOE access period. The Participant shall provide DOE with a copy of the plug and abandonment plan as approved by the Bureau of Land Management. If for any reason the hole is not plugged and abandoned by the end of the period, the hole becomes the legal and financial responsibility solely of the Participant.

Deliverable: Approved P&A Plan

4.7 Site Restoration

The site will be cleared, the pits filled and the site restored in accordance with applicable state and federal regulation and as outlined in the approved Project Drilling Plan. The Participant shall provide DOE with confirmation of restoration activities and Bureau of Land Management or Forest Service approval.

5.0 Reports, Data and Other Deliverables

A. The Project Drilling Plan as required by Subtask 4.3.A.
B. The Project Data Collection Plan as required by Subtask 4.4.A.
C. The Project Management Plan as required by Subtask 4.1.A
D. The Project Institutional Plan as required by Subtask 4.2.A.
E. All data collected by the Participant under Task 4.4.
F. Regulatory documentation and approved environmental document under Subtasks 4.2.B and 4.2.C.
G. Completed hole completion schematic as required by Subtask 4.5.C.
H. Approved plug and abandonment plan as required by Task 4.6.
I. Project status and management reports as identified on DOE Form CR-537, Reporting Requirements Checklist.

GEO - South

(5) PART B - TECHNICAL APPROACH TO THE PROJECT

STATEMENT OF WORK

1.0 Introduction

The Cascade volcanic region has long been suspected to contain considerable geothermal potential, as evidenced by recent volcanism and other thermal expressions. There are few known surface manifestations of geothermal energy in spite of the obvious occurrence of heat sources. One possible explanation is that the downward percolation of the extensive regional cold groundwater system suppresses surface evidence of underlying hydrothermal systems. However, there have been few wells drilled in the Cascades region to a sufficient depth to properly evaluate the temperature and hydrological conditions beneath the cold water zone. There is a great need for characterization and identification of the deeper hydrothermal regime in order to more conclusively define the geothermal potential of the Cascades volcanic environment.

2.0 Scope

GEOOC will drill a deep thermal gradient hole to a depth of (4,000) feet at (4,100' north and 500' east of the southwest corner of Sec. 24, T20S, R12E). GEOOC will perform data collection both during and subsequent to drilling. GEOOC will maintain the hole and allow DOE access to the hole to collect data. GEOOC will be responsible for obtaining any permits or approvals required by government regulatory agencies in the performance of this project. GEOOC will provide the data and information gathered under this project to DOE.

3.0 Applicable Documents

Work performed by GEOOC will be in compliance with all federal, state, and local laws, rules and regulations, and agency orders and guidelines.

4.0 Technical Tasks

4.1 Drilling

A. GEOOC shall prepare and obtain DOE approval of a Project Drilling Plan prior to drilling. The plan shall describe:

- Surface and subsurface conditions anticipated to be encountered during drilling, including configuration of the resource.

- Site access.
- Site preparation.
- Hole design including hole size, casing size, cementing, etc.
- Anticipated hole problems, if any, and proposed solutions.
- Drilling fluids and disposal method.
- Hole completion.
- Plugging and abandonment.
- Site restoration.
- Rig and equipment specifications.
- Well containment during and after drilling.
- Site facilities, if any.
- Health, safety and environmental considerations.
- Drilling schedule including major activities and estimated duration.

B. GEOOC will drill a deep thermal gradient hole in accordance with the approved Project Drilling Plan.

4.2 <u>Data Collection</u>

A. GEOOC shall prepare and obtain DOE approval of a Project Data Collection Plan prior to drilling. This plan will be divided into two sections: one will address data collection during drilling; one will address data collection after drilling. Both sections will identify the type of data to be collected, the depth(s) at which each type of data will be collected, the timing of collection, and the method by which GEOOC plans to collect each type of data.

The plan will specifically identify all logs and samples of rock and fluid required as a minimum by Subtask 4.2B. below.

B. GEOOC shall collect the following data as a minimum, subject, however, to DOE's acceptance of two minor changes: (1) The entire 4,000 feet of core (recovery permitting) shall be stored either (i) where both GEOOC and DOE shall have unrestrained access, or (ii) according to any other mutually agreeable plan that will avoid the unnecessary cost of splitting 4,000' of core; (2) GEOOC shall not run sonic or density logs unless (i) tools can be found that are corrosion resistant, rated for temperatures in excess of 500°F, available is "slim" sizes, or (ii) GEOOC and DOE agree upon a mutually acceptable plan that helps to avoid the cost of replacing "burned out" tools.

Rock Sampling:

- Drill cuttings samples and/or core are required from the entire drilled interval. Cuttings will be collected at a minimum of each 5 meters (15 feet) in four splits of 500 grams each. Cuttings should not be washed. An accompanying lithologic log shall be prepared.

- A minimum of 10 feet of core per hole. This core may be continuous or taken over selected intervals. All or part of the core should come from the bottom 200 feet of the hole.

- DOE will require an equal split of all core taken and will specify if any special preservation of the core is required prior to coring. Should GEOOC have no further need of the split upon completion of analysis, DOE will take possession of any or all of the core.

Fluid Sampling:

- At the start of daily drilling, or whenever the drilling operation will allow, measurements of the hydraulic head.

- Lost circulation amounts, times and depths.

- In the case of artesian flow, GEOOC shall perform a flow test to obtain flow data and to collect representative samples of formation water for chemical analysis. At least 2 liters of clear filtered water should be collected in plastic bottles and sealed to prevent evaporative loss. A two liter sample of the drilling fluids in use prior to sampling should accompany each water sample. DOE will be responsible for providing collection bottles and the chemical analysis of the samples. Copies of the resulting analyses will be given to the proposer.

Geophysical Well Logging:

- Logs which provide temperature, porosity, and lithologic parameters. All logs will cover the entire ilnterval of the hole from the bottom of conductor casing to total depth and will be performed prior to further casing of the hole.

C. GEOOC will perform additional data collection in accordance with the approved Project Data Collection Plan.

4.3 Hole Completion and Maintenance

GEOOC shall complete and maintain the hole and the site facilities for 12 months after hole completion in accordance with the approved Project Drilling Plan. The hole and site facilities shall be made available to DOE during this period for DOE's scientific use. GEOOC may also collect data during this period at its own expense and on a non-interference basis.

4.4 Abandonment

GEOOC shall plug and abandon the hole in accordance with governing regulations within the 12 months subsequent to the end of the DOE access period. If for any reason the hole is not plugged and abandoned by the end of this period, the hole becomes the legal and financial responsibility solely of GEOOC.

4.5 Project Management

A. GEOOC shall prepare and obtain DOE approval of a Project Management Plan within 30 days after award. The plan will include a work breakdown structure, identify the individuals and subcontractors responsible for each task, discuss the management techniques to be used, and include a schedule that shows the period for performance of each subtask and identifies principal milestones and decision points and dates for each.

B. GEOOC shall perform project management in accordance with the approved Project Management Plan. GEOOC shall advise DOE immediately of problems or the need for discussions so that decisions concerning the project can be made in a timely manner.

4.6 Permitting and Environmental Reporting

A. GEOOC shall submit and obtain DOE approval of a Project Institutional Plan. The plan will identify all reports, plans, permits, licenses, and other items required by governmental regulatory agencies for the performance of this work, the agency whose requirement the item fulfills, and the actual or projected submittal and agency approval dates.

The plan will also discuss any legal, social, or institutional problems anticipated during performance of the project and the planned solution.

B. GEOOC shall prepare, submit and obtain approval of any documentation required by governmental regulatory agencies for the performance of this work. A copy of all documentation provided to any governmental agency and pertinent to this project shall be provided to DOE. Costs incurred prior to award will not be considered project costs, even though the effort was in fulfillment of this subtask.

C. GEOOC shall prepare and obtain DOE approval of an Environmental Evaluation Report prior to performance of any group disruptive activity. The Environmental Evaluation Report will be site-specific and in accordance with DOE Environmental Guidelines (see Section J, Attachment 10). GEOOC will identify the Environmental Evaluation Report in its Project Institutional Plan.

D. If DOE determines that an Environmental Assessment is required, DOE will notify GEOOC in writing. Upon such notification, GEOOC will provide information as required by DOE for DOE's preparation of the Environmental Assessment.

5.0 Report, Data, and Other Deliverables

A. The Project Drilling Plan as required by Subtask 4.1.A.

B. The Project Data Collection Plan as required by Subtask 4.2.A.

C. The Project Management Plan as required by Subtask 4.5.A.

D. The Project Institutional Plan as required by Subtask 4.6.A.

E. All data collected by GEOOC under Task 4.2.

F. Reports, identified on the attached DOE Form CR-537, Reporting Requirements Checklist, are required to be submitted as defined in Schedule Article No. VII.

6.0 Special Considerations

Financial

GEOOC shall confirm all financial arrangements for implementation of the project and provide DOE with evidence that project financing is sufficient to complete the project prior to performance of any work under this Agreement. Details are to be negotiated.

Costs associated with obtaining project financing will not be allowable cost or cost-sharing cost.

(5) PART B - TECHNICAL APPROACH TO THE PROJECT

STATEMENT OF WORK - ATTACHMENTS

A) **DRILLING.** On February 7, 1985, GEOOC submitted to the BLM a proposed drilling program which included the corehole being considered in the present project. Such submittals are required as part of the process for the designation of a Federal geothermal unit. Following is a detailed discussion of our proposed drilling operations.

1) **Surface and Subsurface Condition Anticipated.** Surface location of the proposed drill site is topographically flat, at an elevation of 5,730', and at the intersection of an improved and an unimproved road. Rock units we expect to encounter while drilling are flows, interflow breccias, and tephra units ranging from basalt to rhyolite in chemical composition. Perched aquifers and lateral groundwater movement are conditions which may be encountered. Penetration of the regional groundwater table is anticipated at an approximate depth of 2,400'.

2) **Site Access.** The drillsite for the proposed temperature gradient hole is located near the northwest corner of Section 24, Township 20 South, Range 12 East in Deschutes County, Oregon. But for formal approval by the Bureau of Land Management of the Newberry Flank Unit, GEO Newberry Crater, Inc. ("GNC"), an affiliate of the proposer, presently has the absolute right to acquire the entire working interest in the Lease, which right shall be exercised before the anticipated geothermal exploration operations are to begin. For purposes of this proposal only GNC should be deemed to have an "existing right of access for geothermal exploration" in that any and all rights are subordinate to GNC's right to acquire the entire working interest in the Lease. GNC's right is defined and by virtue of an Option Agreement dated August 30, 1984, an Option to Purchase Interests in U.S. Geothermal Leases Agreement dated March 14, 1980, and the terms and conditions of an existing Federal Geothermal Resources Lease (Serial Number OR-12004). A copy of said Lease is attached as Appendix E.

3) **Site Preparation.** The drill pad will be constructed and maintained accessible to a truck-mounted drill rig, supply trucks and pickups. Preparation will include leveling, grading and brush removal if necessary. Two pits, 6'W x 8'L x 6'D, will be dug to collect initial cuttings produced while triconing. The need for road construction is eliminated since the proposed drill sites are immediately adjacent to existing roads.

4) **Hole Design.** The proposed hole will be drilled to a depth of 4,000'. The upper 400' will be 5" in diameter, drilled by rotary tricone. The upper 400' will then be cased with 4' x 4-1/2" "W" series flush-joint casing (11.3 lbs/ft). The casing will be cemented using Portland Type II cement. The lower 3,500' will be core-drilled using "HQ" wireline (3-7/8" diameter hole).

5) **Anticipated Problems.** Given the geologic sections we expect to encounter while drilling at Newberry, the possibility of drilling into lost circulation zones may exist. In order to minimize any problems associated with such zones, the hole will be core drilled. Coring permits "blind" drilling through lost circulation zones, while still allowing sample retrieval.

6) **Drilling Fluids and Disposal Method.** All geothermal drilling wastes will be contained in portable steel tanks with ultimate disposal performed per Oregon Department of Environmental Quality instructions. No toxic drilling additives are anticipated for use. Drilling activities shall be conducted in compliance with Oregon Department of Environmental Quality Noise Standards.

7) **Hole Completion.** Upon satisfactory completion of open-hole geophysical logging, standard black pipe, 2" ID, sealed at the bottom, will be run from surface to total depth, filled with fresh water and capped. After allowing sufficient time for thermal equilibration to occur, a temperature log will be run from which a geothermal gradient will be derived. The site will be maintained for approxiomately 12 months after completion.

8) **Plugging and Abandonment.** The hole shall be plugged and abandoned in accordance with U.S. Bureau of Land Management Form 3200-9, #5 (April, 1980) immediately following expiration of the access period of DOE.

9) **Site Restoration.** The site will be cleared, the pits filled, and the site restored according to pervailing state and federal regulations.

10) **Rig and Equipment Specifications.** The proposed hole will be drilled using a C.P. 50 Hydrostatic diamond core drill. Specifications for this rig are shown in Table 5.1. The contractor will provide the blowout prevention equipment, a diagram of which is shown in Figures 5.1 & 5.2).

11) **Well Containment.** Blowout prevention equipment will include an annular preventer, blind rams, pipe rams, an accumulator, a fill-up line, a kill line, and a blowdown line (see Figures 5.1 & 5.2). This equipment will be installed and present during drilling and logging. Subsequent to logging, the well will be killed if necessary.

12) **Site Facilities.** Site facilities will include the drill rig, water storage tanks, waste disposal tanks, and a portable chemical toilet, all of which will be removed upon completion of drilling and testing activities.

13) **Health, Safety, and Environmental Considerations.**

a) Health and Safety

General considerations: standard drill site safety practices, in accordance with OSHA regulations, will be observed at all times.

Blowout prevention equipment will be installed and tested after surface casing is set. Standard well control devices include pipe rams, blind rams, and a hydril. These devices will be employed during drilling and testing as needed.

Portable hydrogen sulfide monitors will be provided by GEOOC at the site during drilling. If hydrogen sulfide is detected, a detailed monitoring program will be employed, and hydrogen sulfide levels will be chemically abated if necessary.

b) Environmental

(1) Air quality: construction-related dust and wind-blown dust shall be controlled by regular sprinkling with water. Though not expected, if hydrogen sulfide is encountered, it will be chemically abated if necessary.

(2) Noise: construction-related noise will be minimal. Drilling-related noise will be of short duration: approximately six to eight weeks. Very little human or vehicular noise is expected. All activities will be conducted in compliance with Oregon Department of Environmental Quality Standards.

(3) Water quality: the site is located a major distance from existing watershed. All wastes will be contained in on-site portable steel tanks which will be disposed of upon completion of drilling or when rainfall, if

Table 5.1

Specifications
C.P.50 Hydrostatic Diamond Core Drill

CAPACITY (Nominal Rating)	
NQC	10,000 feet
POWER UNIT	
Cat D 330-C, Turbocharged Diesel	130 HP Continuous, 2100 RPM
DRAW WORKS	
Type	Planetary
Drum Diameter	17"
Drum Length	7"
Drum Capacity - 7/8" wire rope	205'
Transmission	2 speed plus infinite range
Hoisting capacity-single line-low gear	52,825 lbs.
Hoisting capacity-double line-low gear	110,000 lbs.
Hoisting speed-engine 2100 rpm-high gear	0 to 430 FPM - 7.2 FPS
Hoisting speed-engine 2100 rpm-low gear	0 to 120 FPM - 2.0 FPS
SWIVEL HEAD	
Size	Through HQC Rod
Spindle I.D.	3 9/16"
Feed Cylinders	2 - 5" I.D. - 31" Feed
Cylinder Area - Downstroke	29.39 IN - 180 IPM Nominal
Cylinder Area - Upstroke	39.27 IN - 120 IPM Nominal
Feed Pump - Axial Piston	29 GPM - pressure compensated
Total Lift - 1500 psi pump	58,875# - downpressure 41,085#
CHUCK	
Holding	Positive Spring Pressure
Releasing	Hydraulic Pressure
Opening or Closing Time	1 second
Control	3 way, shear seal valve
Torque at chuck - high gear	750 ft/lbs maximum
Torque at chuck - low gear	1925 ft/lbs maximum
RPM - High Gear	0 to 1250
RPM - Low Gear	0 to 500
DERRICK	
Type	Telescopic (90')
Rated Hoisting Capacity	110,000 lbs.
Pull Capacity	60'

Table 5.1 (cont'd)

CROWN BLOCK

Rated Capacity	110,000 lbs.
Sheaves	2 x 24"

WIRELINE HOIST

4,000 lb. bare drum pull
0 - 1100 ft/min line speed
Power up, power down operation
10,000' capacity

ELECTRICAL SYSTEM

110 VOH 7.5 KW Hydraulic generator
Interior explosion - proof lighting
Exterior 500 W quartz halogen rig lights

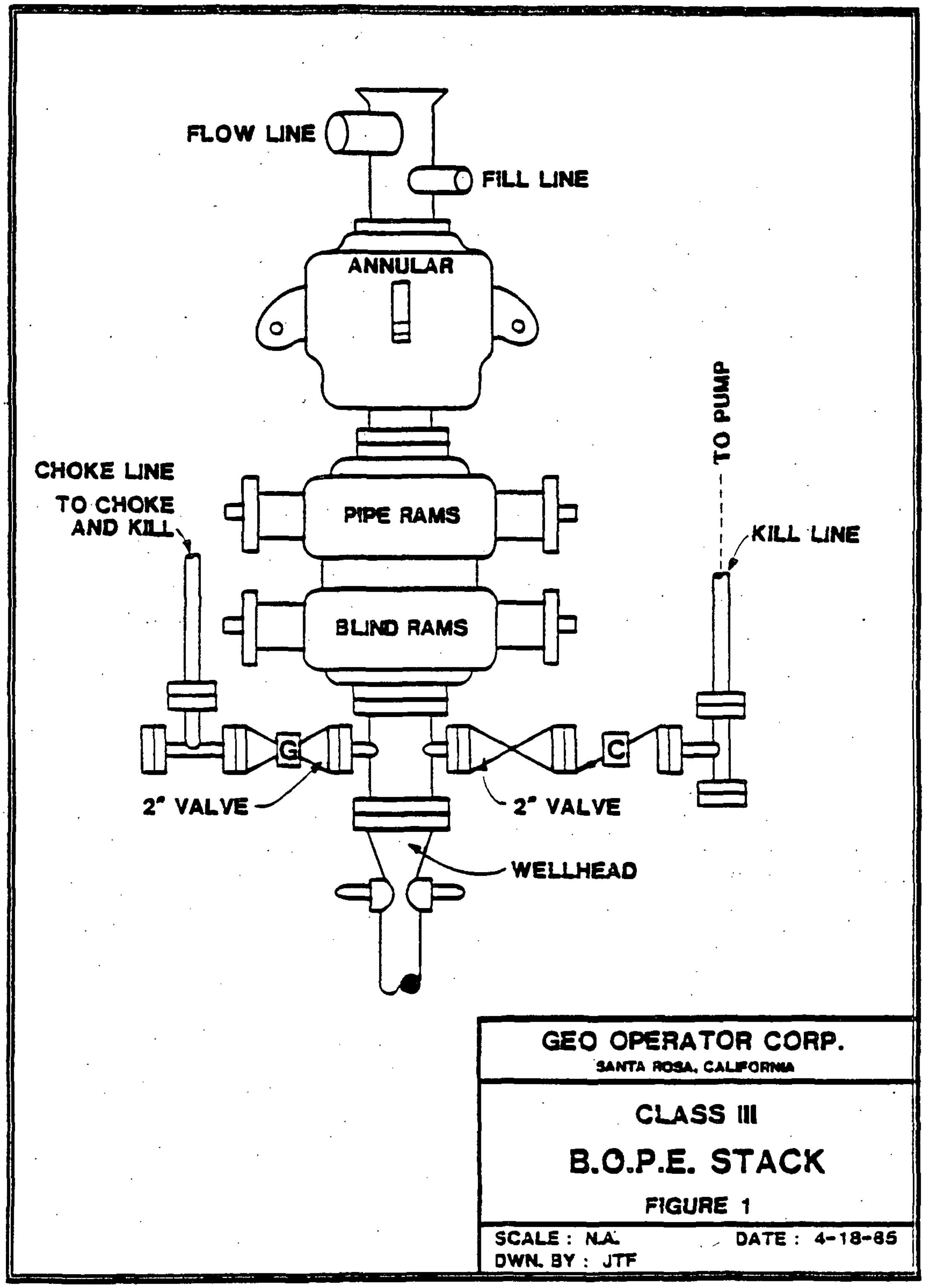

Figure 5.1 - Wellhead assembling and blow out prevention equipment

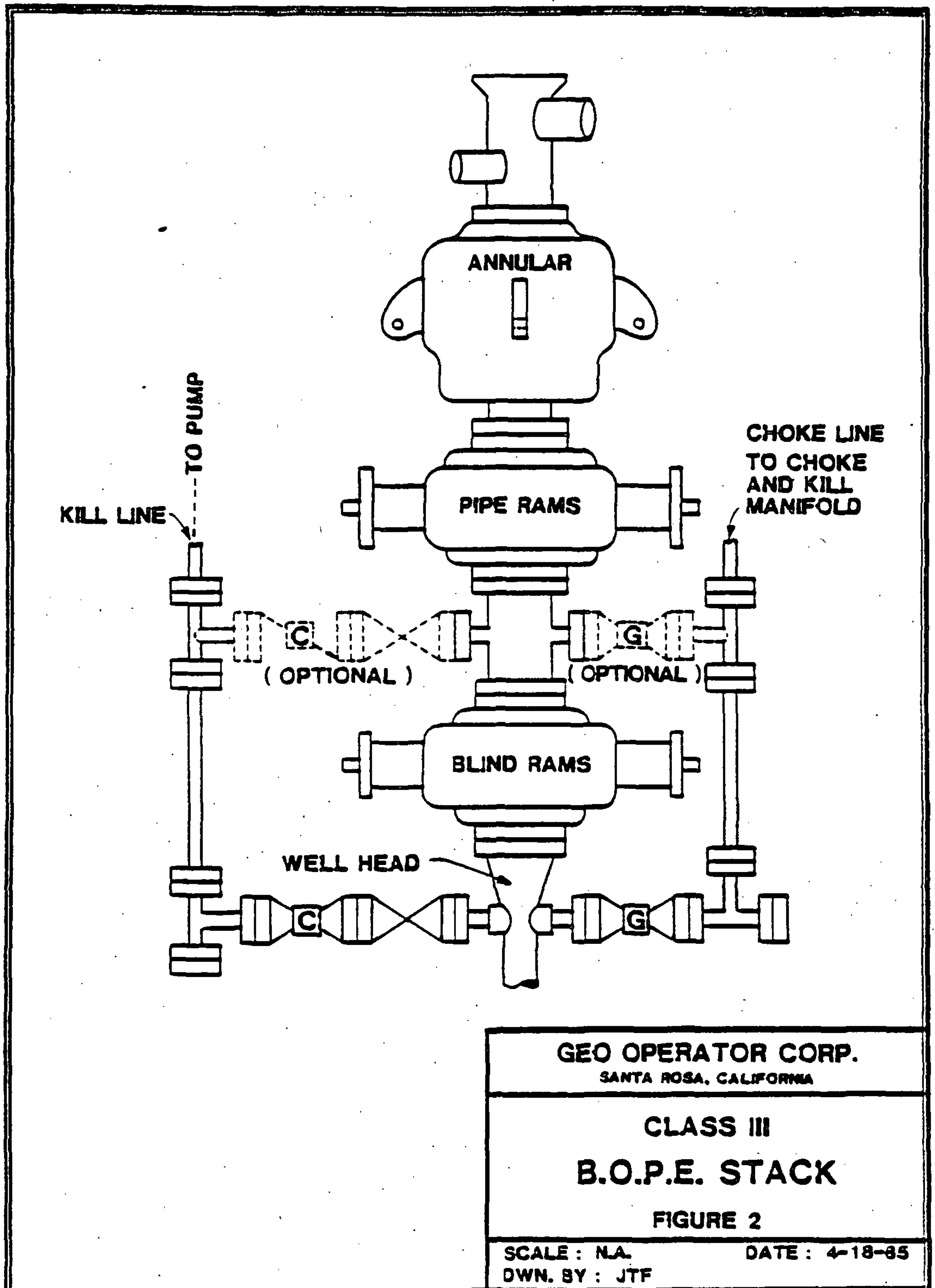

Figure 5.2 - Welldhead assembling and blow out prevention equipment

present, threatens overflow. No fluids of any type will be allowed to enter the watershed. An on-site spill mitigation plan will be prepared and implemented if necessary.

(4) Water supply: water for construction and drilling will be purchased from a local landowner or obtained from a local water well and will be transported to the project site.

(5) Land disturbance: since an improved road exists to the drill site, the only grading will be creation of a level drill pad approximately 50 feet by 100 feet and the digging of a mud pit in which to contain the steel tanks. Only minimal vegetation removal is planned.

(6) Subsidence and seismicity: historical records indicate that seismicity is not a major concern in this area.

(7) Ecology: the low level of construction will result in very little, if any, habitat loss. The area shall be examined on a site specific basis during the Environmental Analysis and appropriate mitigation measures will be identified if necessary.

(8) Socioeconomics: no degradation of recreational activities is anticipated as a result of this project. Because a transient work crew will be utilized, impacts of community services will be negligible.

(9) Heritage resources: the site is not located in an archaelogically sensitive area, however, if artifacts are discovered during grading activities a qualified archaeologist will be consulted and applicable mitigation measured implemented.

(10) Visual: the site is located outside the caldera and the visual impacts, while minimal, will be of a temporary nature.

(11) Site reclamation: at completion of the project, the site will be returned as near as feasible to its original condition and revegetated, if necessary, with native species.

14) **Drilling Schedule.**

a) Prepare pad.

b) Move in drilling rig, rig up.

c) Pick up 5" tricone bit, drill 5" hole to 400'±, dependent upon lithology.

d) Run and cement 4-1/2" casing to total depth.

e) Install blowout preventer on 4-1/2" casing as in Figures 5.1 & 5.2. Test preventer and casing.

f) Drill out 4-1/2" casing, core drill to total depth of 4,000'.

g) Run open hole geophysical logs.

h) Fill hole with shur-gel, run 2" water pipe from surface to total depth, fill pipe with fresh water.

i) Run temperature gradient logs.

Total estimated duration is 50 days.

B) DATA COLLECTION

1) Types of Data.

a) <u>During Drilling</u>:

Temperature. Bottom hole temperatures will be recorded in accordance with Bureau of Land Management NTL Drilling requirements. When drilling without returns, the bottom hole temperature shall be recorded at a minimum of 100 ft. intervals. Should the bottom hole temperature reach 125°F and later 175°F, the recording intervals shall be 50 ft. and 30 ft., respectively.

Rock sampling. The hole will be continuously cored, and core will be warehoused in Bend and made available to DOE, or DOE will receive an equal split of all core taken. Thin sections will be made of selected core samples and petrographic study of these sections will be completed. Core samples will also be selected for age dating. The results of these studies will be made available to DOE.

Logs describing primary lithology and secondary mineral content, lost circulation zones and/or water entries, and mud return temperatures will be kept, copies of which will be provided to DOE.

Fluid sampling. If artesian flow is encountered during drilling, representative samples of any fluid produced from the hole will be collected. Samples will be collected with a peristaltic pump/filter system, pictured in Figure 5.3a. The tip of a short metal probe will be inserted into the artesian flow below where the fluid contact air. The pump (and the artesian pressure) will pull the sample from the probe, through tubing, an ice-water bath if cooling is necessary, a .45 micron filter and into sample containers.

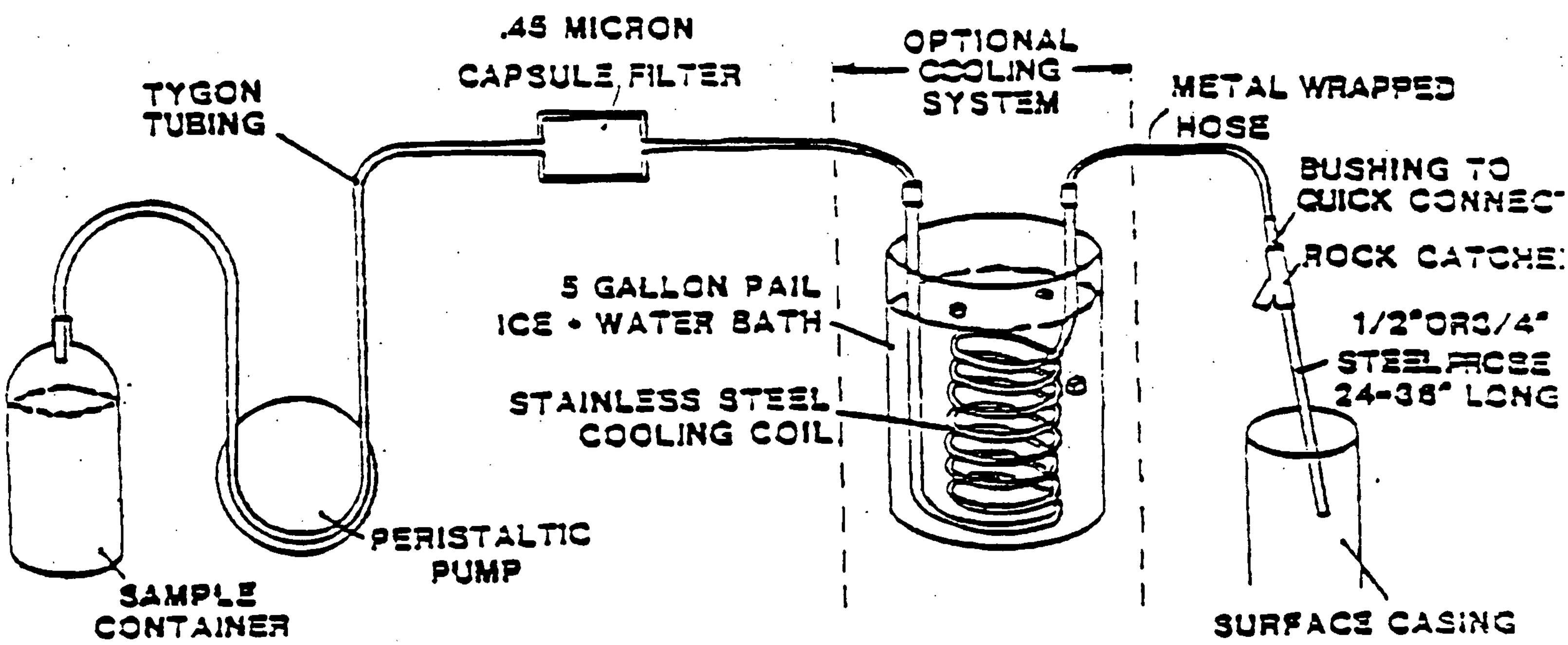

Figure 5.3a- Schematic diagram of peristaltic pump/filter system.

A back-up hand pump system (see Figure 5.3b) will be on site for filtering bucket grab samples if necessary.

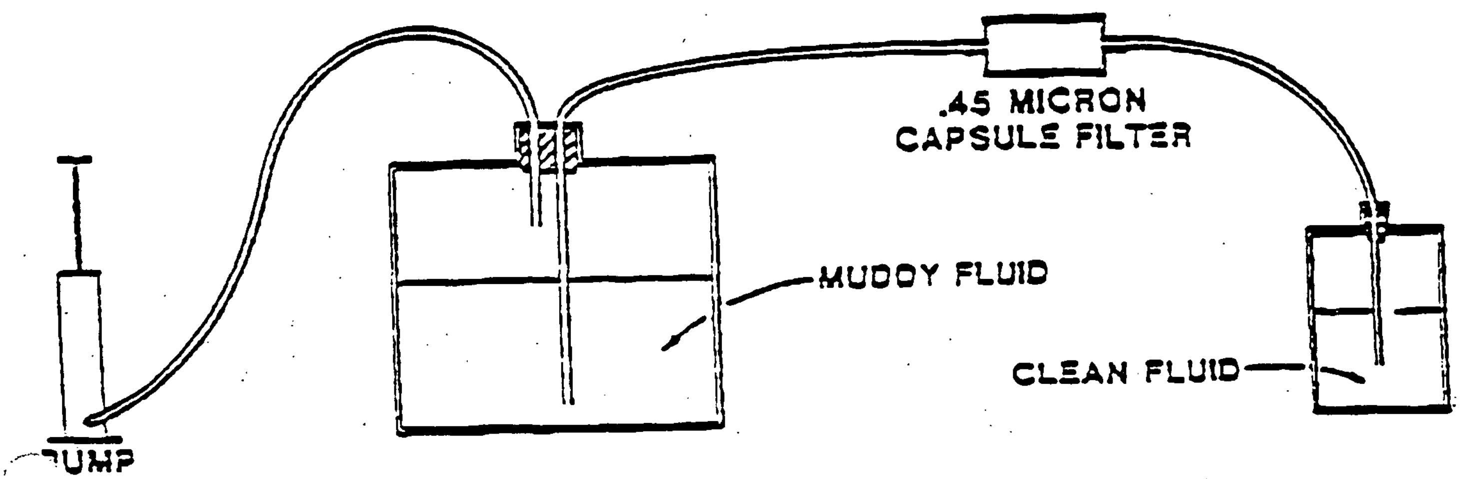

Figure 5.3b - Schematic diagram of back-up hand pump system.

The samples which will comprise one sample set are listed in Table 5.2. 2,000 ml of filtered, unpreserved fluid will be provided to DOE as part of each sample set, in containers provided by DOE. Duplicate sample sets will be collected whenever possible. Each sample set will be analyzed for the standard components of groundwater and geothermal fluids, plus the stable isotopes of water (oxygen-18 and deuterium) and tritium. The analyses of standard components will be performed by Anatec Laboratories, Inc. The analysis of stable isotopes of water and tritium will be performed by the Stable Isotope Laboratory of Southern Methodist University and the Tritium Laboratory of the University of Miami, respectively.

Table 5.2 - Sample Set

Sample Size (ml)	Container	Preservative	Filtered (F) or Not Filtered (NF)	Sample Designation
2000	plastic (provided by DOE)	none	F	DOE
500	polyethylene	concentrated sulfuric acid (H_2SO_4)	F	NH_3 Anatec
250	250 ml polyethylene with polyseal cap	zinc acetate (ZnOAc)	F	H_2S Anatec
1000	1000 ml polyethylene with polyseal cap	concentrated nitric acid (HNO_3)	F	cations Anatec
75-100	1000 ml polyethylene with polyseal cap	dilute 10:1	F	SiO_2 Anatec
2000	2-1000 ml polythylene with polyseal caps	none	F	SO_4, anions dissolved and undissolved Anatec
50	50 ml glass vial	none	F	CO_2 Anatec
125	125 ml glass bottle with polyseal cap	none	F	oxygen-18 deuterium SMU
1000	2500 ml glass bottle with polyseal caps	none	F	tritium Miami

Two sets of samples, two liters each, of drilling fluid will be collected every twelve hours. The drilling fluid sample will be collected by dipping sample containers into the mud pits. If artesian flow occurs, the drilling fluid collected just before the artesian flow occurs will accompany each sample set.

b) <u>After Drilling</u>

Geophysical well logging. GEOOC intends to run temperature, caliper, resistivity, self-potential, sonic velocity and density logs to total depth of the hole. These logs will help determine borehole size variations, lithologic changes, porosity of rock units, formation water resistivity, and fracturing within units. Investigations into the availability of logging tools slim enough to fit down an "HQ" core hole indicate that all tools are readily available, with the possible exception of density and sonic velocity. A search for slim-hole tools of this nature continues. A temperature tool capable of $0.01^{o}F$ precision in measurement will be used to measure the geothermal gradient.

2) **Depths of Data.** The depths at which the various data will be taken has been discussed in Section (5.B.1) immediately above. In addition, mud return temperatures will be recorded and lithologic logs will be kept during the tricone drilling from the surface to 400 feet. These are the only logs being run over this interval.

3) **Timing of Data.** All other data will be recorded subsequent to setting of surface casing. Lithologic records will be kept continuously during coring. Temperatures will be recorded and fluids will be sampled as outlined above. When total depth is reached, geophysical logs will be run in open hole. Upon completion of geophysical logging, standard black pipe, 2" ID, sealed at the bottom, will be run from surface to total depth, filled with fresh water and capped. After allowing sufficient time for thermal equilibration to occur, a temperature log will be run from which a geothermal gradient will be derived.

4) **Method of Data Collection.** The methods of data collection have been discussed in sections (5.B.1), (5.B.2), and (5.B.3).

5) **Additional Data.** No additional tests are proposed at this time.

6) **Additional Core.** Continuous logging is being proposed.

7) **Sampling of Drilling and Formation Fluids.** If possible, samples of formation fluid will be collected as described in Section (5.B.1) above. In such an event, representative samples of drilling fluids will also be collected.

8) **Drill Stem Test.** This type of test is not recommended.

9) **Reservoir Engineering Data.** Traditional reservoir engineering tests are not compatible with the type of corehole we have proposed.

C) **HOLE COMPLETION AND MAINTENANCE.** Upon satisfactory completion of open-hole geophysical logging, standard black pipe, 2" ID, sealed at the bottom, will be run from surface to total depth, filled with fresh water and capped. After allowing sufficient time for thermal equilibration to occur, a temperature log will be run from which a geothermal gradient will be derived. The site will be maintained for approximately 12 months after completion, during which DOE will have access to the site.

D) **ABANDONMENT.** The hole shall be plugged and abandoned in accordance with U.S. Bureau of Land Management Form 3200-9, #5 (April, 1980) immediately following expiration of the access period to DOE.

w/ Sue

- $235,764 GEO NI proposal
- negotiated down ~~$~~ by ± 24,000

$210,432
~~$212,000~~ = contract amount (for DOE share)

as proposed

Total proj $481,151, so DOE 49%

- their estimate for hole was $260,000 358,000 (w/ geol. etc)

other costs permitting 55,000
reporting 5
mang 8
Info dissem 5

OH 71%

- what is in costs they are giving us?

Phase I

w/ Bruce 18 Oct 85

1. Been hanging thermometer on bottom for ½ hr

3864 — 137, 137, 138 } opposite directions -- shake down

3913 (hole 3817) (140, 138, 137) very low gradient

3672 or 3540 where gradient looks pretty low now -

- thermometers in pressurized containers?
open thermometers - may give 4-5° higher -

2 - Bruce reasons no # to GEO below 4000'

3. Alteration increasing:
in basalt - fresh plag, augites
in fracts - some chlorite + some green clay
- some aragonite
- some zeolites - chabazite - (low temp)

4. Drilling going pretty well now -

Figures Chan came up w/ are prob good estimates -- may be a little high -

5. Drilling costs? on Daily Report

Just Tauto's costs. is Bruce's understanding

6. GEO thinking of changing site of north hole – this may be better
- closer to rim
- hydrologic gradient is to north

so this hole may be better.

503-389-6682 - Geo-Newberry
rules motel, Detroit OR 503-854-3921

from Bruce 17 Oct 85

3802' 128°F w/ device thru bit.
129°F above

505-646-2708
digit-geol - they are @ 3840 ± now -

Chan projects 144°C @ 4650 ft.

3100' "fault zone" is really an ash flow tuff @ top, alt'd and compacted. Below basaltic cinders. ~~TOP TO~~ Bottom contain -- [illegible] on down - lithic & lapilli - ash ash flows, red again - none are fresh.

- some calcite, aragonite, chlorite -- same
Zeolites -

Geothermal Resources International, Inc.

NEWS RELEASE

FOR RELEASE AFTER 9:00 A.M. EST ON TUESDAY, NOVEMBER 26, 1985

Menlo Park, California, November 25, 1985

Geothermal Resources International, Inc. ("GEO") has completed drilling an exploratory corehole on the Company's Federal Geothermal Resource Unit around the Newberry Crater in Oregon, according to Chief Executive Officer, Ronald P. Baldwin.

Baldwin said the Company and the United States Department of Energy ("DOE") are engaged in a cost-sharing Cascades Thermal Gradient Drilling Program which will provide important geological information about the area, including temperatures at various depths to evaluate what geothermal resources may be available.

"This first test hole, a heat flow corehole, is essentially isothermal through the "rain curtain" which was penetrated between 3260 feet and 3320 feet where the temperature rose from 62 degrees Fahrenheit to 113 degrees Fahrenheit," he said.

"The preliminary temperature at 4000 feet is 161 degrees Fahrenheit and the geothermal gradient between 3920 feet and 4000 feet is 4.6 degrees Fahrenheit per hundred feet."

According to Baldwin, the entire hole was cored and splits of the core, a full suite of geophysical logs, plus additional information, will be available for examination from University of Utah Research Institute, 391 Chipeta Way #A, Salt Lake City, Utah 84108. (801) 524-3422.

545 Middlefield Road, Suite 200, Menlo Park, CA 94025 (415) 326-5470

GEO is one of the limited number of companies in the United States that produces and supplies steam to power plants for electricity generation. In addition to 49,000 gross acres in The Geysers area of Northern California, GEO has leases outside The Geysers on 270,000 gross acres in Oregon, California, New Mexico, Utah and Nevada.

For further information contact Steven E. Morris, Vice President-Administration, 545 Middlefield Road, Suite 200, Menlo Park, California 94025. (415) 326-5470.

######

N-1 Bruce 16 Oct 85
from Bend, Ore

Bruce:
- had put new bit on - wouldn't work - - had to change again -
3762' @ 6 00/P -
8 hrs trip time now - so no new drilling

- left temp device with [illegible] -
3" piece pipe to screw onto core barrell
- 1" pipe 8" long on end w/ holes drilled -
Thermometer in it.

- takes hour to wireline in & out -
so want to get good temp @ 3800 &
3900. Run w/ Horner plot will give
idea of gradient

Cascades Drilling,

ID F-203
Ref: E&T
(Rev. 12-80)

UNITED STATES DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE

~~USER-COUPLED CONFIRMATION~~ DRILLING PROGRAM

MEMO OF CONVERSATION

Project: Southern Newberry Hole

Person Calling: Bruce Sibbett - Returning call   Date 8-7-85

Representing: ESL/UURI   Time 11:15

Person Called: Chan Swanberg   Phone Number (415) 321-5662

Representing: GRI, Geothermal

City: Santa Rosa

Subject: Water Sampling

Distribution
DOE-NV
DOE-ID
UURI Dennis, Mike
EG&G Reservoir
EG&G Environmental
Monitor Team Secretary
Other

Chan Swanberg said that according to DOE, UURI would be (1) responsible for water sampling at each bit change and at significant fluid entries. This would require the sampler to be on site continuely. Chan offered to collect (his crew) the samples if he could barrow a sampler and be checked out on collecting samples. Chan said he may be able to get a sampler from the USGS, which would work at temperatures up to 280°C, but wanted to know if they could barrow out sampler and it's capabilities. I replied that I would have to check with Dennis Nielson, who is in Yellowstone, about the sampler.

Chan said they planned to spud the southern hole on (2) Aug 19th. Also the drill site geologist will call in a morning report to the GRI office and they can telex us a copy of that report each day.

(1) Ask Sue re this

(2) No coop agree by then -- prob will be later -

Signature

(Continue on reverse side)

UNIVERSITY OF UTAH RESEARCH INSTITUTE
UURI
EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108—1295
TELEPHONE 801-524-3422

September 30, 1985

MEMORANDUM

TO: Susan Prestwich

FROM: Bruce Sibbett

SUBJECT: Site Visit to the GEO-Newberry Corehole N-1

Drilling of the GEO-Newbery Corehole N-1 is going smoothly. Tonto Drilling cored an average of 91 ft per day with 96 percent core recovery during last week. The total costs to September 29th of $175,538 equates to $64.44 per foot which is within the DOE cost estimate. BHT at 2712 feet is less than 60°F. The drillers think the hole is in good condition, and they should be able to drill to 4000 feet with HQ rods.

The GEO personnel are doing a good job curating and logging the core. Arrows pointing downhole are marked on the core and each box of core is photographed under controlled lighting. Mike Johnson, the project geologist, is logging the core with help and training from Gene Ciancanelli. The core log has a good format and reasonable detail. I spent a day checking the log with the core and found the quality of the log generally good.

Most of the rocks penetrated are basalt and possibly basaltic andesite lava flows with a few percent 2 mm plagioclase and olivine phenocrysts. A few thin (less than 20 feet thick) pyroclastic flow units are present. Some of these tuffs or lapilli flows are welded. These beds are significant because they could provide a sealed zone and they indicate pyroclastic non-basaltic eruptions. Pyroclastic flows are located at depths of 1180, 1860 and 2167 feet. Geologic data from the hole is confidential at the present time.

GEO is splitting the core except for a few samples set aside for possible further studies, such as paleomagnetism.

The bottom hole temperature is still less than 100°F and the only alteration is minor hematite and calcite which probably doesn't have any thermal significance. The drilling fluid is standing at about 1600 feet depth in the hole.

Chan Swanberg and Mike Johnson seem to be quite amiable about cooperating with DOE within the framework of the program.

Bruce S. Sibbett

Bruce S. Sibbett

BSS/jp

UNIVERSITY OF UTAH RESEARCH INSTITUTE

EARTH SCIENCE LABORATORY

CASCADES DRILLING PROGRAM
MEMO OF CONVERSATION

Project: Cascades, GEO - Newberry N-1

Person Calling: Susan Prestwich   Date: Sept. 4

Representing: DOE, Idaho   Time: ~ 1:20 PM

Person Called: Bruce, she returned my call.   Phone Number:

Representing: ESL/UURI

City: Distribution:

Subject: N-1, depth, BOP - Casing Cement and Cost rate   DOE-ID
UURI Dennis, Mike W.
Other

I informed Susan P. of the current status of N-1 520' as of 9:PM. Sept. 3rd, and then told her of our concern over the BOP pressure test being run when the casing was filled to 210' with cement and the cement bond at the casing shoe, 465', was therefore not tested.

Susan's concern is will the BLM let them flow the well if a thermal-artesian condition is encountered? This is an environmental concern for both surface discharge and resource subsurface control. There was some discussion of possibilities.

I reported on the current cost figures and stated that as of Sept. 4th, at 420' total cost was $52,783. If mob, $3,000 and est. casing $4,700 cost are removed footage cost average $96/ft. This projects to $388,000 total drilling cost. The original est. was $260,000. Susan said the DOE ceiling on the hole, including Geo overhead & logging etc, was 50% of the $395,000 total.

Costs Break out: Archeology 5,000

Drilling $260,000	$5,000 site preparation
$8,942 geol. supervision of drilling	30,000 geophy. logging
8,942 geol analysis of core	10,000 2 chem. analysis
10,000 Travel	7,000 hole maintaince & Core store.
8,000 materials, core box, sample bags	5,000 abandonment
5,000 - Reporting, & data delivery -	8,145 Project management
	6,150 Hg survey

Signature

These numbers total $369,179 so I'm missing something. Susan was giving some numbers as components of other figures and gave original proposed cost than the DOE reduced costs numbers for some items. So it wasn't totally clear over the phone. The first number she gave me was $358,769 for the total thermal gradient hole project.

The $260K ~~Tonto~~ drilling cost was not broke out any and Susan said she didn't care how much $ went to drilling verses logging, only that the DOE ceiling was 50% of $395K and if too much went to drilling, we wouldn't get what we wanted out of the hole in data.

Bruce Sibbett

Geothermal Resources International, Inc.

NEWS RELEASE

FOR RELEASE AFTER 9:00 A.M. EST ON MONDAY, DECEMBER 30, 1985

San Mateo, California, December 27, 1985

Geothermal Resources International, Inc. (GEO) announced today that it has successfully completed an additional geothermal development well at its Power Plant Area A-1/A-2 steam fields in The Geysers area of Northern California, which will supply the Coldwater Creek Geothermal Power Plant (CCGPP), consisting of two 65-megawatt turbine generators being built by the Central California Power Agency No. 1 (CCPA). The CCGPP is scheduled to begin commercial operation in late 1987 or early 1988.

According to GEO's Chief Executive Officer Ronald P. Baldwin, this new well in Power Plant Area A-1, designated Prati No. 4, has nearly doubled the amount of steam estimated to be deliverable from this part of the A-1/A-2 steam fields for the CCPA power plant.

"Prati No. 4, the largest well ever drilled by the Company, increases the amount of steam deliverable from Power Plant Area A-1 to the power plant from 38 percent to 62 percent. It represents an important advancement of the CCPA project," Baldwin said.

1825 South Grant Street, Suite 900, San Mateo, CA 94402 (415) 349-3232

The Company has now completed seven wells in the A-1/A-2 steam fields which will supply the Coldwater Creek Geothermal Power Plant.

According to Baldwin, the Company is drilling two additional development wells in the A-1/A-2 area and will continue to drill other wells as power plant construction progresses.

Since 1982, GEO has been working under agreements with CCPA to explore and develop 50,000 acres in The Geysers area under lease to the Company.

GEO is one of the limited number of companies in the United States that produces and supplies steam to power plants for electricity generation. In addition to approximately 50,000 gross acres in The Geysers, GEO has leases outside The Geysers totaling 105,000 gross acres in five western states: Oregon, California, New Mexico, Utah, and Nevada. GEO also has options on approximately 170,000 acres around the Newberry Crater in Central Oregon.

For further information, contact Steven E. Morris, Vice President-Administration, 1825 South Grant Street, Suite 900, San Mateo, California 94402 (415) 349-3232.

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