RF-173; 10

FITNESS-FOR-USE CHECKLIST FOR AQUIFER AND PERCHED GROUNDWATER MONITORING/OBSERVATION WELLS

LOCATION: MIDDLE INEL | PAGE 1 of 7 | Well Name/No. INEL-1

A. WELL USE

1) Year well was drilled: 1979

2) Current use for well:
( )DOE 5400.1 Monitoring
( )RCRA Monitoring (X)USGS Observation
( )CERCLA Characterization ( )No Documented Use
( )Other: _

3) Constituents monitored currently: None

4) Water level monitored: (Yes X No _ Insufficient data _)

5) Is the well used for USGS observation: (Yes X No _)
(The sampling protocols for the USGS are "Techniques of Water Resources Investigation" and "National Handbook of Recommended Methods for Water-Data Acquisition".)

6) Is the well used or proposed for compliance/detection monitoring: (Yes _ No X) If yes, specify regulating program plan: _

7) Responsible organization/Contact person: USGS / Larry Mann

B. WELL SHOULD COMPLY WITH INEL BEST MANAGEMENT PRACTICES (BMP) REGARDING SURFACE COMPLETION

Surface completion data is documented in "Idaho National Engineering Laboratory Well Catalog" (DOE/ID-10380). The elevation and coordinates of the measuring point and brass marker for appropriate INEL wells are being resurveyed as described in "INEL Well Inspection and Surveying Project" (EGG-WM-9890). The project started in the summer of 1992.

1) Well located by field inspection: (Yes X No _)
2) Protective posts: (Yes _ No X) or Fence posts: (Yes _ No X)
3) Concrete pad/apron present: (Yes X No _)
4) Does the well contain a survey marker: (Yes X No _)
5) If no to 2, 3 or 4, is the well planned for upgrade: (Yes _ No X N/A _)
6) Based on location of well, is existing or planned surface completion adequate: (Yes _ No X) Explanation The well has a plywood cover and is located in a 10-foot wide concrete pit. The pit is filled with water and covered with old

boards. The well and the pit should have steel covers and be protected with a lock, or the pit should be filled in and the well extended above grade.

C. WELL IS EVALUATED TO IDAHO DEPARTMENT OF WATER RESOURCES "WELL CONSTRUCTION STANDARDS-RULES and REGULATIONS" (1989)

1) Surface Completion

State of Idaho Reg. 3,2,1. The top of the casing shall be completely covered with a 1/4-inch, thick, solid, new or like-new steel plate welded in place, a threaded cap, or a watertight sanitary seal cover cap. State of Idaho Reg. 3,11. The well shall be equipped with an access port with a plug that will allow measurement of the depth to water.

a) Well capped and protected: (Yes _ No X Insufficient Data _) The well currently has a plywood cover.

b) Access to measure water levels: (State of Idaho Reg. 3,11): (Yes X No _ Insufficient Data _)

2) Casing

State of Idaho Reg. 3,3,2,1. Steel surface casing shall be installed to a minimum depth of 18 feet below land surface with a borehole size 2 inches greater than the O.D. of the casing.

a) If well is completed in surficial sediments, does the casing extend to a minimum depth of 18 feet: (Yes _ No _ N/A X)

b) If well is completed in alluvium, is borehole size at least 2 inches greater than the O.D. of casing: (Yes _ No _ N/A X Borehole size _ Casing size _)

State of Idaho Reg. 3,3,4. Steel surface casing shall be installed into bedrock or to a depth of 18 feet, whichever is greater, with a borehole size 2 inches greater than the O.D. of the casing.

c) If well is completed in bedrock, does the casing extend to a minimum depth of 18 feet or bedrock, whichever is greater: (Yes X No _ N/A _)

d) If well is completed in bedrock, is the borehole at least 2 inches greater than the largest diameter casing from ground surface to top of bedrock: (Yes _ No X Borehole size >30 inches Casing size 30 inch I.D. or O.D.?)

e) What is/are the type of casing(s), diameter(s), interval(s), joint type(s) and casing thickness(es):

State of Idaho Reg. 3,2,1. Casing shall extend at least 12 inches above land surface. Casing joints shall be welded or screw-couple joints which shall be water tight or by other means approved by the Director of Idaho Department of Water Resources. All permanent steel casing required to be installed in a well shall meet the minimum specifications listed below. State of Idaho Reg. 3,2,2. The specifications of any plastic casing to be used shall meet or exceed ASTM Standard F-480.

Permanent Steel Casing Minimum Specifications

Nominal Size (inches)	Outside Diameter (inches)	Nominal Wall Thickness (inches)
1 1/2	1.900	.145
2	2.375	.154
2 1/2	2.875	.203
3	3.500	.216
3 1/2	4.000	.226
4	4.500	.237
5	5.500	.244
6 or greater		.250

Casing Type	Casing Diameter (inches)	Casing Interval (feet)	Type of Casing Joints	Stick-up of Casing Above Ground (inches)	Casing Thickness (inches)	Compliance W/ State Regs. on Casing Thickness
N.F. (surface casing)	30 I.D. or O.D.?	0 - 40	N.F.	0	N.F.	N.F.
Steel	20 I.D. or O.D.?	0 - 1511	N.F.	0	N.F.	N.F.
Steel	13 I.D. or O.D.?	0 - 3559	N.F.	0	0.375	Yes
Steel	9 I.D. or O.D.?	3282 - 6796	N.F.	N/A	N.F.	N.F

3) Seal

State of Idaho Reg. 3,3,1 and 3,3,2,1. The annular space between surface casing and borehole shall be filled with cement grout, puddling clay or bentonite grout from ground surface to 18 feet or top of bedrock, whichever is greater, to prevent the possible downward movement of contaminated surface waters. If well is completed in alluvium and greater than 18 feet in total depth, a seal to 18 feet is required.

Annular Fill Material	Interval (feet)	Mixture/Volumes	Material Approved by State of Idaho Regs.
Cement Grout	N.F.	N.F.	N.F.

a) Does the surface seal extend at a minimum from ground surface to 18 feet below land surface (if the well is completed in the alluvium) or to the top of bedrock (if the well is completed in bedrock): (Yes _ No Uncertain/Not documented X)

b) If the seal is documented, how was it emplaced (provide intervals if there was more than one grouting event): N/A _ Uncertain/not documented X Explanation for seal emplacement _

State of Idaho Reg. 3,3,1. The casing seal shall prevent the downward movement of groundwater from zones that have been cased out of the well due to quality or other reasons.

c) Is the well located in proximity to surface water bodies such as percolation ponds, influent streams and spreading areas or other sources that may contribute to perched groundwater above the sampling interval near the well: (Yes _ No X) Explanation The well is located approximately 1 mile west of the Big Lost River. There are no spreading areas or percolation ponds near the well.

d) Is there evidence of saturated formations above the sampling interval from drilling logs, geophysical logs (USGS Open-File Report 90-366) or other indicators: (Yes _ No X Insufficient data _) Explanation (Qualify data/specify perched intervals if applicable) There is no evidence of saturated formations above the sampling interval from the CWS files or the geophysical logs.

e) Is the casing sealed adequately to prevent groundwater movement within the annular space: It is uncertain. A casing seal is documented but its extent is not known. However, no evidence was found of perched water near the well.

4) Gravel Pack. Does the well contain a gravel pack: (Yes _ No X) If yes, is there a packer or adequate seal to prevent the migration of surface water or perched groundwater into the gravel pack: (Yes _ No _ N/A X)

D. IS THE WELL USED FOR RCRA MONITORING (Yes _ No X) OR IS THE WELL TO BE EVALUATED TO RCRA GUIDANCE AS A BEST MANAGEMENT PRACTICE (Yes _ No X). (If no, proceed to section E)

The State of Idaho Well Construction Regulations and INEL Best Management Practices that overlap with RCRA guidelines and regulations will not be duplicated in this section.

1) Were the drill rig, equipment, casing and screen steam cleaned before drilling and installation: (Yes _ No _ No documentation _) Explanation _

2) Were drilling additives used: (Yes _ No _ Uncertain/No documentation _) Drilling Method _ Additive(s)/Quantity _

3) Are the casing (that portion which is within the sampling interval), the screen, the pump and the pump discharge pipe constructed of nonreactive material which does not affect/interfere with chemical, physical, biological or radiological constituents of interests: (Yes _ No _)

Material

Casing ____________________

Screen ____________________

Pump ____________________

Discharge Pipe ____________________

Explanation ____________________

4) Is the screen factory fabricated: (Yes _ No _ No screen _) Type _

5) Is the monitoring interval adequate to detect the contaminants of concern, i.e. "floaters", "sinkers" or dissolved constituents: (Yes _ No _) Explanation _

FITNESS-FOR-USE CHECKLIST FOR AQUIFER AND PERCHED GROUNDWATER MONITORING/OBSERVATION WELLS

6) Is the monitoring interval greater than 30 feet in length: (Yes _ No _) or does the well monitor more than one type of lithology: (Yes _ No _) Monitoring interval(s) _

7) Is a filter pack present: (Yes _ No _) If yes, is the filter pack comprised of chemically inert material: (Yes _ No _ Uncertain _ N/A _) Does it extend no more than 2 feet above screen: (Yes _ No _ N/A_) Filter pack type _ Filter pack interval _

8) Has the well been developed to ensure turbid free groundwater samples, i.e. <5 NTUs: (Yes _ No _ Not Documented _) and to restore the natural hydraulic conductivity of the formation, i.e. stabilization of parameters: (Yes _ No _ Not Documented _) Well development type and duration _

9) Is the pump intake location documented: (Yes _ No _) Depth _

10) Does the pump type collect representative groundwater samples: (Yes _ No _ Not Documented _) Type_ Explanation _

E. THE PRIMARY SOURCE OF INFORMATION FOR THIS CHECKLIST IS IDAHO NATIONAL ENGINEERING LABORATORY COMPREHENSIVE WELL SURVEY OR AS REFERENCED. OTHER SOURCES: None

N.F. - Not Found/No Documentation
N/A - Not Applicable

F. WELL FITNESS DETERMINATION

Intended Use/Applicable Regulations: USGS Observation/State Regulations and INEL Best Management Practices

( ) Well complies with applicable regulations and is acceptable for intended use.
( ) Well complies with applicable regulations except for minor construction details and is acceptable for intended use. for minor construction details.
(X) Well does not meet applicable regulations, a variance should be obtained. If variance not obtained, remediation is required to comply with the regulations.
( ) Well does not meet applicable regulations and intended use, remediation is required.
( ) Well does not meet applicable regulations and should not be used for this purpose.
( ) Insufficient/uncertain data is available to evaluate compliance to the regulations.
( ) Abandonment, well is unneeded or cannot be remediated.

Deficiencies: The well's compliance with state regulations could not be determined because the extent of the casing seal was not documented. The well is located at least 2 miles from TAN and NRF, the nearest INEL facilities, and about 1 mile west of the Big Lost River. Since no evidence was found of surface or perched water near the well and the potential for contaminant migration within the annular spaces is extremely low, a variance should be requested if this information can not be ascertained. Also, the following minor deficiencies were noted: the casing thicknesses and joint types were not documented and the borehole was not two inches larger than the casing diameter as required but was about the same size.

Remediation: The well has a plywood cover and is located in a concrete pit, which is filled with water. The well and pit should have lockable steel covers or the pit should be filled in and the well extended above grade.

GEOLOGIC LOG

Well Name INEL-1

Source: EG&G Generalized Lithologic Log

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Interval (feet below surface)

Begin	End	Description
0	92	Basalt
92	113	Cinders
113	453	Basalt
453	480	Cinders
480	539	Basalt
539	567	Sand and Gravel
567	680	Basalt
680	718	Sand / Silt / Clay
718	813	Basalt
813	845	Cinders
845	966	Sand / Silt / Clay
966	1007	Basalt
1007	1040	Sand / Silt / Clay
1040	1100	Basalt
1100	1133	Sand / Silt / Clay
1133	1213	Basalt
1213	1533	Sand / Silt / Clay
1533	1633	Basalt
1633	1659	Sand / Silt / Clay
1659	2166	Basalt
2166	2446	Tuffaceous Interbed

COMPILED BY/ORGANIZATION: F.S. Mocker / GAI Date August 25, 1992

GEOLOGIC LOG

Well Name INEL-1

Source: EG&G Generalized Lithologic Log

****

Interval (feet below surface)

Begin	End	Description
2446	2800	Welded Tuff
2800	2846	Tuffaceous Interbed
2846	3039	Welded Tuff
3039	3080	Tuffaceous Interbed
3080	3312	Welded Tuff
3312	3353	Tuffaceous Interbed
3353	3426	Welded Tuff
3426	3454	Tuffaceous Interbed
3454	4233	Welded Tuff
4233	4289	Tuffaceous Interbed
4289	4487	Welded Tuff
4487	4512	Tuffaceous Interbed
4512	4774	Welded Tuff
4774	4800	Tuffaceous Interbed
4800	5080	Welded Tuff
5080	5106	Tuffaceous Interbed
5106	5987	Welded Tuff
5987	6006	Tuffaceous Interbed
6006	7053	Welded Tuff
7053	7087	Tuffaceous Interbed
7087	7146	Welded Tuff

COMPILED BY/ORGANIZATION: F.S. Mocker / GAI Date August 25, 1992

GEOLOGIC LOG

Well Name INEL-1

Source: EG&G Generalized Lithologic Log

****

Interval (feet below surface)

Begin	End	Description
7146	7174	Tuffaceous Interbed
7174	7226	Welded Tuff
7226	7259	Tuffaceous Interbed
7259	8074	Welded Tuff
8074	10365	Rhyodacite Ashflow

COMPILED BY/ORGANIZATION: F.S. Mocker / GAI Date August 25, 1992

INEL 1 ; 1

FORM NO. 9—1904—A
Revised September 1980

SITE NO. 3N-29E-01abd1

U.S. DEPT. OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
SITE SCHEDULE

Recorded by PR Fischer

W001

Date 5-29-85

Check One ✓ English ___ Metric Units

GENERAL SITE DATA (0)

Site Ident No 433717112563501 (5 … 19)

RG Number R=0 *

Transaction T= A D M V * (add, delete, modify, verified)

Site-Type 2= C D E H I M Ø P S T W * (colloc-tor, drain, excava-tion, sink-hole, connect-or well, multi-ple, out-crop, pond, spring, tunnel well, or shaft)

Data Reliability 3= (C) U L M * (field checked, unchecked, location not accurate, minimal data)

Reporting Agency 4= USGS *

Project No. 5= 1,0476107080 *

District 6= 16 *

State 7= 16 *

County (or town) Butte

8= 023 *

Latitude 9= 433717 * (deg min sec)

Longitude 10= 1125635 * (deg min sec)

Lat-Long Accuracy 11= S (F) T M * (sec, 5 sec, 10 sec, Min)

Local Number 12= 03N29E01abd1 *

Land Net Loc. 13= SE NW NE S 01 T 03N R 29E B * (1/4 1/4 1/4 section, township, range, merid)

Location Map 14= Circular Butte 3SW *

Scale 15= 24000 *

Altitude 16= 4873.00 *

Method of Measurement 17= A L (M) * (altimeter, level, map)

Accuracy 18= 5.0 *

Topo Setting 19= A B C D E F G H K L M Ø P S T (U) V W * (alluvial fan, playa, stream channel, depression, dunes, flat, flood plain, hill-top, sink, swamp, mangrove swamp, off-shore, pediment, hill-side, terrace, undulating, valley flat, upland draw)

Hydrologic Unit (OWDC) 20= 17040218 *

Use of Site 23= A C D E G H (O) M P R S T U W X Z * (anode, standby emer. supply, drain, geo-thermal, seismic, heat reserv., observation, mine, oil or gas, recharge, repress, test, unused, withdrawal, waste, destroyed)

Secondary Site Use 301= *

Tertiary Site Use 302= *

Use of Water 24= A B C D E F H I J K M N P Q R S T U Y Z * (air cond., bottling, commercial, dewater, power, fire, domestic, irrigation, industrial (cooling), mining, medicinal, industrial, public supply, aquaculture, recreation, stock, institution, unused, desal, other)

Secondary Water Use 25= *

Tertiary Use of Water 26= *

Depth of Hole 27= 10365.00 *

Depth of Well 28= 10333.00 *

Source of Depth Data ① 29= A *

Water Level 30= 306.00 *

Data Measured 31= 05/02/1979 * (month day year)

Source ① 33= A *

Method of Measurement 34= A B C E G H L M N R (S) T V Z * (airline, analog, calibrated airline, estimated, pressure gage, calibrated pressure gage, geophysical logs, manometer, non-rec. gage, reported, steel tape, electric tape, calibrated electric tape, other)

Site Status 37= D E F G H I J N Ø P R S T V W X Z * (dry, recently flowing, flowing, nearby flowing, nearby recently flowing, injector site, inj-site monitor, meas. discon., obstruction, pumping, recently pumped, nearby pumping, nearby recently pumped, foreign substance, well destroyed, surface water effects, other)

Source of Geohydrologic Data ① 36= *

Pump Used 35= * (no)

Date of First Construction/Completion 21= 05/27/1979 * (month day year)

OWNER IDENTIFICATION (1)

R=158 * T= A D M * (add, delete, modify)

Date of Ownership 159# / / * (month day year)

Name: Last 161# * First 162= * Middle Initial 163= *

OTHER SITE IDENTIFICATION NUMBERS (1)

R=189 * T= A D M * (add, delete, modify)

Ident 190# INEL #1 * Assigner 191= USGS WRD INEL *

New Card Same R & T

Ident 190# * Assigner 191= *

SITE VISIT DATA (1)

R=186 * T= A D M * (add, delete, modify)

Date of Visit 187# / / * (month day year)

Name of Person 188= *

FIELD WATER QUALITY MEASUREMENTS (1)

R=192 * T= A D M * (add, delete, modify)

Date 193# / / * (month day year)

Geohydrologic Unit 195# *

New Card Same R thru 195

Temperature 196# 00010 * Degrees C 197= . *

Conductance 196# 00095 * μ Mhos 197= . *

Other (STORET) Parameter 196# * Value 197= . *

Other (STORET) Parameter 196# * Value 197= . *

FOOT NOTES:

① Source of Data Codes:

A D G L M O R S Z

other, driller, geologist, log, memory, owner, other ...

PRODUCTION DATA (1)

R = 134 146 * (flowing, pumped) | T = A D M * (add, delete, modify) | Entry No 147 # | Date 148 = / / * (month, day, year)

Discharge 150 = * | Source of Data[1] 151 = * | Drawdown 309 = *

Method of Measurement 152 = B C E F M O P R T U V W Z * (bailer, current meter, estimated, flume, totaling meter, orifice, pitot-tube meter, reported, trajectory, venturi, volumetric, weir, other)

Production Level 153 = * | Static Level 154 = * | Source of Data ① 155 = * | Specific Capacity 272 = *

Method of Measurement 156 = (A) B C E G H L M N R S T V Z * (airline, analog, calibrated airline, estimated, pressure gage, calibrated pressure gage, geophysical logs, manometer, non-rec. gage, reported, steel tape, electric tape, calibrated electric tape, other) | Pumping Period 157 = *

LIFT DATA (1)

R = 42 * | T = A D M * (add, delete, modify) | Type of Lift 43 = A B C J P R (S) T U Z * (air, bucket, centrifugal, jet, piston, rotary, submergible, turbine, unknown, other) | Entry No 254 # *

Pump Intake Setting 44 = * | Type of Power 45 = (D) E G H L N W Z * (diesel, electric, gasoline, hand, LP gas, natural gas, windmill, other)

Date 38 = / / * (month, day, year) | Horsepower 46 = 30.00 *

MAJOR PUMP DATA (2)

R = 47 * | T = A D M * (add, delete, modify) | Type of Lift 43 # * | Lift Entry No 254 # * | Manufacturer of Pump 48 = *

Serial No of Pump 49 = * | Name of Power Company 50 = *

Power Company Account No 51 = * | Power Meter No 52 = * | Pump Rating 53 = *

Person or Company Who Maintains the Pump 54 = * | Additional Lift 255 = * | Rated Pump Capacity 268 = *

STANDBY POWER DATA (2) (See LIFT DATA for codes of fields 43 and 56 below)

R = 55 * | T = A D M * (add, delete, modify) | Type of Lift 43 # * | Type of Power 56 = * | Horsepower 57 = * | Lift Entry No 254 # *

AVAILABLE LOG DATA (1)

R = 198 * | T = A D M * (add, delete, modify) | New Card for Each Log Type Same R & T

Type of Log②	Begin Depth	End Depth	Source of Data①
199 # D *	200 = 0.00 *	201 = 10365.00 *	202 = A *
199 # C *	200 = 40.00 *	201 = 3500.00 *	202 = A *
199 # T *	200 = 40.00 *	201 = 9700.00 *	202 = A *
199 # N *	200 = 0.00 *	201 = 10094.00 *	202 = A *

WATER QUALITY DATA COLLECTION (1)

R = 114 * | T = (A) D M * (add, delete, modify) | Begin Year 115 # * | End Year 116 = * | Source Agency 117 # *

Frequency of Collection③ 118 = * | Network Site⑤ 257 # * | Type of Analyses④ 120 = * | Analyzing Agency 307 = *

WATER LEVEL DATA COLLECTION (1)

R = 121 * | T = A D M * (add, delete, modify) | Begin Year 122 # * | End Year 123 = * | Source Agency 124 = *

Frequency of Collection③ 125 = M * | Network Site⑤ 258 # *

WATER PUMPAGE/WITHDRAWAL DATA COLLECTION (1)

R = 127 * | T = A D M * (add, delete, modify) | Begin Year 128 # * | End Year 129 = * | Source Agency 130 # *

Frequency of Collection③ 131 = * | Network Site⑤ 259 # * | Method of Collection 133 = C E M Z * (calculated, estimated, metered, other)

OTHER DATA AVAILABLE (1)

R = 180 * | T = A D M * (add, delete, modify) | Entry Number 312 # * | Type of Data 181 = * | Loc 182 = C D R Z * (cooperator, district, reporting agency, other) | Format 261 = F M P Z * (files, machine readable, published, other)

New Card Same R & T | 312 # * | 181 = * | 182 = C D R Z * | 261 = F M P Z *

FOOT NOTES:

① Source of Data Codes: (A) D G L M O R S Z (other gov't, driller, geologist, logs, memory, owner, other reported, reporting agency, other)

③ Frequency of Collection Codes: A B C D F I M Ø Q S W Z (annual, bi-monthly, continuous, daily, semi-monthly, intermittent, monthly, one time only, quarter annual, semi-annual, weekly, other)

② Type of Log Codes: A B C D E F G H I J K L M N Ø P Q (time, collar, caliper, driller's, electric, fluid conduct, geologist, magnetic, induction, gamma ray, dipmeter, laterlog, microlog, neutron, μ later, photo, radio-active)

S T U V X Z (sonic, temp, gamma-gamma, fluid velocity, core, other)

4 Type of Quality Analyses Codes: A B C D E F G H I J K L M N Z (physical, common chemical, trace elements, pesticides, nutrients, sanitary, codes B&D, codes B&E, codes B&C, codes B&F, codes D&E, codes C,D&E, all or most, codes B&C & radioactive, other)

⑤ Network Codes: 1 2 3 4 (national, district, project, cooperator)

L	40.00	10094	A
S	1500.00	3500	A
S	9700.00	10200	A
U	0.00	440	A
J	0.00	700	A

CONSTRUCTION DATA (1)

*	T- A D M * (add, delete, modify)	Entry No 59 # *	Date of Construction Completion 60- 05/27/1979 * (month day year)
Source of ① Const. Data	64- *		

Name of Contractor/Driller 63- Brinkerhoff * — Brinkerhoff-Signal

Method of Construction 65- A (air-, rotary) B (bored, or augered) C (cable-, tool) D (dug) H (hydraulic, rotary) J (jetted) P (air-percussion) R (reverse, rotary) T (trenching) V (driven) W (drive, wash) Z (other) *

Finish 66- C (porous, concrete) F (gravel w. perf) G (gravel, screen) H (horizontal, gallery) Ø (open, end) P (perforated, or slotted) S (screen) T (sand point) W (walled) X (open, hole) Z (other) *

Type of Seal 67- B (bentonite) C (clay) (G) (cement, grout) Z (other) *

Bottom of 68- * — Method of Development 69- A (air-lift, pump) B (bailed) C (compressed, air) J (jetted) N (none) P (other, pump) S (surged) Z (other) * — Number of Hours in Development 70- *

Special Treatment During Development 71- C D E F H M Z * (chemicals, dry ice, explosives, deflocculent, hydrofracturing, mechanical, other)

DIMENSIONS OF THE HOLE CONSTRUCTED (2)

72 * T- A D M * (add, delete, modify) — Construction Entry No 59 # *

New Card for Each Hole Segment Same R, T & Field 59

Top of Hole Segment Below LSD	Bottom of Hole Segment below LSD	Diameter of Hole Segment
73 # .00 *	74- 1524.00 *	75- 26.50 *
73 # 1524.00 *	74- 3561.00 *	75- 17.50 *
73 # 3561.00 *	74- 10333.00 *	75- 12.25 *
73 # 10333.00 *	74- 10365.00 *	75- 8.75 *
73 # . *	74- . *	75- . *

CASING SCHEDULE (2)

-76 * T- A D M * (add, delete, modify) — Construction Entry No 59 # * — New Card for Each Casing With Same R, T & Field 59

Top of Casing Segment Below LSD	Bottom of Casing Segment Below LSD	Diameter of Casing Segment	Casing Material ⑤	Thickness of Casing
77 # .00 *	78- 40.00 *	79 # 30.00 *	80- *	81- . *
77 # .00 *	78- 1511.00 *	79 # 20.00 *	80- *	81- . *
77 # .00 *	78- 3559.00 *	79 # 13.00 *	80- *	81- .375 *
77 # 3282.00 *	78- 6796.00 *	79 # 9.00 *	80- *	81- . *
77 # . *	78- . *	79 # . *	80- *	81- . *

OPENINGS SCHEDULE (2)

-82 * T- A D M * (add, delete, modify) — Construction Entry No 59 # * — New Card for Each Open Section With Same R, T and Field 59

	(Openings Data)	(Openings Data)	(Openings Data)
Top of Section Below LSD	83 # 4210.00 *	83 # 6796.00 *	83 # 10333.00 *
Bottom of Section Below LSD	84- 6275.00 *	84- 10333.00 *	84- 10365.00 *
Type of Openings ⑥	85- P *	85- X *	85- X *
Type of Material ⑦	86- *	86- *	86- *
Diameter of Open Section	87- 9.00 *	87- 12.25 *	87- 7.00 *
Width of Opening	88- . *	88- . *	88- . *
Length of Opening	89- . *	89- . *	89- . *

NOTES:

① Source of Data Codes: A (other, gov't) D (driller) G (geologist) L (logs) M (memory) O (owner) R (other, reported) S (reporting, agency) Z (other)

⑤ Casing Material Codes: B (brick) C (concrete) D (copper) G (galv, iron) I (wrought, iron) M (other, metal) P (PVC or, plastic) R (rock or, stone) S (steel) T (tile) U (coated, steel) W (wood) Z (other)

⑥ Type of Openings Codes: F (fracture) L (louvered, shuttered) M (mesh) P (perforated, or slotted) R (wire-wound) S (screen (unknown)) T (sand, point) W (walled) X (open, hole) Z (other)

⑦ Type of Material Codes for Open Sections: B (brass or, bronze) C (concrete) G (galv, iron) I (wrought, iron) M (other, metal) P (PVC or, plastic) R (stainless, steel) S (steel) T (tile) Z (other)

4210	4240	4300	4490	4775	5085	5230	5995
4225	4270	4315	4520	4790	5100	5245	6010
P	P	P	P	P	P	P	P
9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00

6220	6260
6235	6275
P	P
9.00	9.00

GEOHYDROLOGIC UNIT DESCRIPTIONS (1)

R=90 * T= A D M * (add, delete, modify) Entry No 256 # * Depth to Top 91= . * Depth to Bottom 92= . *

93= * Unit Identifier 304= * (1) Contributing Unit 96= * Lithology 97= * Lithologic Modifier

AQUIFER DATA (2)

R=94 * T= A D M * (add, delete, modify) Geohydrologic Unit Entry No 256 # *

Date 95 # / / * (month day year) Water Level 126= . * % Water Contributed 132= *

GEOHYDROLOGIC UNIT DESCRIPTIONS (1)

R=90 * T= A D M * (add, delete, modify) Entry No 256 # * Depth to Top 91= . * Depth to Bottom 92= . *

93= * Unit Identifier 304= * (1) Contributing Unit 96= * Lithology 97= * Lithologic Modifier

AQUIFER DATA (2)

R=94 * T= A D M * (add, delete, modify) Geohydrologic Unit Entry No 256 # *

Date 95 # / / * (month day year) Water Level 126= . * % Water Contributed 132= *

PERTINENT REMARKS

R=183 * T= A D M * (add, delete, modify) New Card Same R&T

Remark No.

311 # * 185= ` '*

311 # * 185= ` '*

311 # * 185= ` '*

311 # * 185= ` '*

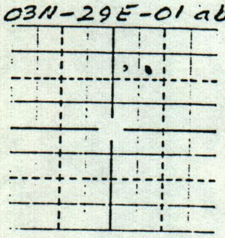
311 # * 185= ` '*

(1) Contributing Unit Codes

P	S	N	U
primary contributing	secondary contributing	non-contributing	unknown

NOTES:

03N-29E-01 abd1



INEL 1 J2

WELL DATA
MEMORANDUM TO FILE

DATE: 8/9/90

ORIGINATOR: R. WILLSON

ORGANIZATION/SOURCE (PERSONS CONTACTED):

WELL NAME: INEL 1

LOCATION COORDINATE: T3N-R29E-1abd1

FACILITY LOCATION:

REFERENCE NUMBER: W001

PROBLEM/INFORMATION DESCRIPTION:

- open HOLE IN THE COMPLETION ZONE HAS A DIAMETER of 7" whereas the HOLE DIAMETER, WHEN CUT, was 8.75". IS THIS possible?

RESOLUTION (DATE):

INEL 1; 4

W124

Well Name: INEL 1

Composite confidence level: D

Coordinates

TRS: T3N-R29E-1abd1
Northing: 713320.97
Easting: 294408.53
Latitude: 433717.00
Longitude: 1125635.00

Elevation Information

Elevation (ft.): 4873
Datum: NF

Well Category

Well type: Observation
Well status: NF
Well installation type: Single

Drilling Information

Driller's name: Brinkerhoff
Year: 1979
Drilling method: NF
Work-over year: NF

Depth

Bore hole total depth BLS (ft.): 10365
Well total depth BLS (ft.): 10333

Water Information

Initial water level BLS (ft.): 306
Date: 05/02/79
Water quality sampling frequency: ~~NF~~ Intermittent

Pump Information

Pump type: ~~NF~~ None
Depth BLS (ft.): NF
Discharge rate (gpm): NF
Water level access type: NF

Available Information

Construction diagram: N
Lithographic log: Y
Natural gamma log: Y
T.V. camera/photo log: N
Fluid conductivity log: N
Gamma gamma log: Y
Driller's log: Y
Geologist's log: Y
Site schedule: Y
Caliper log: Y
Neutron log: Y
Electric log: N
Field book: N

WELL DATA
MEMORANDUM TO FILE

DATE: 10/23/90

ORIGINATOR: Sandy Williams

ORGANIZATION/SOURCE (PERSONS CONTACTED): USGS / Rodger Jensen and Brennon Orr (see ref * 124)

WELL NAME: many

LOCATION COORDINATE: —

FACILITY LOCATION: General INEL

REFERENCE NUMBER: — (see 124)

PROBLEM/INFORMATION DESCRIPTION:

USGS was requested by EG&G to review the Draft INEL Comprehensive Well Survey Report and provide comments. R. Jensen and B. Orr (USGS) reviewed all or part of the draft report. The resulting marked up copy has been designated as reference *124 (3 volumes). When comments were incorporated into the comprehensive well inventory, a copy of the appropriate comments were attached to a copy of this MTF and were entered into each file folder as a reference to the changes that were made.

Comments which were made on the maps were translated to paper and attached to this memo-to-file and placed in the appropriate well file folder. The original comments are contained in ref. * 124.

INEL 1; 5

W130

Table 1.--Types of geophysical logs available and number of each digitized for wells and coreholes on or near the Idaho National Engineering Laboratory, Idaho--Continued

Well identifier	Total depth	Geophysical log type: Neutron	Gamma-gamma	Natural gamma	Caliper	Temper-ature	Resis-tivity	Specific conductance	Other
GIN-6	201	--	1/1	1/1	--	--	--	--	--
GIN-7	151	--	1/1	1/1	1/1	--	--	--	--
GIN-8	203	--	2/2	1/1	2/2	--	--	--	--
GIN-9	204	--	1/1	1/1	1/1	--	--	--	--
GIN-10	161	--	1/1	1/1	1/1	--	--	--	--
GIN-11	163	--	1/1	1/1	2/2	--	--	--	--
GIN-12	140	--	1/1	1/1	2/1	--	--	--	--
GIN-13	142	--	1/1	1/1	2/1	--	--	--	--
GIN-14	75	--	1/1	1/1	1/1	--	--	--	--
GIN-15	74	--	2/2	1/1	1/1	--	--	--	--
GIN-16	75	--	1/1	1/1	2/2	--	--	--	--
GIN-17	76	--	2/2	2/2	1/1	--	--	--	--
GIN-18	198	--	1/1	1/1	1/1	--	--	--	--
GIN-19	199	--	1/1	1/1	1/1	--	--	--	--
GIN-20	198	--	1/1	1/1	1/1	--	--	--	--
HIGHWAY-1	1280	--	4/3	4/4	3/3	--	--	--	M,1/0
HIGHWAY-2	788	--	3/3	4/3	--	1/0	1/0	1/0	--
HIGHWAY-3	754	--	1/1	1/1	1/1	1/1	--	--	--
IET-DISP.	250	--	--	1/1	--	--	--	--	--
INEL-1	10240	--	--	7/3	6/3	11/2	4/0	--	--
INEL-1(WS)	698	3/3	1/1	6/3	1/1	--	--	--	--
LPTF(Disp)	317	--	--	1/1	--	--	--	--	--
Leo Rogers	717	--	3/3	2/2	2/2	1/0	1/0	--	--
M-ETR-Disp	1235	--	20/4	12/3	13/4	4/0	2/0	--	F,1/0
MTR-1(TEST)	589	1/1	1/1	5/5	--	7/0	4/0	1/0	--
MTR-3	598	--	1/1	1/1	1/1	--	--	--	--
NA89-1	237	2/2	1/1	1/1	--	--	--	--	--
NA89-2	234	1/1	1/1	1/1	--	--	--	--	--
NONAME-1-TANE	549	--	2/2	3/3	3/2	1/0	--	--	--
NPR-TEST	600	1/1	1/1	1/1	1/1	--	--	--	--
PBF(CW)	222	--	1/1	1/1	2/2	--	--	--	--
PBF(WW)	224	--	2/2	2/2	2/2	--	--	--	--
PSTF	314	--	1/1	2/2	--	4/0	4/0	2/0	--
PW-1	115	1/1	1/1	1/1	--	--	--	--	--
PW-2	129	2/2	2/2	2/2	--	--	--	--	--
PW-3	122	2/2	1/1	1/1	--	--	--	--	--
PW-4	142	2/2	1/1	1/1	--	--	--	--	--
PW-5	122	2/2	1/1	1/1	--	--	--	--	--
PW-6	124	3/3	2/2	1/1	--	--	--	--	--
PW-7	232	2/2	2/2	1/1	--	--	--	--	--
PW-8	164	2/2	1/1	1/1	--	--	--	--	--
PW-9	196	2/2	2/2	1/1	--	--	--	--	--
P&W-1	432	--	3/3	3/3	--	2/0	2/0	2/0	--
P&W-2	383	--	1/1	3/3	--	2/0	2/0	2/0	--
P&W-3	407	--	1/1	3/3	--	2/0	2/0	1/0	--
QAB	1102	--	1/1	1/1	1/1	--	--	--	--
RRW	623	1/1	1/1	2/2	2/2	--	--	--	--
RWMC78-1	78	1/1	--	1/1	--	--	--	--	--
RWMC78-2	234	1/1	1/1	1/1	1/1	--	--	--	--
RWMC78-3	166	1/1	1/1	1/1	1/1	--	--	--	--
RWMC78-4	343	1/1	1/1	1/1	1/1	--	--	--	--
RWMC78-5	227	1/1	1/1	1/1	1/1	--	--	--	--
RWMC79-1	239	1/1	1/1	1/1	1/1	--	--	--	--
RWMC79-2	218	3/3	1/1	1/1	1/1	--	--	--	--
RWMC79-3	255	1/1	1/1	1/1	1/1	--	--	--	--
RWMC88-1D	232	2/2	2/2	2/2	2/2	--	--	--	--
RWMC88-02D	220	2/2	2/2	2/2	2/2	--	--	--	--
RWMC89-01D	242	2/2	2/2	2/2	2/2	--	--	--	--
S5G-TEST	1325	--	17/5	17/3	17/6	5/0	3/0	--	--
S5G-2	599	--	3/3	3/3	2/2	--	--	--	--

Well identifier: INEL-1

Well location: 03N-29E-01abb1

Latitude and longitude: 433717 1125635

Site identifier: 433717112563501

County: Butte

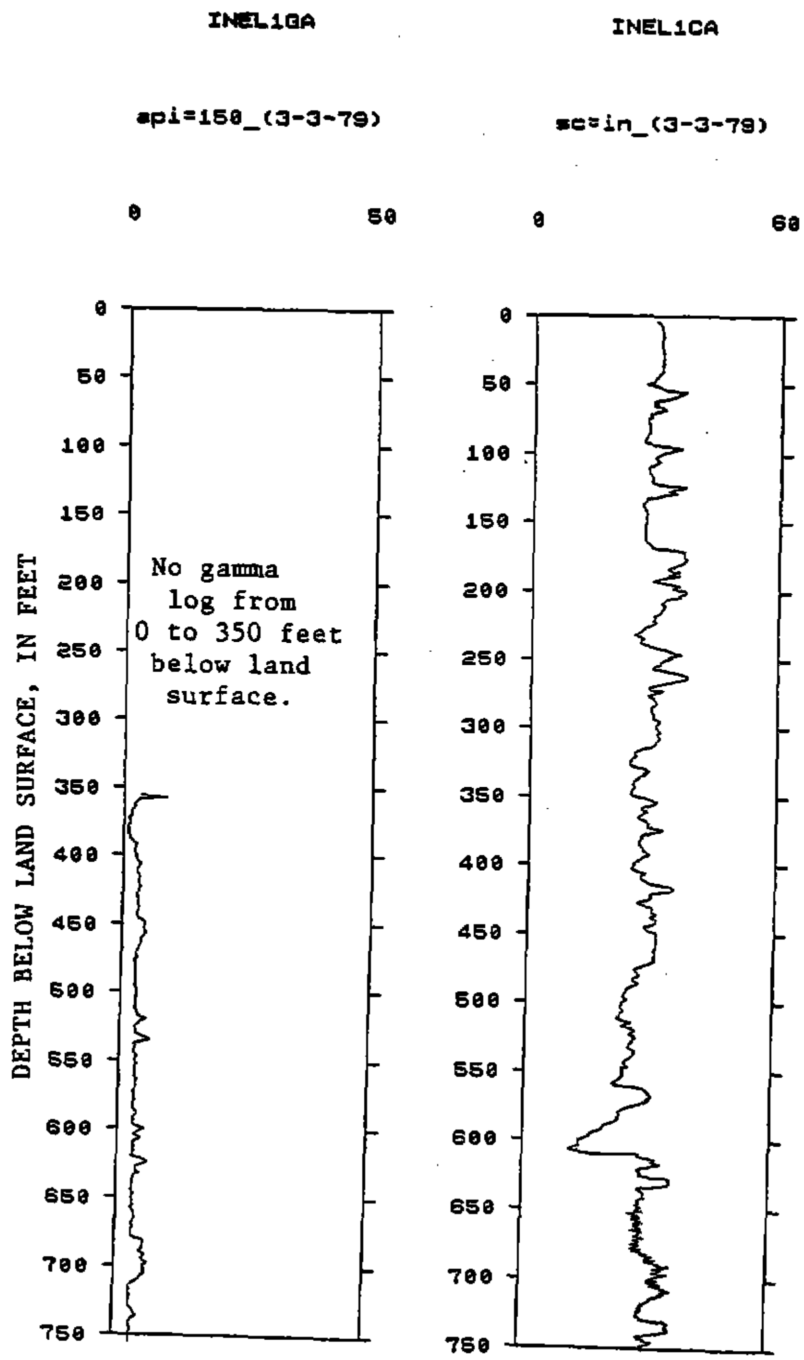
Altitude: 4873 ft

Depth of well: 10333 ft

Depth of hole: 10365 ft

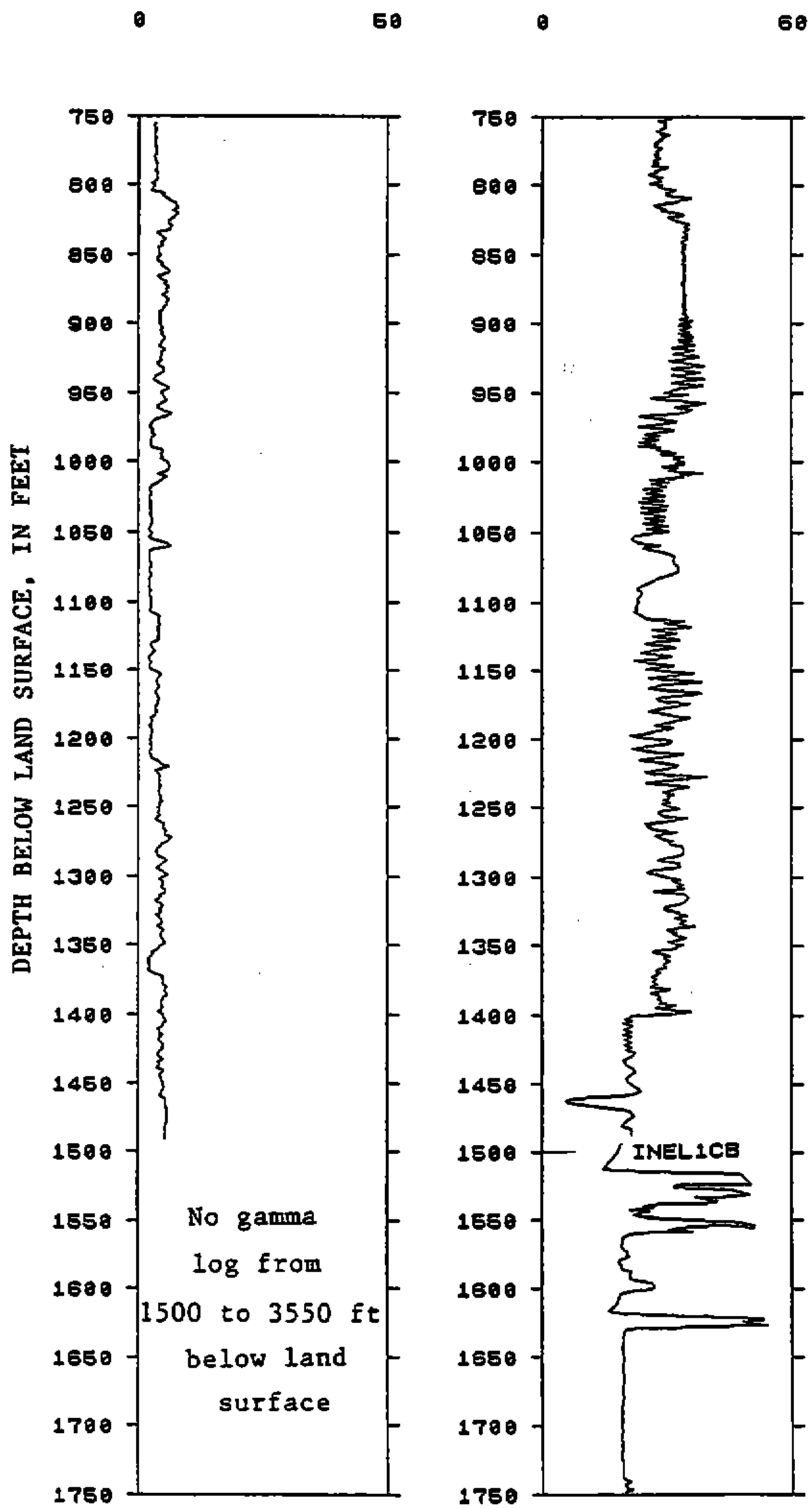
Total depth logged: 10240 ft

Remarks: Additional digitized and undigitized logs are available (see Table 1). Digitized and unprocessed logs are on disk 10. Digitized and processed logs are on disk 12. Gamma log shown is a combination of 2 digitized logs. Line breaks separate INEL1GA and INEL1G81-4. Caliper log shown is a combination of 3 digitized logs. Line breaks separate INEL1CA, INEL1CB, and INEL1CC.



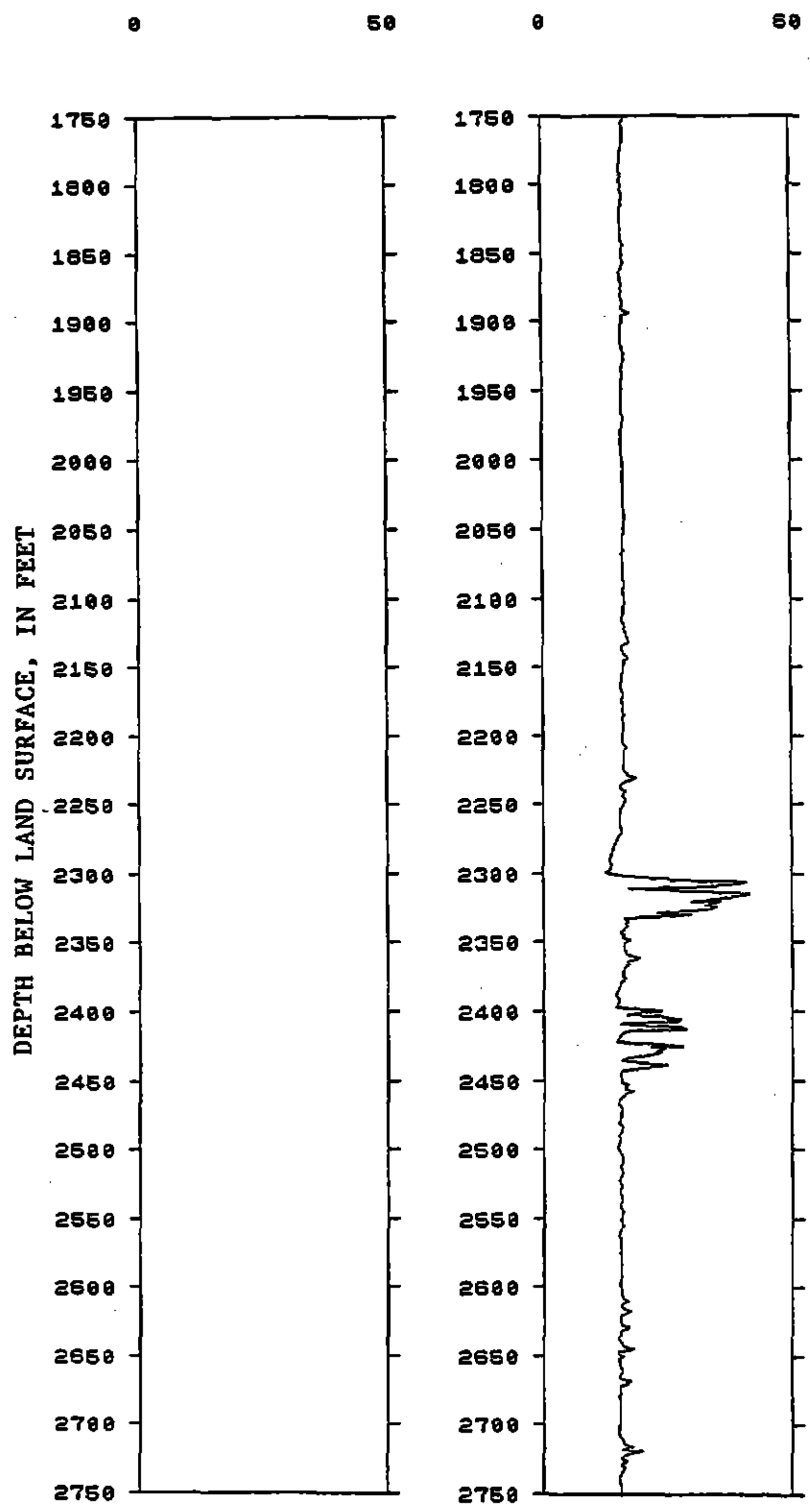
INEL1GA--Continued INEL1CA--Continued

api=150_(3-3-79) sc=in_(3-3-79)

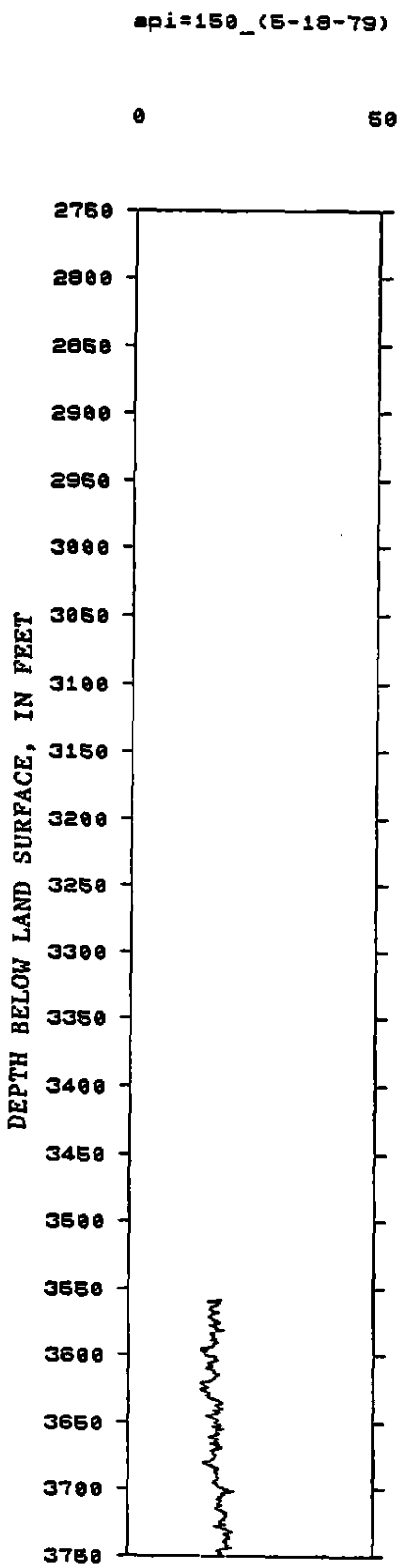


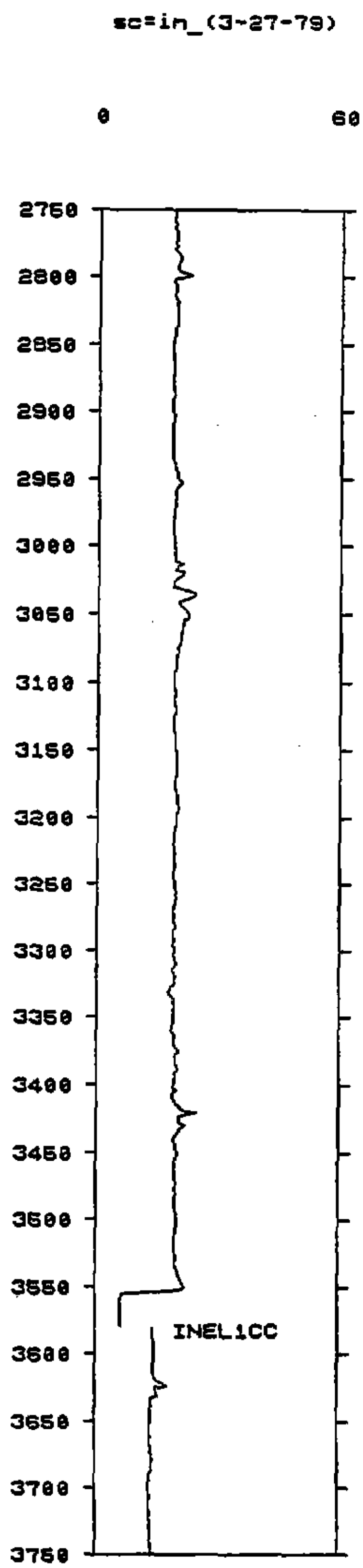
INEL1GB1--Continued INEL1CB--Continued

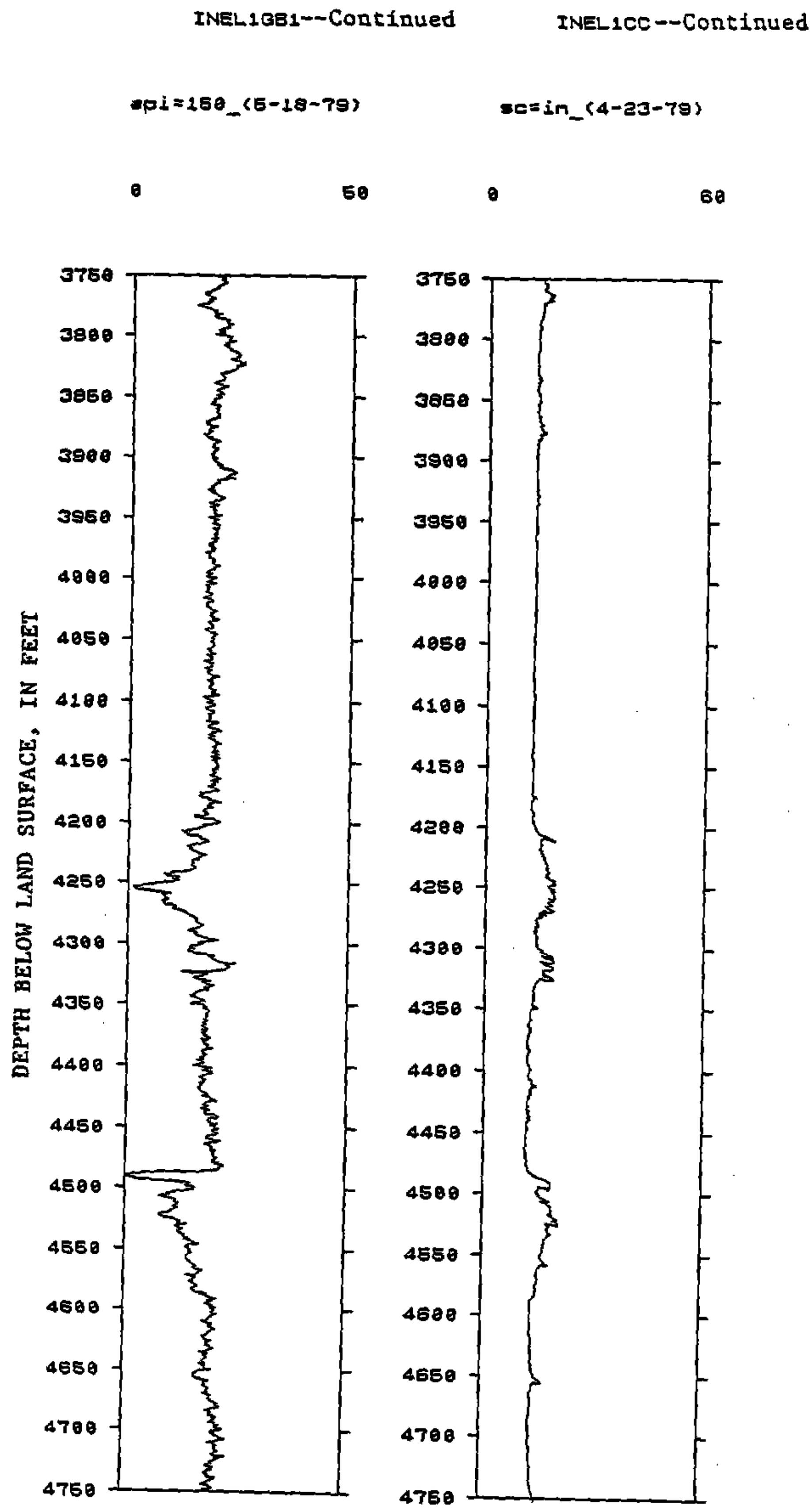
api=150_(5-18-79) sc=in_(3-27-79)

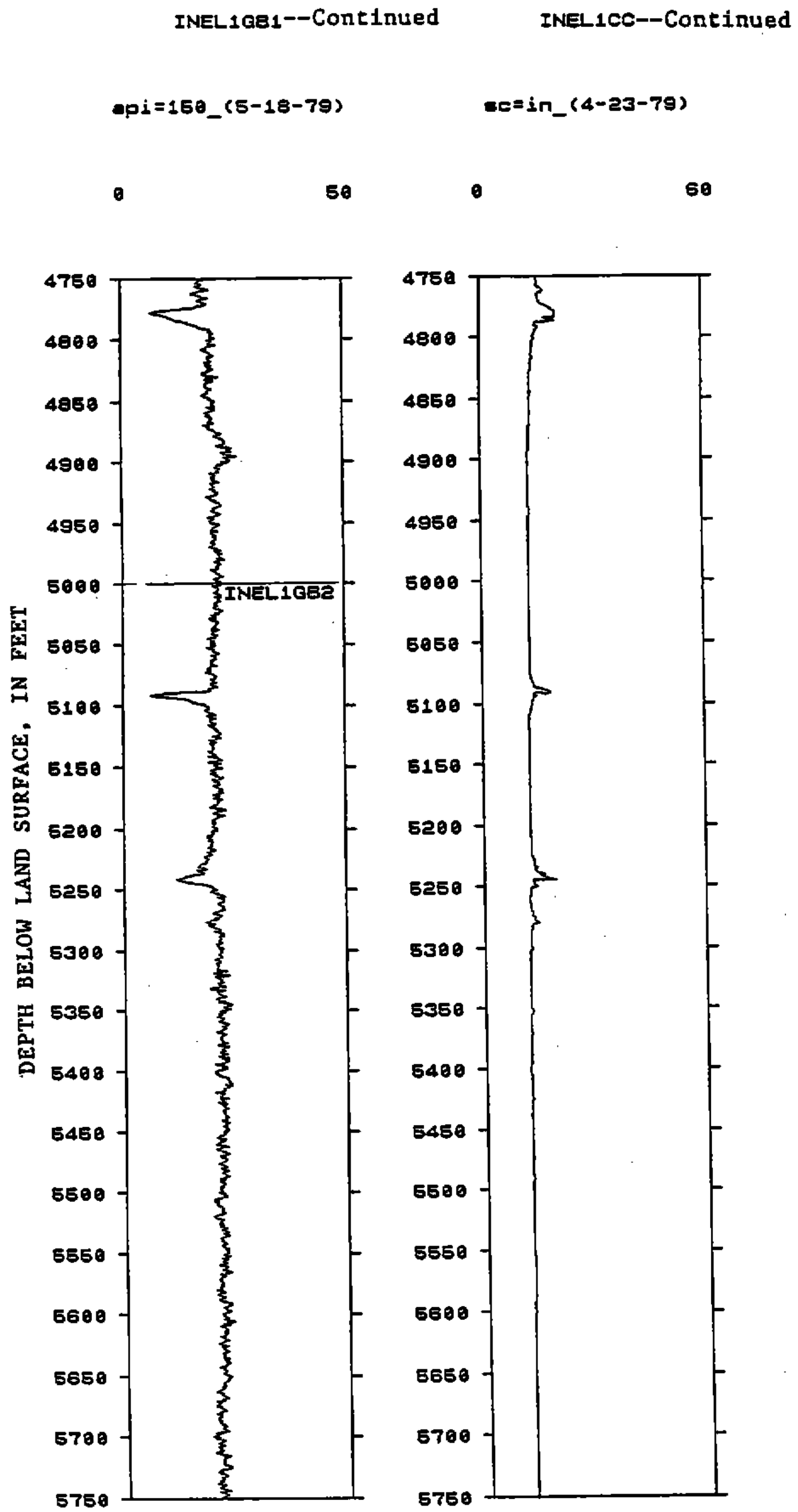


INEL1GB1--Continued INEL1CB--Continued



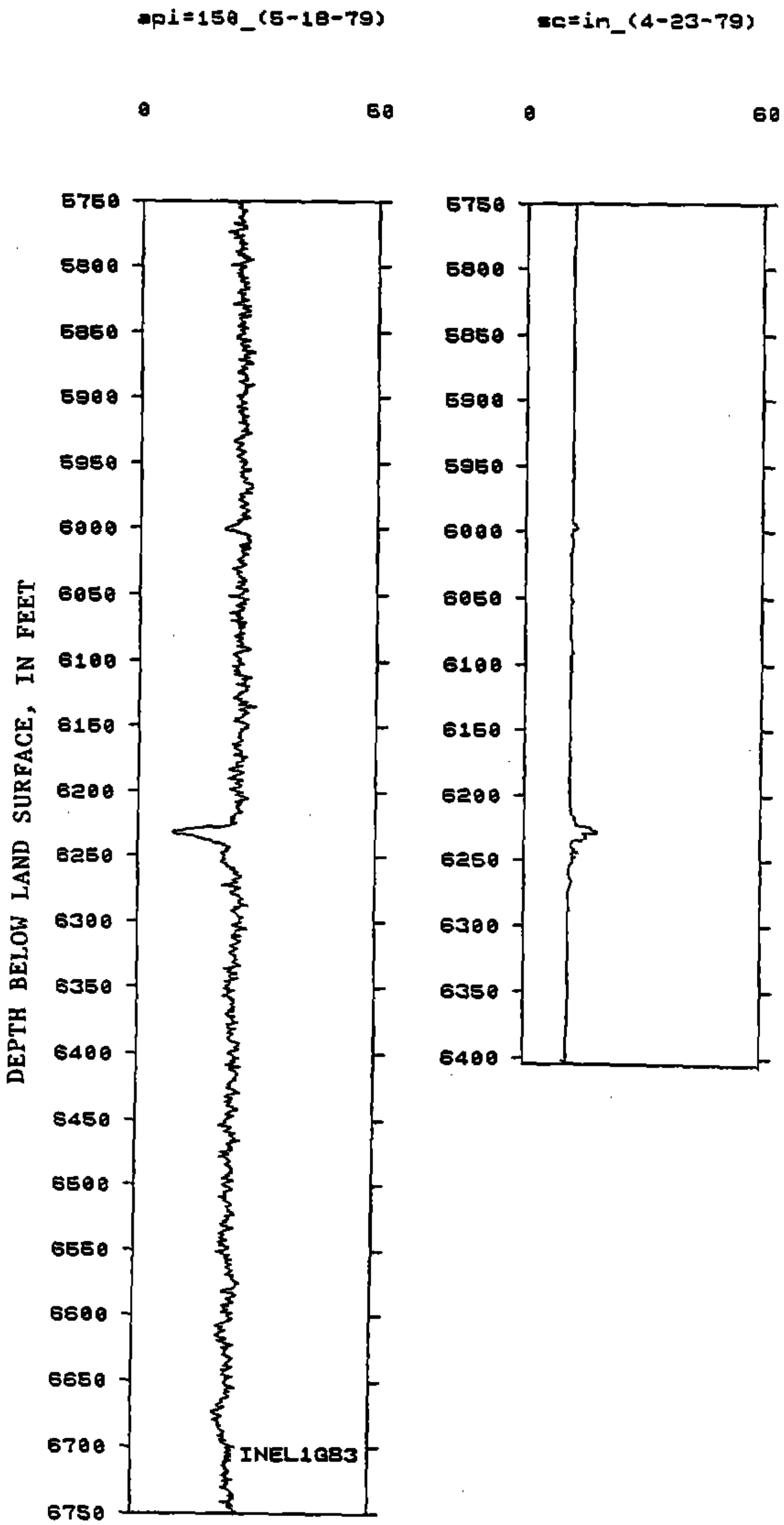



INEL1GB1--Continued
INEL1CC--Continued
epi=150_(5-18-79)
sc=in_(4-23-79)
0
50
0
60
3750
3800
3850
3900
3950
4000
4050
4100
4150
4200
4250
4300
4350
4400
4450
4500
4550
4600
4650
4700
4750
DEPTH BELOW LAND SURFACE, IN FEET

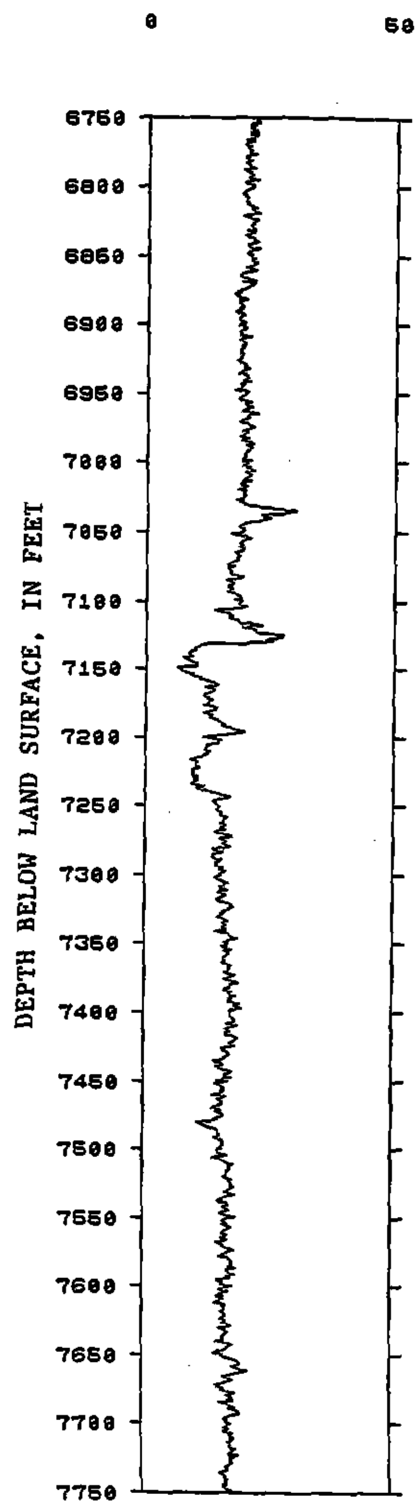

INEL1GB1--Continued
INEL1CC--Continued
api=150_(5-18-79)
sc=in_(4-23-79)
0
50
0
60
4750
4800
4850
4900
4950
5000
5050
5100
5150
5200
5250
5300
5350
5400
5450
5500
5550
5600
5650
5700
5750
INEL1GB2
DEPTH BELOW LAND SURFACE, IN FEET

INEL1GB2--Continued

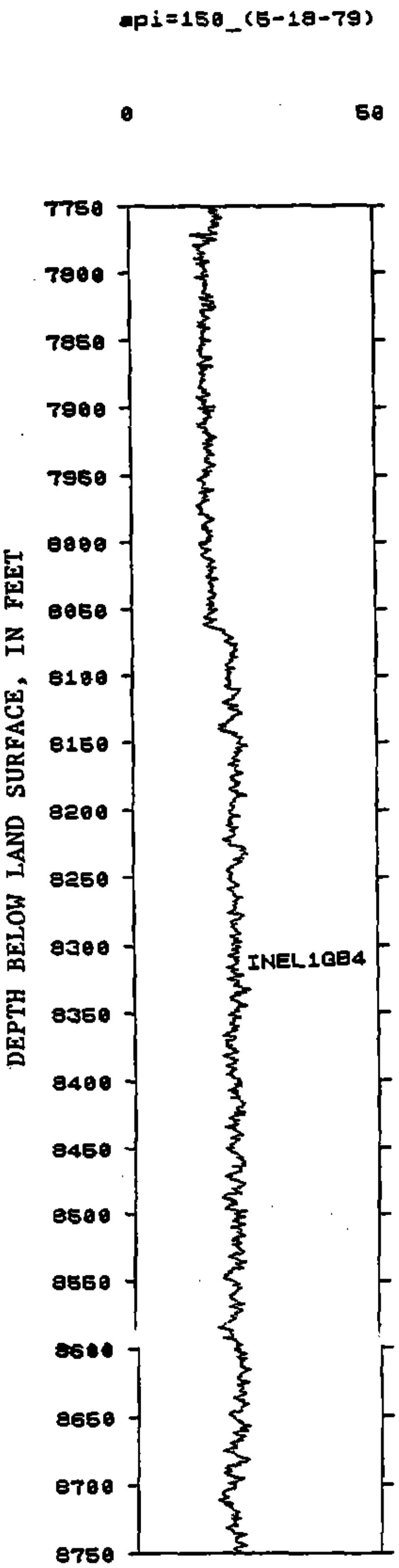
INEL1CC--Continued



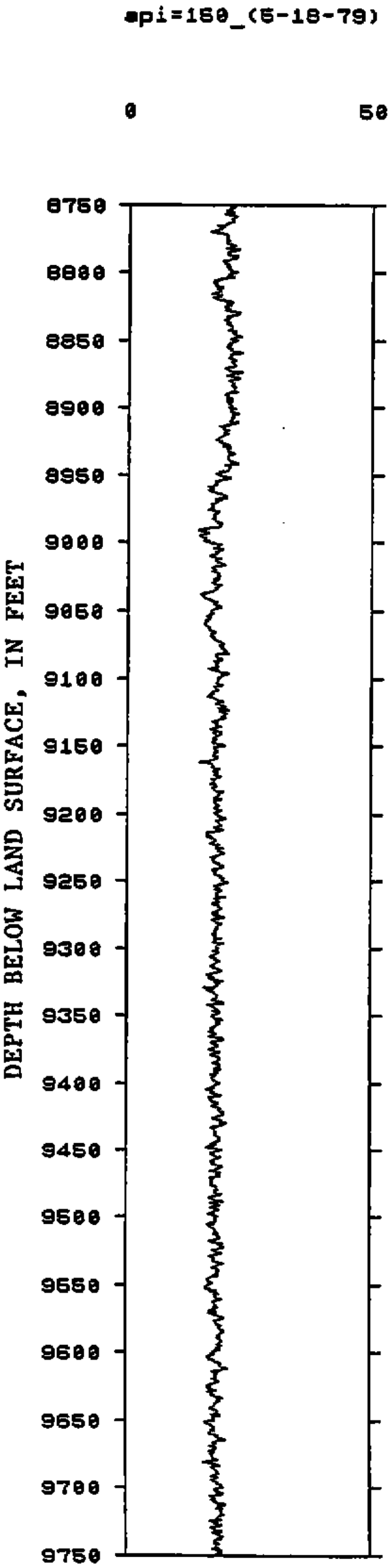
api=150_(5-18-79)



INEL1GB3--Continued

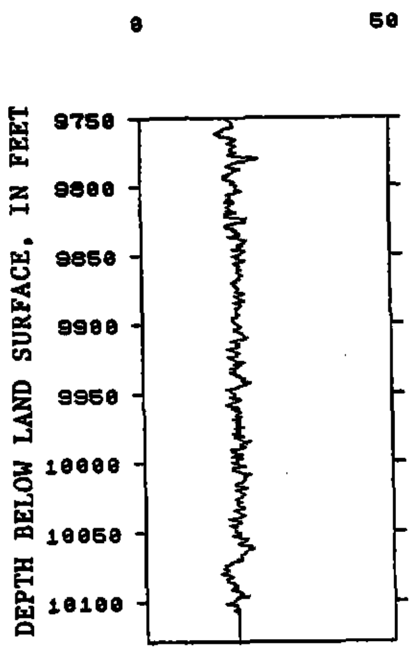


INEL1GB4--Continued



INEL1GB4--Continued

api=150_(5-18-79)



W131
INEL 1, 6

FORM NO. 9–1904–E

U.S. DEPT. OF INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

GROUND WATER SITE INVENTORY
WATER-LEVEL DATA

COUNTY Butte LOCAL WELL NO. 03N 29E 1abb1 OWNER US DOE

Site Ident. No. 433717112563501

Water Level Data R=234 T=A

Method of W/L Selection from Recorder 240= M (Max daily value) N (Min daily value) A (12:00 noon Reading) P (Midnight Reading)

Meas. Point R=320 T= (A) add D delete M modify

M. P. Begin Date 321= / /

M. P. End Date 322= / /

M. P. Height 323= 0.75 (ABOVE) / BELOW LSD

Top of Conc. Sump 4873.86'
bottom of Conc. Sump 4863.86'

M.P. Remark 324= MP NOT TOP OF 12" FLANGE 4874.61 FEET ABOVE MSL

Date M.P. Punched / / By

DATE (236)	WATER LEVEL (BELOW LSD) 0.75 (237)	STATUS (238)	METHOD (239)	HOLD	CUT	DEPTH BELOW MP	MEAS BY TIME	REMARKS	DATE PUNCHED
10/28/1985	306.17		S	310.00	3.08	306.92	PRF RJ 1338		
12/03/1985	306.06		S	310.00	3.19	306.81	PF 1440		
02/03/1986	305.95		S	310.00	3.30	306.70	LP 1550		
04/29/1986	305.81		S	310.00	3.44	306.56	RJ 1337		
10/28/1986	305.92		S	310.00	3.33	306.67	DE RJ 1035		
12/22/1986	305.57		S	310.00	3.68	306.32	PRF 1452		
02/25/1987	305.19		S	310.00	4.06	305.94	PRF 1509		
04/21/1987	305.47		S	308.00	1.78	306.22	RJ 1545		
08/11/1987	305.10		S	310.00	4.15	305.85	RJ 1510		
11/06/1987	304.88		S	309.00	3.37	305.63	RJ 1355		
01/19/1988	304.90		S	309.00	3.35	305.65	RJ 1505		
03/21/1988	304.60		S	309.00	3.65	305.35	RJ 1100		
03/20/1989	304.44		S	310.00	4.81	305.19	RJ 1005		
03/22/1990	304.25		S	310.00	5.00	305.00	RJ 0920		
/ /	.								
/ /	.								
/ /	.								
/ /	.								
/ /	.								

Site Status 238= D dry, E flowed recently, F flowing, G nearby flowing, H nearby recently flowing, N measurement discontinued, O obstruction, P pumping, R recently pumped, S nearby pumping, T nearby recently pumped, V foreign substance, W well destroyed, X surface water effects, Z other

INEL #1

Method of Measurement 239= A airline, C calibrated airline, E estimated, G pressure gage, H calibrated pressure gage, L geophysical logs, M manometer, R reported, S steel tape, T electric tape, V calibrated electric tape, Z other

W141

WELL DATA
MEMORANDUM TO FILE

DATE: 10/21/91

ORIGINATOR: Richard Willson

ORGANIZATION/SOURCE (PERSONS CONTACTED): EG&G/Jack Barraclough (see ref #141)

WELL NAME: Many

LOCATION COORDINATE:

FACILITY LOCATION: General INEL

REFERENCE NUMBER: (See #141)

PROBLEM/INFORMATION DESCRIPTION:

EG&G reviewed the Draft INEL Comprehensive Well Survey Report and provided comments. Jack Barraclough provided the actual comments to parts of the draft and well reports. This MTF only addresses comments pertaining to the well reports. The mark-up copy has been designated as reference #141. A copy of the appropriate comments for each well is attached to this MTF and has been entered into the appropriate well folder. The well folder reference sheet (at the beginning of each well folder) has also been updated. Since documentation of the changes did not accompany EG&G's comments, only items identified which are "not found" will be changed. If/when the documentation is acquired, the remaining changes will be made (if they are different, and if the documentation has a better confidence level than what was originally used). The complete set of comments are contained in ref #141.

RESOLUTION (DATE):

Well Name: INEL 1

Composite confidence level: D

Coordinates

1abc 2

TRS: T3N-R29E-1abd1
Northing: 713320.97
Easting: 294408.53
Latitude: 433717.00
Longitude: 1125635.00

Elevation Information

Elevation (ft.): ~~4873~~ 4895
Datum: NF MSL

Well Category

Well type: Observation was Geothermal Exploration well
Well status: ~~NF~~ Active
Well installation type: Single

Drilling Information

Driller's name: Brinkerhoff
Year: 1979
Drilling method: ~~NF~~ Rotary
Work-over year: NF

Depth

Bore hole total depth BLS (ft.): 10365
Well total depth BLS (ft.): 10333

Water Information

Initial water level BLS (ft.): 306
Date: 05/02/79
Water quality sampling frequency: NF

Pump Information

Pump type: NF None ✓
Depth BLS (ft.): NF
Discharge rate (gpm): ~~NF~~
Water level access type: NF

was submersible - temporary installed
57 gpm in January 1981 with 290 feet of drawdown
Specific Capacity = 0.20 gpm/ft of drawdown

Available Information

Construction diagram: N
Lithographic log: Y
Natural gamma log: Y
T.V. camera/photo log: N
Fluid conductivity log: ~~N~~ Y
Gamma gamma log: Y
Driller's log: Y
Geologist's log: Y
Site schedule: Y
Caliper log: Y
Neutron log: Y
Electric log: N
Field book: ~~N~~ Y ✓

Perforations of 9 casing
4210' to 4225',
4240' to 4270',
4300' to 4315',
4490' to 4520',
4775' to 4790',
5085' to 5100',
5230' to 5245',
5995' to 6010',
6220' to 6235',
6260' to 6275'

Add in

Well: INEL 1 (continued)

Construction Information

Borehole Dimensions:

Top/Bottom BLS (ft.)	Diameter (in.)
0/1524	26.50
1524/3561	17.50
3561/10333	12.25
10333/10365	8.75

Surface/Protective Casing:

Type	Material	Top/ Bottom BLS (ft.)	Diameter (in.)
Surface	NF	0/40	30

Well Casing:

Top/Bottom BLS (ft.)	Diameter (in.)	Material
0/1511	20	~~NF~~ Steel
0/3559	13	~~NF~~ Steel
3282/6796	9	~~NF~~ Steel

Cement/Fill:

Top/Bottom BLS (ft.)	Type
NF/NF	NF

Completion Zone:

Type	Top/Bottom BLS (ft.)	Diameter (in.)
Perforated	4210/6275	9.0
Open hole	6796/10333	12.25
Open hole	10333/10365	7.0

not perforated all of this – selected perforations

Material	Slot Size	Filter Pack Type
NF	NF	NF
NA	NA	NA
NA	NA	NA

Concrete Pad: NF

Locking Cap: NF

Well: INEL 1 (continued)

Comments

FOR THE INTERVAL (4210-6275 FEET) GIVEN IN THE COMPLETION ZONE, 10 PERFORATION ZONES EXIST W/SECTIONS OF BLANK CASING BETWEEN EACH. Drilled for geothermal exploration. Water temperature in bottom is 295° F

INEL 1; 9
W160

Outlier well upgrades.

Well Name	Surveyor's Monument	Apron	Fence Post	Pad	Guard Posts
Arbor Test	X[a]	--[b]	--	X	--
NTP Area 2	X	X	X	--	--
Badging Facility Well	X	--	--	--	--
Corehole 1	X	X	X	--	--
Corehole 2A	X	X	X	--	--
DH-1B	X	--	X	X	--
DH-2A	X	X	X	--	--
EBR 1	X	--	--	--	--
EOCR Production Well	X	--	--	--	--
Fire Station Well	X	--	--	--	--
Highway 3	X	--	--	--	--
INEL 1	X	--	--	--	--
OMRE	X	--	--	--	--
Rifle Range Well	X	--	--	--	--
Site 04	X	--	--	--	--
Site 06	X	--	X	X	--
Site 09	X	--	--	X	X
Site 14	X	X	X	--	--
Site 17	X	--	X	--	--
SPERT Disp. 1	X	--	X	--	--
SPERT Disp. 2	X	--	X	--	--
SPERT Disp. 3	X	--	X	--	--
USGS 001	X	--	--	--	X
USGS 002	X	--	X	--	--
USGS 004	X	--	X	--	--
USGS 005	X	--	X	--	--
USGS 006	X	--	X	--	--
USGS 009	X	--	X	--	--
USGS 012	X	--	X	--	--
USGS 015	X	--	X	--	--

WELL UPGRADE CHECKLIST

WELL NAME: INEL 1 CWS #: ________

UPGRADES: Describe upgrades installed at well. If item was already existing at well before upgrading activities occurred, place "AE" on appropriate line. If item is not needed, place "N/A" on appropriate line.

MEASURING POINT (MP): NONE (HAZARDOUS AREA)

MP DIRECTIONS: NONE

IMPINGEMENT POSTS/FENCE POST: N/A

PAD/APRON: N/A

SURVEY MONUMENT: BRONZE MARKER IN CONCRETE IN AUGER HOLE NEXT TO PIT

ADDITIONAL INFORMATION: ________

PHOTOGRAPH NUMBER(S): NONE

SIGN-OFF:
Inspected by [signature] Date: 9/14/92

IDEL 1°8
0159

Table 9. Outlier wells listed in the CWS but not found.

ACRE I Well	USGS 003A
EOCR Injection Well	USGS 010
PBF Chem. Wst. Inj. Well	USGS 033
Testhole 0	

Table 10 shows the wells found in outlying areas and the hardware existing at each well.

Table 10. Outlier Wells.

Well Name	Well Type	Surveyor's Monument	Pad/Apron	Guard Posts	MP[a]
ARA 1	Production	--[b]	X[c]	N/A[d]	--
ARA 3	Production	--	X	N/A	--
Arbor Test	Observation	--	--	N/A	--
NTP Area 2	Observation	--	--	N/A	--
Badging Facility Well	Production	--	X	N/A	--
Corehole 1	Test Well	--	--	N/A	--
Corehole 2A	Observation	--	--	N/A	--
DH-1B	Observation	--	--	N/A	--
DH-2A	Observation	--	--	N/A	--
EBR 1	Production	--	X	N/A	--
EOCR Production Well	Production	--	X	N/A	--
Fire Station Well	Production	--	X	N/A	--
Highway 3	Production	--	X	--	--
INEL 1	Observation	--	X	N/A	--
NPR Test	Observation	--	X	X	--
OMRE	Production	--	X	N/A	--
PBF Clean H2O Inj. Well	Injection	--	--	N/A	X
Rifle Range Well	Production	--	X	N/A	--

WELL INSPECTION CHECKLIST

A. WELL NAME: INEL 1 CWS #:

B. GENERAL LOCATION: BETWEEN NRF & CPP. WEST OF HIGHWAY 1 MILE

C. WELL IDENTIFICATION:
- Is the well identified? YES
  If yes, explain (how it is identified): PLASTIC TAG W/ INEL #1

D. MONUMENT (BRASS CAP):
1. Does a survey monument exist at the well-site? NO
   If yes, describe (material, location, how monument is affixed, survey rod indentation, etc.):
2. Write down any inscription that exists on the monument (well name, coordinates, elevation, etc.): N/A

E. CONCRETE PAD:
- Is there a concrete pad around the well casing? YES
  If yes, describe (thickness, dimensions, etc.): 10' X 10' CONCRETE PIT

F. IMPINGEMENT PROTECTION:
1. Are there any impingement protection posts present? NO
   If yes, describe (number, height, diameter, spacing, material, condition):
2. Is the well-site in a high traffic area? NO

G. WELL HEAD DESCRIPTION:
1. Does the well have an outer control box? NO
2. Is the well capped? Outer casing YES ? Inner casing —
   If yes, describe (type of cap or control box, etc.):
3. Is the cap/box locked in place? NO
4. Does the well appear to be (abandoned) or destroyed?
   If yes, explain:
5. Distance outer and/or inner casing extends above ground surface or pad: N/A
6. Well casing diameter: Inner — Outer ~24"
7. Well casing material: Inner — Outer C. STEEL
8. Well use (circle one): monitor, (production), or injection well?
9. Is a water level probe pipe installed? NO
   If so, describe (material, diameter, etc.):
10. Is a pump or other instrumentation installed? NO
    If yes, describe:
11. Does a measuring point (MP) exist? NO
    If yes, describe what the MP is and what directions exist as to where to find the MP:

H. WELL PHOTOGRAPHS:

Take photograph of outer well head including any monument, pad, and nameplate; close-up photograph of inside of control box; and wide-angle photograph of well-site.

1. Initial for photo of the outer well head: 654 KUB
2. Initial for photo of inside of control box: ———
3. Initial for wide-angle photo of well-site: 653 KUB
4. Remarks (include description of additional photographs:

655 KUB

I. UNSAFE OR UNUSUAL CONDITIONS AT OR NEAR WELL-SITE: WELL SITS IN PIT FILLED W/ WATER & COVERED W/ OLD BOARDS

J. DESCRIBE THE GENERAL WELL CONDITION: POOR

K. SOIL OR BEDROCK SURROUNDING WELL HEAD: CONCRETE-SOIL

L. ADDITIONAL INFORMATION: A 14" OPEN CASING IS 15' EAST

M. SIGN-OFF:
Inspected by Ken Beard Date: 1/13/92

INEL-1; 3
W004

ell data for INEL wells Sept 27, 1989

ell	easting	northing	elevation	depth	comp_code	use_code	comp_date	bh_elev	aka	mp_offset
BR-II-2	371000.00	703322.00	5121.91			PRO	1957/01/23			
OCR	306144.03	677079.01	4940.00	1237.00	AQ	PRO		3703.0		
IRE RANGE	282850.40	685735.60	4968.75	626.00	AQ			4342.8		
IRE STA 2	295186.24	704351.11	4902.31	516.10	AQ	PRO	1957/09/26	4386.2		
IN-01	360720.00	788806.00	4787.13	373.00	AQ			4414.1		1.45
IN-02	361166.66	788941.41	4786.72	402.00	AQ			4384.7		1.51
IN-03	361552.00	788538.00	4786.68	386.00	AQ			4400.7		2.29
IN-04	361164.00	788872.00	4786.81	306.00	AQ			4480.8		1.84
IN-05	361368.00	789394.00	4787.14	430.00	AQ			4357.1		1.80
IN-06	350940.00	796420.00		200.00	GP					
IN-07	350300.00	796840.00		200.00	GP					
IN-08	349550.00	796520.00			GP					
IN-09	350950.00	795600.00		203.00	GP					
IN-10	349440.00	795730.00		163.00	GP					
IN-11	348940.00	797000.00		163.00	GP					
IN-12	348440.00	796050.00		142.00	GP					
IN-13	349650.00	797500.00		141.00	GP					
IN-14	349880.00	796305.00		75.00	GP					
IN-15	349370.00	796450.00		75.00	GP					
IN-16	349570.00	796635.00		75.00	GP					
IN-17	349560.00	796470.00		78.00	GP					
IN-18	349890.00	796300.00		200.00	GP					
IN-19	349180.00	796370.00		200.00	GP					
GIN-20	349605.00	796930.00		200.00	GP					
RAZING-2	325383.02	583046.08	4771.67	390.00	AQ	PRO	1939/01/01	4381.7		
HANSEN	265715.22	795427.92	4945.00	201.00	AQ	PRO	1961/07/31	4744.0		
HIWAY-1	459046.18	682124.98	5089.83	1100.00	AQ			3989.8		
HIWAY-2	411631.14	687427.66	5216.55	786.00	AQ	PRO	1950/08/29	4430.5		1.46
HIWAY-3	277297.85	687160.41	4980.88	750.00	AQ	PRO	1967/09/15	4230.9		
IDAHO F&G	445616.52	820462.52	4818.15	58.10	AQ	OBS	1953/09/25	4760.0		
IET-01	359081.00	801623.00	4790.14	324.00	AQ	INJ	1953/08/01	4466.1	IET DISP	4.73
INEL-1	294408.53	713320.97	4895.00	10333.00	AQ			-5438.0		
INEL-1WS			4878.45		AQ					2.08
LF2-01	294431.90	682893.30	4932.44	27.17	VZ			4905.3		
LF2-02	294010.20	683042.40	4933.37	31.00	VZ			4902.4		
LF2-03	294420.60	682893.70	4932.20	22.00	NP			4910.2		
LF2-04	294011.00	683051.10	4933.26	21.67	NP			4911.6		
LF2-05	294589.20	683235.50	4930.03	21.58	VZ			4908.4		
LF2-06	294323.00	683321.50	4931.79	19.25	VZ			4912.5		
LF2-07	294595.10	683241.80	4929.70	18.17	NP			4911.5		

TEMPERATURES AND HEAT FLOW IN INEL-GT1, SNAKE RIVER PLAIN, IDAHO

A Report to

EG & G, Idaho

Box 1625

Idaho Falls, Idaho

by

David D. Blackwell

Department of Geological Sciences

Southern Methodist University

Dallas, Texas 75275

November 10, 1990

SMU

TEMPERATURES AND HEAT FLOW IN INEL-GT1

INTRODUCTION

We have logged temperatures in the deep geothermal test at the INEL test site on the eastern Snake River Plains in Idaho (INEL-GT1) three times over a period of 8 years. The first logging was on 8/20/82 when we reached a depth of 2100 m. We were unable to get past the casing shoe at that depth. In 1983 (7/25/83) we relogged the well with a centralizer on the temperature tool and got past the casing hanger to the end of our cable at 2870 m. In both cases the logs were made at a 0.5 m recording interval, our finest depth increment of temperature measurement at that time. In 1990 we relogged the well for a third time and for the first time reached the bottom of the well at 3130 m. In this log the temperatures were measured at 0.2 m intervals. The temperature-depth plots for the last two logs are compared in Figure 1 and the gradient logs for the three logs are compared in Figure 2. The differences in temperature are almost too small to see on the plot. The only significant differences are in the depth interval 700 to 1850 m, a section of the hole with a number of fluid disturbances that will be described below.

TEMPERATURE AND GRADIENT COMPARISONS

To clarify the discussion the hole will be divided into sections for the purposes of discussion. These sections are listed in Table 1 and the characteristics of the gradient in each section are summarized. The average gradients of some intervals are listed in Table 2.

The temperatures and gradients for the two loggings in 1982 and 1983 are identical within the resolution of the temperature tool, even in the section of the hole that shows extreme fluctuations of gradient, 700 to 1850 m. There is a data gap for the logging of 1990 between 2110 and 2205 m so this section will appear different in most of the plots and should be disregarded. The thermal conditions in the hole are generally conductive in the region 250 to 700 m and 1850 to 3150 m. The gradient variations there are generally associated with thermal conductivity variations related to lithologic variations. The best heat flow is determined in this section of the well and will be discussed in a subsequent section of the report.

The temperatures from the 1990 and 1983 loggings are compared in Figure 3. The temperatures are essentially the same above 1100 m. Between 1100 and 1850 m the temperature differences range from about plus 1°C to minus 1°C in the areas of the well disturbed by fluid effects as described below. The background differences are about 0.2°C at 1850 m and systematically approach minus 1°C at the bottom of the 1983 log. The slight offset between 2100 and 2200 m is due to changing the range on a DVM. We believe that the differences below 1800 m are due to electrical leakage in the cable head in 1983 at temperatures above 100°C. We are pursuing the discrepancy in more detail at this time, however, to resolve the cause or causes.

The fine scale variations of gradient (the noise in the gradient plots, see Figure 4) are associated with small convection cells in the fluid column related to the decrease in density of water with depth due to the positive geothermal gradient. The greatest noise is in the interval 850 to 1000 m where the gradient is highest and the fluctuations are lowest in the interval 1600 to 1820 m where the gradient is lowest. For the gradient of 40°C typical of much of the hole the noise is lower in the section of the hole that is 9 5/8" in diameter than in the larger sections of the hole above and below. The decrease in the gradient in the bottom of the hole is an end effect of the bottom of the hole.

A summary of several of the geophysical logs for the well are shown in Figure 5. The plotted curves are based on 6.1 m (20 ft) averages of the original open hole logs used by Williams (1981) in a study of the thermal conductivity of the well. This study will be discussed in more detail in a subsequent section. We do not have original copies of the logs at this time, so the comparisons in this discussion will refer to the logs as displayed in Figure 5. The logs shown include natural gamma-ray, travel time (displayed as velocity), and density (from the gamma-gamma log). The 6 m averages were prepared to smooth out the local fluctuations due to hole size so the areas where there are obvious hole size effects on the logs (areas of low velocity) are major zones of hole enlargement. Many of these areas coincide with areas of anomalous temperature gradients.

Convective Disturbances The temperatures and gradients depart from conductive behavior in a significant way in the interval between 700 and 1850 m. The interpretation of this region is shown diagrammatically in Figure 6. The gradients in the interval between 750 and about 1100 m are disturbed by two major areas of moving water in the rocks around the drill hole. There appears to be water moving from higher elevation to lower elevation past the drill hole in the ash flows directly below the thin layer of sediments encountered in the depth interval 670 to 750 m. The evidence for this behavior is the negative excursion of the temperatures in this interval relative to the interpolation of the temperature-depth curve through this region. This general downward movement past the hole is mirrored by a similar upward movement past the hole in the depth interval 1000 to 1100 m. The temperatures in areas of the hole adjacent to the zones of water flow have changed temperature significantly between loggings (Figure 4, down about 0.1°C in the upper zone and up about 0.1°C in the lower zone), indicating the disturbed nature of the temperatures in these areas.

The most obvious disturbance to the temperatures and gradients in the well is in the depth interval 1580 to 1850 m. The shape of the upper part of this disturbance is a classic example of up-flow in the well bore between two water bearing zones connected by the drilling (in this case the water is flowing in the annulus outside the 9 5/8" casing). The bottom part of this disturbance is a classic example of down-flow in the well bore between two water bearing zones connected by the drilling (in this case also the water is flowing in the annulus outside the 9 5/8" casing). The geophysical logs show evidence of porous zones at 1600 and 1820 m that may be the acceptor zones. The donor zone (or zones) is not so obvious from the available log data although the original logs need to be examined again for evidence of the location of this zone. It should be in the 1680 to 1720 m depth interval. The temperature in this 270 m interval has decreased about 0.7°C in the time interval between loggings again indicating that the temperatures in this portion of the hole are relatively unstable.

The behavior of the temperatures and gradients in the interval 1100 to 1540 m is the most puzzling in the whole hole. The gradients vary by too great an amount to be explained by simple conductive heat transfer. The gradient pattern on the logs of 8/20/82 and 7/25/83 was identical, so the effects do not appear to be transient. The pattern was similar, although slightly more simple on the 1990 log. The temperatures changed the most between the loggings of 1983 and 1990 in this interval, being plus about 1 °C at 1380 m and minus about the same amount at 1450 m. The geophysical logs show evidence of major hole enlargements at both depths. The pattern in 1990 between 1380 and 1460 m appears to be a miniature case of the interval between 1600 and 1800 m described above. Perhaps flow began in the well between the two logging periods. The zone between 1280 and 1320 m is enlarged. Blackwell et al. (1981) found that areas with hole enlargements in a geothermal well in Oregon were characterized by areas of sigmoidal gradient-depth plots. Thus some combination of intrawell flow and hole size complications may explain the complicated gradient pattern in this region. The average gradient in this interval is about the same as in the rest of the hole so the heat flow does not appear to be affected (see discussion below). The Schlumberger logs need to be examined in conjunction with this new temperature data for a final evaluation of the controls on the temperature and gradients in this interval of the well.

THERMAL CONDUCTIVITY AND HEAT FLOW

Several cores were obtained during the drilling of the well. Thermal conductivity values were measured on samples of these cores at room temperature and the temperature corrected values were used to calculate a heat flow for the hole by Brott et al. (1981; the results are also discussed by Blackwell, 1989). Williams (1981) also measured the P-wave velocity as a function of pressure on these core samples and developed empirical relationships relating thermal conductivity, P-wave velocity and some of the well log properties. Plots of these predicted thermal conductivity values at room temperature conditions for four different relationships are illustrated in Figure 7. For the purposes of this report the curves are not significantly different and only curve THC1 was used in the analysis. The thermal conductivity was calculated from the 6 m average velocity log for intervals divided into lithologic sections using the lithology and natural gamma-ray information using the relationship

$$TC = -0.36 + 1.38*Vp$$

for the section of the hole in rhyolite and by the relationship

$$TC = -0.26 + 0.86*Vp$$

for the section of the hole in basalt..

The gradient, thermal conductivity, and heat flow values for the well were averaged over a 100 m interval to smooth out the smaller scale fluctuations in the values and are shown in Figure 8. The thermal conductivity values shown are corrected for temperature effects so they should closely reflect in situ values. The heat flow panel shows that the bottom of the well has an average heat flow of about 100 mWm^{-2}.

A better way to evaluate the heat flow for the well is to prepare a plot of the sum of the thermal resistance down the well and the corresponding temperature (Figure 9). The thermal resistance is calculated from the inverse of the average thermal conductivity for each 6.1 m interval from Figure 7 (after temperature correction) multiplied times 6.1 meters and added to the preceding value representing the sum to the preceding depth (or temperature). The advantage of this form of the calculation is that the slope of the straight line between temperature and thermal resistance is the heat flow for that interval. The second and third panels in Figure 9 show a straight line fit for the intervals 21 to 137°C and 100 to 137°C respectively. The slopes of the lines are 99 and 107 mWm^{-2} respectively.

The best heat flow for the hole is the 107 mWm^{-2} value. This value agrees with the heat flow at USGS-2a and is determined for the portion of the INEL-GT1 well below the sections of the hole disturbed by water flow outside the well bore (above about 1100 m). The line representing this heat flow value passes through the midpoints of the disturbances associated with the intrabore water flow zones below 1200 m so the inference that they represent disturbances related to the connection of fractures by the drill hole, and not natural flow, is reinforced. There appears to be a small net cooling of the upper part of the well, but the effect is most pronounced above 700 m (40°C). This may be real, or it may be due to an incorrect estimation of the thermal conductivity of the basalts in this part of the well.

TABLE 1. CHARACTERISTIC GRADIENT INTERVALS

INTERVAL (METERS)	TYPE OF GRADIENT	CATEGORY
0-100	----------	Air-above water table
100-240	Near Zero	Snake River Plain aquifer
240-700	40 to 60 °C/km	Dominantly Conductive
700-1200	Negative to 80°C/km	Water flow past hole
1200-1580	Fluctuating	Hole size (?) and water flow
1580-1850	High to Isothermal	Intrahole water flow
1850 3100	40±5°C/km	Conductive
3100-3150	Low	Hole end effect

TABLE 2. AVERAGE GRADIENTS FOR SECTIONS

DEPTH (m)	GRADIENT AND S.E. (°C/km)
250 - 3120	43.6±0.1
1880 - 3120	44.4±0.1
250 - 760	52.0±0.1
760 - 1580	41.9±0.2
760 - 1880	40.9±0.2
1580 - 1880	28.6±0.7

Figure Captions

Figure 1. Temperature-depth and gradient-depth curves for 9/22/90 log. 1 meter average gradients are plotted. There is a data gap between 2110 and 2205 m.

Figure 2. Comparison of gradient-depth measurements for the logs of 9/22/90, 7/25/83, and 8/20/82. 1 meter average values are plotted at each meter.

Figure 3. Temperature difference for 9/22/90 and 7/25/83 logs. Difference plotted at each 0.5 m.

Figure 4. Gradient difference for 9/22/90 and 7/25/83 logs. Difference plotted at each 0.5 m.

Figure 5. Plot of natural gamma-ray, P-wave velocity, and density (gamma-gamma) log values from Schlumberger open hole logs. The plotted values are averaged over 20 ft (6.1 m) intervals (after Williams, 1981). The gamma-gamma log was not run above 1085 m.

Figure 6. Schematic diagram of the nature of fluid disturbances to the well.

Figure 7. Plot of calculated thermal conductivity based on several empirical relationships between thermal conductivity and various well log parameters (Williams, 1981). Values are not corrected for in situ temperatures.

Figure 8. Plot of 300 ft (90 m) average geothermal gradient, thermal conductivity (corrected for temperature effects), and heat flow.

Figure 9. Plot of thermal resistance as a function of temperature for the well. Lines representing least squares fits to the sections of the curve between 21 and 137°C and 100 and 137°C are shown in panels 2 and 3 respectively.

REFERENCES CITED

Blackwell, D.D., Regional implications of heat flow of the Snake River Plain, northwestern United States, Tectonophysics, 164, 323-343, 1989

Blackwell, D.D., C.F. Murphey, and J.L. Steele, Heat flow and geophysical log analysis for OMF-7A geothermal test well, Mount Hood, Oregon, p. 47-56, in Geology and Geothermal Resources of the Mount Hood Area, Oregon, ed G.R. Priest and B.F. Vogt, Oregon Dept. Geology and Min. Industries Special Paper 14, 100 pp., 1981

Brott, C.A., D.D. Blackwell, and J.P. Ziagos, Thermal and tectonic implications of heat flow in the eastern Snake River Plain, Idaho, J. Geophys. Res., 86, 11709-11734, 1981.

Williams, J.W., In situ thermal conductivity measurement from geophysical well logs in the eastern Snake River Plain, unpublished M.S. Thesis, Southern Methodist University, Dallas, Texas, 79 pp., 1981.

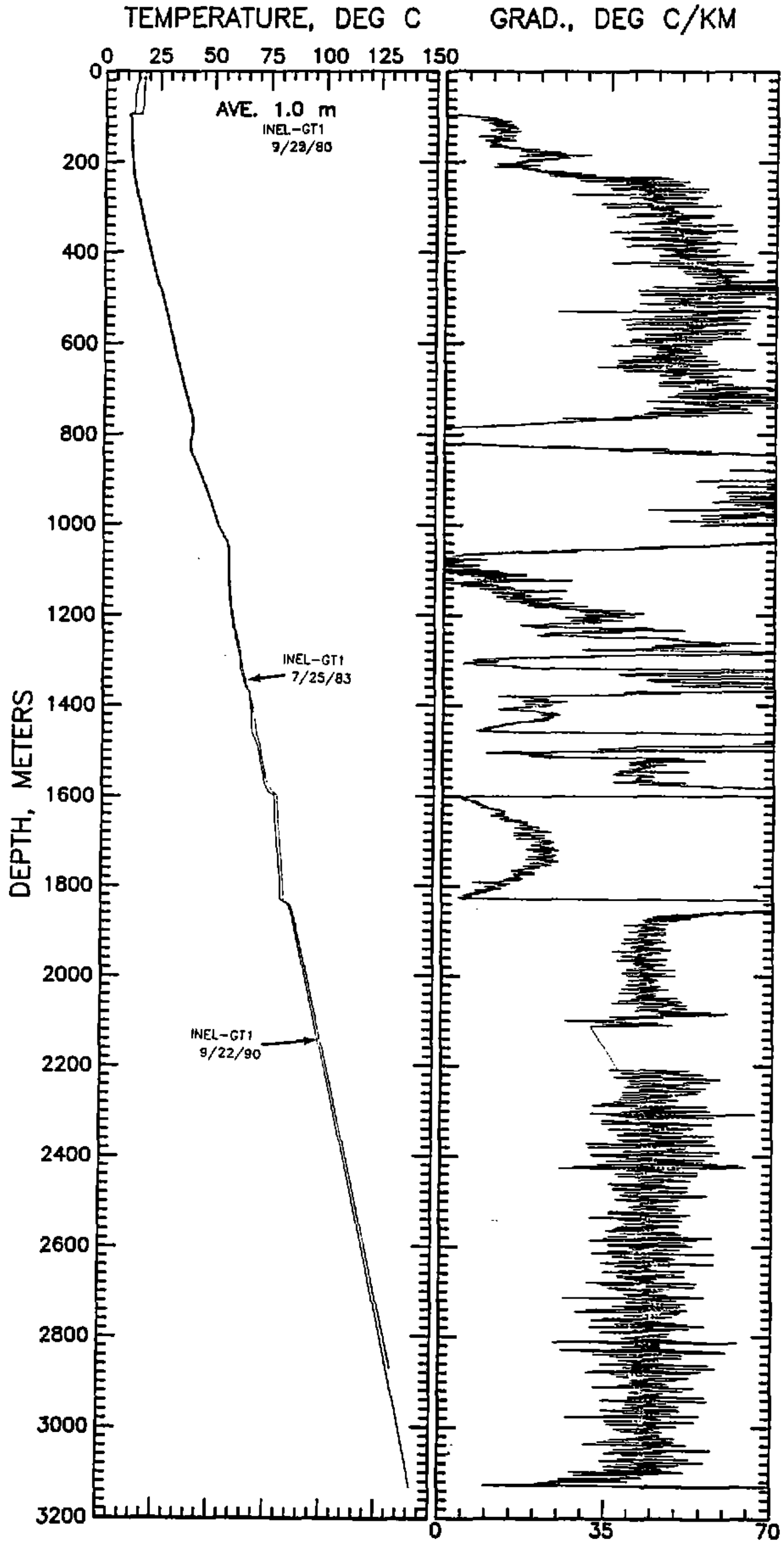
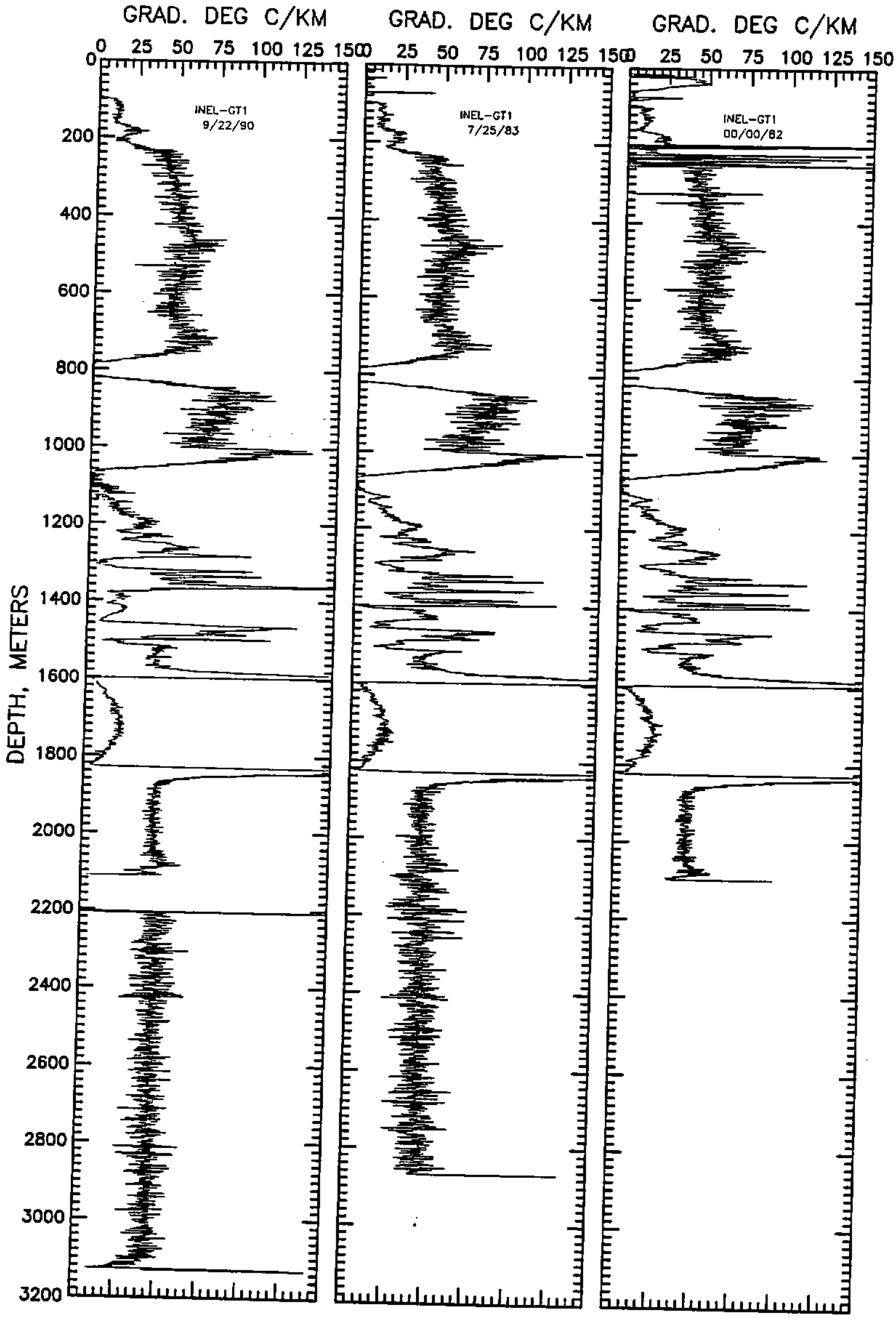

TEMPERATURE, DEG C
GRAD., DEG C/KM
0 25 50 75 100 125 150
AVE. 1.0 m
INEL-GT1
9/29/80
INEL-GT1
7/25/83
INEL-GT1
9/22/90
DEPTH, METERS
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200
0 35 70

Fig 1



GRAD. DEG C/KM
GRAD. DEG C/KM
GRAD. DEG C/KM
0 25 50 75 100 125 150
INEL-GT1
9/22/90
INEL-GT1
7/25/83
INEL-GT1
00/00/82
DEPTH, METERS
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200

Fig. 2

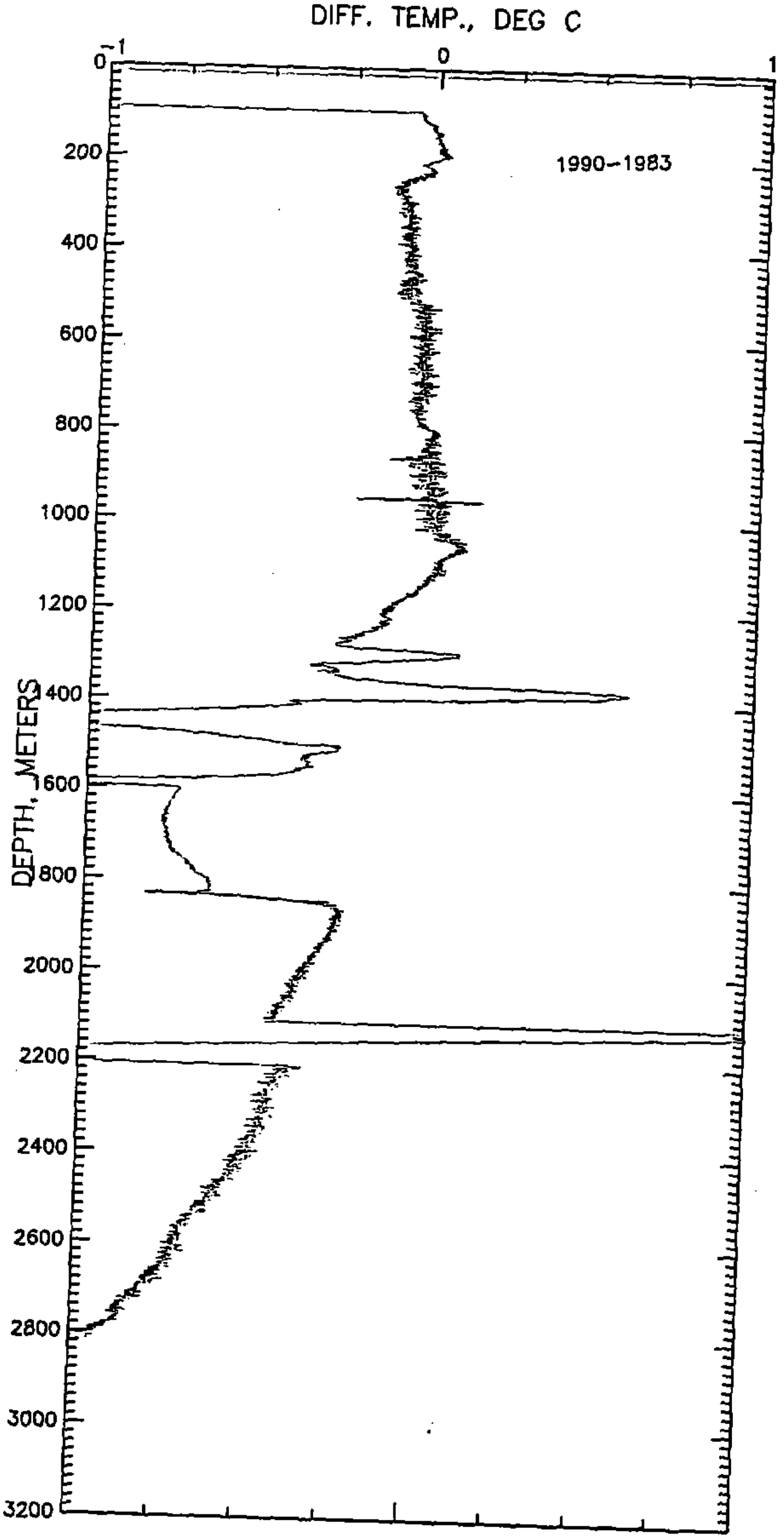

DIFF. TEMP., DEG C
-1
0
1
1990-1983
DEPTH, METERS
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200

Fig 3

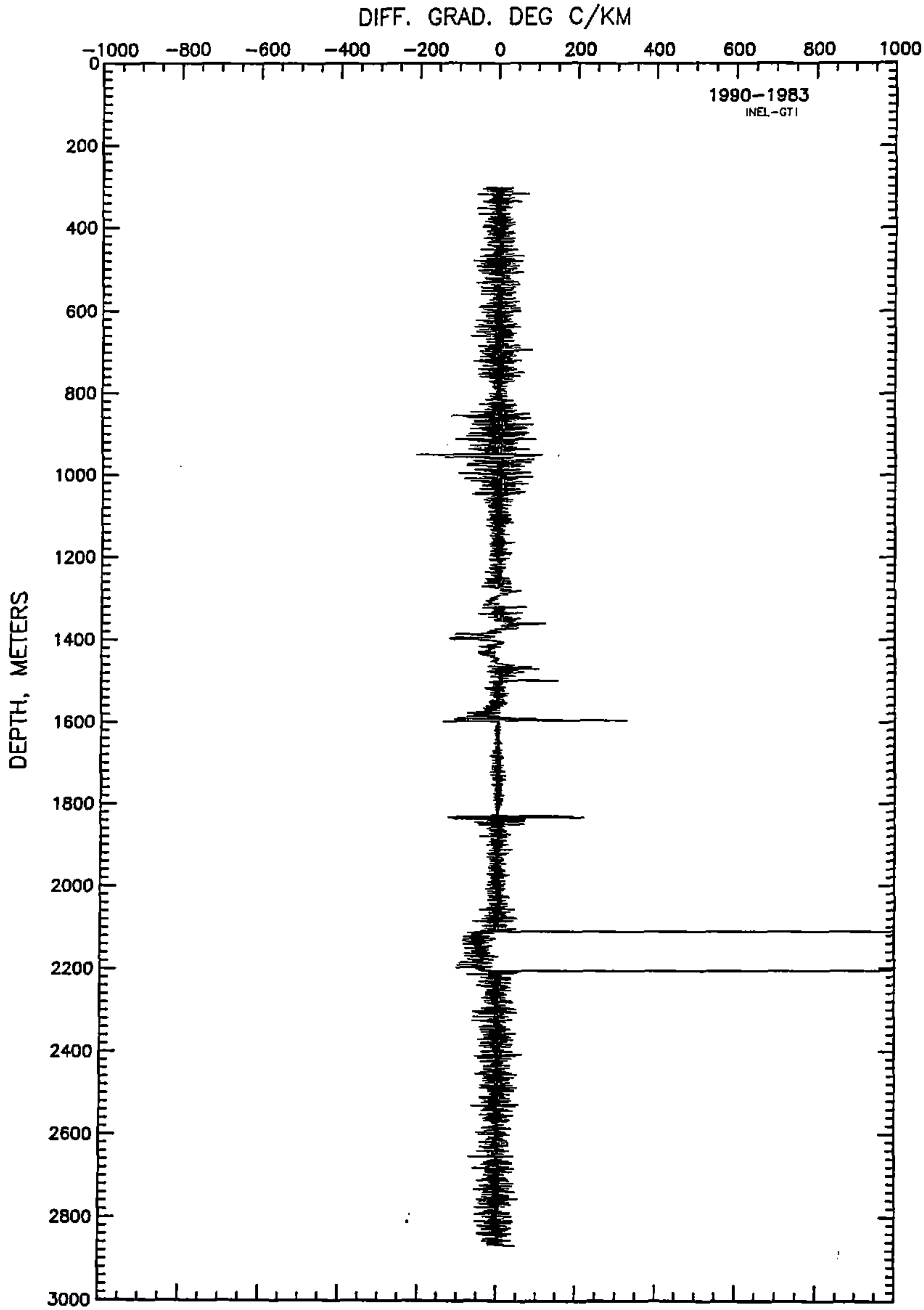


Fig. 4

Difference in gradient

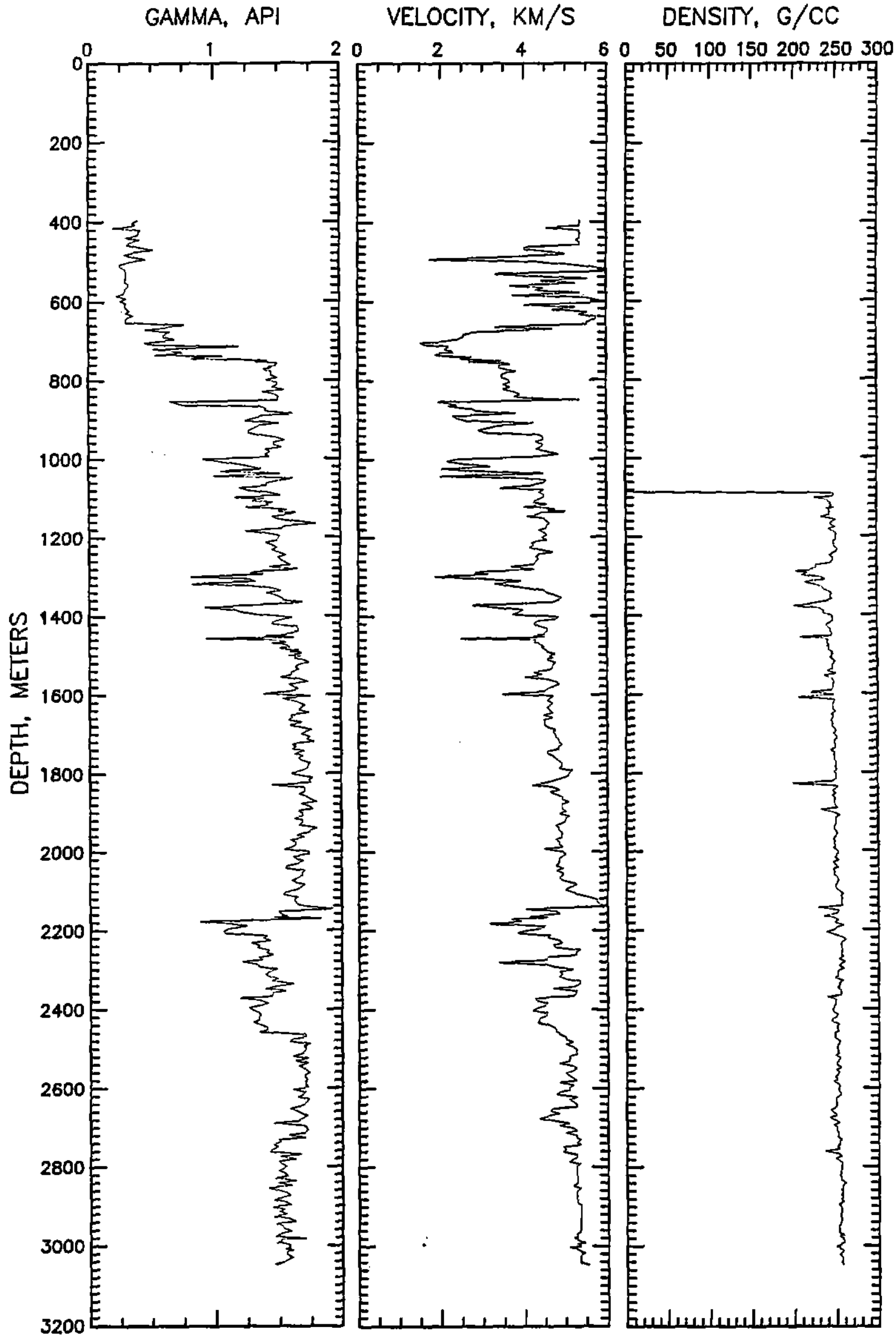

GAMMA, API
VELOCITY, KM/S
DENSITY, G/CC
DEPTH, METERS
0 1 2
0 2 4 6
0 50 100 150 200 250 300
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200

Fig 5

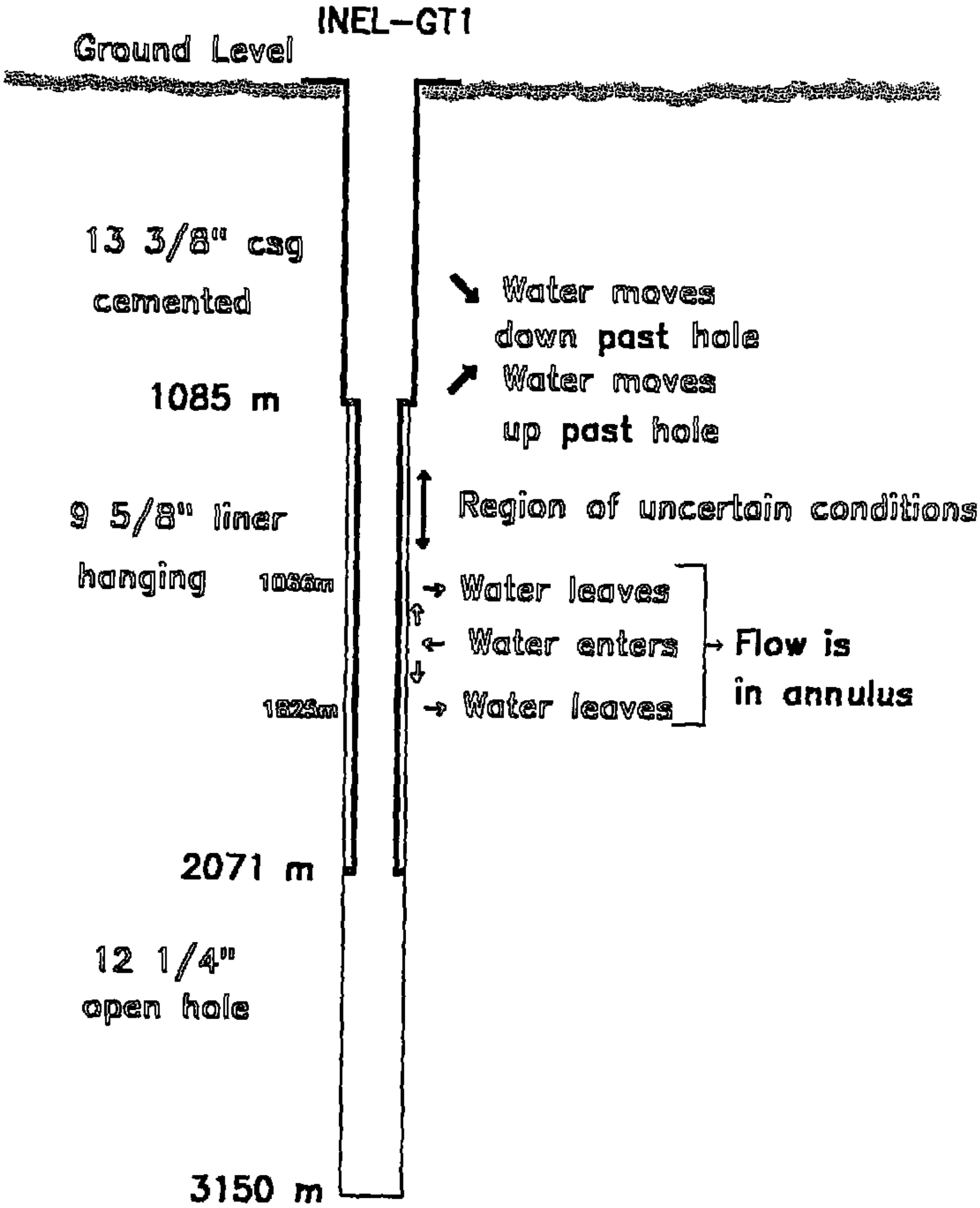

INEL-GT1
Ground Level
13 3/8" csg
cemented
1085 m
Water moves
down past hole
Water moves
up past hole
9 5/8" liner
hanging
Region of uncertain conditions
1066m
Water leaves
Water enters
Flow is
in annulus
1825m
Water leaves
2071 m
12 1/4"
open hole
3150 m

Fig 6

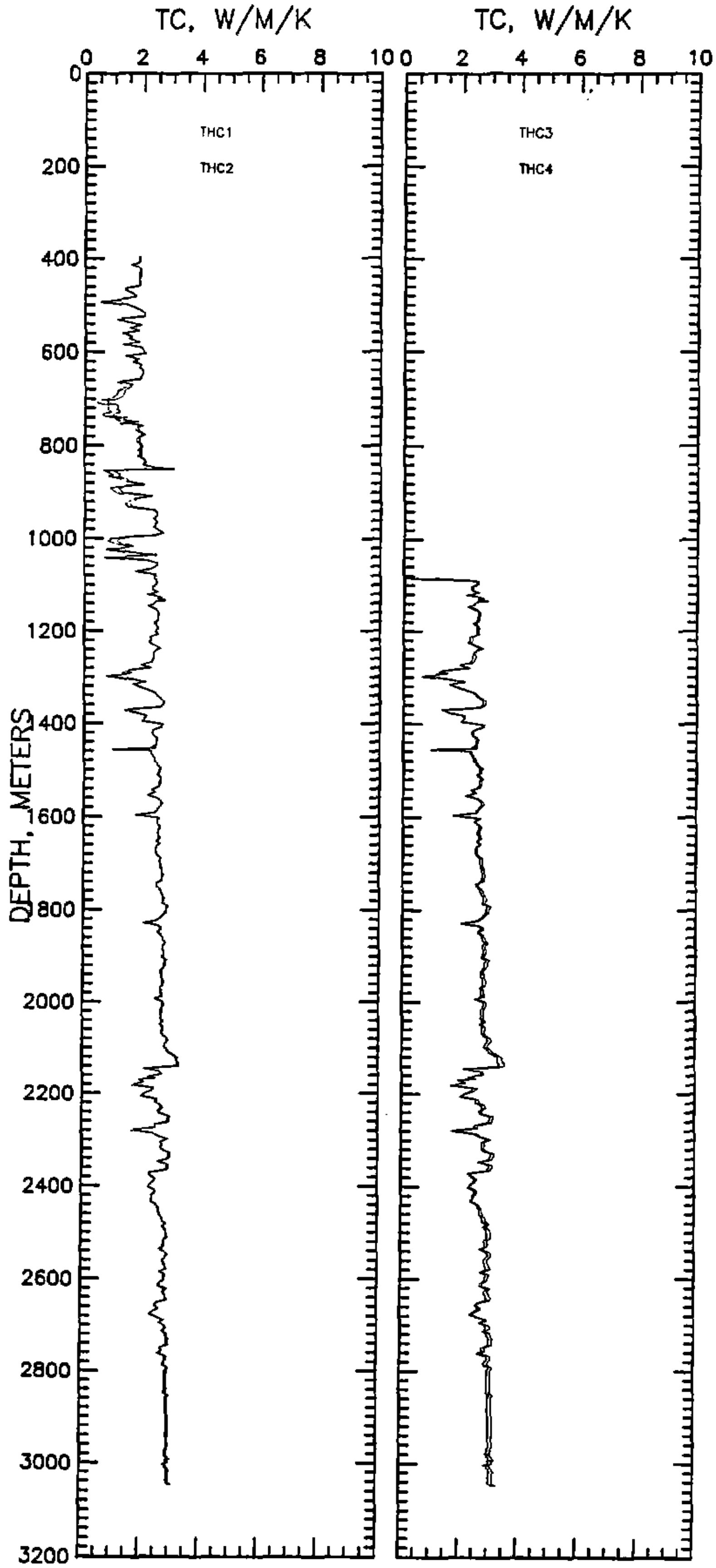

TC, W/M/K
TC, W/M/K
THC1
THC2
THC3
THC4
DEPTH, METERS
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
0 2 4 6 8 10

Fig. 7

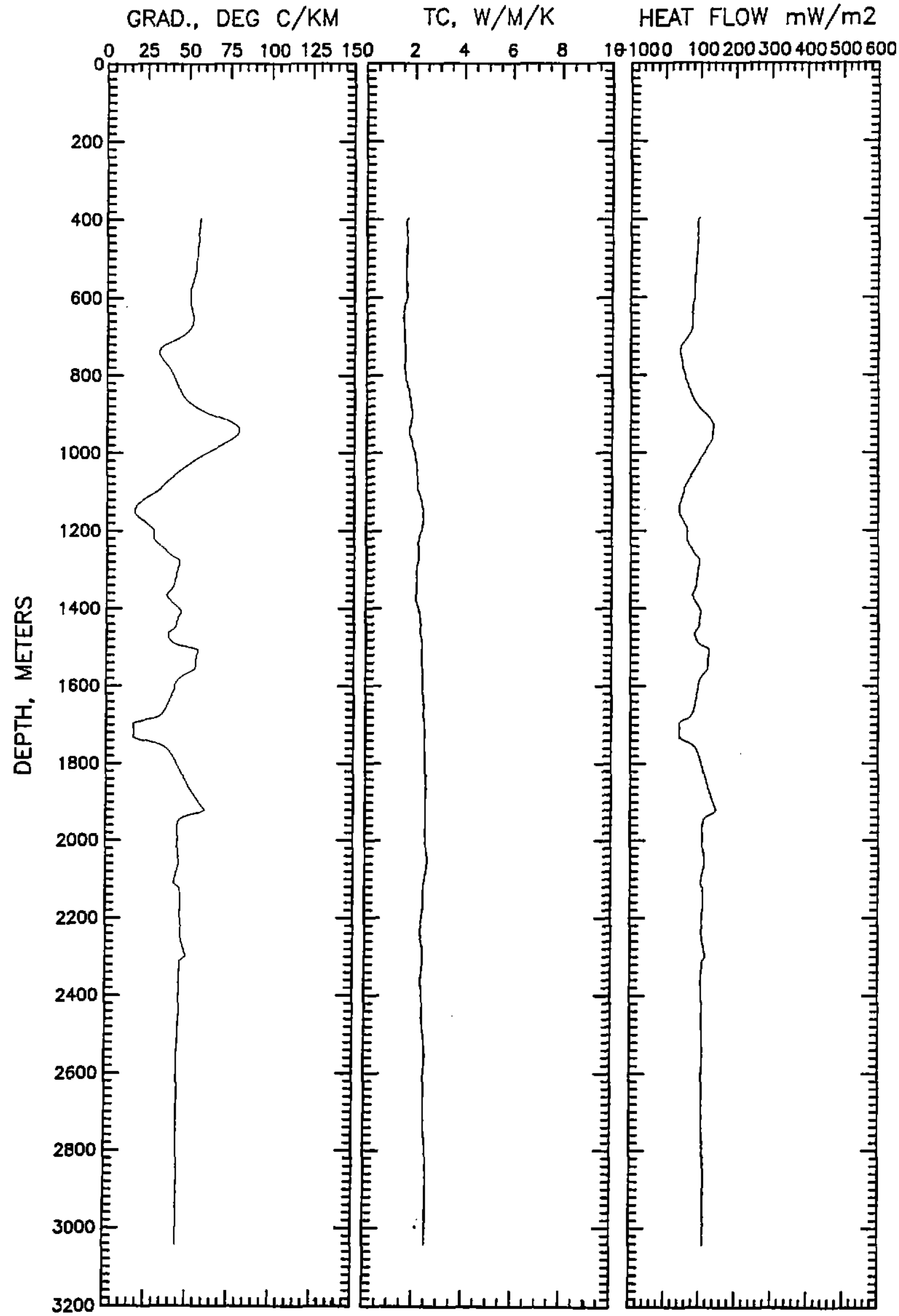
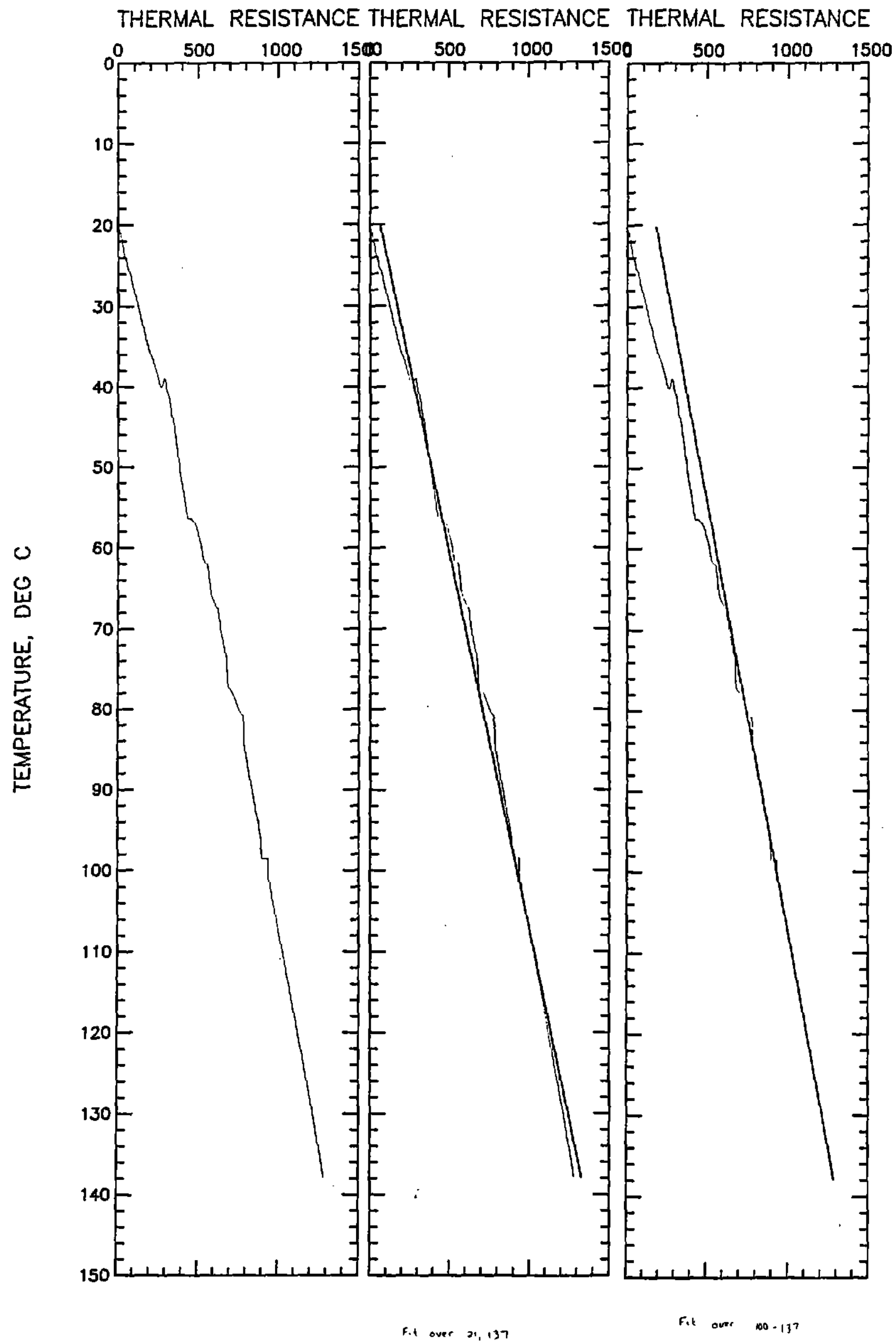

GRAD., DEG C/KM
TC, W/M/K
HEAT FLOW mW/m2
0 25 50 75 100 125 150
2 4 6 8 10
1000 100 200 300 400 500 600
DEPTH, METERS
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200

Fig 8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0 500 1000 1500
TEMPERATURE, DEG C
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Fit over 21, 137
Fit over 100 - 137

Fig. 9

Jack B.

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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Preliminary Geological Interpretation and Lithologic Log of the Exploratory Geothermal Test Well (INEL-1), Idaho National Engineering Laboratory, Eastern Snake River Plain, Idaho

by

David J. Doherty, Lisa A. McBroome, and Mel A. Kuntz

Open-File Report 79-1248

1979

ABSTRACT

A 10,365 ft (3,159 m) geothermal test well was drilled in the spring of 1979 at the Idaho National Engineering Laboratory, eastern Snake River Plain, Idaho. The majority of rock types encountered in the borehole are of volcanic origin. An upper section above 2,445 ft (745 m) consists of basaltic lava flows and interbedded sediments of alluvial, lacustrine, and volcanic origin. A lower section below 2,445 ft (745 m) consists exclusively of rhyolitic welded ash-flow tuffs, air-fall ash deposits, nonwelded ash-flow tuffs, and volcaniclastic sediments. The lithology and thickness of the rhyolitic rocks suggest that they are part of an intracaldera fill.

INTRODUCTION

The U.S. Department of Energy drilled a 10,365 ft (3,159 m) exploratory geothermal test well at the Idaho National Engineering Laboratory (INEL), eastern Snake River Plain, Idaho, from February 15 to May 19, 1979. The well is designated INEL-1 and is located in the SE 1/4 NE 1/4, sect. 1, T. 3 N., R. 29 E. in the Circular Butte 3 SW U.S. Geological Survey 7 1/2-minute topographic quadrangle (fig. 1). This is the deepest well drilled to date on the eastern Snake River Plain. INEL-1 was sited primarily on the basis of resistivity and seismic refraction anomalies defined by the U.S. Geological Survey in cooperation with the U.S. Department of Energy. Well cuttings were collected every 10 ft (3 m) during the drilling process, and seven cores were obtained at various depths. Few cuttings were collected from the upper 1,600 ft (488 m), where loss of circulation of drilling fluids to porous basaltic rocks and alluvial sediments was a major problem.

Samples are also missing from one other thick zone, from 2,750 to 2,940 ft (838-896 m). The first casing was set at a depth of 1,511 ft (460 m) and drilling proceeded in a normal fashion below that depth. Approximately 90 percent of the bore is represented by cuttings and core. The maximum temperature yet recorded is 302°F (150°C) at a depth of 10,110 ft (3,081 m).

GEOLOGY

Basaltic lava flows, interbedded with silty to sandy alluvial and lacustrine sediments, rhyolitic air-fall ash deposits, and ash-flow tuffs, constitute the upper 3,000 ft (900 m) of the eastern Snake River Plain in the vicinity of the INEL (Walker, 1964; Zohdy and Stanley, 1973; Nace and others, 1975; Kuntz and others, 1979; Kuntz and Dalrymple, 1979; and Doherty, 1979). Rocks below 3,000 ft (900 m) have been inferred from geological models and limited geological data and had not been drilled until INEL-1. The drilling data from INEL-1 support the hypothesis that upper crustal rocks beneath the basalt-sediment layer of the eastern Snake River Plain are chiefly rhyolitic tuffs and ash-flows that formed collapsed calderas. Precambrian, Paleozoic, and Mesozoic sedimentary rocks found in mountain ranges north and south of the eastern Snake River Plain may also be present locally below the volcanic cover of the Plain (Armstrong and others, 1975; Eaton and others, 1975; and Christiansen and McKee, 1978).

LITHOLOGY OF ROCKS IN INEL-1

The rocks encountered in INEL-1 comprise 10,365 ft (3,159 m) of volcanic rocks and interbedded sediments of alluvial, lacustrine, and volcanic origin (fig. 2). The upper 2,445 ft (745 m) consist of basaltic lava flows interbedded with cinders, silt, sand, and tuffaceous silt. The basalts are mostly fresh, diktytaxitic olivine basalts that are typical of eastern Snake River Plain tholeiitic basalts. Below 1,600 ft (488 m), propylitic alteration and secondary zeolite mineralization in the denser vesicular to amygdaloidal basalts are common. Alteration is most intense from depths of 2,000 ft (610 m) to 2,160 ft (658 m). The depth intervals of the altered basalt in INEL-1 compare closely to similar zones of alteration in basaltic lavas in core hole 2-2A (fig. 2), located about 9 mi (15 km) northeast of INEL-1 (Doherty, 1979).

The overlying basalt section is separated from a rhyolitic ash-flow tuff section below by 275 ft (84 m) of slightly altered, tuffaceous silt and silty clay. In the rhyolitic ash-flow tuff section, individual ash-flow sheets typically are separated from one another by 10-100 ft (3-30 m) of altered vitroclastic air-fall ash, nonwelded ash-flow tuffs, or reworked tuffaceous sand. Several of the welded ash-flow tuff sheets are over 500 ft (152 m) thick, and one sheet is nearly 1,100 ft (335 m) thick. Most of the rhyolitic rocks are devitrified and dense.

Hydrothermal alteration is most evident on fracture surfaces within the rhyolitic rocks. Nearly all fractures are sealed by propylitic alteration products, including calcite, quartz, hematite, pyrite, a septechlorite mineral, and a variety of clay minerals.

A dense, hydrothermally altered, recrystallized, aphanitic rhyodacite porphyry occurs below a depth of 8,070 ft (2,460 m). This unit is at least 2,295 ft (700 m) thick. Gamma and electrical logs suggest a slight change in the characteristics of the rhyodacite, at approximately 8,950 ft (2,728 m) (A. Zohdy, U.S. Geological Survey, oral commun., 1979). The rhyodacite above 8,950 ft (2,728 m) may have sustained more hydrothermal alteration than rock below that depth.

Petrographic evidence such as broken and resorbed phenocrysts of plagioclase, sanidine, and quartz suggests that the rhyodacite may be a thick ash-flow tuff. An alternate possibility is that the rhyodacite represents a high-level intrusive rock, possibly the source for the hydrothermal alteration and mineralization within the overlying rhyolitic welded tuffs and basaltic lava flows.

GEOLOGIC INTERPRETATION

The thick sequence of rhyolitic rocks encountered in INEL-1, without intervening basaltic lava flows and alluvial sediments, suggests that it constitutes the fill of a collapsed rhyolitic caldera. The ring-fracture zone for such an inferred caldera is probably buried beneath younger rhyolitic rocks, basaltic lava flows, and associated sediments of the eastern Snake River Plain. We wish to emphasize that the inferred ring-fracture zone, shown in figure 1, has been located with a minimum of geological and geophysical data and should not be used alone as a guide for future drilling.

Rhyolitic domes typically are emplaced along ring-fractures of calderas about 10^5 to 10^6 years after the major caldera collapse, as in the model presented by Smith and Bailey (1968). On the basis of unpublished regional geologic studies of the eastern Snake River Plain by us and our colleagues, and of radiometric studies by Armstrong and others (1975), we believe that the ash-flow sheets associated with the caldera inferred in this study are about 7-9 million years old. Thus, rhyolitic domes on the inferred ring-fracture zone should be no younger than about 6 million years old. Radiometric ages of rhyolitic domes (East Butte and an unnamed dome between East and Middle Buttes) and the basalt capping Middle Butte on the ring-fracture of the inferred caldera are less than 2 million years old (Kuntz and Dalrymple, 1979). This suggests that either they are related to a longer and more complex caldera history than the model presented by Smith and Bailey or else they are rhyolitic domes emplaced by processes and structures unrelated to a caldera. We favor the first hypothesis based on the thick sequence of rhyolitic rocks present, the absence of numerous basaltic vents within the inferred rim of the caldera, recent faulting with the downthrown side toward the plain, on the north side of the plain, and the positions of East, Middle, Cedar, and Big Southern Buttes and the unnamed dome between East and Middle Buttes. (Middle Butte is capped with Snake River Plain basalts and its slopes are covered with talus from the capping basalt. Magnetic and gravity data suggest the core of Middle Butte is rhyolitic.)

Some calderas have eruption and thermal histories lasting at least 3-4 million years. If the inferred caldera of this study is of that type, it may represent a significant geothermal resource for many of the facilities at the Idaho National Engineering Laboratory. Porous and fractured rocks in ring-fracture zones provide channelways for circulation and storage of water and, therefore, rocks in these zones may be likely targets for future geothermal explorations.

Post-Pliocene, north- to northwest-trending faults with displacements of several hundred to several thousand feet are exposed in the Lemhi and Lost River Ranges a few miles north of the inferred caldera (M. H. Hait, U.S. Geological Survey, oral commun., 1979). The faults may intersect the suspected caldera ring-fracture zone and increase the potential for a geothermal resource.

Extensive geological and geophysical studies need to be performed before a more precise location for the ring fracture zone can be determined.

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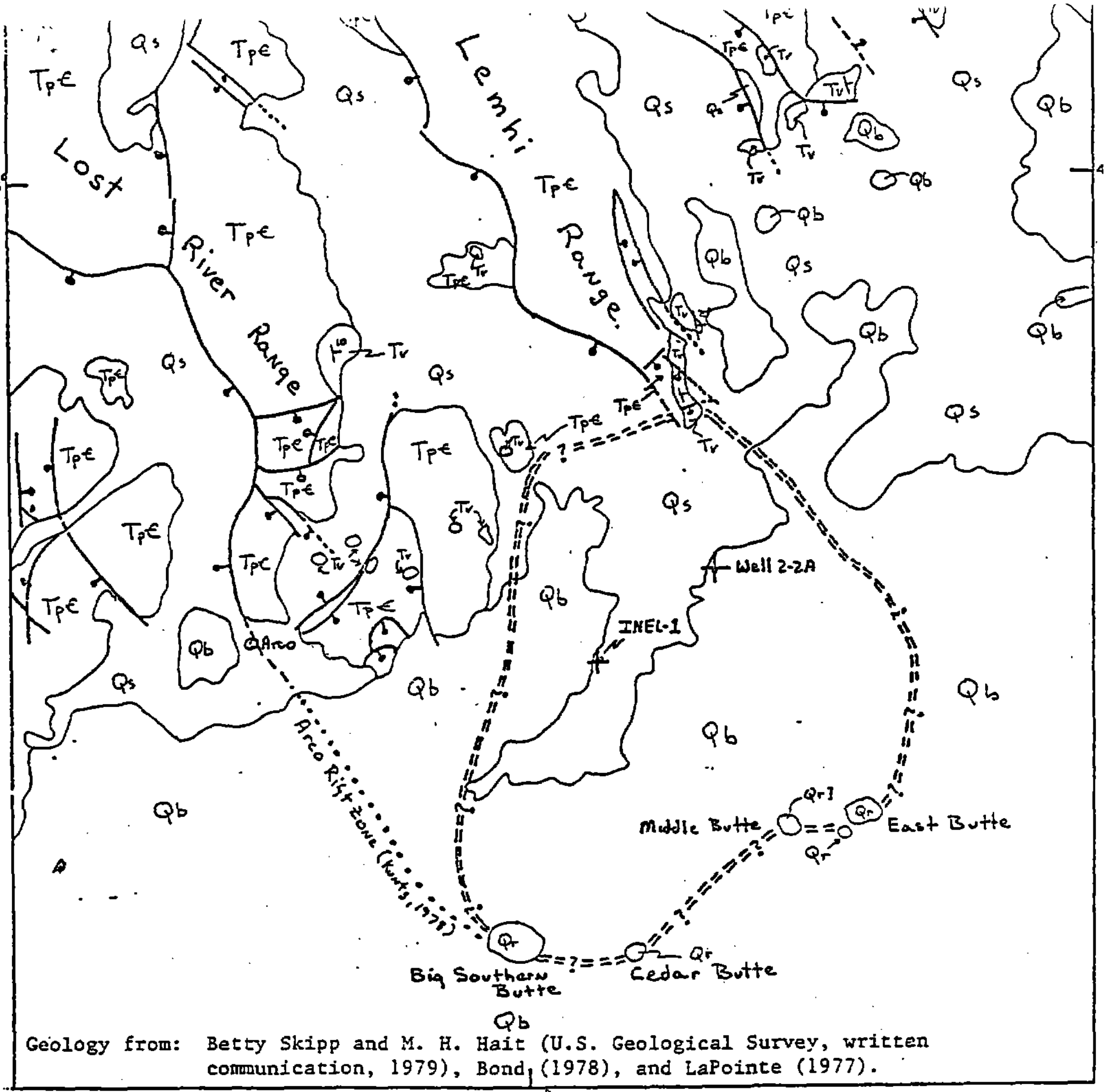


EXPLANATION

Qs Holocene to Pleistocene surficial deposits

Qb Holocene to Pleistocene basalt flows

Qr Holocene to Pleistocene rhyolitic domes

Tv Pliocene rhyolitic ash-flow tuffs

TpЄ Eocene to Precambrian

Fault, bar and ball on downthrown side

Inferred fault, bar and ball on downthrown side

Rift zone

Inferred caldera rim

Figure 1. Generalized geologic map of the area surrounding INEL-1.

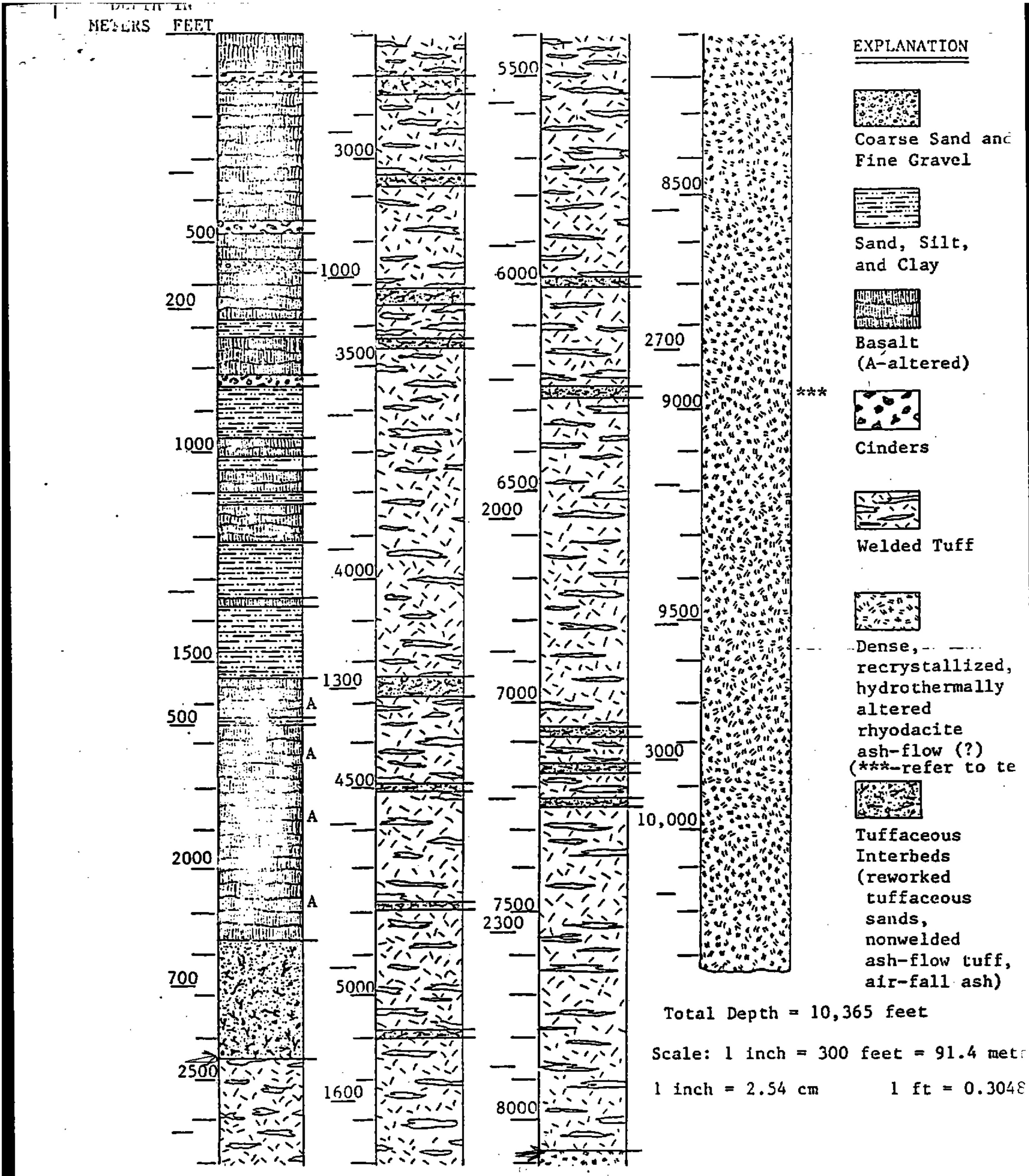


Figure 2.--Generalized lithologic log from exploration geothermal well (INEL-1), Idaho National Engineering Laboratory, Idaho.

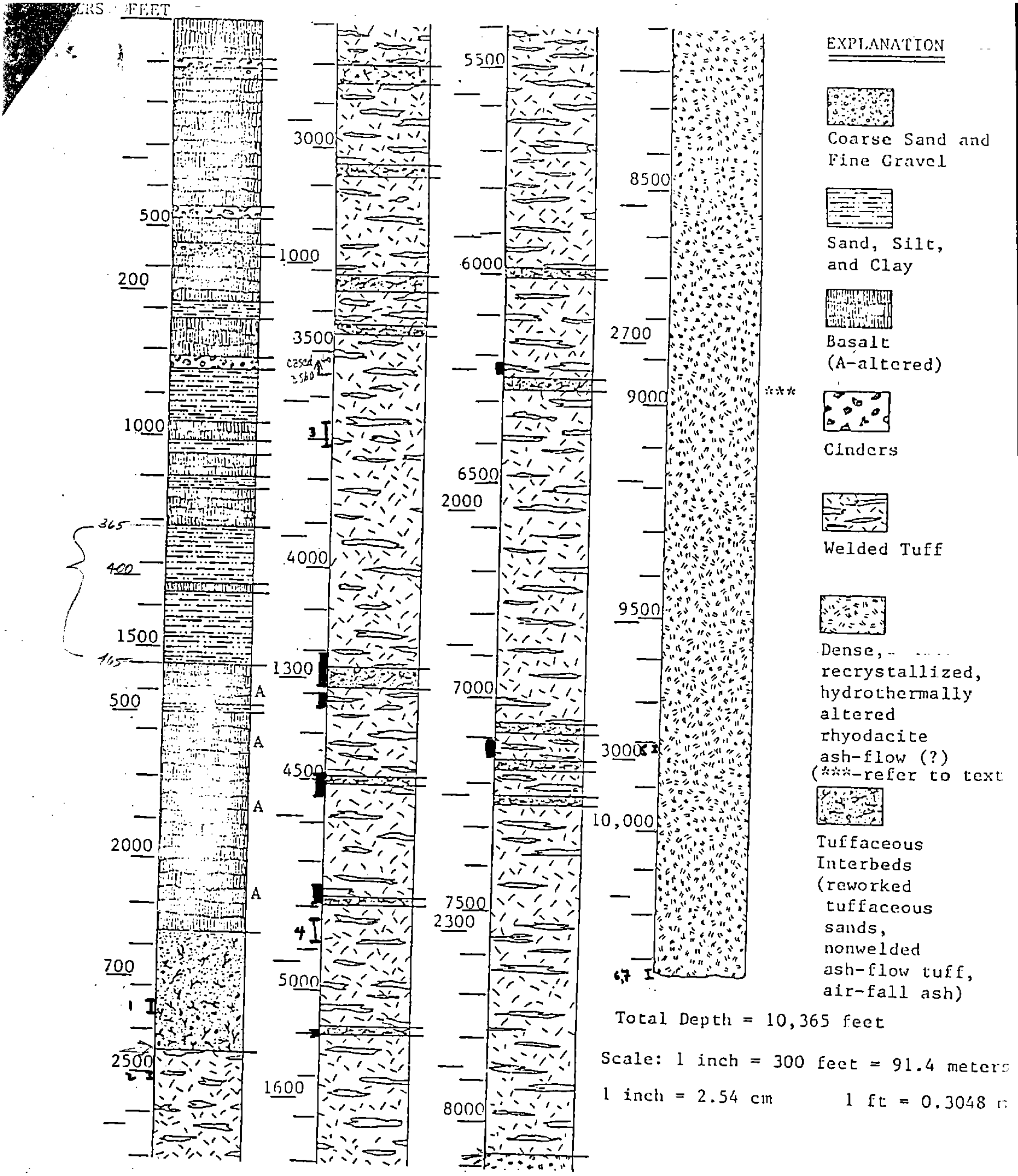


Figure 2.--Generalized lithologic log from exploration geothermal well (INEL-1), Idaho National Engineering Laboratory, Idaho.

1,2,3,...7 = cored intervals

I = intervals where caliper off-scale.

6/5/89 R.P. Smith

INEL-1

Core #1 - Thick interbed between Basalt section & Rhyolite section,
Interval cored 2340-2361
Core recovered = 5'
Core remaining in box ~ 1-1.5'

~~Fine clay-rich ash-rich sediment. Faint, Tiny biotite & muscovite flakes. Healed fractures. Well sorted. Probably a clay-rich playa or fluvial sediment. Calcareous matrix.~~
Primary airfall tuff. Contains glass shards, lapilli. Probably correlative with tuff at bottom of 2-2A, except finer-grained and probably more distal than tuff in 2-2A.

2-2A

Thick sedimentary section from 65' - 250'

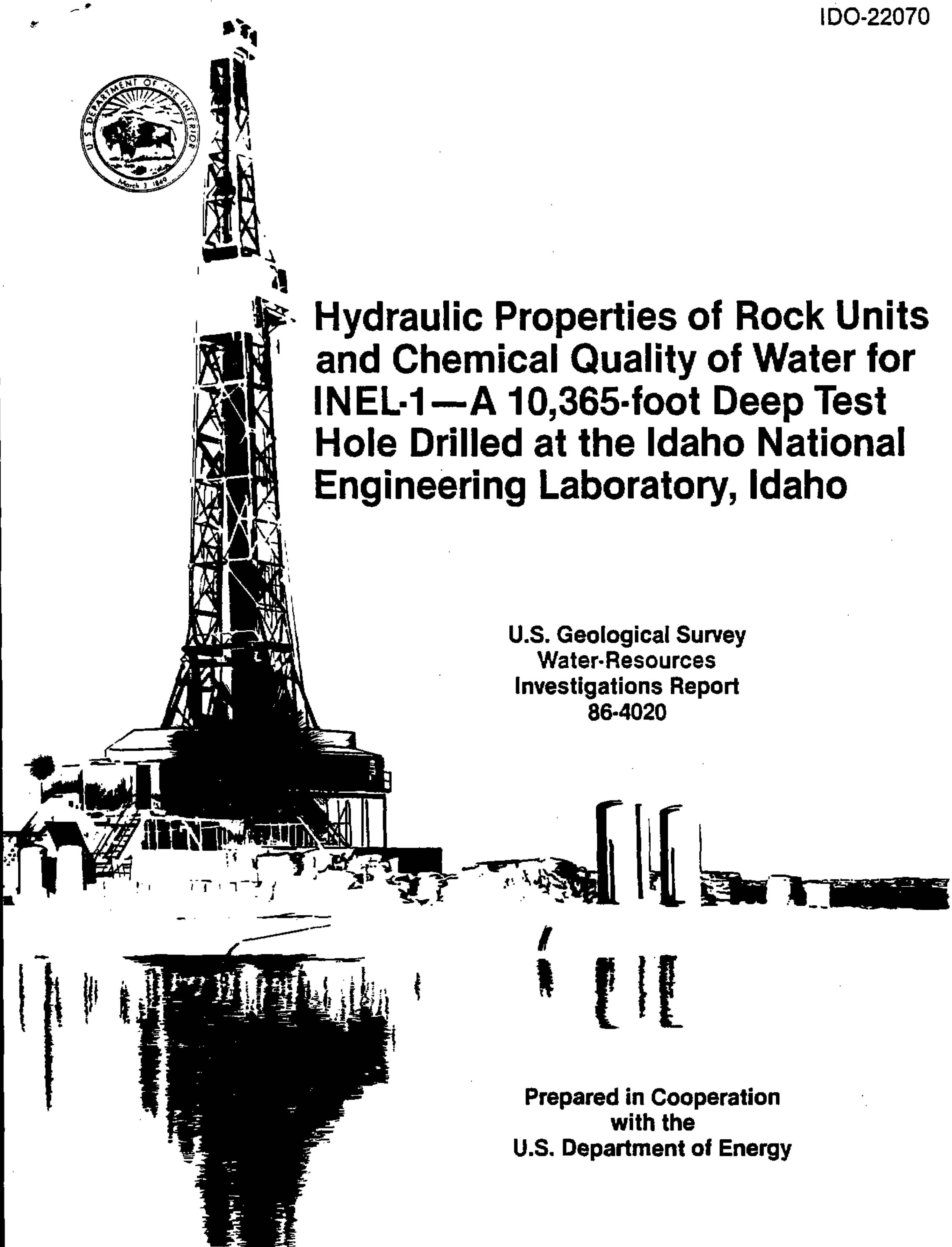
Mainly a clay unit with silty-fine sandy layers. Silt-fine sand intervals: 65'-114' - oxidized at top.

136'-140'
146-154
164-167
180-184
188-194
237-243
247-250

} Intervals between are gray mudstone with dessication cracks

Shaly interval - 235'-237' (hard laminated shale) - sample @ 237'

IDO-22070



Hydraulic Properties of Rock Units and Chemical Quality of Water for INEL-1—A 10,365-foot Deep Test Hole Drilled at the Idaho National Engineering Laboratory, Idaho

U.S. Geological Survey
Water-Resources
Investigations Report
86-4020

Prepared in Cooperation
with the
U.S. Department of Energy

HYDRAULIC PROPERTIES OF ROCK UNITS AND CHEMICAL QUALITY OF WATER FOR INEL-1—A 10,365-FOOT DEEP TEST HOLE DRILLED AT THE IDAHO NATIONAL ENGINEERING LABORATORY, IDAHO

By Larry J. Mann

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 86-4020

Prepared in cooperation with the

U.S. DEPARTMENT OF ENERGY

Idaho Falls, Idaho

February 1986

UNITED STATES DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

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CONVERSION FACTORS

For readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square foot (ft^2)	0.09290	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
foot squared per day (ft^2/day)	0.09290	meter squared per day (m^2/day)
gallon per minute (gal/min)	0.06309	liter per second (L/s)

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) as follows:

$$°F = 1.8\ °C + 32$$

HYDRAULIC PROPERTIES OF ROCK UNITS AND CHEMICAL QUALITY OF WATER FOR INEL-1—A 10,365-FOOT DEEP TEST HOLE DRILLED AT THE IDAHO NATIONAL ENGINEERING LABORATORY, IDAHO

By

Larry J. Mann

ABSTRACT

A 10,365-foot deep test hole drilled at the INEL (Idaho National Engineering Laboratory) in southeastern Idaho provided hydraulic information for rock units underlying the Snake River Plain aquifer. Four aquifer tests showed that the hydraulic conductivity decreased with depth—from an average of 0.03 feet per day for the interval from 1,511 to 2,206 feet below land surface to an average of 0.002 feet per day for the interval from 4,210 to 10,365 feet. In contrast, the hydraulic conductivity of the Snake River Plain aquifer ranges from 1 to 100 feet per day. The hydraulic head increased with depth; the head at depth was about 115 feet greater than that for the Snake River Plain aquifer.

Water temperature in the test hole increased from 26 °C (Celsius) at 600 feet below land surface to 146 °C at 9,985 feet. The gradient was nearly linear and averaged about 1.3 °C per one-hundred feet of depth. Water from the Snake River Plain aquifer contained 381 milligrams per liter of dissolved solids and had a calcium bicarbonate chemical composition. The dissolved solids concentration in underlying rock units ranged from 350 to 1,020 milligrams per liter and the water had a sodium bicarbonate composition.

Hydrologic data for the test hole suggest that the effective base of the Snake River Plain aquifer near the test hole is between 840 and 1,220 feet below land surface. The upward vertical movement of water into the Snake River Plain aquifer from underlying rock units could be on the order of 15,000 acre-feet per year at INEL.

INTRODUCTION

A 10,365-ft deep test hole was drilled in 1979 at Idaho National Engineering Laboratory (INEL). The main purpose of the test hole was to ascertain whether a hydrothermal resource existed beneath INEL and, if so, whether it would be economically feasible to develop the resource. Drilling and completion of the test hole was performed under a contract administered by the U.S. Department of Energy's Idaho Operations Office.

Few drill holes penetrate the rocks underlying the INEL more than 1,000 ft and most holes are less than 750 ft in depth. Because the test hole penetrated more than 7,000 ft of rocks that had not previously been explored by drill holes, the test hole also yielded new information on the physical, chemical and hydraulic properties of the rocks and the chemical characteristics of the ground water contained therein. This report presents aquifer hydraulic and ground-water chemical data collected as part of the test-drilling program. A geologic interpretation and lithologic log of the test hole was presented by Doherty and others (1979), and a general discussion of the drilling techniques and hydrogeology of the rocks penetrated was presented by Prestwich and Bowman (1980).

The INEL includes about 890 mi^2 of the eastern Snake River Plain in southeastern Idaho (fig. 1). It was established in 1949 and is used by the U.S. Department of Energy to test different types of nuclear reactors. The INEL is one of the main centers in the United States for developing peacetime uses of atomic energy.

The 10,365-ft test hole—referred to as INEL-1 on figure 1—was drilled in the SE¼NW¼NE¼ of section 1 in Township 3N, Range 29E. The altitude of the land surface at the drill site is 4,875 ft. Hydrologic data for a drill hole located about 200 ft south of the INEL-1 test hole are also described in this report. The drill hole was completed at a depth of 595 ft below land surface to supply water for the drilling of INEL-1 and is referred to as the Water-Supply well.

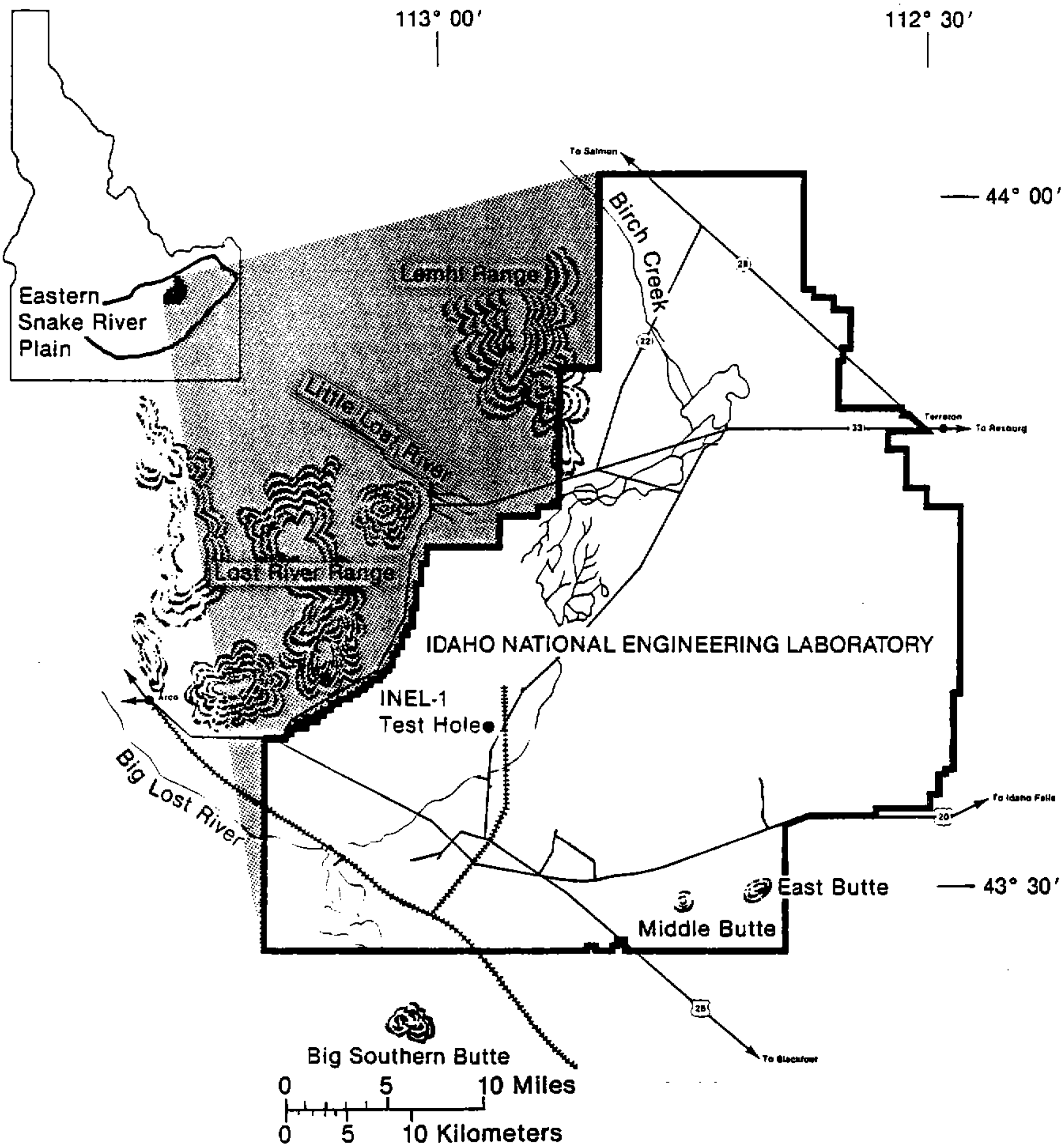


Figure 1.--Location of the Idaho National Engineering Laboratory and INEL-1 test hole.

GEOLOGIC SETTING

The eastern Snake River Plain is a structural basin about 200 mi long and 50 to 70 mi wide. The plain is underlain by a bedded sequence of basaltic lava flows and cinder beds intercalated with alluvium and lake-bed sedimentary deposits. Individual flows range from 10 to 50 ft in thickness, although the average thickness may be from 20 to 25 ft (Mundorff and others, 1964, p. 143). The sedimentary deposits consist mainly of lenticular beds of sand, silt and clay with lesser amounts of gravel. Locally, rhyolitic lava flows and tuffs are at the land surface or occur at depth. The basaltic lava flows and intercalated sedimentary deposits combine to form the Snake River Plain aquifer which is the main source of ground water on the plain. The total thickness of the sequence of the volcanic rocks and the nature of the underlying rocks are poorly defined in all but a few places on the plain.

At the INEL-1 drill site, basaltic rocks that are highly fractured occur at the land surface. The highly-fractured basalts likely extend downward to at least 840 ft as evinced by geophysical logs and the loss of circulation of drilling fluids. Circulation was first lost at 137 ft and was not regained until casing was set to a depth of 1,511 ft (Prestwich and Bowman, 1980, p. 14). Above a depth of 840 ft the test hole penetrated mostly basalt and cinders although three sedimentary units were encountered (fig. 2). At 840 ft, a 120-ft thick bed of sand, silt, and clay was penetrated; from 840 to 1,530 ft the material penetrated was largely sedimentary deposits with 20 to 80 ft layers of basalt. From 1,530 to 2,160 ft, the test hole penetrated a thick sequence of basalts with one 20-ft thick sedimentary unit (fig. 2). Below a depth of about 1,600 ft the basaltic rocks were altered and mineralized (Doherty and others, 1979, p. 3).

Between 2,160 and 2,435 ft tuffaceous interbeds were penetrated (fig. 2); a 5-ft core recovered between 2,340 and 2,361 ft showed a calcareous and occasionally silty claystone (Prestwich and Bowman, 1980, p. 15). From 2,435 to 8,080 ft, the material penetrated mainly consisted

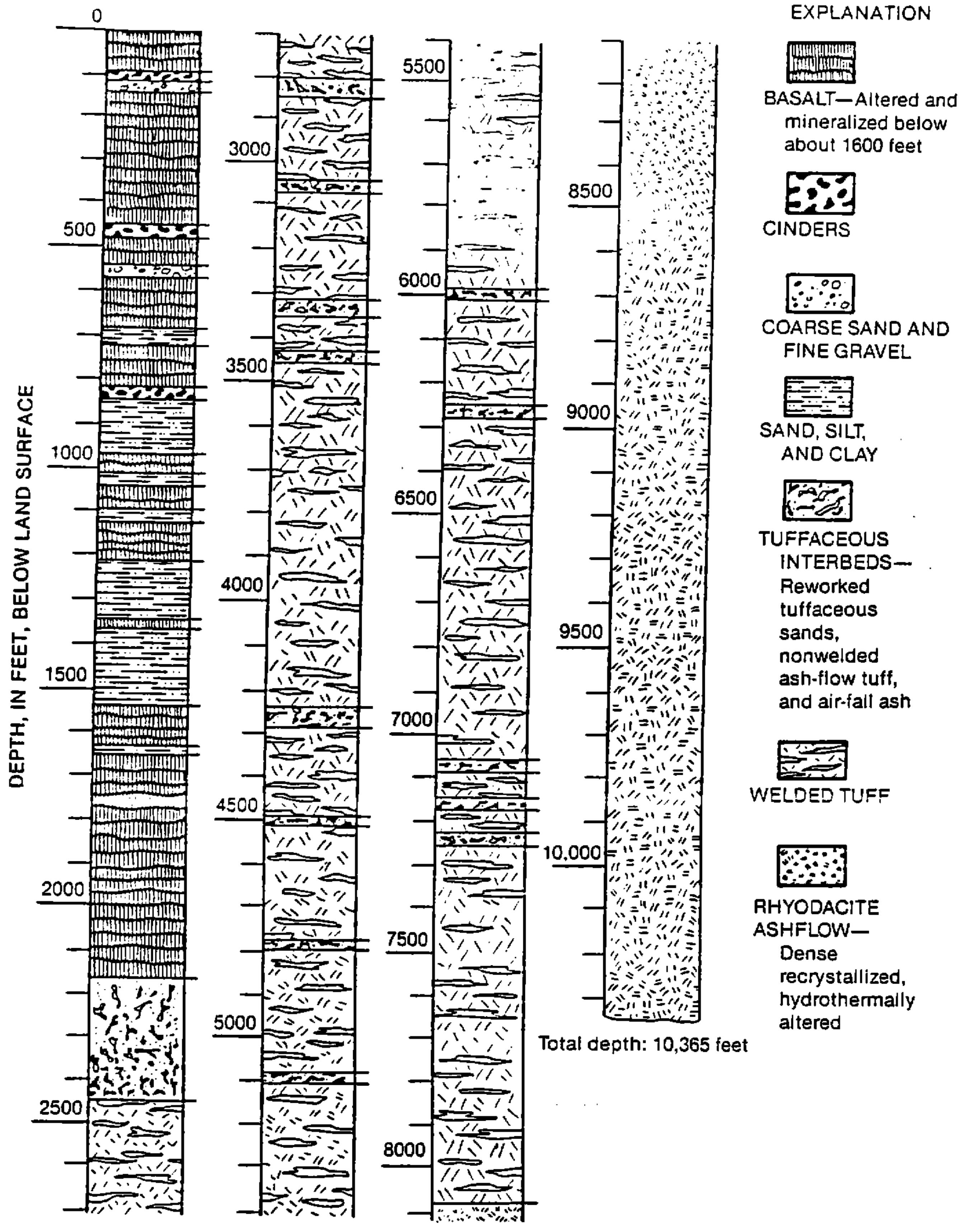


Figure 2.--Generalized lithologic log of rock units penetrated by INEL-1 test hole (modified from Doherty and others, 1979).

of welded tuff with several 20- to 40-ft thick tuffaceous interbeds. And from 8,080 to 10,365 ft the test hole penetrated a hydrothermally altered rhyodacite ash flow.

HYDRAULIC PROPERTIES OF ROCK UNITS

The hydraulic properties of rock units underlying the eastern Snake River Plain below a depth of about 1,500 ft were, for the most part, undefined prior to drilling the INEL-1 test hole. During and subsequent to the drilling and completion of the test hole, four tests were conducted that define the transmissivity and hydraulic conductivity of selected intervals of rock. Aquifer test 1 tested the interval from 1,511 to 2,206 ft; test 2, the interval from 3,559 to 3,713 ft; test 3, the interval from 3,559 to 4,879 ft; and test 4, the interval from 4,210 to 10,365 ft. Each test consisted of a pumping phase and a recovery phase. On the basis of depth-to-water measurements made during the recovery phase of the aquifer tests, the hydraulic head increases with increasing depth.

Aquifer Test 1: Interval from 1,511 to 2,206 feet

On March 23 and 24, 1979, the interval of rocks from 1,511 to 2,206 ft below land surface was tested to define the transmissivity and hydraulic conductivity. Prior to testing, 20-in. casing was set and grouted from the surface to 1,511 ft. A 17-1/2 in. hole was drilled from 1,511 to 2,518 ft. At the beginning of the test the hole was open from 1,511 to 2,518 ft, but during the test sediment filled the hole from 2,206 to 2,518 ft; the tuffaceous interbeds from 2,160 to 2,450 ft were probably the source of the sediment. It is likely that the sediment filling began when the viscosity of the fluid in the hole began to decrease as a result of pumping. Therefore, it can be safely assumed that the interval tested was from 1,511 to 2,206 ft and that units below that interval were effectively sealed off by an admixture of sediment and drilling mud.

The aquifer test was plagued with pump motor problems. The test was started at 0800 hours on March 23 and the pump was pulled later on that day to replace the motor. Subsequent to the replacement of the motor, the pump repeatedly overloaded and tripped a circuit breaker until about 2255 hours. Beginning at about 2255 hours and continuing until 0814 hours on March 24, the pump functioned without fail.

The depth to water, pumping rate, and temperature of the water pumped from the test hole from 1530 hours on March 23 to 1100 hours on March 24 are shown in figure 3; prior measurements are not shown because of the pump problems. Depth to water in the test hole at the beginning of the test was about 104 ft below land surface. However, ground-water levels measured during the recovery phase of the test indicate that the static water level was about 330 ft below land surface.

An analysis of the drawdown data does not give a reliable estimate of transmissivity because of the sporadic failure of the pump prior to 2255 hours on March 23; drawdown cannot be calculated because the water-level trend for the previous 5 hours was eratic owing to the repeated failure of the pump.

The recovery phase of the aquifer test shows that the transmissivity of the interval from 1,511 to 2,206 ft is on the order of 20 ft^2/day. The average hydraulic conductivity, therefore, is about 0.03 ft/day.

Aquifer Test 2: Interval from 3,559 to 3,713 feet

Following aquifer test 1, the test hole was drilled to a depth of 3,713 ft and 13-3/8 in. casing was set and grouted from the land surface to a depth of 3,559 ft. From 3,559 to 3,663 ft the diameter of the borehole was 12-1/4 in. and from 3,663 to 3,713 ft it was 7-7/8 in. The welded tuff in the interval from 3,559 to 3,713 ft (fig. 2) was tested on April 6 to 8, 1979 to define the transmissivity of the unit.

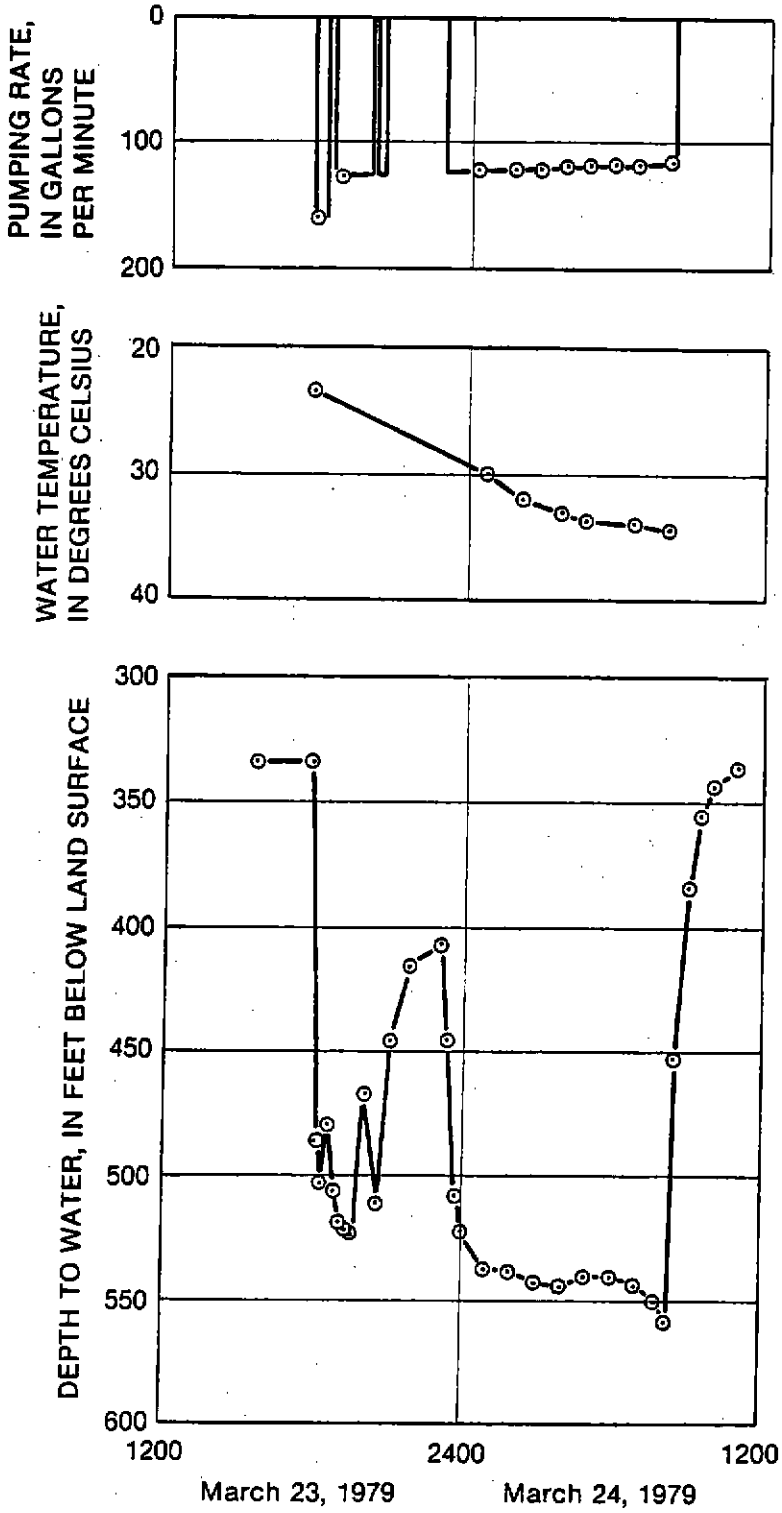


Figure 3.--Depth to water, pumping rate and water temperature for aquifer test 1.

The depth to water, pumping rate and temperature of the water pumped from the test hole are shown in figure 4. The fluid level in the test hole was about 18 ft below land surface at the beginning of the test owing to the presence of the drilling mud. The level declined to nearly 800 ft below land surface in the first 90 minutes of the test. During the following 18 hours of pumping, the water level recovered to about 745 ft below land surface and remained near that level for the rest of the aquifer test. The recovery and stabilization of the water level was probably due to one or a combination of three factors: (1) the test hole was developing during the pumping phase of the test—that is, drilling fluids and mud used during drilling were being removed from the formation in the tested interval; (2) the pumping rate decreased by about 10 percent during the test; and (3) it is likely that there was vertical movement of water into the tested interval from overlying and underlying rock units.

The transmissivity of the welded tuff in the open interval from 3,559 to 3,713 ft was calculated using data collected during the recovery phase of the test. An analysis of the recovery data indicates that the transmissivity of the open interval is about 2 ft^2/day. The average hydraulic conductivity for the welded tuff in the 154-ft open interval is about 0.01 ft/day. Water levels at the end of the recovery test suggest that the static water level would be about 290 ft below land surface.

Aquifer Test 3: Interval from 3,559 to 4,879 feet

Once aquifer test 2 was completed, the test hole was deepened to 4,879 ft. A 12-1/4 in. diameter open hole was drilled from 3,663 to 4,839 ft and a 7-7/8 in. diameter core was collected between 4,839 and 4,879 ft. The rocks penetrated from 3,713 to 4,879 ft were similar to those from 3,559 to 3,713 ft except for a few thin tuffaceous interbeds (fig. 2).

On April 14 to 16, 1979, a third aquifer test was performed to define the transmissivity and hydraulic conductivity of the open interval

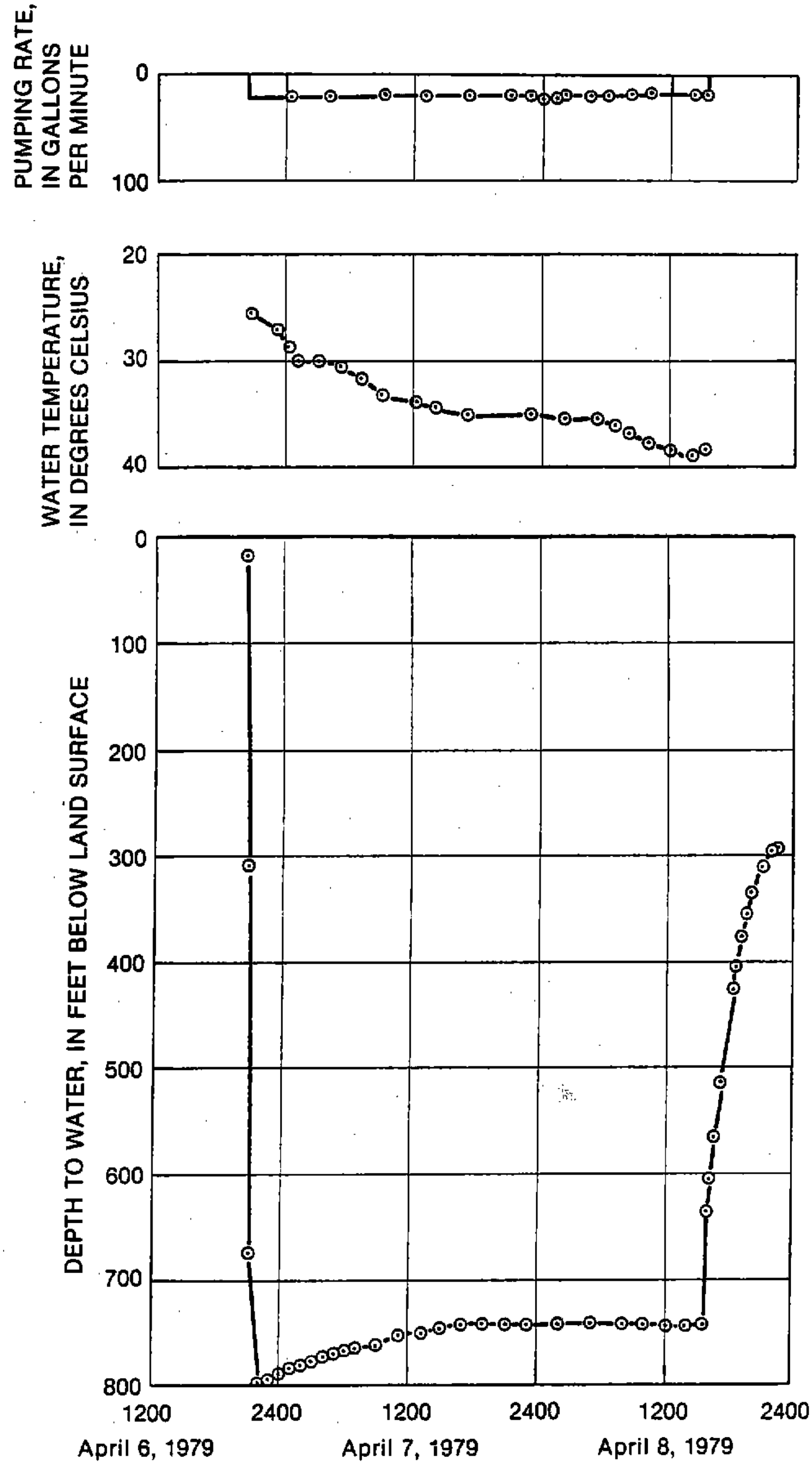


Figure 4.--Depth to water, pumping rate and water temperature for aquifer test 2.

from 3,559 to 4,879 ft. The transmissivity of the open interval was calculated using drawdown data collected between 1245 hours on April 14 and 0600 hours on Aoril 15, and from about 3 hours of recovery data collected after pumping had stopped (fig. 5). An analysis of both the drawdown and recovery data shows that the transmissivity of rocks in the open interval is about 8 ft^2/day. The average hydraulic conductivity of the rocks in the open interval is about 0.006 ft/day. The depth to water at the end of the recovery test was about 290 ft below land surface.

Aquifer Test 4: Interval from 4,210 to 10,365 feet

On May 26, 1979 the test hole was completed at a depth of 10,365 ft below land surface. At completion, the test hole was cased from 3,282 to 6,796 ft with 9-5/8 in. casing; the casing was grouted at the top and bottom of this section and the mid-section was kept free of cement in the anticipation of perforating it. The casing was then perforated with 730 one-quarter inch holes between 4,210 and 6,266 ft. Below 6,796 ft the test hole was not cased. The open intervals through which water could flow from rock into the well bore, therefore, was from 4,210 to 6,266 ft and 6,796 to 10,365 ft.

During January 1981, a fourth aquifer test was run to define the transmissivity and hydraulic conductivity of rocks opposite the open intervals. The test hole was pumped for seven days. Water-level measurements were made to document the amount of drawdown owing to pumping and the rate of water-level recovery once pumping had stopped. Depth to water, pumping rate and temperature of water pumped from the test hole are shown on figure 6.

For the first 23 hours, the average pumping rate was 50 gal/min. After 23 hours of pumping the rate was increased and averaged about 57 gal/min for the remainder of the test. After the pumping rate was increased, the water level declined to about 570 ft below land surface and remained near that depth for the duration of the test.

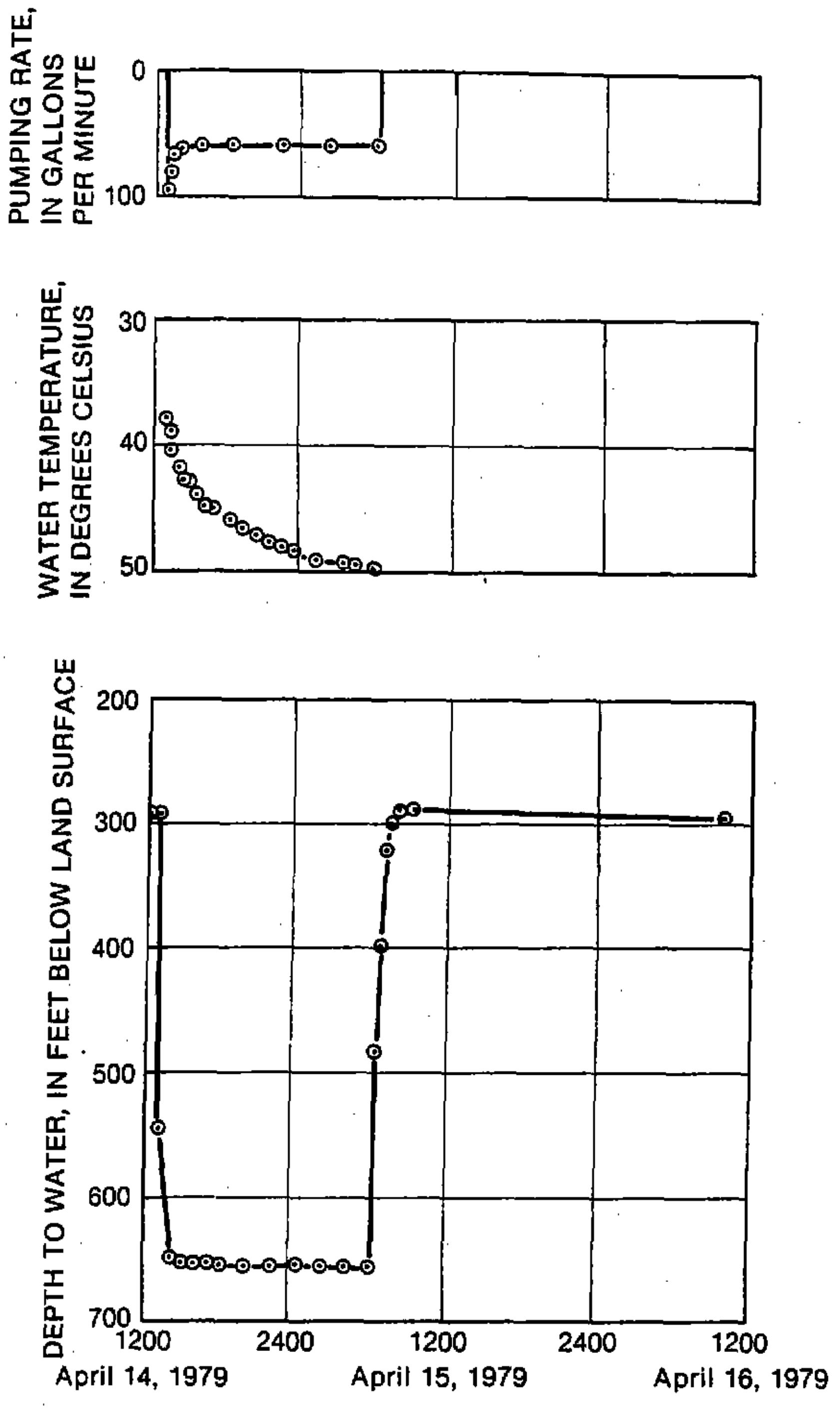


Figure 5.--Depth to water, pumping rate and water temperature for aquifer test 3.

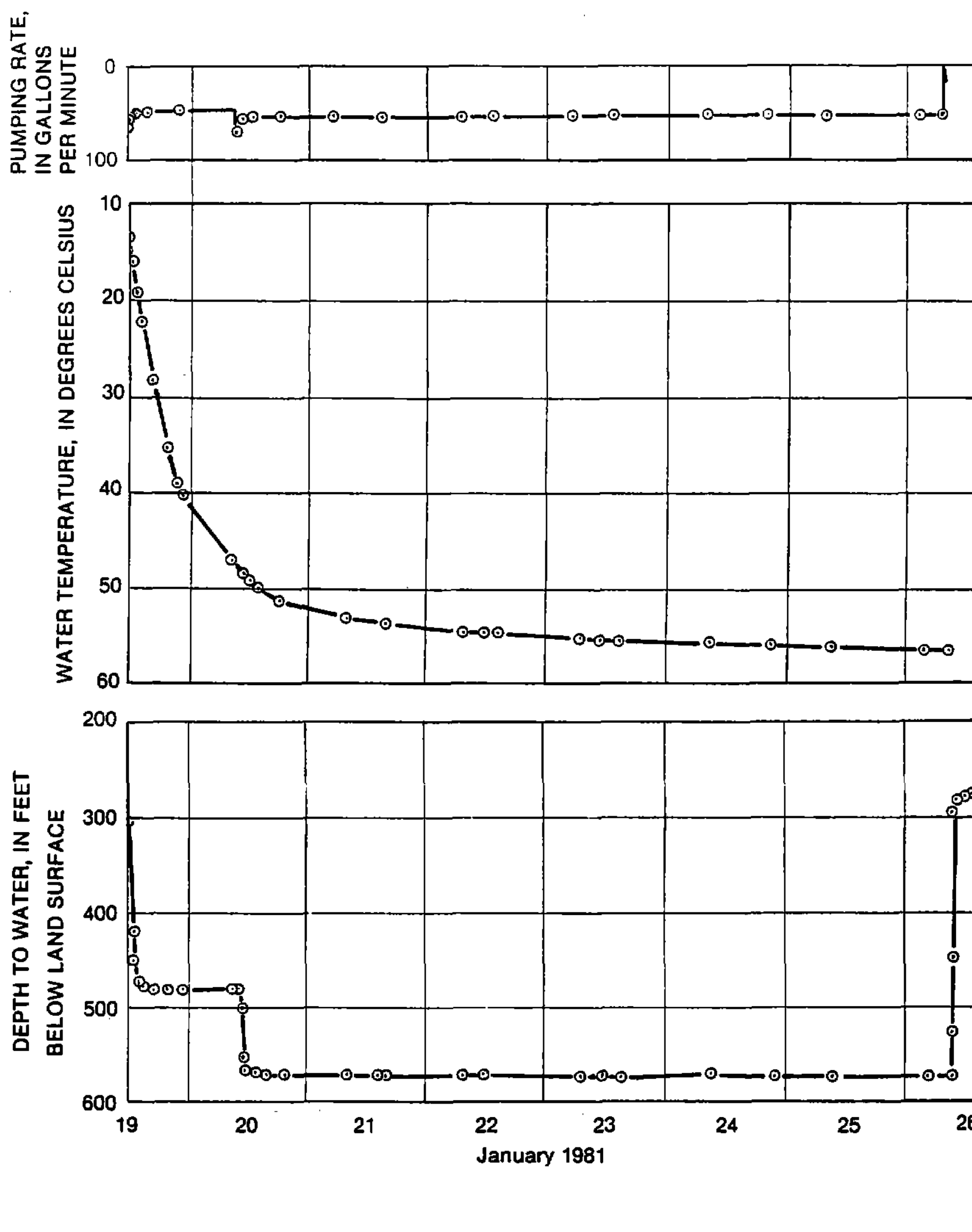


Figure 6.--Depth to water, pumping rate and water temperature for aquifer test 4.

The transmissivity for the intervals open to the well bore was calculated using drawdown data for the first 23 hours of pumping and the recovery data. Transmissivity calculated using drawdown data was 10 ft^2/day and that using recovery data was 7 ft^2/day. Less weight is given to the 7 ft^2/day value because the recovery data would be affected by the increase in the pumping rate at the end of 23 hours of pumping. Using a transmissivity 10 ft^2/day, the average hydraulic conductivity for the 5,625 ft of rock open to the well bore is 0.002 ft/day. The recovery data indicated that the static water level would be about 280 ft below land surface.

Hydraulic Head

Hydraulic head differs from one interval to another as a function of the depth of a specific interval below the land surface. In general, the greater the depth that an interval is below land surface, the greater the hydraulic head. The head in intervals deeper than 3,559 ft below land surface is about 100 ft higher than the head in the upper 200 ft of basaltic rocks of the Snake River Plain aquifer (table 1).

Table 1.--Approximate depth to water and altitude of the water level for intervals tested in INEL-1 test hole

Interval open to test hole (feet below land surface)	Approximate depth to water (feet below land surface)	Altitude of water level (feet above sea level)
* 395 to 595	395	4,480
1,511 to 2,206	330	4,545
3,559 to 3,713	290	4,585
3,559 to 4,879	290	4,585
4,210 to 10,365	280	4,595

*Information is for the Water-Supply well which taps the upper 200 ft of the Snake River Plain aquifer

TEMPERATURE AND CHEMICAL QUALITY OF WATER

The physical and chemical properties of water pumped from the INEL-1 test hole differ with depth. Water temperature in the INEL-1 test hole gradually increased from 26 °C at 600 ft below land surface to 146 °C at 9,985 ft (fig. 7). The temperature log was run on July 19, 1979, after the test hole had been undisturbed for slightly more than one month.

The temperature of water in the test hole, however, had not come to equilibrium after being undisturbed for slightly more than one month. The temperature at a depth of 600 ft below land surface was still about 13 °C greater than the temperature of water at the same depth in the Snake River Plain aquifer. The greater temperature may be the result of the circulation of water in response to convection currents within the well bore. The temperature gradient in the test hole was nearly linear and averaged slightly less than 1.3 °C per one-hundred feet of depth below land surface. From 600 to about 4,000 ft, the temperature gradient was not as uniform as it was below 4,000 ft (fig. 7). In the interval from 1,300 to 1,600 ft, the temperature increased about 1 °C or about 0.3 °C per one-hundred feet. This decrease in gradient corresponds to the thick zone of sand, silt and clay (fig. 2). From 2,450 to 2,750 ft, the temperature increased about 1 °C (fig. 7), also about 0.3 °C per one-hundred feet. This decrease was near the contact between the tuffaceous interbeds that immediately underlie the lowermost basalt and the underlying welded tuff (fig. 2). The relatively low temperature gradient in the two intervals may result from the rocks having a slightly greater hydraulic conductivity than adjacent rocks.

The dissolved solids and chemical composition of the water pumped from INEL-1 change markedly with depth. Water from the Water-Supply well, which taps the upper 200 ft of the Snake River Plain aquifer, contained 381 mg/L (milligrams per liter) of dissolved solids and had a calcium bicarbonate type of chemical composition with significant amounts of magnesium and chloride (table 2).

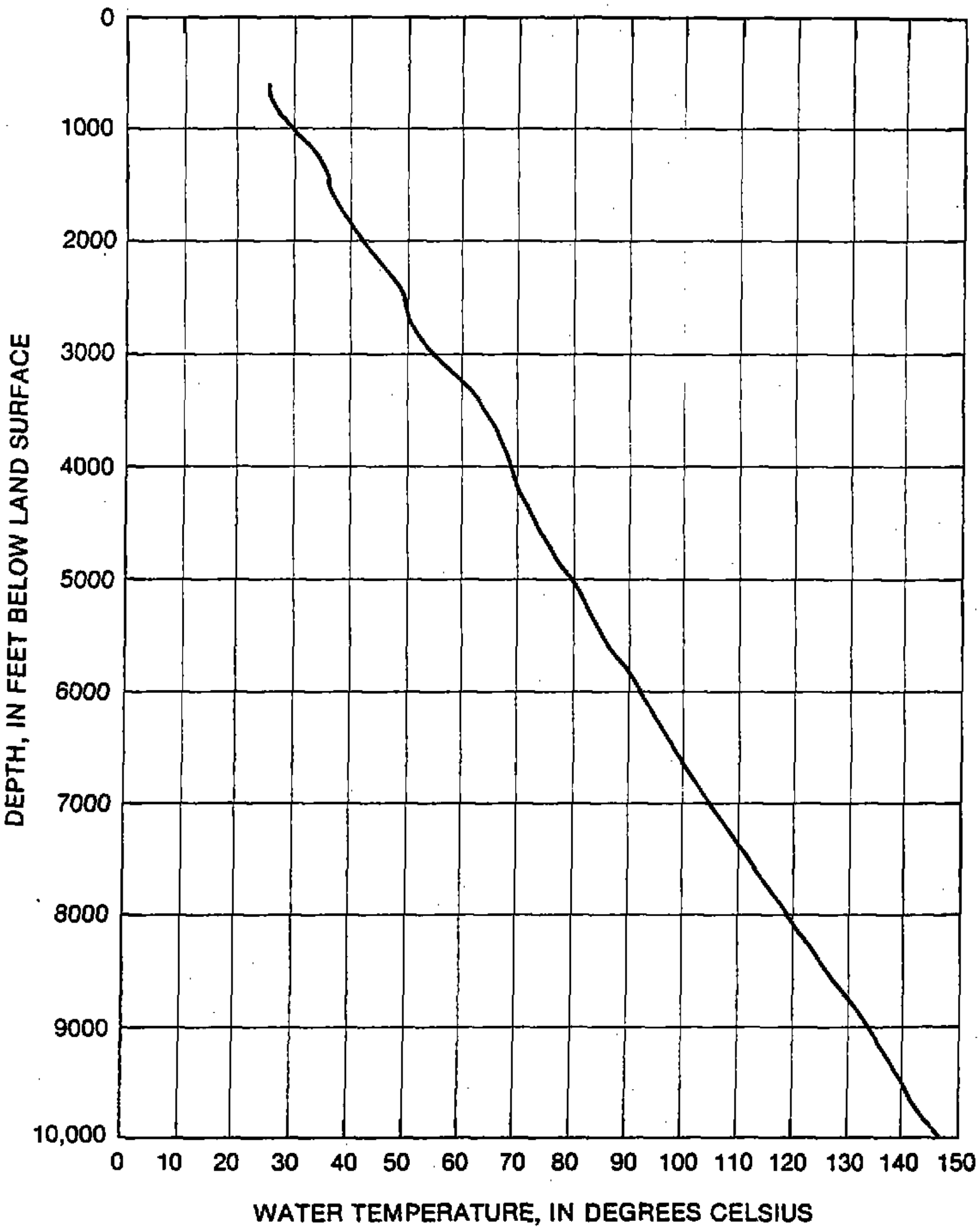


Figure 7.--Water-temperature profile for INEL-1 test hole.

Table 2.--Selected water-quality data for Water-Supply well and INEL-1 test hole

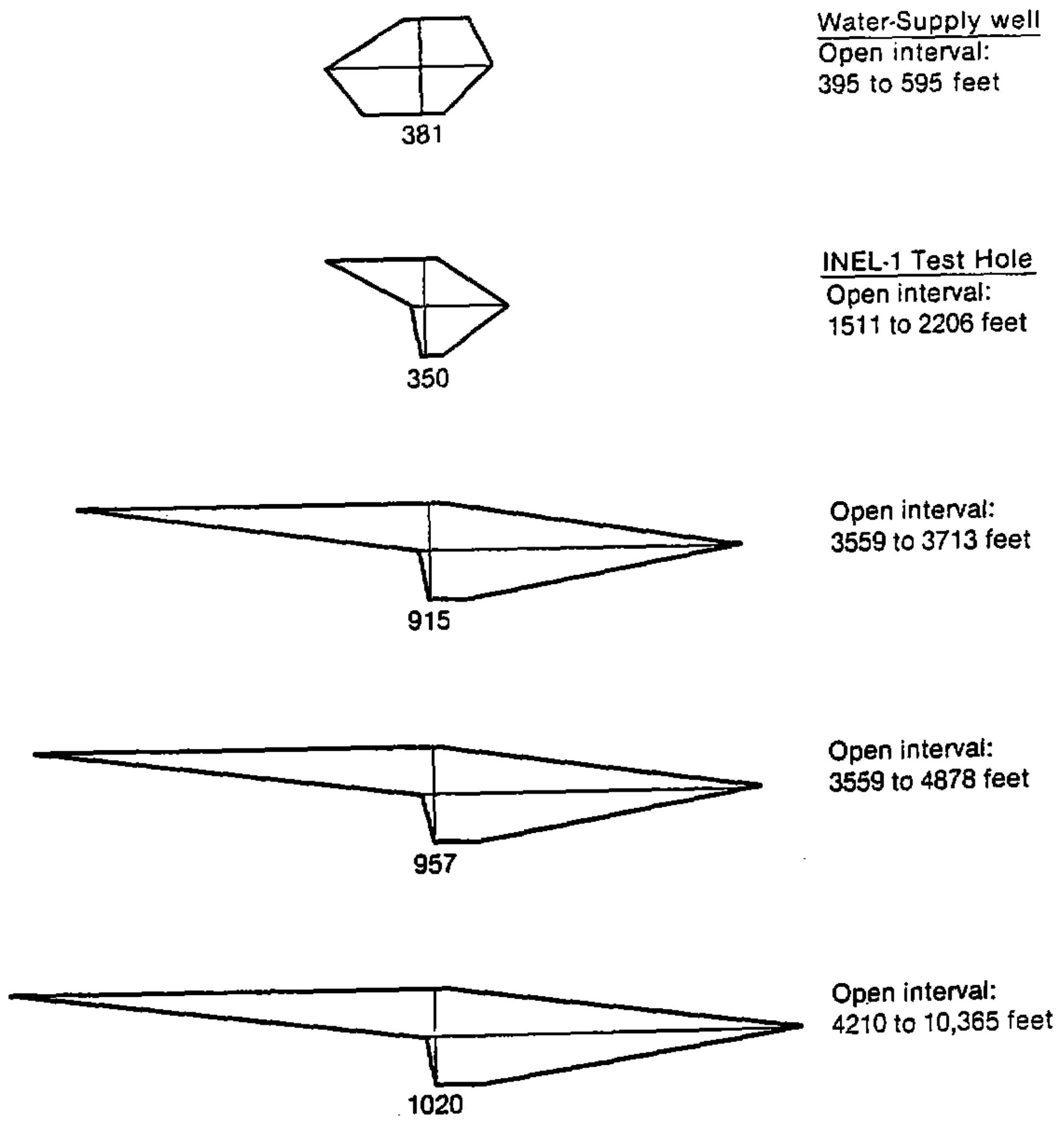
[Analyses are in milligrams per liter unless otherwise noted. Constituent concentrations in dissolved state unless otherwise noted. Abbreviation, μg/L, represents micrograms per liter.]

	Water-Supply Well	INEL-1 Test Hole			
Interval tested (feet below land surface)	395-595	1,511 2,206	3,559-3,713	3,559-4,878	4,210-10,365
Alkalinity	160	210	720	670	740
Arsenic (μg/L)	1	20	24	73	--
Bicarbonate	190	220	780	820	900
Boron (μg/L)	280	900	580	530	560
Calcium	76	10	8.1	8.9	7.3
Chloride	74	17	17	13	12
Chromium-total (μg/L)	20	20	10	10	0
Fluoride	0.2	1.1	12	13	13
Iron (μg/L)	0	0	770	1,200	1,100
Lead (μg/L)	0	0	0	0	--
Lithium (μg/L)	5	50	290	280	--
Magnesium	28	2.0	1.1	1.1	0.5
Manganese (μg/L)	0	20	110	60	50
pH	7.8	8.2	8.2	8.3	7.9
Potassium	3.0	10	9.2	8.1	7.5
Dissolved solids (calculated)	381	350	915	957	1,020
Selenium (μg/L)	2	1	0	0	--
Silica	24	60	33	39	47
Sodium	12	92	330	370	390
Strontium (μg/L)	370	100	120	140	150
Sulfate	50	32	69	97	99
Water temperature (°C)	12	34	38	50	57

The dissolved solids concentration increases from 350 to 915 mg/L in the interval between 2,206 and 3,559 ft. Whether the increase is gradual or abrupt is not known, because this interval was neither pumped nor was the water sampled. If the increase is abrupt, it may occur at the contact between the altered basalt and tuffaceous interbeds at about 2,160 ft below land surface; the vertical and horizontal hydraulic conductivity also would likely decrease at this depth. From 3,559 to 10,365 ft, the dissolved solids increase from 915 to 1,020 mg/L— a relatively small increase when compared to the 565 mg/L increase that occurs between 2,206 and 3,559 ft.

The smaller concentration of dissolved solids in the upper 2,200 ft of rocks tapped by INEL-1 is attributed to dilution by the infiltration of streamflow, rainfall and snowmelt and underflow from upgradient recharge areas. Streamflow in the Big Lost and Little Lost rivers has a calcium bicarbonate type of chemical composition (U.S. Geological Survey, 1982). The infiltration of streamflow along the channels of these rivers constitutes a significant part of the recharge to rocks that underlie the INEL.

The transition from a calcium bicarbonate to sodium bicarbonate type of chemical composition occurs in the interval between 595 and 1,511 ft below land surface (fig. 8). It is not known whether the transition is gradual or abrupt because the interval was not pumped and samples were not collected. The transition most likely occurs in the interval from 850 to 1,220 ft which is mainly sand, silt and clay (fig. 2). The change in chemical composition is caused by an increase in sodium and a decrease in calcium in the water. Dilution of the sodium type of water with a calcium type of water, ion exchange, and precipitation of calcite accounts for the change in the chemical composition of water. In the vicinity of the INEL-1 test hole, dilution is the prime controlling factor. The sodium-type water at depths greater than 1,511 ft below land surface vertically moves upward in response to a higher hydraulic head. It is diluted by the calcium-type water present in the shallow basaltic rocks.



EXPLANATION

CHEMICAL-QUALITY DIAGRAM—Shows major constituents in milliequivalents per liter. The diagrams are in a variety of shapes and sizes, which provides a means of comparing, correlating, and characterizing similar or dissimilar types of water. Number, 381, is the dissolved solids concentration in milligrams per liter.

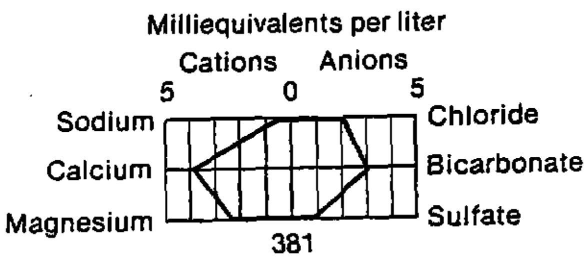


Figure 8.--Chemical quality of water for open intervals in Water-Supply well and INEL-1 test hole.

Water samples collected from the Water-Supply well and INEL-1 test hole were analyzed for selected trace elements in addition to dissolved solids and common ions (table 2). In general, the concentrations of trace elements increased with depth. The larger concentrations are likely associated with the higher water temperature and the hydrothermal alteration of rock units below a depth of 1,600 ft.

Chromium and selenium, on the other hand, were present in slightly greater concentrations in water from the Water-Supply well which taps the upper 200 ft of the Snake River Plain aquifer than in the deeper rock units tapped by INEL-1 (table 2). Strontium was present in a significantly greater concentration in the aquifer—370 μg/L (micrograms per liter)—than in deeper units—100 to 150 μg/L. For the observed concentrations in water from the Snake River Plain aquifer, chromium, selenium and strontium are likely introduced into the ground-water flow system via water recharged along the major stream channels or is derived from minerals in the sand, silt and clay deposits that are intercalated with the basalts.

Boron and silica concentrations were greater in the interval from 1,511 to 2,206 ft than in underlying or overlying units (table 2). The reasons for these greater concentrations are not known, but probably are associated with the altered and mineralized basaltic rocks that occur from 1,600 to 2,160 ft below land surface (fig. 2).

HYDROLOGIC IMPLICATIONS OF THE DATA

Geohydrologic data collected during the drilling and testing phases of the INEL-1 test hole and the Water-Supply well can be used to make some general statements regarding the ground-water hydrology of INEL. The hydraulic head increases with depth below land surface. If these conditions persist over most of the INEL, it is likely that water locally recharged to the basaltic rocks of the Snake River Plain aquifer does not circulate to depths of more than 1,000 to 2,000 ft. This supposition is supported by the age of the water pumped from the interval between 3,559 and 10,365 ft below land surface. Carbon-14 age dating indicates that the water is on the order of 35,000 years old (J.T. Barraclough, EG&G Idaho, Inc., written communication, August 1985). If significant quantities of water moved downward to depths greater than 2,000 ft, the water would be markedly younger. Circulation to greater depths could occur along the mountain fronts that bound the Snake River Plain or deep-seated fracture systems such as the rift zones delineated by Kuntz (1978).

The hydraulic conductivity of rocks below 1,500 ft is markedly less than that of the upper 200 to 800 ft of basaltic rocks. The basaltic rocks generally have a hydraulic conductivity of 1 to 100 ft/day. By comparison, the hydraulic conductivity of rocks below a depth of about 1,500 ft is from 0.002 to 0.03 ft/day—two to five orders of magnitude less than that of the upper 200 to 800 ft of basaltic rocks.

The marked reduction in the hydraulic conductivity may be coincident with the sand, silt and clay in the interval from 1,220 to 1,540 ft below land surface. But, it also could be associated with the sand, silt and clay in the interval from 850 to 960 ft. On the basis of data from INEL-1, the effective base of the Snake River Plain aquifer near the test hole is somewhere between 850 and 1,220 ft below land surface. These sand, silt and clay beds are likely to be continuous over most, if not all, of INEL. Similar sedimentary deposits have been penetrated in other deep holes drilled at INEL. The change in the chemical quality of water with depth, carbon-14 age dating, and the increase in hydraulic head with depth also support this conclusion.

Although the rocks below 1,220 ft have a small hydraulic conductivity when compared to the basaltic rocks of the Snake River Plain aquifer, the higher hydraulic head at depth indicates that there is an upward component of flow. The amount of vertical flow across the interval between 595 and 1,511 ft can be crudely estimated on the basis of field measurements and laboratory data, using the following equation:

$$Q = K_v IA \tag{1}$$

where Q = vertical flow (ft^3/day);

K_v = vertical hydraulic conductivity (ft/day);

I = vertical hydraulic (ft/ft); and

A = unit area through which the vertical flow occurs (ft^2).

The vertical hydraulic conductivity of the sedimentary deposits which make up a large part of the rocks from 595 to 1,511 ft is estimated to be on the order of 0.001 ft/day. This order of magnitude estimate is based on values for fine-grained sediment as shown by Bouwer (1978), and Freeze and Cherry (1979).

The hydraulic gradient across the interval from 595 to 1,511 ft is based on the field measurements shown in table 1. The depth to water for the interval from 395 to 595 ft is 395 ft, and the interval from 1,511 to 2,206 ft is 330 ft. The vertical hydraulic gradient, therefore, is 65 ft per 916 ft or 0.071 ft/ft.

By substituting these estimates plus a unit area (A) into equation 1, it follows that the vertical flow across the interval from 595 to 1,511 ft is on the order of 0.00007 (ft^3/day)/ft^2. If the geohydrologic conditions at the INEL-1 test hole are widespread, inflow into the basalts of the Snake River Plain aquifer from underlying rocks on the 890-mi^2 INEL area could be on the order of 15,000 acre-ft/year.

Given that the vertical movement of water into the Snake River Plain aquifer from underlying rocks could be on the order of 15,000 acre-ft/year at INEL, this amount of inflow could have an influence on the way the aquifer would respond to applied stresses. The contribution of water to the aquifer could be of significant importance, although of a smaller magnitude than the 130,000 acre-ft/year of recharge from the Big Lost River estimated by Robertson (1974, p. 26). Geologic and hydraulic information is inadequate, however, to define the magnitude of this inflow and the effective base of the aquifer at all but a few locations at the INEL and on the Snake River Plain.

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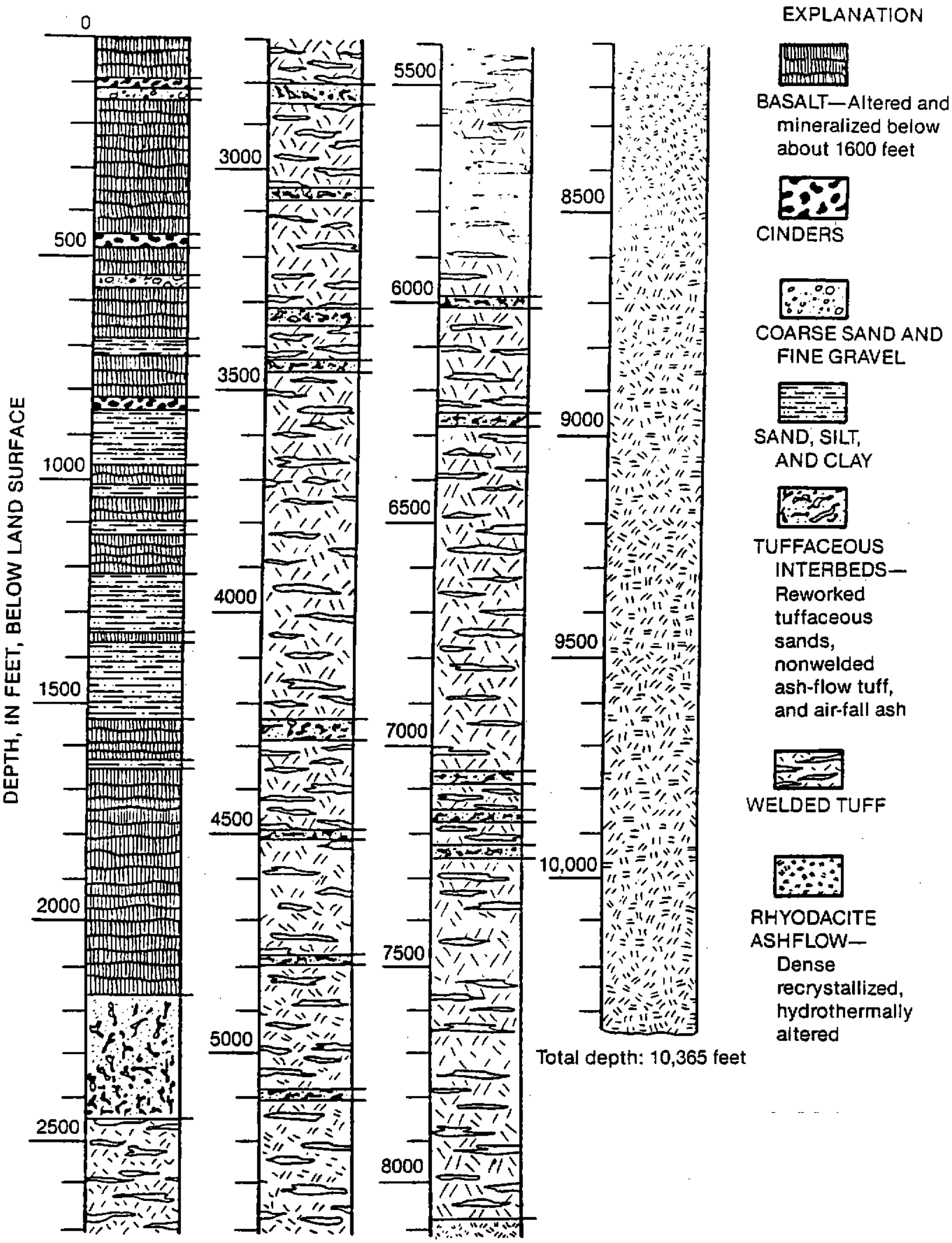


Figure 2.--Generalized lithologic log of rock units penetrated by INEL-1 test hole (modified from Doherty and others, 1979).

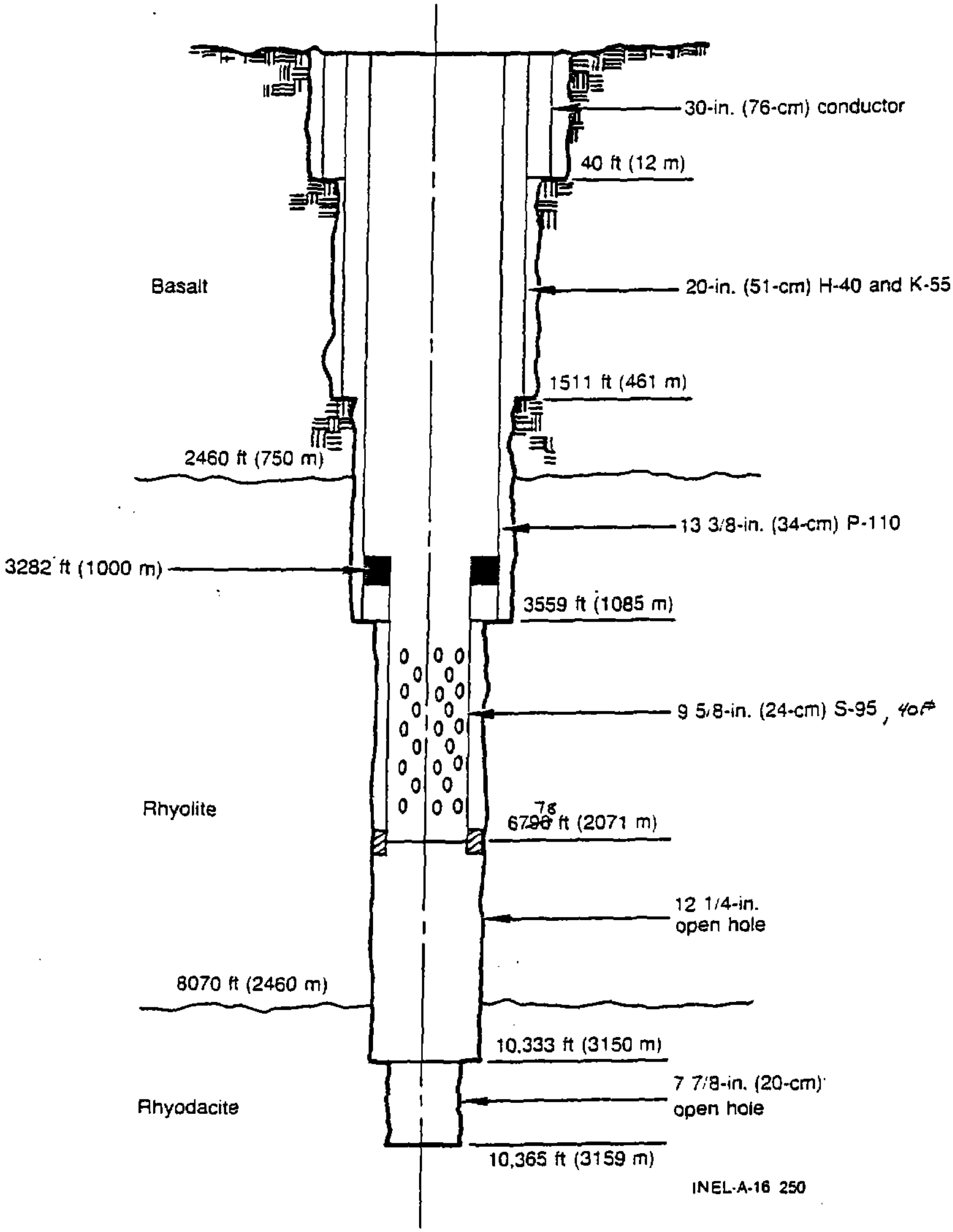
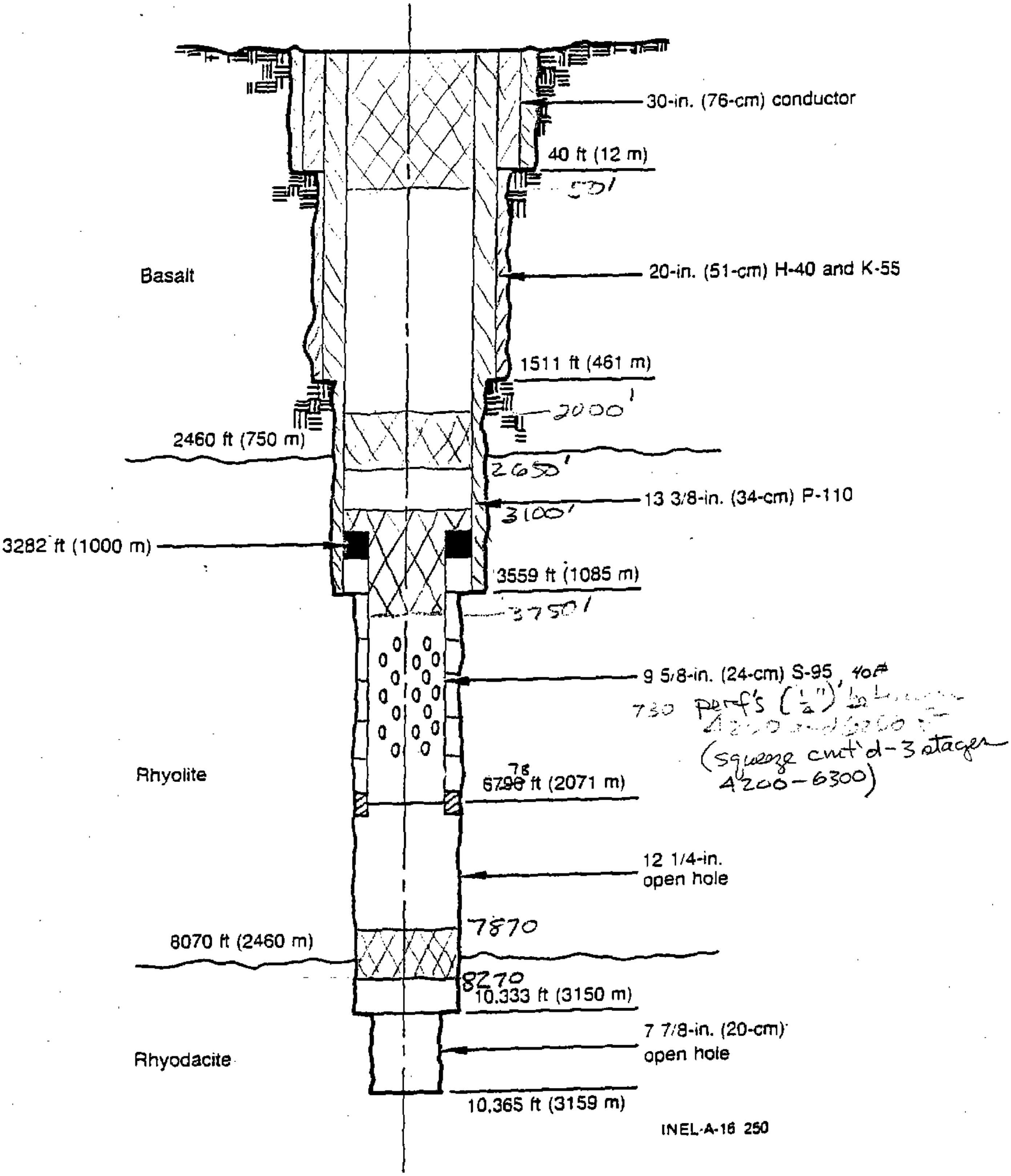


Figure 7. INEL-1 well subsurface status.



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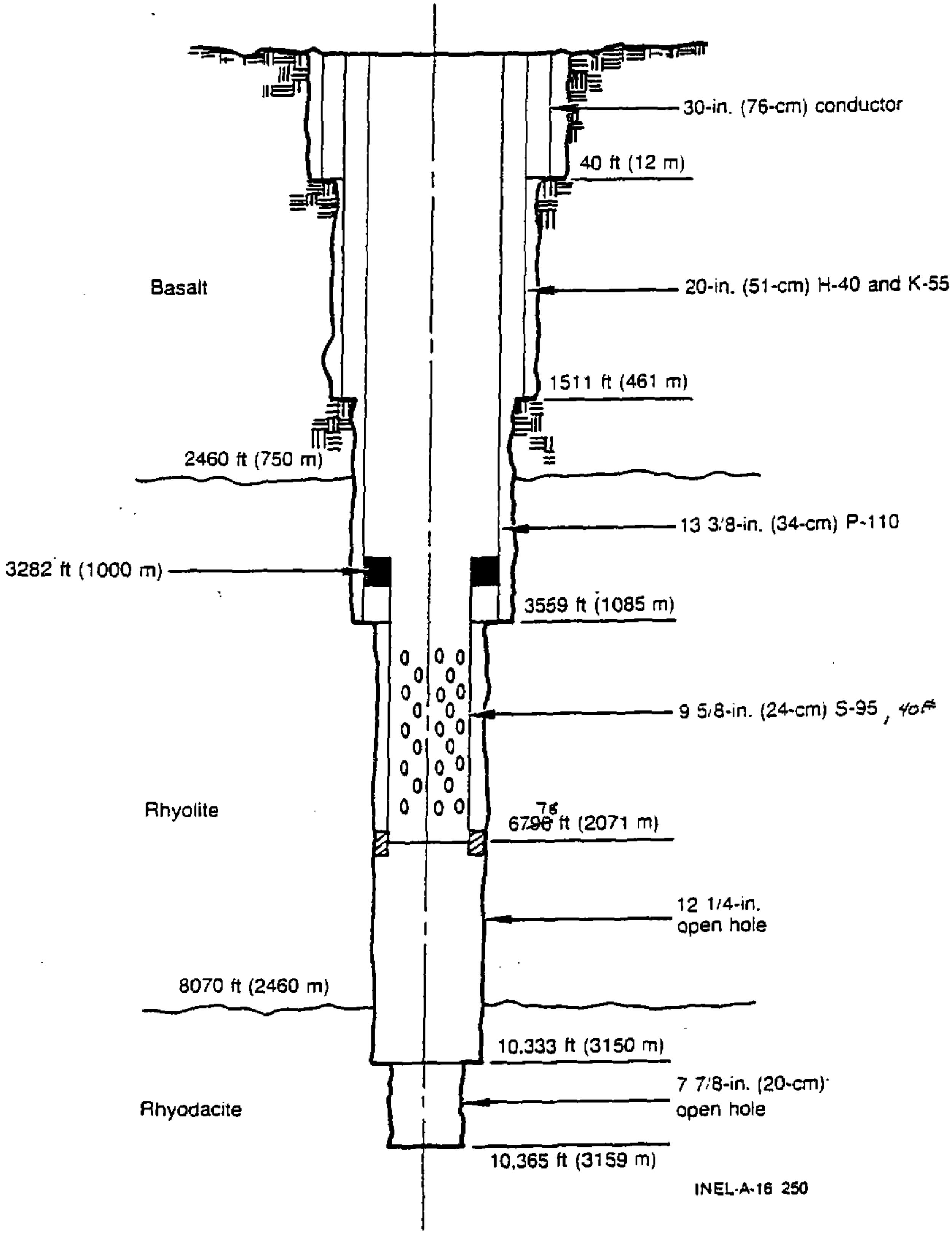

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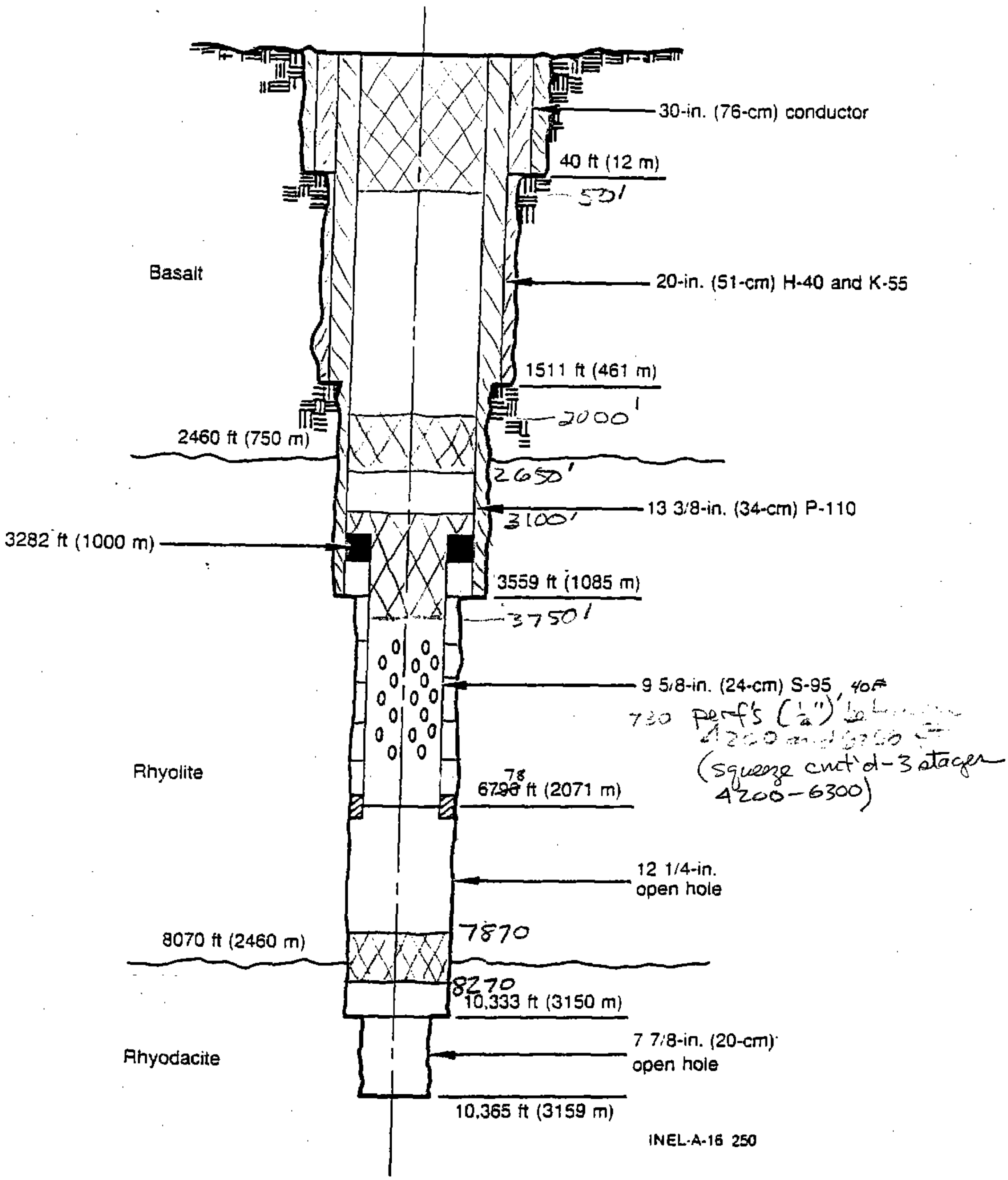

Figure 7. INEL-1 well subsurface status.

DYNAMIC MECHANICAL PROPERTIES Well 2-2A and Well INEL-1

by

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TR 90-20
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EXECUTIVE SUMMARY

The dynamic elastic moduli of nine volcanic tuff samples were determined from ultrasonic wave velocities and bulk densities at temperatures and pressures simulating in-situ conditions. Table 1, on the following page, summarizes the results.

Table 1. E G & G Dynamic Mechanical Properties.

SAMPLE /WELL	DEPTH (ft)	TEMP. °F	CONFINING PRESSURE (psi)	DENSITY (gm/cc)	P-WAVE VELOCITY (ft/sec)	S-WAVE VELOCITY (ft/sec)	POISSON'S RATIO	YOUNG'S MODULUS (10^6 psi)	BULK MODULUS (10^6 psi)	SHEAR MODULUS (10^6 psi)
2-2A	122	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2-2A	217	69	255	2.31	4727	3187	.10	0.68	0.27	0.32
2-2A	369	70	420	1.79	5959	3955	.11	0.84	0.35	0.38
2-2A	403	70	290	2.44	13781	7599	.28	4.87	3.71	1.90
	403	70	515	2.44	13637	7597	.28	4.84	3.59	1.90
2-2A	1828	80	1180	1.79	6805	3058	.37	0.62	0.82	0.23
	1828	80	2235	1.80	6938	3156	.37	0.66	0.85	0.24
2-2A	2288	98	0	2.77	16639	8495	.32	7.12	6.73	2.69
	2288	98	1600	2.78	16984	9768	.25	8.95	6.03	3.57
	2288	98	2705	2.78	16839	9673	.25	8.79	5.95	3.50
INEL-1	2340-50	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2-2A	2544	100	295	2.11	14027	6977	.34	3.70	3.75	1.38
	2544	100	1570	2.12	14475	6829	.36	3.61	4.21	1.33
	2544	100	3065	2.13	14792	7315	.34	4.11	4.23	1.53
2-2A	2735	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2-2A	2938	115	200	1.68	6291	3192	.33	0.61	0.59	0.23
	2938	115	1500	1.68	6400	3221	.33	0.63	0.61	0.24
	2938	115	2350	1.68	6453	3241	.33	0.63	0.63	0.24
2-2A	2972	105	250	2.47	11920	6106	.32	3.28	3.07	1.24
	2972	105	1765	2.47	12519	6167	.34	3.39	3.53	1.27
	2972	105	3515	2.47	12514	6258	.33	3.48	3.48	1.30
INEL-1	3690	134	0	2.37	11254	4860	.39	2.09	3.04	0.75
	3690	134	2200	2.37	11551	7132	.19	3.88	2.10	1.63
	3690	134	4220	2.38	11465	7190	.18	3.89	2.00	1.65

INTRODUCTION

Ultrasonic velocity measurements were performed on nine samples of volcanic tuff and basalt provided by EG&G. The samples were saturated with water prior to testing. The objective of these tests was to determine the dynamic mechanical properties of the samples from acoustic ultrasonic wave velocities and bulk densities at temperatures and confining pressures simulating in-situ conditions. Temperature data was provided by EG&G. Confining pressures were calculated from the overburden density and depths. Calculations are presented in Appendix A.

SAMPLE PREPARATION

Twelve, unpreserved, core samples were provided for preparation by EG&G. Suitable test specimens were not obtained from samples 2-2A (122 ft), 2-2A (2735 ft), and INEL-1 (2340-50 ft), due primarily to dessication fractures. The samples had been unpreserved for approximately ten years. A total of nine samples, all approximately 1 inch in diameter and lengths varying from 0.4 to 2.0 inches, were cut and endground to within ASTM and ISRM standards. Each sample was placed under a vacuum and saturated with distilled water.

TEST PROCEDURES

For testing, each sample was fitted with titanium endcaps, each with a built-in piezoelectric wave transducer. Transducers were mounted on the sample to measure axial strain and two radial strains in orthogonal directions. The sample was sealed in a Teflon jacket and placed in a servo-controlled pressure vessel for testing. Pore fluid lines were connected to the endcaps and vented to the atmosphere. The pressure vessel was then sealed and flooded with confining fluid. The confining pressure was raised at a rate of 1 psi/sec and the sample allowed to equilibrate for approximately ten minutes at each confining pressure selected for analysis.

The pulse propagation method was used to determine the ultrasonic velocities of compressional (p) and shear (s) waves. A pulse generator system is used to generate periodic electrical pulses at a set repetition rate, which excites a transmitting piezoelectric transducer built into one endcap. The transmitting transducer converts the electrical impulse into an elastic, mechanical impulse, and the energy is transferred through the sample. A receiving piezoelectric transducer, in the endcap at the opposite end of the sample, converts the incoming mechanical impulse back into an electrical impulse. The impulse travelling through the transducers and the sample was compared to the impulse originating from the pulse generator with an oscilloscope. A schematic drawing of the system configuration is shown in Figure

1. The resulting transit time for the compressional and shear waves was calculated by subtracting the full transit time (sample plus endcaps) from the delay factor (time for the wave to travel through the endcaps). Wave velocities, bulk densities, and dynamic mechanical properties were calculated indirectly using strains and ultrasonic wave travel times. Appendix A contains pertinent information on calculations.

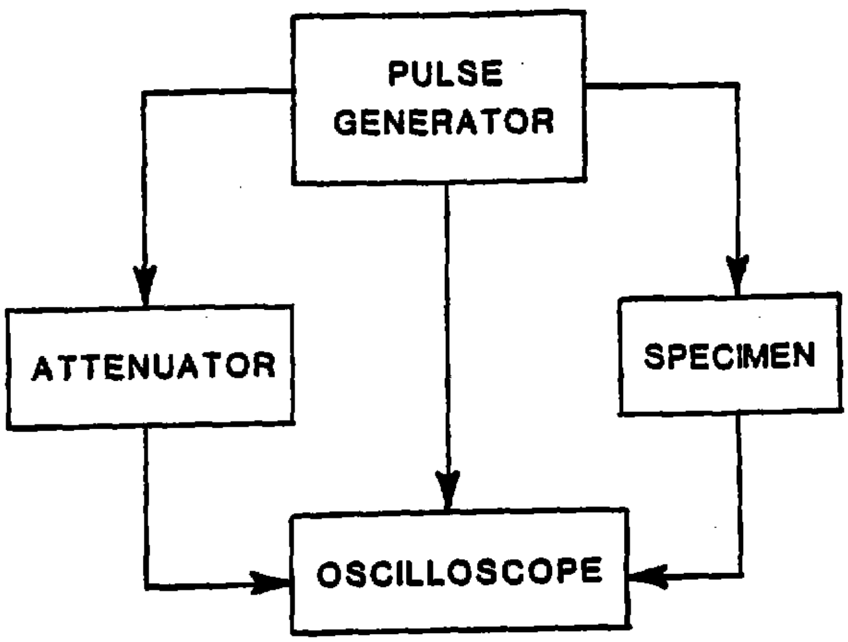


Figure 1. Schematic Drawing of System Configuration.

RESULTS

Table 1 (page 2) contains the dynamic elastic moduli and velocities for the samples tested. Sample 2-2A (2938 ft) was tested prior to communication concerning the pressure gradient and overburden density and, thus, the confining pressure does not correlate with the other tests.

DISCUSSION

The samples tested can be placed into five groups based on dynamic mechanical properties, density, and lithology (Table 2).

Group 1 consists of weakly indurated, very fine grained tuffs with the following average properties: density, 1.90 gm/cc; Poisson's ratio, 0.23; Young's modulus, 0.70×10^6 psi; bulk modulus, 0.53×10^6 psi; and shear modulus, 0.30×10^6 psi.

Group 2 consists of a single tuff which is lithologically similar to Group 1, but well indurated. This sample has a density of 2.47 gm/cc; Poisson's ratio, 0.32; Young's modulus, 3.28×10^6 psi; bulk modulus, 3.07×10^6 psi, and shear modulus, 1.24×10^6 psi.

Group 3 consists of welded tuffs with the following average properties: density, 2.26 gm/cc; Poisson's ratio, 0.26; Young's modulus, 4.00×10^6 psi; bulk modulus, 3.12×10^6 psi; and shear modulus, 1.59×10^6 psi.

Group 4 consists of a single, fine grained, well indurated, altered tuff with a density of 2.44 gm/cc; Poisson's ratio, 0.28;

Young's modulus, 4.84×10^6 psi; bulk modulus, 3.59×10^6 psi; and shear modulus, 1.24×10^6 psi.

Group 5 consists of a single basalt with density, 2.78 gm/cc; Poisson's ratio, 0.25; Young's modulus, 8.79×10^6; bulk modulus, 5.95×10^6; and shear modulus, 3.50×10^6 psi.

Acoustic wave velocity readings were taken at bench and in-situ conditions for comparison purposes. Groups 1, 2 and 4 (tuffs and altered tuffs) showed no considerable differences in velocities between bench and in-situ conditions. Group 5 (basalt) showed an increase in shear wave velocity, from approximately 8,500 ft/sec at bench conditions to 9,700 ft/sec at in-situ conditions.

Sample INEL-1 (3,690') of Group 3 (welded tuff) showed a major increase of approximately 1.5 percent in the velocity of the shear wave from bench to in-situ conditions. There are two possible explanations for this increase. First, the shear wave may be considerably slower at bench conditions due to open fractures. These fractures were closed by the stress applied to simulate in-situ conditions, thus accounting for a faster shear wave.

The second possibility is that a measurable shear waveform may not have been obtained at low stress bench conditions, but appeared at higher in-situ stresses. Examination of the core sample revealed several visible fractures; thus, the first possibility appears more plausible. For correlation of the dynamic mechanical properties presented in this report with downhole geophysical logs, the measurements taken at in-situ conditions are unquestionably more reliable.

Table 2. Sample groupings based on dynamic mechanical properties, density and lithology.

Group	Sample /Well	Depth (ft)	Lithology	Density (gm/cc) ($\overline{X}$, s)	Poisson's Ratio ($\overline{X}$, s)	Young's Modulus (x 10^6 psi) ($\overline{X}$, s)	Bulk Modulus (x 10^6 psi) ($\overline{X}$, s)	Shear Modulus (x 10^6 psi) ($\overline{X}$, s)
1	2.2A	217 369 1828 2938	Tuff	1.90,0.28	0.23,0.14	0.70,0.09	0.53,0.27	0.30,0.07
2	2.2A	2972	Tuff	2.47	0.32	3.28	3.07	1.24
3	2.2A INEL-1	2544 3690	Welded Tuff	0.26,0.18	0.26,0.11	4.00,0.16	3.12,1.58	1.59.0.09
4	2.2A	403	Altered Tuff	2.44	0.28	4.84	3.59	1.90
5	2.2A	2288	Basalt	2.78	0.25	8.79	5.95	3.50

APPENDIX A

ULTRASONIC WAVE VELOCITY EQUATIONS

A-1: Determination of Confining Pressure

Confining pressures used in this testing program were determined by expressing an overburden density of 2.73 gm/cm^3 in psi/ft (Dick Smith, personal communication). A pressure gradient of 1.18 psi/ft was calculated. Confining pressure for each sample was then calculated (1.18 psi/ft x Sample Depth (ft) = Confining Pressure (psi)).

A-2: Calculation of Mechanical Properties Using Ultrasonic Velocities

Ultrasonic wave travel times:

$P_t = P_{t(observed)} - P$ (delay time)

$S_t = S_{t(observed)} - S$ (delay time)

where:

P_t: P-wave (compressional) travel times (μsec) through sample

$P_{t(observed)}$: Observed P-wave travel time (μsec)

P (delay time): Travel time of P-wave through endcaps (μsec)

S_t: S-wave (shear) travel times (μsec) through sample

$S_{t(observed)}$: Observed S-wave travel times (μsec)

S (delay time): Travel time of S-wave through endcaps (μsec)

Ultrasonic wave velocities:

$V_p = L_s/P_t$

$V_s = L_s/S_t$

where:

V_p: P-wave velocity (ft/sec)

L_s: Sample length (ft)

P_t: P-wave travel time (sec)

S_t: S-wave travel time (sec)

Dynamic Elastic Moduli Calculations

Poisson's Ratio:

$$\nu = 1/2[(V_p/V_s)^2 - 2]/[(V_p/V_s)^2 - 1]$$

Young's Modulus:

$$E_Y = \rho[(V_s \times 0.3048)^2 \times 0.145] \times [(3(V_p/V_s)^2 - 4)/((V_p/V_s)^2 - 1)]$$

Bulk Modulus:

$$K = (E_Y/3.0)/((1.0 - 2.0(\nu))$$

Shear Modulus:

$$G = E_Y/2.0)/1.0 + \nu)$$

Department of Energy **Information**

Idaho
Operations Office

550 Second Street
Idaho Falls, ID 83401

FOR IMMEDIATE RELEASE
JUNE 11, 1979

FINAL DRILLING PROGRESS REPORT FOR INEL-1

Geothermal Exploratory Deep Well at the Department of Energy's Idaho National Engineering Laboratory

Location:	NE NW Section 1, T3N, R29E (BM) Butte County, Idaho
Operator:	Department of Energy, Idaho Operations Office
Contractor:	Brinkerhoff-Signal, Rig 26
Spud:	2-15-79
Present Depth:	10,356 ft.
Surface Casing	20" set at 1,511 ft.
Intermediate Casing:	13-3/8 set at 3,559 ft.
Production Liner:	9-5/8 set between 3,282 to 6,796 ft.
Open Hole:	12-1/4 6796 - 10,333 ft. 7-7/8 10,333 - 10,356 ft.
Drilling Fluid:	Water
Formation:	Dacite(?)

Operation to Present Drilled 12-1/4 in. hole to 10,324 ft. Took Core #6 10,324 ft. to 10,330 ft; recovered 1.5 ft. Reamed core hole to 10,333 ft. Ran nitrogen lift and ran logs. Set cement plug with 62 cu. ft. neat cement. Top of plug at 6,794 ft. Ran 9-5/8 in. liner between 3,262 ft. and 6,796 ft. Cemented 200 ft. overlaps and bottom 500 ft. of casing to avoid cement contamination of intermediate production zones. Drilled plugs; ran temperature log. USGS took bottomhole Core #7 10,333 ft. to 10,365 ft., recovered 16.5 ft. Laid down pipe and released rig. BHT: 302°F.

Drilling Summary

The well began 2-15-79. A 30 in. conductor had been set to 40 ft. Anticipated lost circulation problems indicated drilling one pass with a 26-in. bit was the better method for drilling the ±1,500 ft. surface hole. A gel/lime/water (spud) mud was used to drill the surface hole, vis. 50-60, wt. 8.5-8.7. Lost circulation at 136 ft. which continued to 1,524 ft. A primary lost circulation zone has since been defined at 325 to 350 ft. just above the water table. Drilling continued by "dry" drilling with water and periodically pumping high viscosity pills to clean the hole. Penetration rates averaged 5-10 fph, bit wt. 15-40,000 lbs. The surface hole was drilled to 1,524 ft. Logs were run, but of poor quality due to the large hole size. BHT was 63°F, which was expected in the Snake River Plain Aquifer system. Ran 38 jts 20" casing - 24 jts K55 133# and 14 jts K55 94# jts = 1,558.13 ft. (set at 1,511 ft. - G.L.). Cemented casing with 7,526 cu. ft. class G cement with 20% silica flour 25 sks kolite and 8% gypseal. Cement was tagged at 210 feet from surface. Cemented to surface in stages. The major thief zone during cementing was 130 ft. Nippled up the 20" BOP stack—bradenhead, spacer spool, double gate, hydril, and rotating head. Ran pressure test on casing and BOP.

Began drilling a 17-1/2 in. hole on 3/16/79. Drilled to 3,564 ft. without lost circulation problems. Penetration rates ranged from 10-20 fph with a bit wt. 30-45,000 lbs. Hole deviation did not exceed 3/4°. The hole was drilled with a gel-water system, wt, 8.5-9 vis. 32-47. Cores were taken during the interval:

(continued)

Core #1 2,340-2,361 rec'd 5 ft.
Core #2 2,507-2,518 rec'd 8 ft.

Pump test #1 tested the 1,511-2,518 ft. interval. The purpose of these upper aquifer tests by the USGS Water Resources group was to sample water quality, established head, temperature and permeability and also define the Snake River Plain Aquifer, intermediate aquifer and the geothermal aquifer. Logs were run prior to casing the interval. BHT was 130°F. Ran 87 jts 13-3/8" P110 72# casing set at 3,559 ft. Cemented with 4,781 cu. ft. Class G, 1:1 perlite, 40% silica, 3% gel. Cement top at 245 ft. (This was cemented during 9-5/8" liner job.) Nippled BOP for 12-1/4" hole. Stack - 20" braden head 20x12 WKM expansion spool, 12" WKM master gate valve, flow spool, banjo box, double gate, hydril, rotating head. Tested BOP and casing.

Began drilling the 12-/14 in. hole with water and pumping occasional high viscosity pill (100-200 bbl) for hole cleaning. Drilled to 6,486 ft. Ran temperature, borehole televiewer and caliper logs with USGS. BHT 161°F. Prior to reaching this depth, cores and pump tests were taken. Core #3 3,661 to 3,718 ft., rec'd 44 ft. and pump test 3,559-3,713 ft. Core #4 4,839-4,878 ft. rec'd 39 ft. and pump test 3,559 to 4,878 ft. Selection of coring intervals was based on alteration and flow pattern changes of the volcanic sequence. The pump tests were to better understand the basal Snake River Plain Aquifer, and intermediate aquifers. Drilling continued to the objective depth of 7,500 ft. with no significant temperature increases or lithologic changes. Drilling was continued to 9,810 ft. where there was a subtle change in cuttings and drilling rate. Took Core #5 9,810-9,816 ft., rec'd 1 ft., core barrel jammed. Borehole geophysical logs were run to analyze lithologic changes and to compare with the surface geophysical models developed by the USGS. A subtle lithologic change was noted on the log data at 9,460 ft., but the visual inspection of the core and cuttings showed little change. BHT was 238°F. Drilling continued to 10,324 ft. Took Core #6 10,324 to 10,330 ft., rec'd 1.5 ft. The core substanciated a change from the rhyolite lithology. Rigged up to run nitrogen lift and run spinner and temperature tools simultaneous with lift. Set 4-1/2 in. drill pipe at 3,500 ft. The wellbore bridged during nitrogen lift at several places between 4,300 and 5,300 ft. However, flow was too irratic to define. Rigged down nitrogen lift equipment and finished logging. BHT was 262°F and rising, indicating significant cooling of the wellbore by the drilling fluids.

Set a cement plug at 6,860 ft., 62 cu. ft. neat cement, with a 70bbl 80 vis. mud pill set below the cement. Top of plug was tagged at 6,794 ft. Cleaned off the plug to 6,801 ft. Ran 84 jts. 9-5/8 in S-95 special drifted, 40" LT&C liner 6,796 ft. with top of liner at 3,282 ft. Cemented bottom between 6,796 and 6,250 with 251 cu. ft. Class G with kolite and silica flour. Cemented top of liner with 241 cu. ft. Class G with kolite and silica flour between 3,700 and 3,282 ft. A temperature survey was run to total depth after drilling the cement plug, BHT 302°F and rising. Circulated and cleaned the hole for Core #7 10,330 to 10,356 ft., rec'd 16 ft. Lay down pipe and released rig May 27, 1979.

Remarks

Hole guage was good throughout drilling with few washout areas. Hole deviation was not a problem with one exception--the surface hole. The 26 in. hole had to be reamed prior to running casing. The 26 in. bit had "walked" in the fractured basalts. This condition occurred near surface before full weighted and stabilization drill string was established.

Washout zones depicted on the caliper log correlate with "kicks" on the temperature logs and are being defined as production zones until more extensive testing is completed.

(continued)

The 9-5/8 in. production liner was cemented only at the top and bottom to insure no cement damage to moderate temperature production zones between 4,000 and 6,000 ft. These zones can be produced at a future time for direct geothermal applications.

The lower production zone was left in a static condition during the setting of the 9-5/8 in. liner with no circulation below 7,500 ft. to better establish static bottomhole temperatures

The well will undergo both airlift and pump tests by mid-July to establish well producibility and temperatures.

Future Reports

1. Well Completion Report by DOE-ID and EG&G Idaho, Inc.
2. Aquifer Tests Open File Report by Jack Barraclough, USGS Water Resource Division.
3. Well Testing Report by EG&G Idaho, Inc. Reservoir Engineering
4. Open file reports by Dave Doherty, Lisa McBroome, Mel Kuntz, USGS Geological Division:

Publication	Possible Title	Publication Date
1	Preliminary geologic evaluation of INEL-1. Open-file report.	3-4 weeks after drilling is completed
2	Lithologic and geophysical logs of INEL-1. Open-file report.	6-7 weeks after drilling is completed
3	A geological evaluation of INEL-1. Open-file report.	2-3 months after drilling is completed
4	A multi-authored bulletin or professional paper discussing geology, geophysics, and geothermal resources of INEL-1. To be published first as open-file report, later as a USGS bulletin or professional paper.	6-10 months for open file. 1-2 years for bulletin or professional paper

-XXX-

News Media Contact: R. L. Blackledge, (208) 526-1318

EG&G Idaho

"Providing research and development services to the government"

INTEROFFICE CORRESPONDENCE

Date: September 1, 1992

To: L. V. Street, MS 1545

From: D. D. Faulder, MS 2107

Subject: INEL-1 EXISTING COMPLETION AND OPTIONS - DDF-30-92

The visit to the INEL-1 on August 27, uncovered many serious deficiencies in the existing conditions of the well and a general lack of good housekeeping for the location. The purpose of this memo is to point out the deficiencies in the existing well completion and offer several options to correct this problem.

Findings

The INEL-1 lacks a proper wellhead assembly. One 12" 900 series WKM gate valve is present on the top of the well, but is partially closed. The 10,365′ well is literally open at the surface. At present, a round piece of weathered plywood is used as a cover for the well. This is a gross violation of geothermal regulations and extremely poor operating practice. This aspect alone is a serious ES&Q issue. The well internal diameter is approximately 12.5", thus providing the opportunity for entry of almost anything into the well and possible contamination of subsurface fluids.

The well sits in a 10′ deep concrete cellar which currently has approximately 8′ of water with oily scum and debris floating on top. Thus, most of the casinghead, flanges, surface kill and annular valves are under water, inaccessible and vulnerable to corrosion and plugging. The cellar is covered with a loose collection of haphazardly placed bridge planks, providing a ready means to fall into the 10′ deep cellar.

Adjacent to the well cellar is the old rathole used during drilling operations. This rathole consists of one joint (≈30′) of 13 3/8" casing. The rathole should have been removed at the end of drilling operations. It is no longer required and constitutes a safety hazard.

The INEL-1 used a nearby source water well for drilling water. This well was located and apparently still has the submersible pump in the well. This pump may still be used intermittently for the collection of water samples. Adjacent to the source water well is a below surface pump house which contains the discharge line from the source water well and a manifold and valve. The pump house is a confined area, approximately 10′ deep, with access provided by a steel lid and ladder. The confined area is not noted as such and there is no padlock to prevent unauthorized entry.

Recommendations

The first priority is to immediately secure the well. This can be accomplished by the following steps:

1. Sample the fluids in the cellar and develop a plan to pump out the water, and muck out the bottom of the cellar. This step will provide safe access to the wellhead for the next steps.

2. Once the cellar has been cleaned out, inspect the wellhead assembly and determine the condition of the casinghead, flanges, casing, valves and lines. The wellhead assembly should be inspected by a qualified oil field wellhead specialist. Depending on the condition, it may have to be rebuilt.

   At a minimum, the final wellhead configuration should consist of the existing 12" WKM valve, with the 12" diameter nippled down to a 3-4" stem with a fully opening ball valve install at the bottom of the stem, a pressure gauge located on one side of the stem and a 0.25" bleed line and valve located on the other side. At the top of the stem, a second fully opening ball valve with a flange and bull plug should be installed. Once the wellhead has been rebuilt, it should be pressure tested to a nominal pressure, i.e. about 100 psi. When the wellhead has been rebuilt and tested, the 12" gate valve should shut, the valve handle chained and padlocked. The padlock should be tagged indicating the well custodian and how to contact, including a phone number.

3. The bridge planks covering the cellar should be removed and a tight fitting, expanded metal grate installed. To prevent the accumulation of water in the cellar, two options exist. One is to drill several holes in the bottom of the cellar to allow the rain water to drain out. The second is to place a easily removable building over the cellar to prevent water from entering.

4. A sign should be placed at the well noting the name of the well, surface coordinates, dated drilled and completed, the owner of the well, casing configuration, and depth of the well.

The rathole can be removed by a backhoe and the hole back filled.

The pump house lid should be padlocked and tagged.

Options for the INEL-1

Once the well is secured, several options exist for the well.

The first is to properly plug and abandon the well. This course is not suggested as the well, the deepest on the Eastern Snake River Plain, has scientific and research value. One possible future use would be to re-enter the well and deepen, as part as a deep continental scientific well. The existing well configuration could allow the well to be deepened to a total depth of 15,000′ to 20,000′, depending on drilling problems encountered.

The second option is to properly maintain the well for future access to conduct various geoscience projects, such as vertical seismic profiles, velocity surveys, testing of new geophysical tools, groundwater sampling, etc. If it is decided to maintain the well, it would be highly advisable to conduct a casing inspection and cement bond logging program of the well. With the well sitting idle for the past 13 years, the casing at the fluid level is susceptible to corrosion. It would be prudent to conduct the casing inspection logging to measure the current condition and to provide a baseline for future casing inspection logs. The cement bond log would determine the present cement conditions and indicate if there are any problem areas with potential annular flow and mixing of subsurface fluids.

The lack of a central location of well records for the INEL-1 is a serious shortcoming. If the well is to be maintained, all available well records should be located, inventoried, copies made and micro-fiched, and a central repository established. The well has too much scientific value for important well records to be haphazardly maintained and stored.

Costs

Detailed costs estimates have not been made for any for the above proposed actions. A rough estimate of costs to properly secure the well would be about $20,000. However, a more detail estimate cannot be made until the cellar is drained and the wellhead inspected. The cost to plug and abandon the well would probably be on the order of +$100,000. A casing inspection and cement bond logging program would cost an estimated $10,000.

If provided with a approved course of action, I would be available to prepare a detailed cost estimate for your use and to conduct well site supervision. I am a registered Petroleum Engineer in the State of California and have over 11 years of drilling, production, and reservoir experience for oil & gas, and geothermal operations.

vek

cc: W. E. Harrison, MS 2107
P. North, MS 2214
J. L. Renner, MS 3526
T. R. Wood, MS 2107 TRW
Central Files, MS 1651
D. D. Faulder Letter Files

REGISTERED PROFESSIONAL ENGINEER
DAVID D. FAULDER
P 001590
EXP. 9/95
PETROLEUM
STATE OF CALIFORNIA

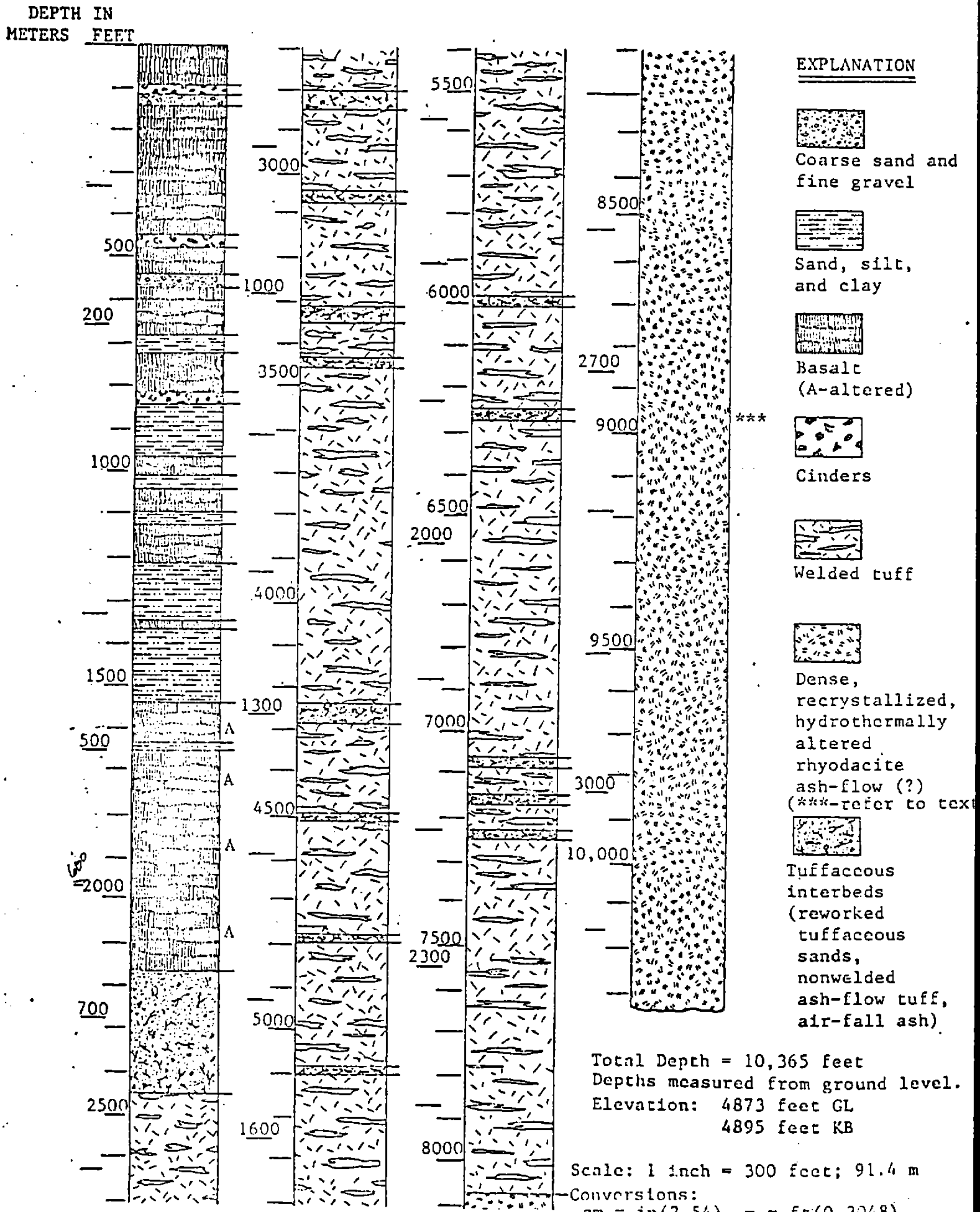


Figure 2.--Generalized lithologic log from exploration geothermal well (INEL-1), Idaho National Engineering Laboratory.

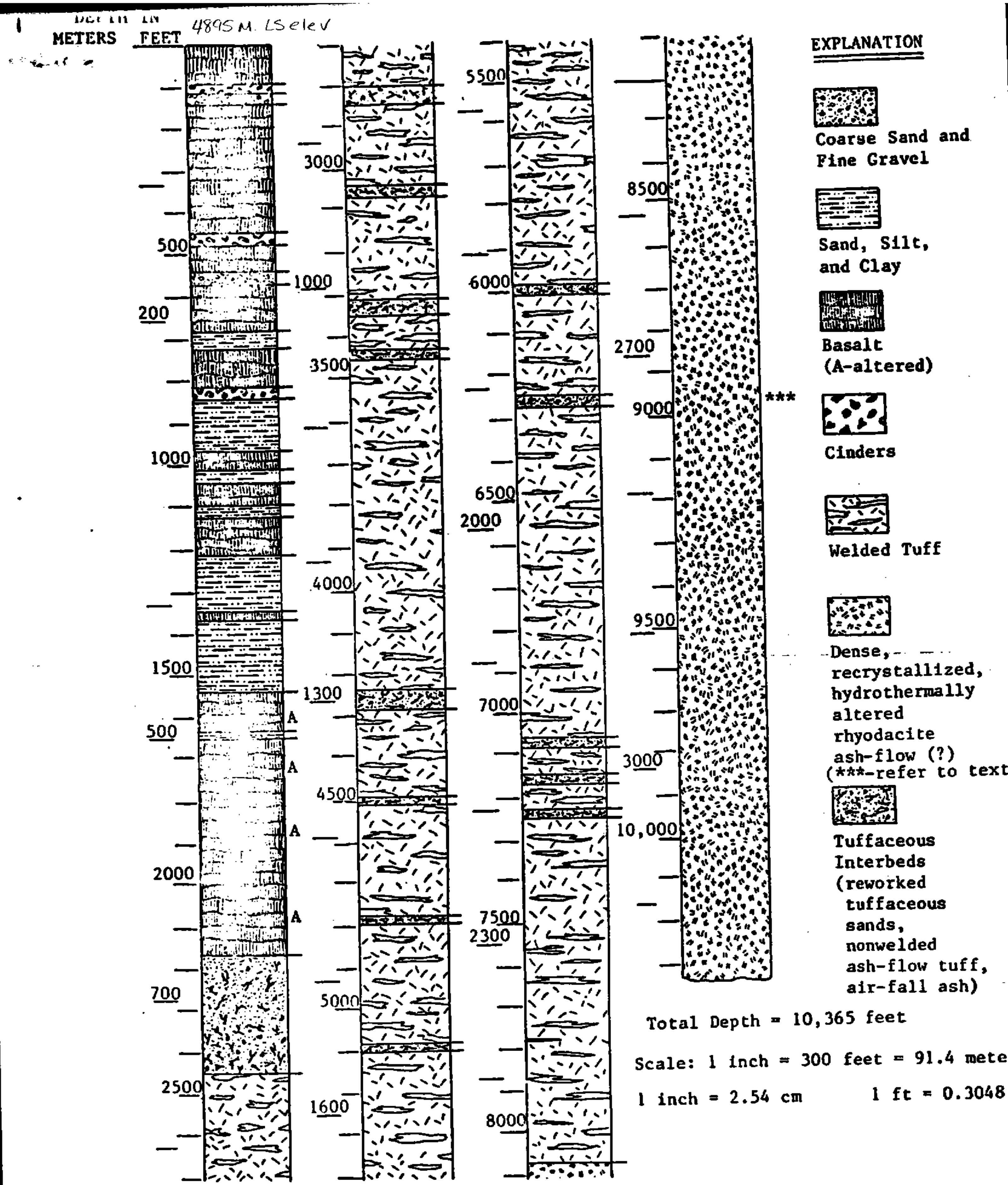


Figure 2.--Generalized lithologic log from exploration geothermal well (INEL-1), Idaho National Engineering Laboratory, Idaho.

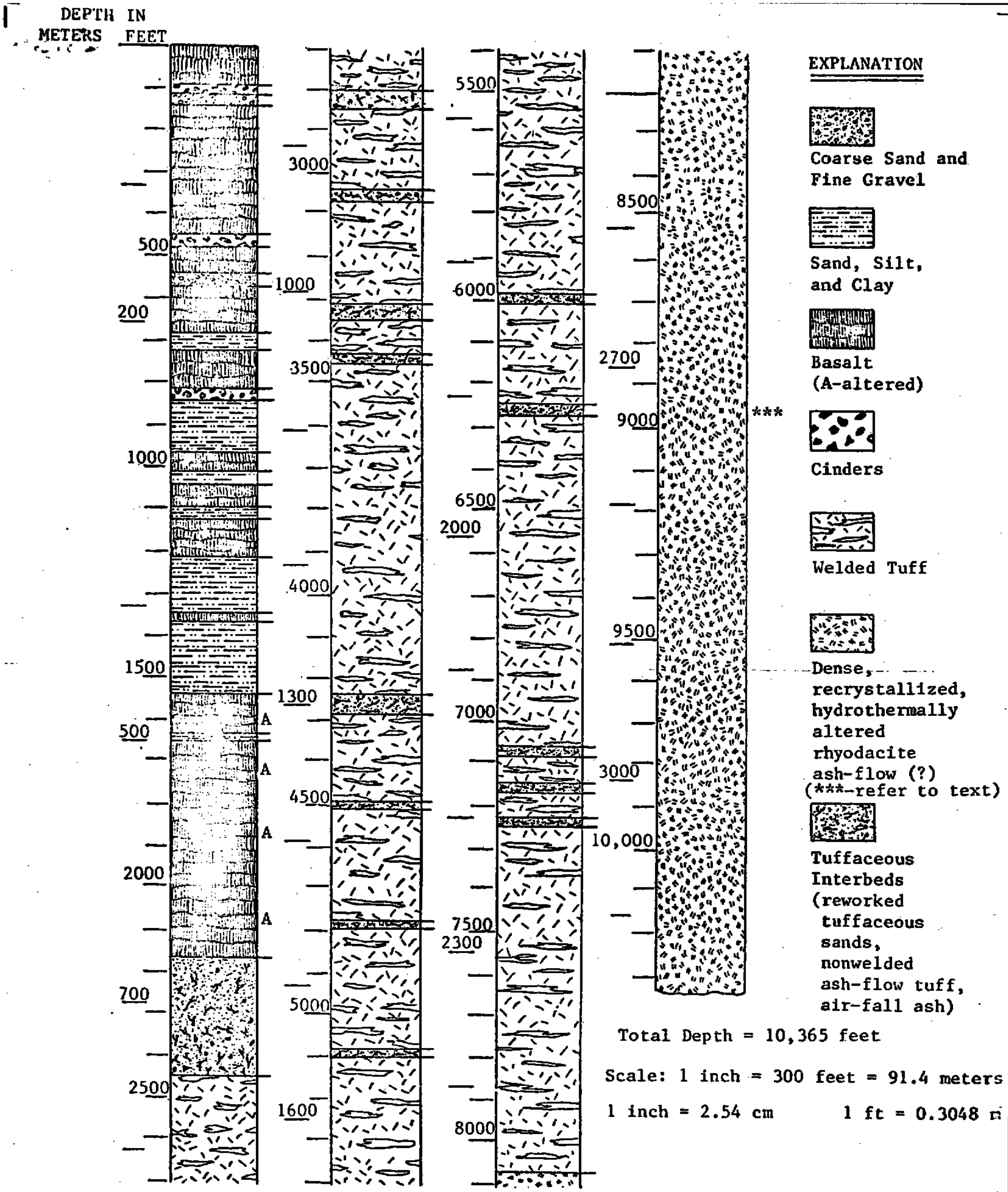


Figure 2.--Generalized lithologic log from exploration geothermal well (INEL-1), Idaho National Engineering Laboratory, Idaho.

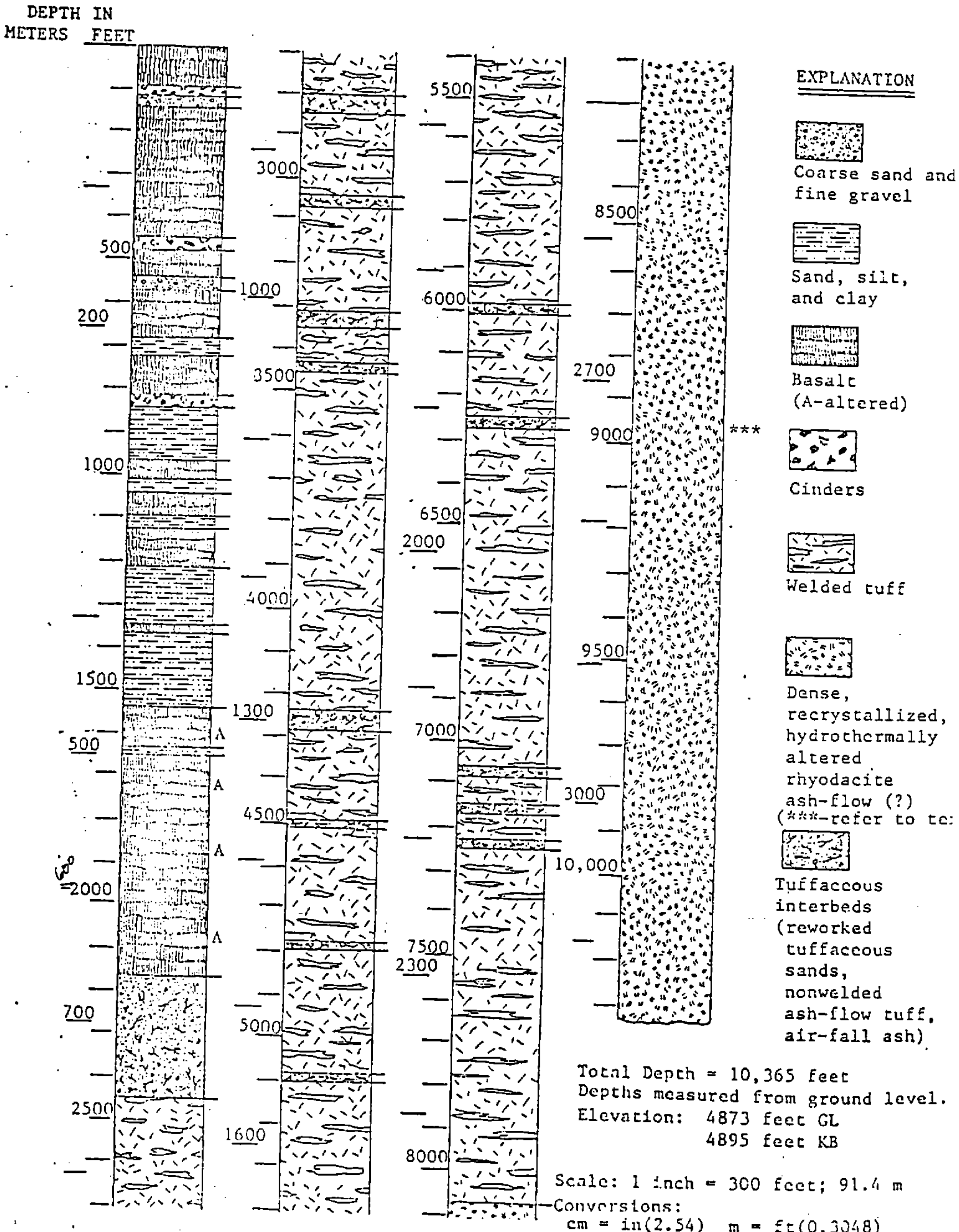
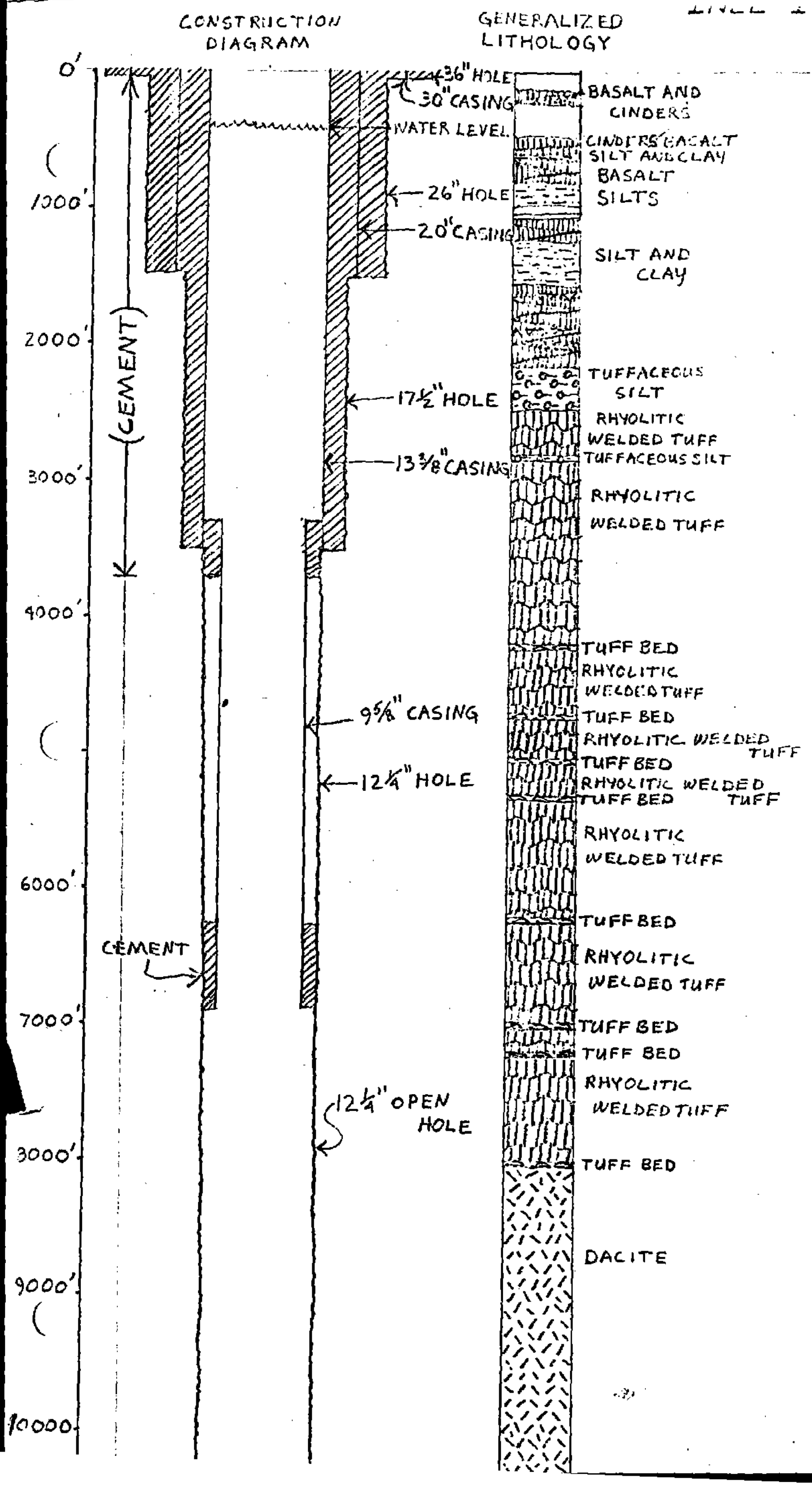


Figure 2.--Generalized lithologic log from exploration geothermal well (INEL-1), Idaho National Engineering Laboratory.

INEL-1


CONSTRUCTION DIAGRAM
GENERALIZED LITHOLOGY
0'
1000'
2000'
3000'
4000'
6000'
7000'
8000'
9000'
10000'
36" HOLE
30" CASING
WATER LEVEL
26" HOLE
20" CASING
17½" HOLE
13⅜" CASING
(CEMENT)
9⅝" CASING
12¼" HOLE
CEMENT
12¼" OPEN HOLE
BASALT AND CINDERS
CINDERS BASALT SILT AND CLAY
BASALT
SILTS
SILT AND CLAY
TUFFACEOUS SILT
RHYOLITIC WELDED TUFF
TUFFACEOUS SILT
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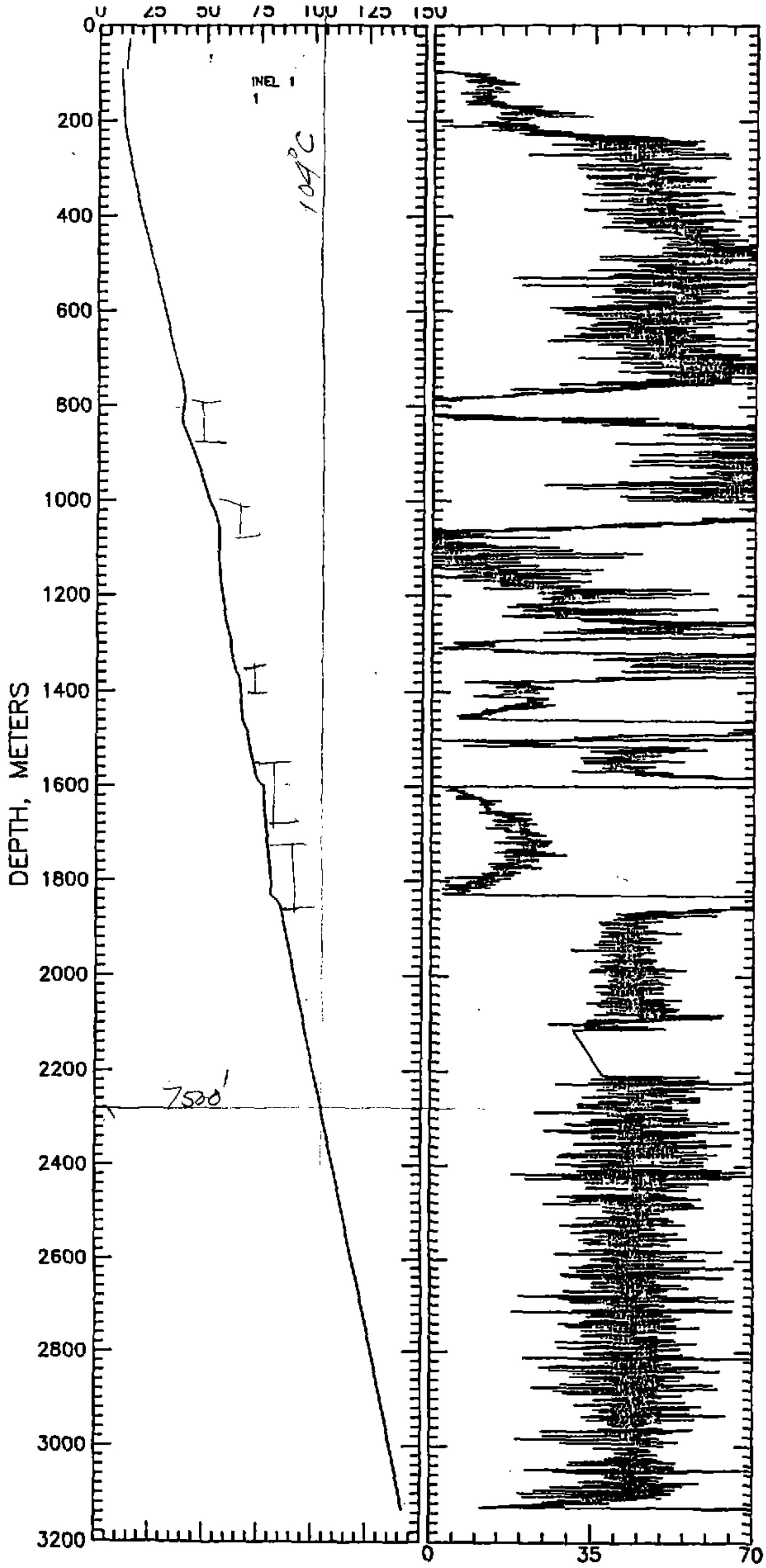
TUFF BED
DACITE

1 m average, plotted at 3 m

No offset 12/5/9[illegible]



Compare footages of Temp anomalies with formation contacts & casing laps. If needed, incorporate into above document plus also use (+ quote) INEL logs

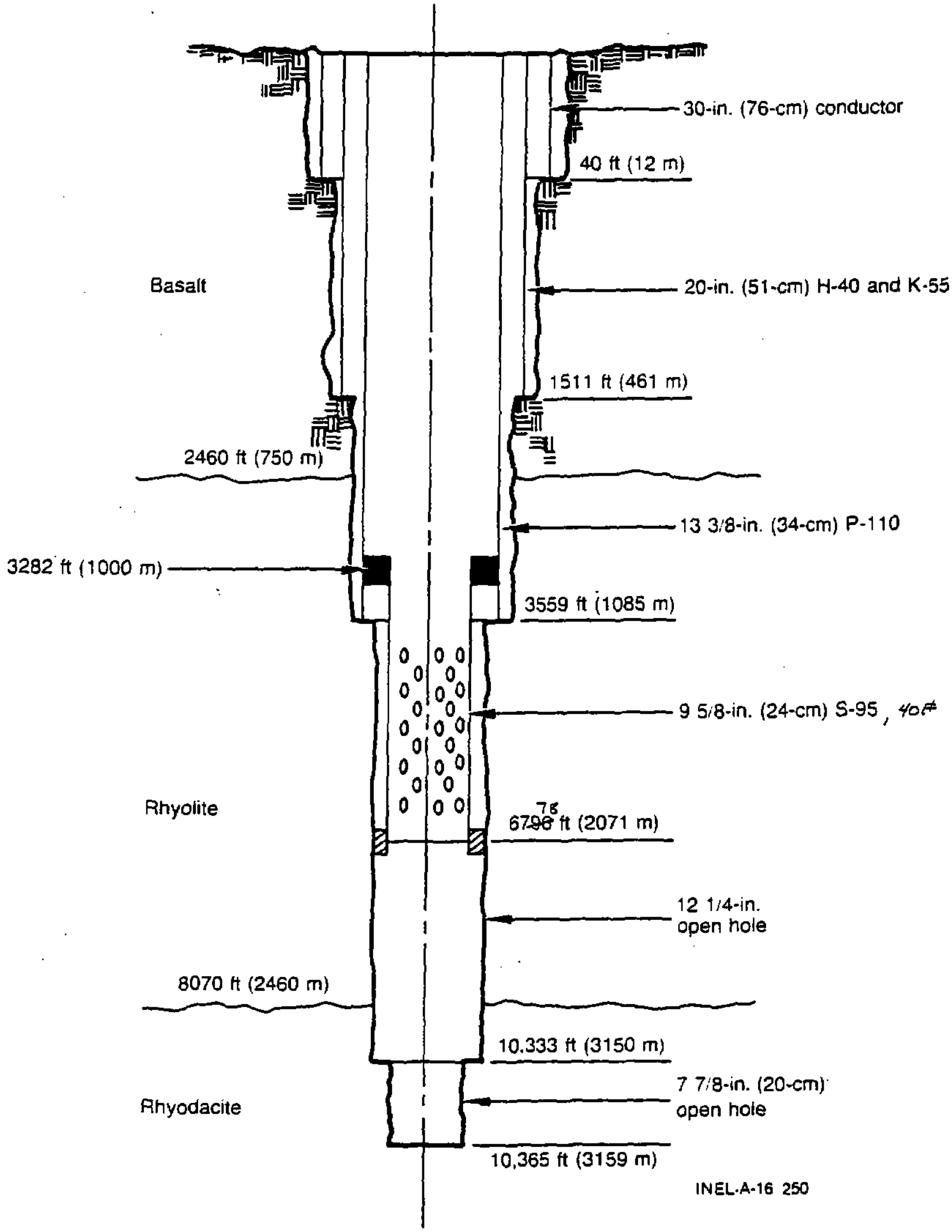


Figure 7. INEL-1 well subsurface status.

INEL - 1
Proper Closure or Abandonment.

Fixed considerations for either option -

don't forget rathole and mousehole

1. Clear wood planks from cellar
2. Pump-out / Muck-out cellar
   - SAP
     - holding tank
     - sampling equipment

3. Remove all sub-structure equipment (BOP, valves, etc. are all suspect from years of corrosion) probably including top casing flange.

4. Have all materials and service subcontracts in place for the options below.

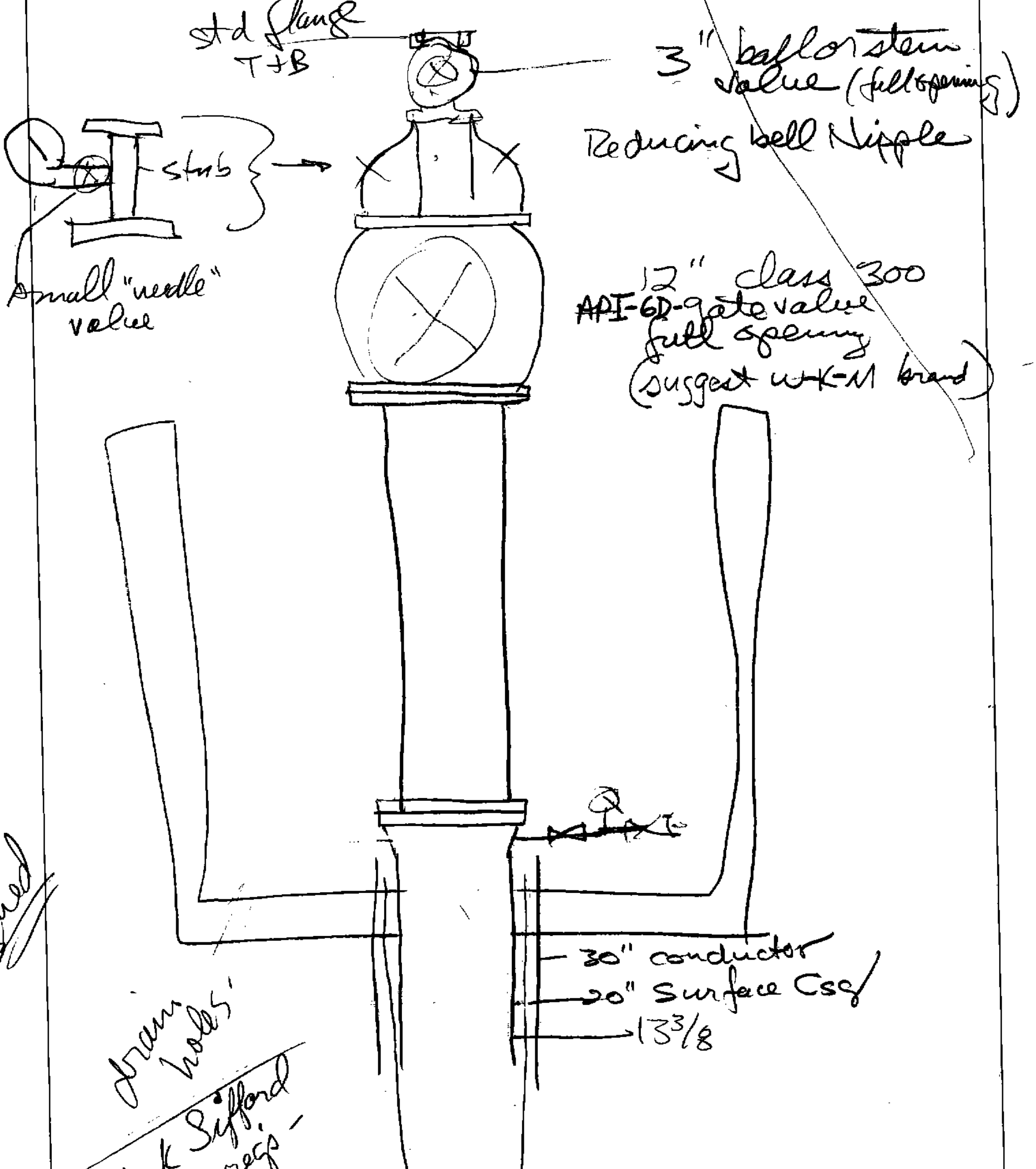
OPTION A - Total/Proper Abandonment

1. Equipment + Services
   - Workover rig rated for at least 12000 ft
   - Subcontract with Haliburton Cementing services
     A. MATERIALS
        - Cement and any additives
        - Drillable bridge plugs

     B. TASKS
        - spot cmt plugs per drawing (set drillable bridge plugs or packers first)
        - squeez cmt perforated zone (4200-6296 ft) in three stages with a drillable packer at bottom of each (6300-5600, 5600-4900, and 4900-4200).

Consider Coiled Tubing Unit vs Work Over Rig

use 250# BOP for cmt/abandoning
Hydril



Shed

drain holes

Call Mark Sifford
for O+G regs

TerraTek

Geoscience Services

TerraTek Inc.

July 19, 1989

Mr. Dick Smith
E. G. & G.
I. N. E. L.
Idaho Falls, Idaho

Telefax No.: (208) 526-9822

Dear Mr. Smith:

The following is interim reporting on the in-situ acoustic behavior of an unwelded rhyolite tuff from a depth of 2938 ft.

The results may be summarized as follows:

	Confining Pressure (psi)			
	200	1500	2350	2970
P-Wave Velocity (ft/s)	6290.51	6399.76	6453.34	6483.96
S-Wave Velocity (ft/s)	3192.19	3220.60	3240.74	3380
Dynamic Young's Modulus (10^6 psi)	.612	.625	.633	.655
Dynamic Poisson's Ratio	.327	.330	.331	.313
Saturated Bulk Density (gm/cm^3)	1.680	1.680	1.681	1.681

As indicated, a more formalized report will be issued clearly outlining the test conditions, test procedures and analysis methodology.

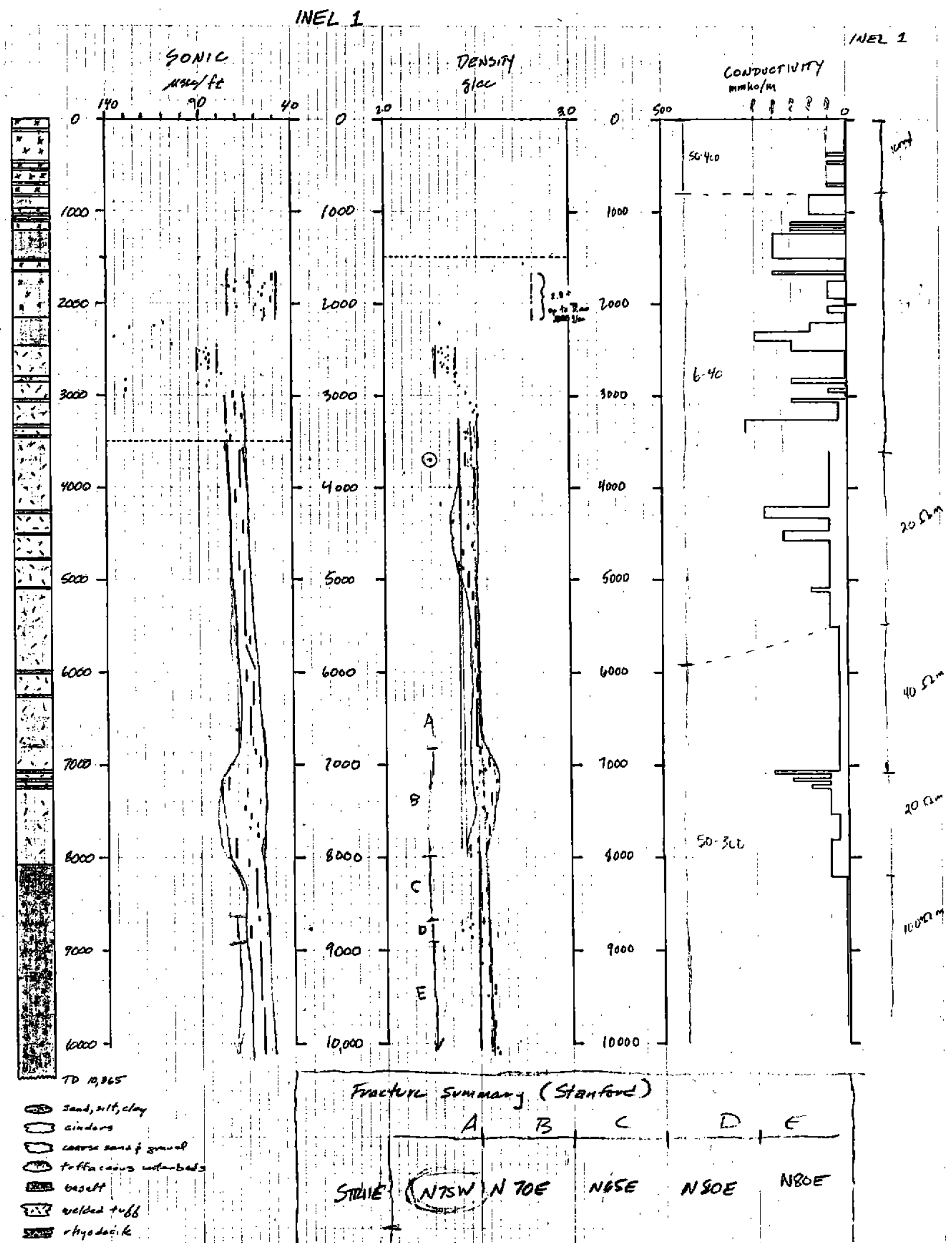
Sincerely yours,

TERRA TEK, INC.

John D. McLennan

John D. McLennan
Vice President

JDM:ja



Fracture Summary (Stanford)

	A	B	C	D	E
STRIKE	N75W	N70E	N65E	N80E	N80E
DIP	80°NE	75°NW	75°NW	75°SE	80°NW
GEOL	TUFF		RHYODACITE		


INEL #1