Goldman

GL07322

United States Department of the Interior
GEOLOGICAL SURVEY
Box 25046
Denver Federal Center
Denver, Colorado 80225
Mail Stop 403

IN REPLY REFER TO:

November 4, 1977

MEMORANDUM

TO: R. C. Stoker, INEL, Idaho Falls, Idaho

FROM: Chief, Borehole Geophysics Project, WRD, Denver, CO

SUBJECT: Technical Memorandum No. 49--Interpretation of geophysical logs made in RRGE-1, November 17-21, 1977

Enclosed you will find copies of the following logs we made of the uncased interval of RRGE-1: temperature, caliper, and natural gamma made with our high temperature spectral probe. I am also sending gamma spectra for the following depths, 2895, 3602, 3868, 4295, 4593, 4694, 4818, 4906, 4922, 4934, 4950, and acoustic televiewer logs for the depth interval 4180 to 4975 feet. Now that I have taken over our efforts at Raft River personally, I plan to send you logs and interpretation much more promptly than in the past. I will not, however, provide copies of logs without interpretation. The preliminary interpretations and data herein are for internal INEL use only. They will ultimately become part of a second report we plan to publish on Raft River.

I wish you would pass on our thanks for the cooperation and assistance provided at the site by Gary Cooper. I feel it is extremely important that we attempt to determine which of the fractures is producing hot water and for that purpose we modified a new centralized flowmeter so that it would pass through 4-inch I.D. riser pipe and stinger. We stuck this flowmeter in your top valve and subsequently determined that this valve is considerably less than 4 inches I.D. Gary was not able to find a replacement valve at the time. I understand that installation of the pumps has now been delayed until December. If you can modify the well heads on both RRGE-1 and RRGE-2 so that the smallest I.D. is 4 inches

AMERICAN REVOLUTION BICENTENNIAL 1776-1976 and cut the necessary holes in the building over RRGE-2, we will attempt to return the week of November 28 to make more televiewer logs and flowmeter logs in both wells. Can RRGE-2 be flowed if we are able to get in with the new flowmeter? Please call me regarding arrangements for returning to Raft River. Gary Cooper should talk directly to Dick Hodges about changes needed so we can log RRGE-2.

The "Cherry Picker" you provided was in better condition than the one provided for previous logging trips, however, the hydraulic system leaks on this one also. It was necessary to periodically raise the boom during logging. I am pointing this out because of the depth error it produces on the logs. We have probes with a vertical resolution in excess of .1 inch and we introduce an unknown, varying depth error on the order of several feet. We have no way of compensating for such an error. You will notice acoustic televiewer reruns where the same feature is at different depths. All of these logs are zeroed at the top of the present concrete pad which is an unknown distance below the original kelly bushing and 6 inches above original ground level.

Temperature Log

We ran a temperature log first in order to locate any sources of water that might be identified by a change in temperature. Apparently the well has been flowing for a number of months at approximately 170 gpm. The most significant temperature anomaly on our log occurs at 4268-4275 feet. This corresponds with a reversed anomaly on Schlumberger's temperature log (run #4, 2-9-75) when the well was apparently not flowing. The reversed anomaly disappeared on Schlumberger Run #16 after a number of hours of flow at 350 gpm. Possibly flow increases from deeper in the hole at higher flow rates. This temperature anomaly coincides with a major fracture zone seen on our televiewer and caliper logs. A printout of differential temperature computer by Ticie Taylor on the basis of 2-foot spacing is enclosed. The printout for the interval 4201 to 4326.5 feet shows the major thermal anomaly is actually from 4263 to 4275.5. The fracture zone on the televiewer log is from 4265 to 4283 feet.

The other anomalies on the temperature log, although of much smaller magnitude, are located at the following approximate depths: 3895-3917; 4030-4040 (negative); 4324-4330 (negative); 4496 and 4605-4612. Note that the temperature probe would not go deeper in the hole than 4702 feet.

Caliper Log

In order to improve the quality of our caliper logs in inclined holes, such as some of the wells at Raft River, we developed a removable bow spring centralizer which was used for the first time in RRGE-1. The probe demonstrated noise and calibration shift problems, but the log is being enclosed with this memo because it also shows some of the fractures located with the televiewer log. We are further modifying the probe and will run it again during our next visit to Raft River. If the caliper log is in error then the angle of dip calculated from the acoustic televiewer log will be incorrect. The dip error in degrees caused by incorrect caliper values is greatest for features with a low dip and very little for steeply dipping features.

Acoustic Televiewer

The enclosed televiewer logs are only of fair quality, but they do show some interesting structures. We made three trips into the well in attempt to log the entire open hole interval, but the probe demonstrated intermittent failure which we were unable to correct. We hope to have spare electronics and transducer sections for the next trip so we cannot only finish RRGE-1 and 2, but relog some of the poorest quality sections already done in 1.

The attached table lists my preliminary interpretation of the enclosed televiewer logs. It is subject to revision based on new televiewer or caliper logs. In addition to the already mentioned depth error caused by the Cherry Picker, an error in dip can be caused by hole deviation for which I have not corrected. Other potential sources of error suggest that the best accuracy you can expect for angle of dip is 2 or 3 degrees at low angles. Direction of dip or strike is rounded off to the nearest 5 degrees and is given with respect to magnetic north.

Contacts or bedding planes cannot always be distinguished from "tight" fractures; those that do not appear to have measurable width at the borehole face. I use the term "open" fracture for those that appear to have a measurable width at the borehole face. The terms are qualitative and an open fracture at the borehole face may have been broken out by the action of drilling and may not, therefore constitute a pathway for water movement.

To summarize the features interpreted from the televiewer logs there are several major open fracture zones: 4265 to 4283 feet; 4612 to 4645 feet; 4674 to 4733 feet; 4762 to 4787 feet; 4847 to 4859 feet, and 4888 to 4907 feet. These fracture systems are predominantly vertical and the strike averages N40°-65°E. The fracture zone at 4265 to 4283 feet has the same general strike, but does not appear to be vertical. It is the only zone where we have good evidence of hot water influx at the present time, but flow from the vertical fractures may not be indicated by sharp anomalies on temperature logs. The minor temperature anomaly at 4605-4612 feet is at the top of the widest fracture in the well and the combined evidence suggests flow from this zone. It may be possible to determine the relative contribution from these vertical fractures with a centralized flowmeter when the well is flowing at a higher rate. Before coming to Raft River for this last trip I was told that the major zone contributing hot water in RRGE-1 was from 4250 to 4650 feet with minor zones at 3800 to 4250 feet and 4650 to 4800 feet. Our data do not refute the major zone, but define it much more closely. We have no evidence yet for a contribution from the interval 3800 to 4250 feet and some evidence that the deeper part of the well is a potential source of hot water based on fracture distribution. We obtained no evidence to substantiate the fault reported from 3800 to 4800 feet, but we may locate such a structure if we are able to complete logging the hole.

The orientation of the bedding and apparent lithologic contacts seem to vary considerably which is not uncommon in the shallower holes we have logged at Raft River. The angle of dip varies from horizontal to a maximum of 37 degrees. Strike appears inconsistent, however I have not measured enough beds for a statistically significant sample. With better televiewer pictures and more time, a study of the bedding might provide more insight into the structure at Raft River.

Are the steep fractures hydraulically induced during drilling? I know nothing of the pressure history during drilling but based on the character of the fractures I would say they are probably natural. The strike is consistent but the dip varies somewhat and they are en echelon systems that appear to curve in and out of the well. These characteristics and the width of the fractures at the well face are not typical of the hydraulically induced fractures I have seen on televiewer logs, but this evidence is not conclusive. Of course it would be interesting to set packers and attempt hydraulic fracturing where we have televiewer logs -- both to determine the state of stress and to attempt to increase productivity.

Gamma Spectrometry

This is the first time we have been able to run our high temperature gamma spectral probe in one of the deep wells at Raft River. We hope to improve the probe further and run more logs and spectra in the deep wells in the future. Gamma spectrometry not only offers a potentially more diagnostic technique for distinguishing lithology, but as I pointed out in our first Raft River report, differences in radioisotope concentration may be indicative of hydrothermal alteration. Another reason to run gamma logs and spectra periodically is to determine if there has been any leaching of the natural radioisotopes by the large amounts of hot water flowing through the rocks to the producing wells. The gamma logs we ran of RRGE-1 in October do not suggest any change in gross concentration of radioisotopes since the log we ran in November 1975. Changes may still occur when more water is produced and these logs and the enclosed spectra which we recorded in digital form on magnetic tape will provide a baseline record for monitoring future changes.

The gamma log made with the spectral probe shows a major increase in gamma intensity at a depth of 4927 feet that coincides with a change to more acoustically reflective rock on the televiewer log. This probably represents the upper contact of the quartz monzonite. A major unit of intermediate radioactivity from 4600 to 4717 feet probably represents biotite schist and the interval with low radioactivity below is apparently quartzite. On the basis of the gamma log there are several lithologic units within the quartzite or just above the monzonite that I cannot identify.

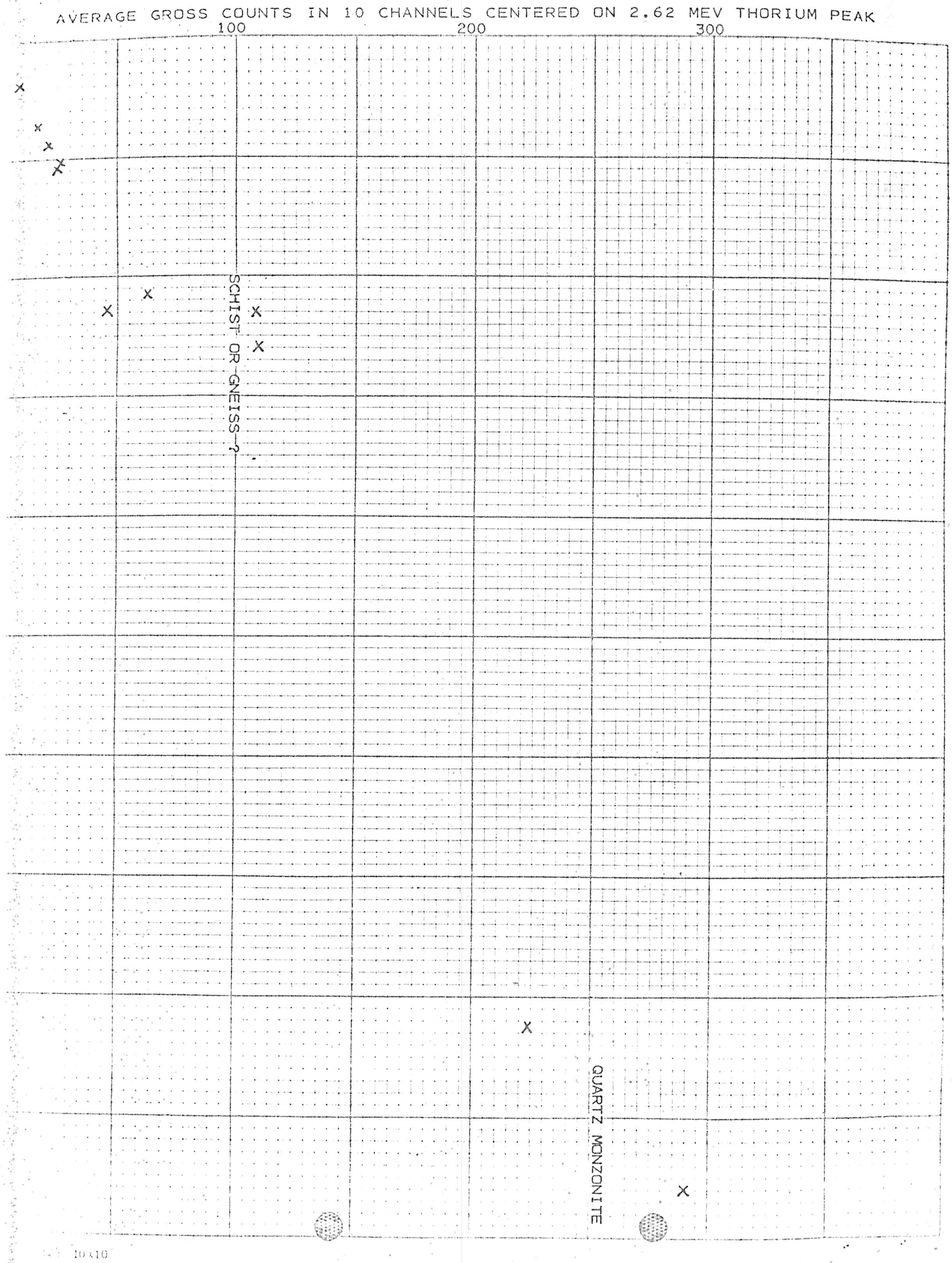
I have only had time to make a semiquantitative analysis of the spectra sent to you and as yet we have no samples for calibration. Without calibration data to determine stripping ratios, thorium is the only isotope where area under the peak (2.62 MeV) is directly related to concentration. The enclosed plot shows that there is a fairly linear relationship between gross gamma and thorium concentration. The high radioactivity of the quartz monzonite is mostly due to thorium and the schist and possibly gneiss at the top of the monzonite have an even higher relative concentration of thorium. Potassium and uranium constitute a relatively higher present of the total radioactivity in the tertiary sediments than in the quartz monzonite. Within these sediments the few spectra recorded suggested that an increase in gross gamma radiation is mostly due to a higher concentration of potassium.

If you have any suggestions for our next logging trip to Raft River please call me.

Scott

W. Scott Keys

Enclosures
cc: Regional Research Hydrologist, CR
Geothermal Coordinator, WRD
Jerry Crosthwaite
Don Mabey


AVERAGE GROSS COUNTS IN 10 CHANNELS CENTERED ON 2.62 MEV THORIUM PEAK
100
200
300
SCHIST OR GNEISS ?
QUARTZ MONZONITE
10x10

U. S. Geological Survey

Interpretation of Acoustic Televiewer Logs

RRGE-1 October 1977

Top of Feature Feet	Bottom of Feature Feet	Dip θ Degrees	Direction of Dip Degrees	Direction of Strike Degrees	Remarks
bed 4196.2	4197	31	S55E	N35E	Distinct bedding 4190-4216 ft
bed 4227.3	4227.9	25	East	N-S	Several beds with low dip 4249-4262 ft
Open fracture?	4270.4	?	S40E?	N50E	Major fracture zone. 4265-4283 ft. Some steep frac.
Fractures 4284.4	4291?	Vertical		N15-20W?	Minor fractures not through center of well
---					Fractures? with low dip 4332-4335 ft
Bed 4338	4339?	37?	S30W?	N60W	Several beds with similar attitude 4338-4345 ft
Contact 4347.3	4347.9	24	N30E	N60W	
---					Possible fractures 4407-4409 ft
Bed 4433.5	4434.2	28	S50W	N40W	Well bedded 4430-4600 ft Poor quality televiewer log
Bed 4488.8	4489.3	21	S70E	N20E	
Contact 4560.7		Horizontal			
Fracture? 4566.1	4567.2	41	S40E	N50E	Several low dip fractures just above this one
Fracture 4571.6	4572.4	32	S70W	N20W	
Fracture? 4573		Nearly horizontal			Open zone
Fracture? 4574.45	4575.1	27	East	N-S	

INTERPRETATION OF ACOUSTIC TELEVIEWER LOGS, RRGE-1, OCTOBER 1977, USGS

TOP OF FEATURE FEET	BOTTOM OF FEATURE FEET	DIP θ DEGREES	DIRECTION OF DIP DEGREES	DIRECTION OF STRIKE DEGREES	REMARKS
Contact 4585		Nearly horizontal			
4601.1?	4601.6?	24	N70W	N20E	Major contact--soft rock above, hard below
Fracture 4602.85	4603.75	39	S80W	N10W	
Fracture or fault 4612.2	4645	Nearly vertical	N35-50W	N40-55E	Major open fracture zone. Indistinct below 4645.
Fracture 4656.5					Subhorizontal fracture?
Vein 4670±	4675±	Nearly vertical			Possible branching quartz vein.
Fractures or fault zone 4674±	4733	Nearly vertical		N40E to N50E	Major system of subparallel open fractures
4676	4678	Nearly horizontal			Several low angle beds or fractures
Tight fracture 4741.4	4749.4	83	East	N-S	Several indistinct sub-parallel fractures just above this one
Lithologic contact 4751.8		Horizontal			Several near vertical fractures to 4758.5 ft
Open fracture 4762	4767.4	80	N45W	N45E	
Open fracture 4768		Vertical		N40E±	Open fracture leaves hole @ 4768+ appears to end at contact at 4787.4 ft
Contacts 4787.4, 4792, 4796		Horizontal	SW	NE	
Bed? 4810-4812		?			Inclined bed?
Contact? 4813.7		Horizontal			

INTERPRETATION OF ACOUSTIC TELEVIEWER LOGS, RRGE- , OCTOBER L977, USGS

TOP OF FEATURE FEET	BOTTOM OF FEATURE FEET	DIP 0 DEGREES	DIRECTION OF DIP DEGREES	DIRECTION OF STRIKE DEGREES	REMARKS
4823		Horizontal			Contact or fracture
4833.8	4834	12	S50W?	N40W?	Bed? 0.2 ft thick
Top 4847.5	Bottom of system 4858.8	Vertical		N40E±	Major open fracture. Several subparallel fractu[r]es above and below
Top of system 4871.8		Vertical		N-S	Top of tight fracture syst[em] extend into open system below
Top of system 4888.3	Bottom of system 4906.6	Nearly vertical		N50-65E	System of subparallel open fractures
4923.7	4924.4	37	West	N-S	Tight fracture or bedding plane
Contact 4927		Low dip			Top of quartz monzonite
Open fracture or bedding plane 4928.1	4930	64	S75W	N15W	
4951	4953				Brecciated zone?
Fracture? 4960.6	4963	69	N35W	N55E	
4969.4	4971.3	64			??

U. S. Geological Survey

Computer derived differential temperature log

RRGE-1   October 1977   2-foot spacing

R PIP
$TT:•DTO:FTNG.DAT

4201.0	0.01
4201.5	-0.01
4202.0	-0.01
4202.5	0.01
4203.0	0.00
4203.5	0.01
4204.0	0.02
4204.5	0.05
4205.0	0.05
4205.5	0.03
4206.0	0.07
4206.5	0.01
4207.0	0.02
4207.5	0.01
4208.0	-0.01
4208.5	0.04
4209.0	-0.01
4209.5	0.08
4210.0	-0.02
4210.5	-0.01
4211.0	-0.01
4211.5	-0.05
4212.0	0.01
4212.5	-0.01
4213.0	0.02
4213.5	-0.01
4214.0	0.00
4214.5	0.00
4215.0	0.00
4215.5	-0.02
4216.0	-0.03
4216.5	-0.02
4217.0	-0.03
4217.5	-0.03
4218.0	0.01
4218.5	0.06
4219.0	-0.02
4219.5	0.03
4220.0	0.02
4220.5	-0.08
4221.0	-0.01
4221.5	-0.02
4222.0	-0.03
4222.5	-0.01
4223.0	0.01
4223.5	0.00
4224.0	-0.02
4224.5	0.02
4225.0	0.01
4225.5	-0.01
4226.0	-0.02
4226.5	-0.02
4227.0	0.00
4227.5	0.02
4228.0	0.02
4228.5	0.03
4229.0	-0.01
4229.5	-0.01
4230.0	-0.01
4230.5	0.01
4231.0	0.01
4231.5	0.01
4232.0	0.04
4232.5	-0.02
4233.0	0.01
4233.5	0.04
4234.0	0.01
4234.5	0.05
4235.0	-0.04
4235.5	0.00
4236.0	0.01
4236.5	-0.04
4237.0	0.01
4237.5	-0.02
4238.0	-0.07
4238.5	-0.03
4239.0	0.00
4239.5	-0.05
4240.0	0.00
4240.5	0.00
4241.0	0.02
4241.5	0.01
4242.0	0.03
4242.5	0.04
4243.0	0.04
4243.5	0.04
4244.0	0.02
4244.5	0.04
4245.0	-0.02
4245.5	0.03
4246.0	0.03
4246.5	-0.01
4247.0	0.06
4247.5	0.00
4248.0	0.03
4248.5	0.02
4249.0	-0.04
4249.5	-0.01
4250.0	-0.03
4250.5	-0.02
4251.0	-0.02
4251.5	-0.05
4252.0	-0.03
4252.5	-0.03
4253.0	0.00
4253.5	-0.02
4254.0	-0.05
4254.5	-0.07
4255.0	-0.05
4255.5	-0.06
4256.0	-0.03
4256.5	0.00
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4257.5	-0.01
4258.0	-0.06
4258.5	-0.06
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4260.0	0.08
4260.5	0.12
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4261.5	0.06
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4262.5	0.07
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4263.5	0.18
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4264.5	0.00
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4266.5	-0.06
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4268.5	0.54
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4269.5	0.35
4270.0	0.17
4270.5	0.12
4271.0	0.12
4271.5	0.11
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4272.5	0.12
4273.0	0.19
4273.5	0.15
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4274.5	0.12
4275.0	0.11
4275.5	0.10
4276.0	0.07
4276.5	0.06
4277.0	0.00
4277.5	0.03
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4279.5	0.00
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4280.5	0.03
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4282.5	0.02
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4283.5	0.01
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4284.5	0.00
4285.0	0.00
4285.5	0.00
4286.0	0.05
4286.5	0.02
4287.0	-0.02
4287.5	-0.01
4288.0	-0.03
4288.5	-0.01
4289.0	0.04
4289.5	0.05
4290.0	0.02
4290.5	0.01
4291.0	0.01
4291.5	0.02
4292.0	0.00
4292.5	0.00
4293.0	0.02
4293.5	-0.04
4294.0	0.04
4294.5	-0.01
4295.0	0.00
4295.5	0.05
4296.0	-0.02
4296.5	0.02
4297.0	0.01
4297.5	0.00
4298.0	0.00
4298.5	0.00
4299.0	-0.01
4299.5	-0.01
4300.0	0.00
4300.5	0.05
4301.0	0.04
4301.5	0.06
4302.0	0.05
4302.5	-0.02
4303.0	-0.04
4303.5	-0.05
4304.0	-0.06
4304.5	0.03
4305.0	0.03
4305.5	0.03
4306.0	0.00
4306.5	-0.04
4307.0	-0.04
4307.5	-0.04
4308.0	0.00
4308.5	-0.01
4309.0	0.01
4309.5	-0.01
4310.0	0.02
4310.5	0.00
4311.0	-0.02
4311.5	0.02
4312.0	-0.01
4312.5	0.02
4313.0	0.02
4313.5	-0.01
4314.0	0.01
4314.5	0.02
4315.0	0.00
4315.5	-0.01
4316.0	0.01
4316.5	-0.01
4317.0	0.00
4317.5	0.02
4318.0	-0.04
4318.5	-0.09
4319.0	-0.06
4319.5	-0.06
4320.0	-0.03
4320.5	0.03
4321.0	0.00
4321.5	0.02
4322.0	-0.01
4322.5	-0.01
4323.0	0.01
4323.5	-0.04
4324.0	0.05
4324.5	0.08
4325.0	0.06
4325.5	0.03
4326.0	-0.04
4326.5	-0.10
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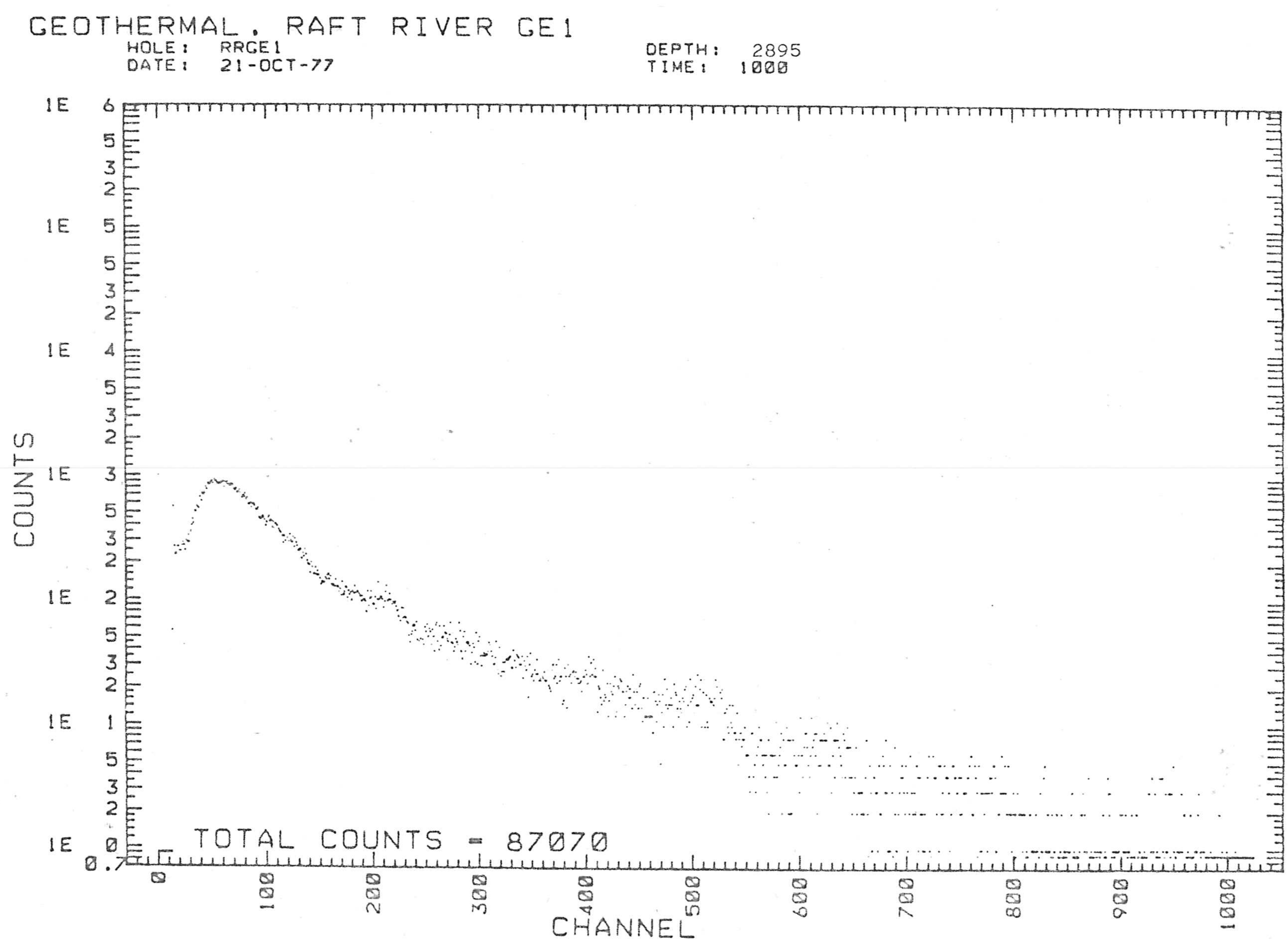
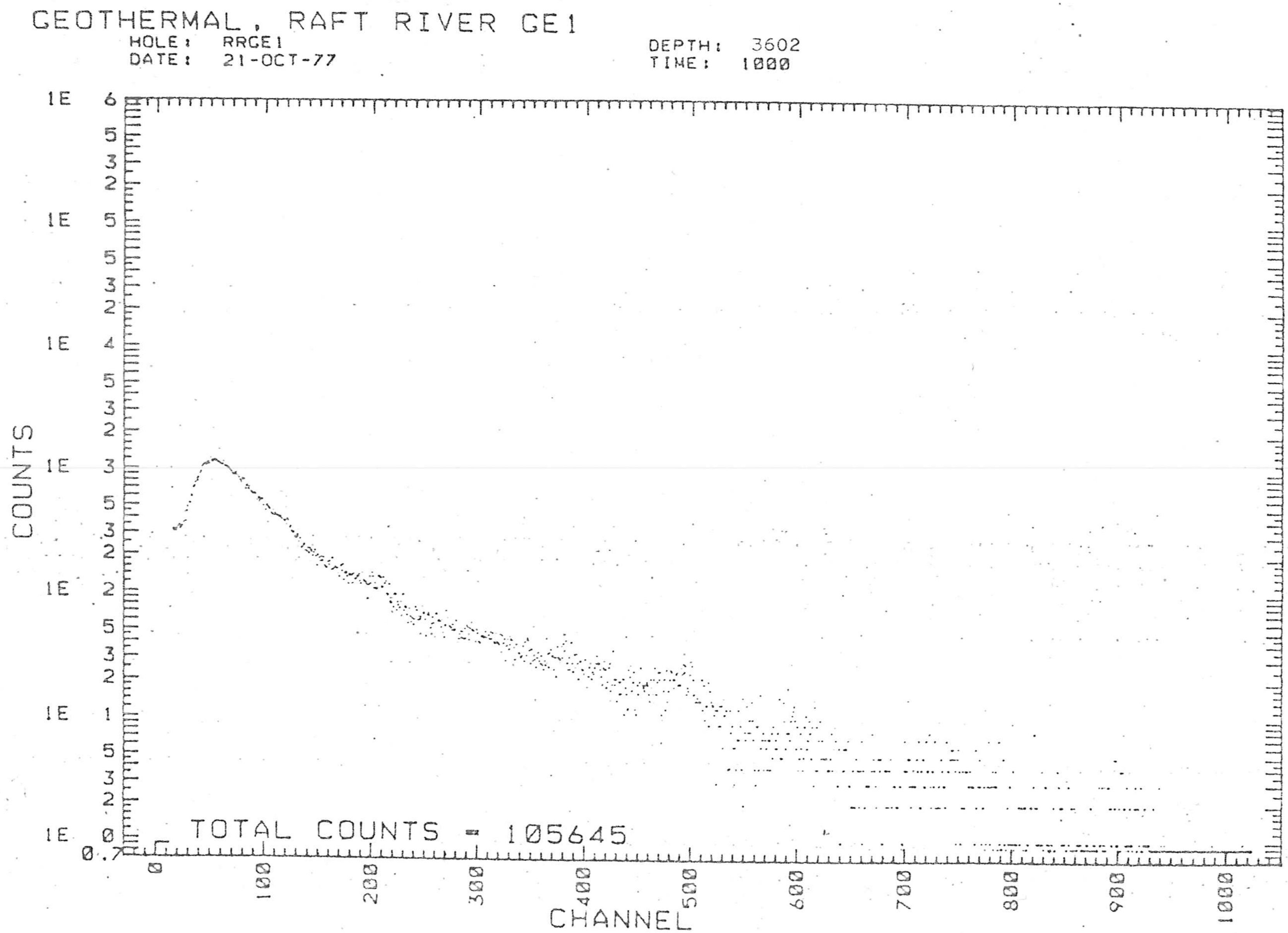

GEOTHERMAL, RAFT RIVER GE1
HOLE: RRGE1
DATE: 21-OCT-77
DEPTH: 2895
TIME: 1000
COUNTS
1E 6
1E 5
1E 4
1E 3
1E 2
1E 1
1E 0
0.7
TOTAL COUNTS = 87070
0
100
200
300
400
500
600
700
800
900
1000
CHANNEL

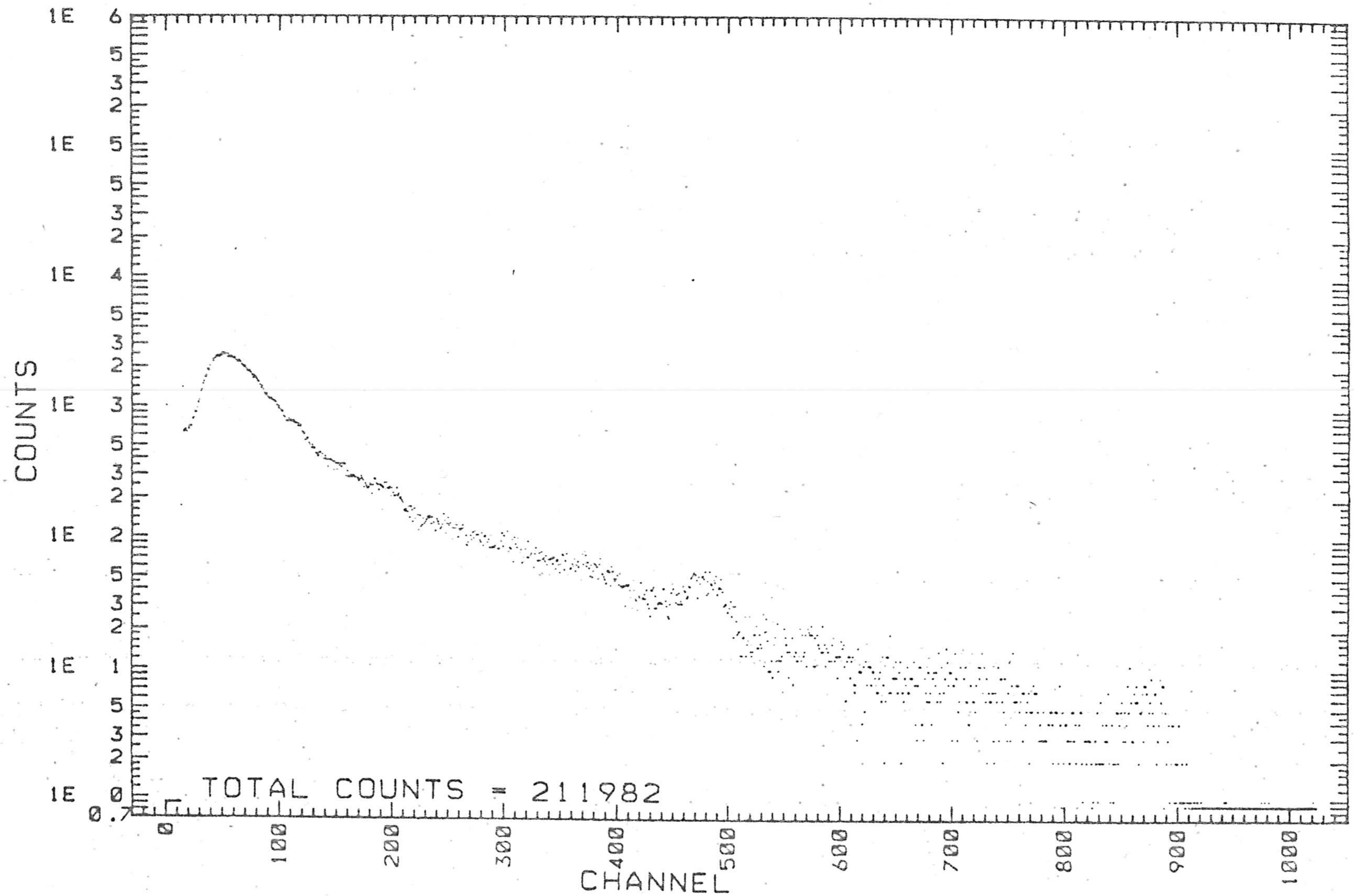


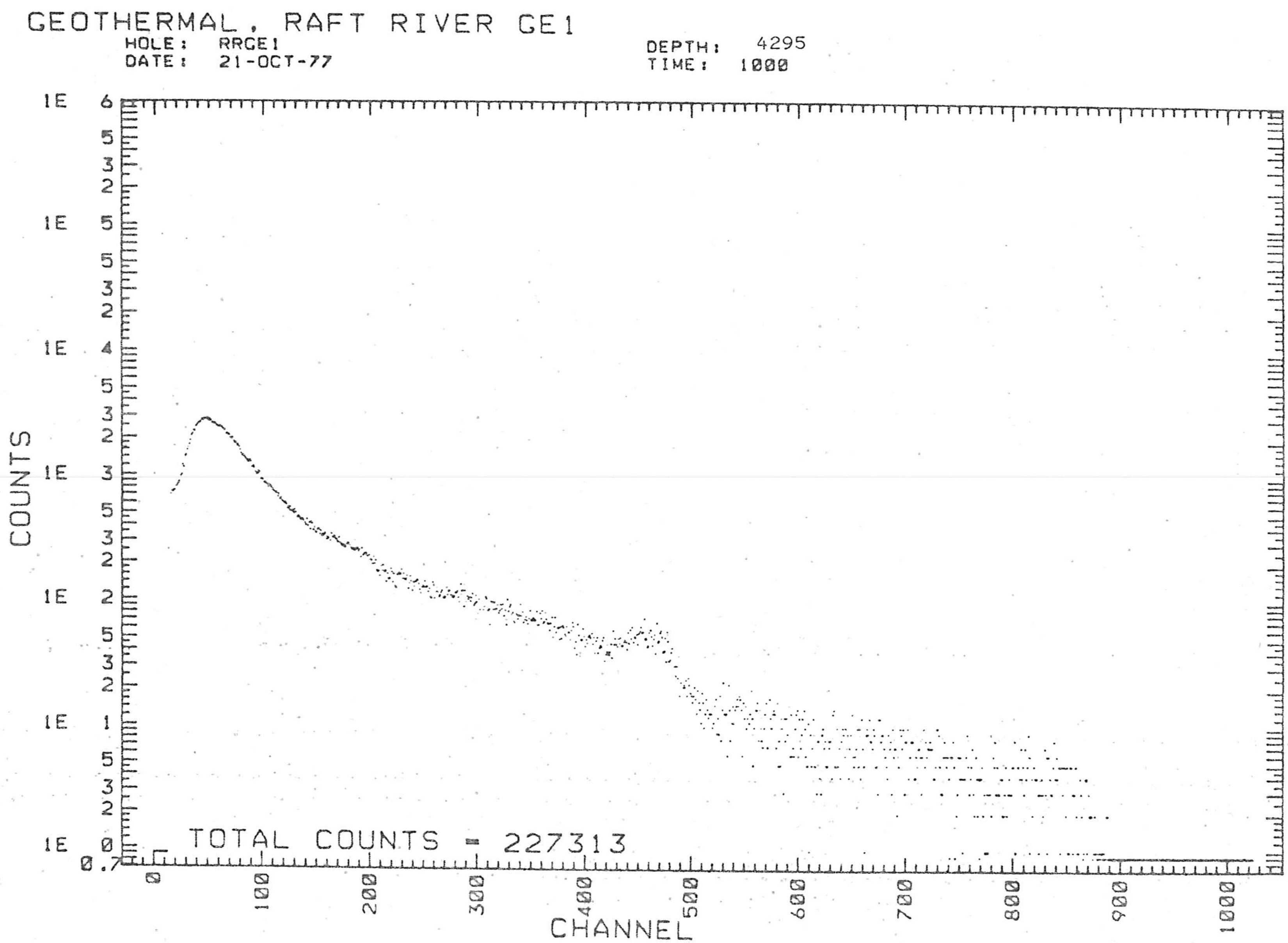
GEOTHERMAL, RAFT RIVER GE1
HOLE: RRGE1
DATE: 21-OCT-77
DEPTH: 3602
TIME: 1000
COUNTS
CHANNEL
TOTAL COUNTS = 105645

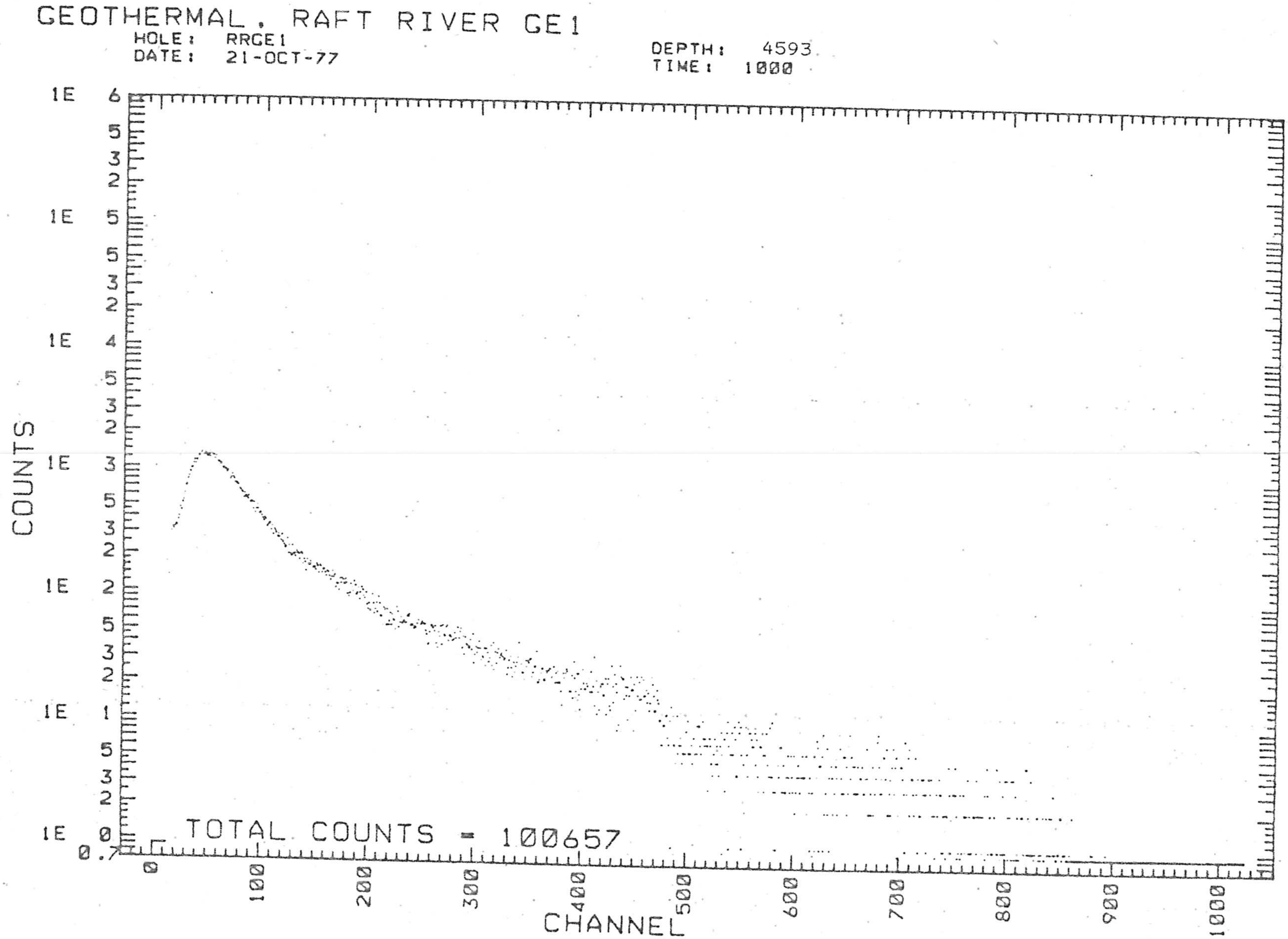
GEOTHERMAL, RAFT RIVER GE1

HOLE: RRGE1
DATE: 21-OCT-77

DEPTH: 3868
TIME: 1000




GEOTHERMAL, RAFT RIVER GE1
HOLE: RRGE1
DATE: 21-OCT-77
DEPTH: 4295
TIME: 1000
COUNTS
CHANNEL
TOTAL COUNTS = 227313


GEOTHERMAL, RAFT RIVER GE1
HOLE: RRGE1
DATE: 21-OCT-77
DEPTH: 4593
TIME: 1000
COUNTS
TOTAL COUNTS = 100657
CHANNEL
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100
200
300
400
500
600
700
800
900
1000
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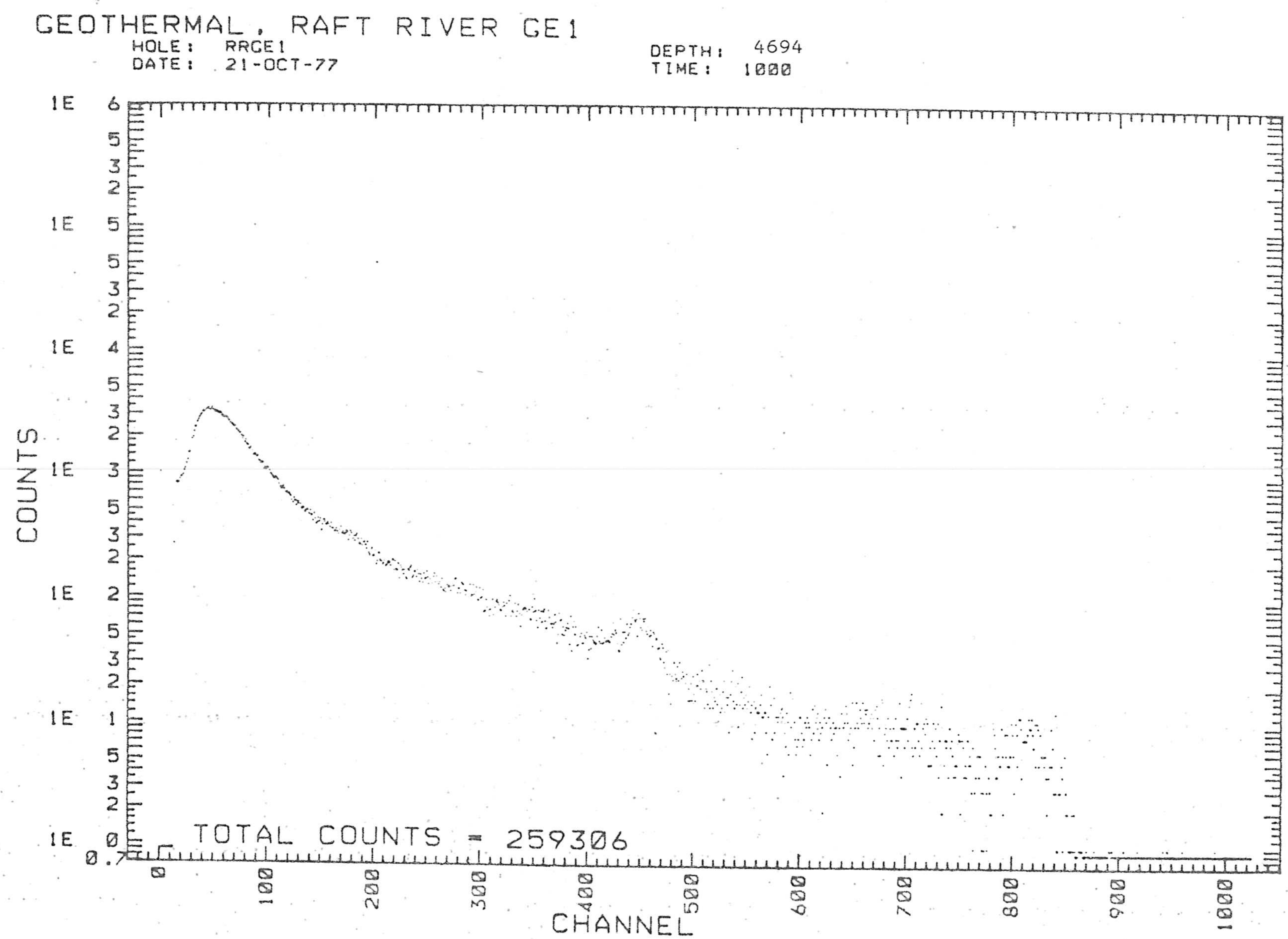
1E 5
1E 4
1E 3
1E 2
1E 1
1E 0
0.7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HOLE: RRGE1
DATE: 21-OCT-77
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1E 3
1E 2
1E 1
1E 0
0.7
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CHANNEL
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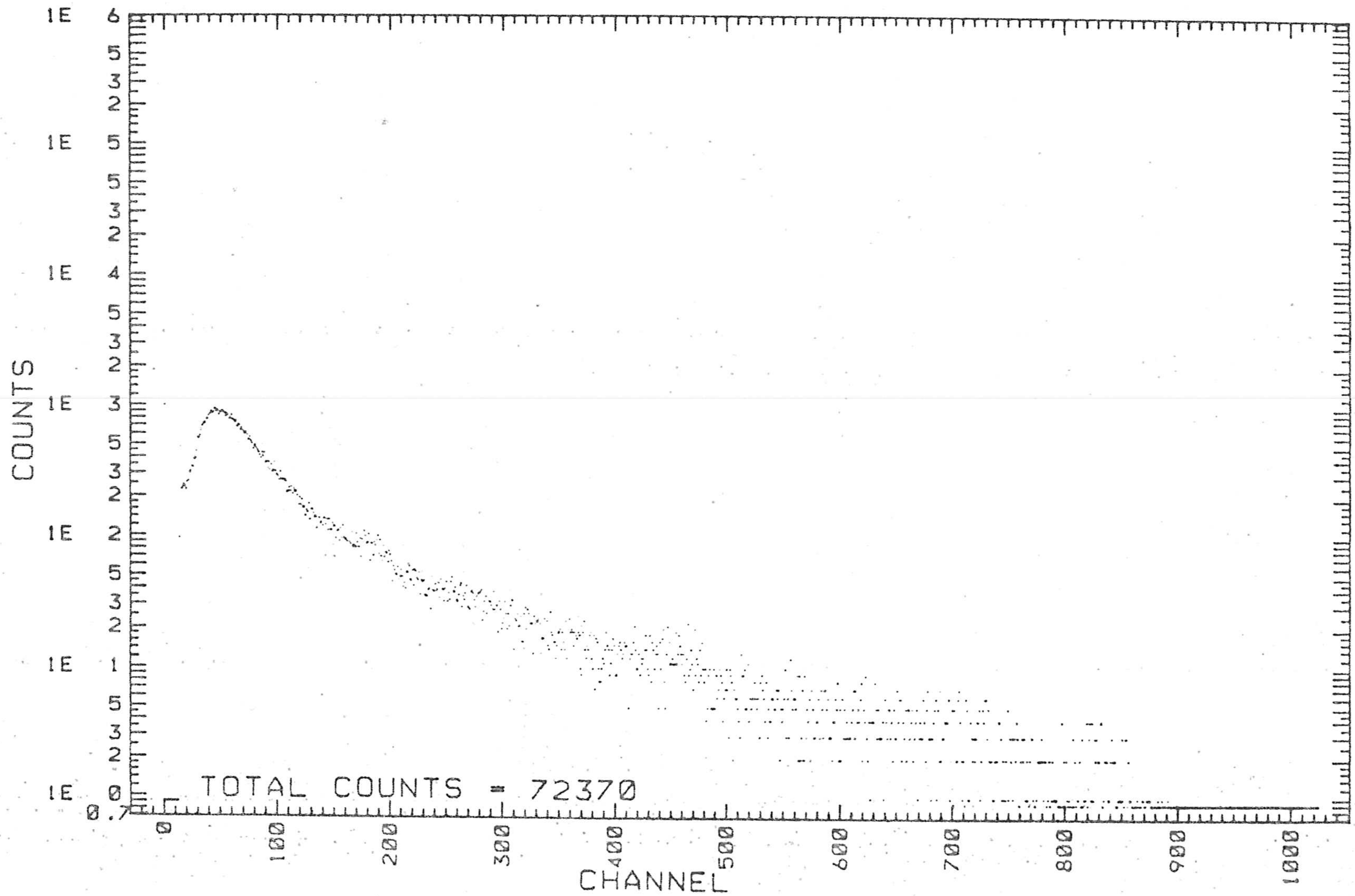
100
200
300
400
500
600
700
800
900
1000

GEOTHERMAL, RAFT RIVER GE1

HOLE: RRGE1
DATE: 21-OCT-77

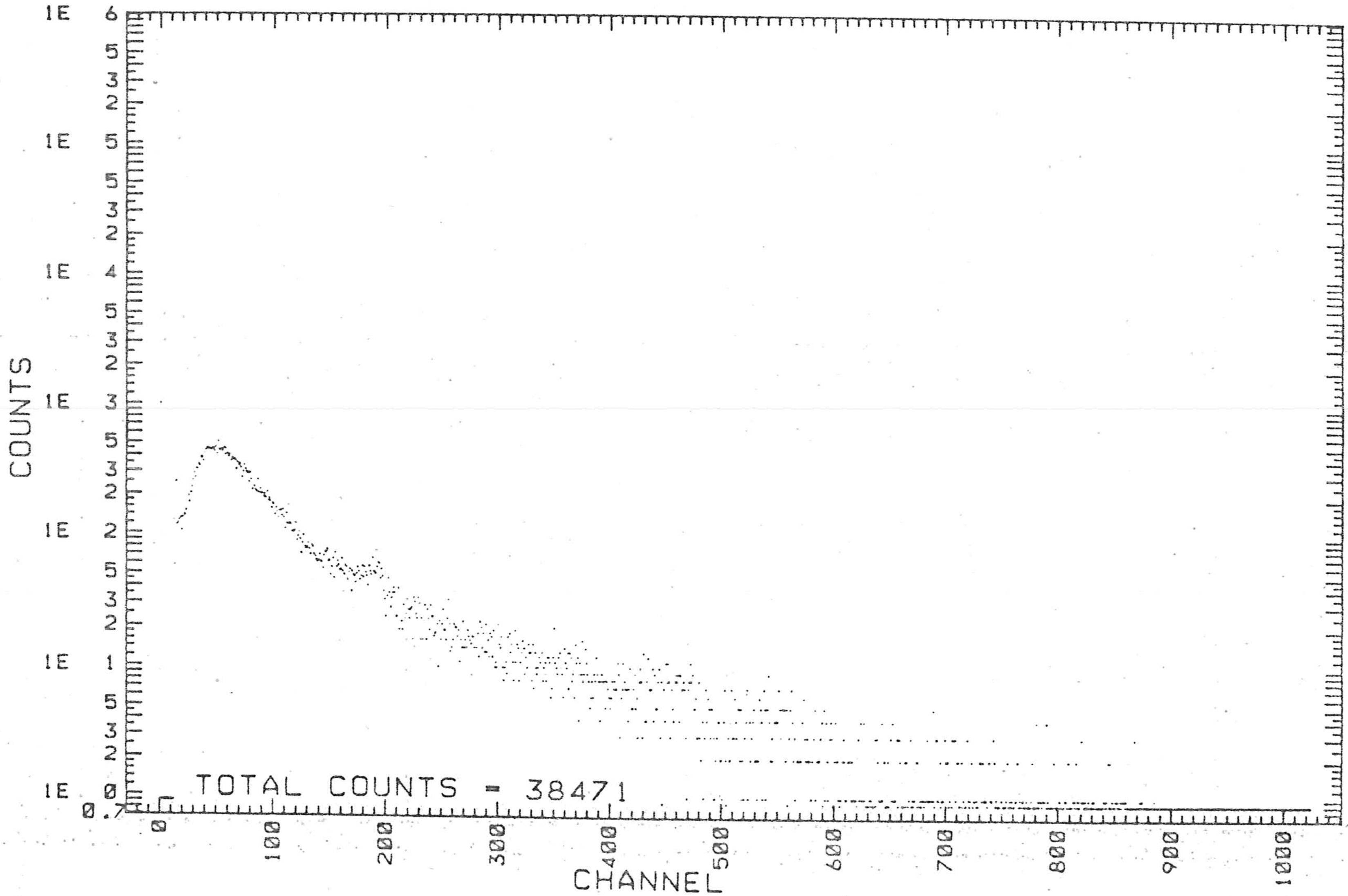
DEPTH: 4818
TIME: 1000



GEOTHERMAL, RAFT RIVER GE1

HOLE: RRGE1
DATE: 21-OCT-77

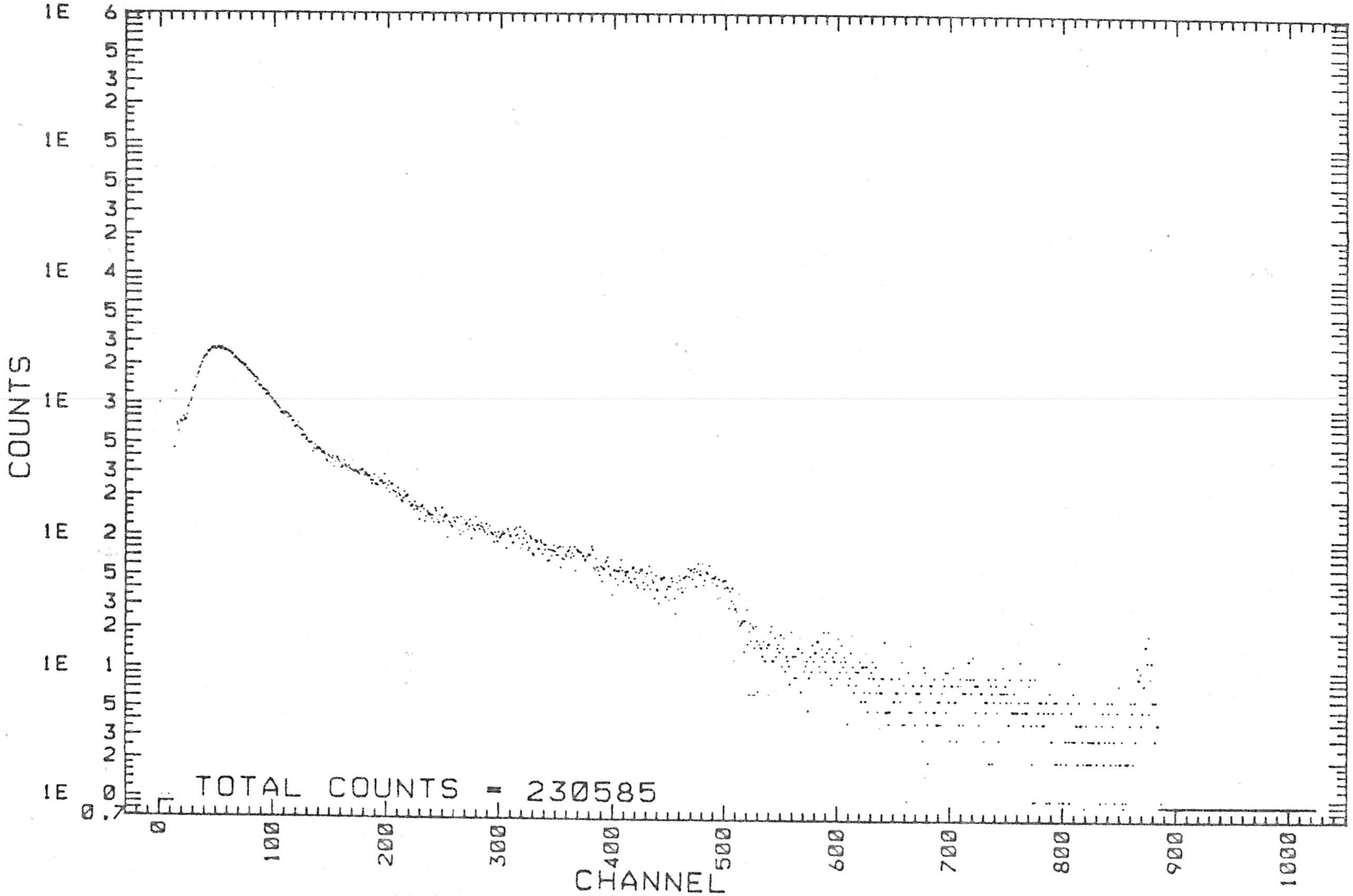
DEPTH: 4906
TIME: 1000

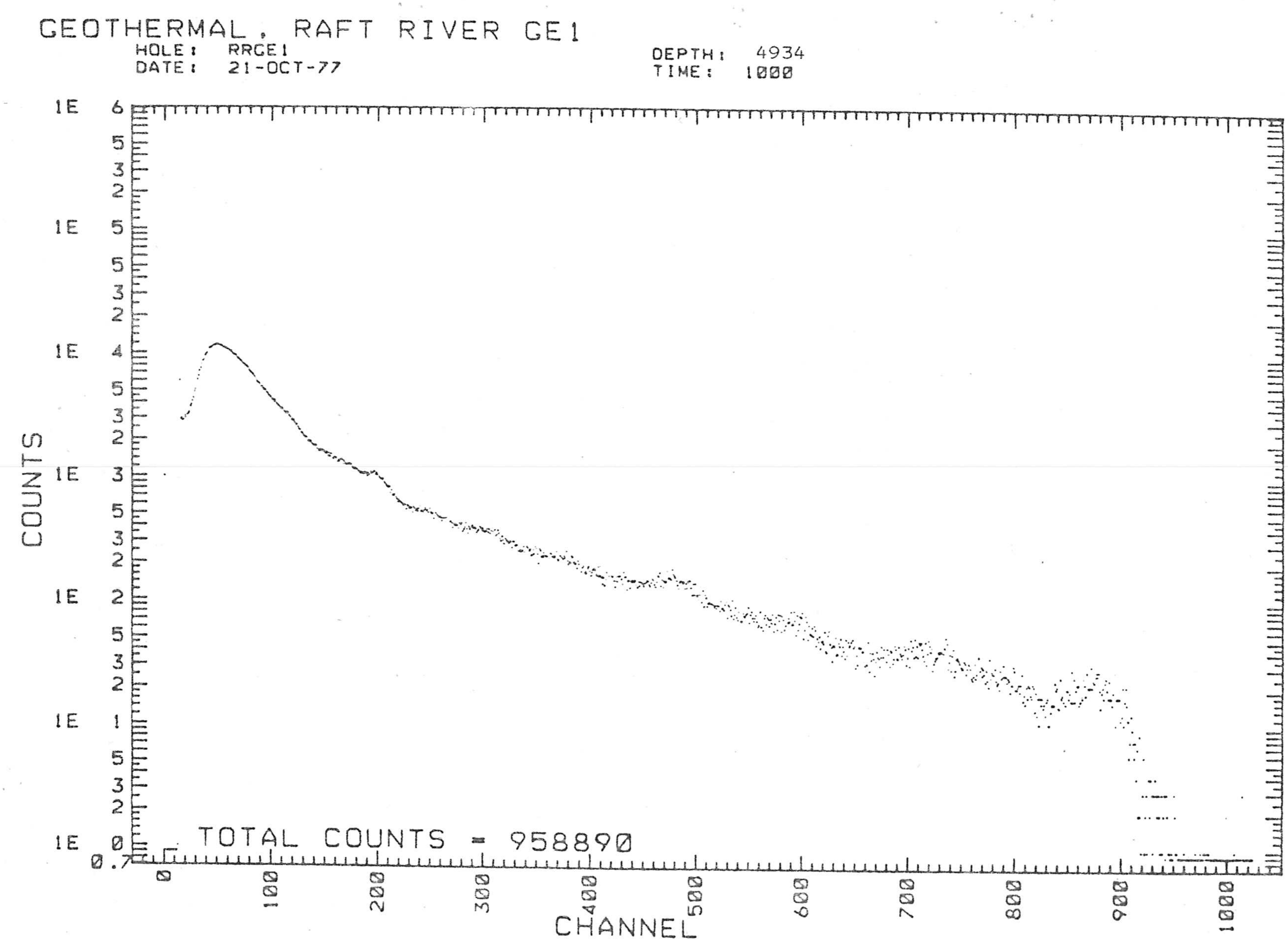


GEOTHERMAL, RAFT RIVER GE1

HOLE: RRGE1 DEPTH: 4922

DATE: 21-OCT-77 TIME: 1000




GEOTHERMAL, RAFT RIVER GE1
HOLE: RRGE1
DATE: 21-OCT-77
DEPTH: 4934
TIME: 1000
COUNTS
1E 6
1E 5
1E 4
1E 3
1E 2
1E 1
1E 0
0.7
TOTAL COUNTS = 958890
0
100
200
300
400
500
600
700
800
900
1000
CHANNEL

GEOTHERMAL, RAFT RIVER GE1

HOLE: RRGE1
DATE: 21-OCT-77

DEPTH: 4950
TIME: 1000