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RADIOLOGICAL SURVEY OF PROPERTIES IN THE VICINITY OF THE FORMER COTTER SITE, HAZELWOOD/BERKELEY, MISSOURI (LM003)

W. D. Cottrell
R. F. Carrier
C. A. Johnson

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HEALTH AND SAFETY RESEARCH DIVISION

Nuclear and Chemical Waste Programs
(Activity No. AH 10 05 00 0; ONLWCO1)

RADIOLOGICAL SURVEY OF PROPERTIES IN THE VICINITY OF THE FORMER COTTER SITE, HAZELWOOD/BERKELEY, MISSOURI (LM003)

W. D. Cottrell, R. F. Carrier* and C. A. Johnson*

*Biology Division

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B. A. Berven – Environmental Assessments Program Manager
W. D. Cottrell – FUSRAP Project Director

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ABSTRACT

A radiological survey was conducted in 1984 by the Oak Ridge National Laboratory of private properties adjacent to the former Cotter site at 9200 Latty Avenue, Hazelwood/Berkeley, Missouri. During the 1960s and 1970s, process wastes and residues generated by the production and refining of uranium materials were stored at the site (currently owned by the Jarboe Realty and Investment Company). Subsequent to the removal and transport of the stored wastes, along with a portion of the top soil, to other locations, it was found that the soil remaining on the site contained radioactive residuals. This report describes the survey of the properties adjacent to the site. Included were gamma exposure rates at the ground surface and at 1 m above the surface throughout the site; sampling of surface soil; sampling of subsurface soil from auger holes; gamma logging of auger holes; and, sampling of sediment and surface waters receiving drainage from the site. The results of the survey demonstrated some degree of radioactive contamination over most of the area surveyed. The major contaminant was ^{230}Th with ^{226}Ra and ^{238}U occurring in lesser amounts. The maximum concentrations of ^{226}Ra, ^{230}Th, and ^{238}U found in soil were 1400, 81,000, and 990 pCi/g, respectively. The maximum depth at which contamination was measured was 2 m. Although samples of drainage waters showed no evidence of contamination, migration of the radioactive materials was indicated by elevated concentrations of ^{226}Ra, ^{230}Th, and ^{238}U in sediment samples taken from those waters. The pattern of radionuclide contamination observed in most soil and sediment samples is typical of the wastes and residues which had been stored at the former Cotter site.

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INTRODUCTION

Process wastes and residues associated with the production and refining of uranium materials were generated by the Mallinckrodt Chemical Works, St. Louis, Missouri, during the period 1942 through the later 1950s. According to a Nuclear Regulatory Commission (NRC) report,[1] residues which had been stored at the St. Louis Airport property were moved by the Continental Mining and Milling Company of Chicago, Illinois, to the Latty Avenue Storage Site in Hazelwood, Missouri, in early 1966. The Latty Avenue Storage Site is located in a low-lying industrialized area in Hazelwood/Berkeley, Missouri, approximately 12 miles northwest of St. Louis. The Commercial Discount Corporation, Chicago, Illinois, purchased the residues in January 1967. Much of the material was dried and shipped to the Cotter Corporation facilities in Canon City, Colorado. These materials included ore residues and uranium-, thorium-, and radium-bearing process wastes. Materials remaining at the Latty Avenue Storage Site were sold to the Cotter Corporation in December 1969. Records indicate that residues remaining on the site at that time included 74,000 tons of Belgian Congo pitchblende raffinate containing 113 tons of uranium, 32,500 tons of Colorado raffinate containing 48 tons of uranium, and 8700 tons of leached barium sulfate containing about 7 tons of uranium. During August through November 1970, Cotter Corporation dried some of the remaining residues and shipped them to a Cotter mill in Canon City, Colorado. An estimated 10,000 tons of Colorado raffinate and 8700 tons of leached barium sulfate remained at the Latty Avenue site in December 1970.

In April 1974, an NRC inspector was informed that the remaining Colorado raffinate had been shipped without drying to Canon City during the prior year (1973) and that the leached barium sulfate had been transported to a landfill area in St. Louis County. Twelve to eighteen inches of top soil were reported to have been stripped from the Latty Avenue site surface and supposedly were removed from the site with the leached barium sulfate. However, analysis of soil samples taken during an NRC investigation of the site in 1976 indicated the presence of uranium- and thorium-bearing residues.[1]

In 1977, a survey was conducted by Oak Ridge National Laboratory (ORNL) to characterize the radiological conditions at the site. It was determined that alpha and beta-gamma contamination levels on surfaces in buildings on the site exceeded NRC guidelines for release of decontaminated property for unrestricted use.[2] Numerous areas having gamma exposure rates of 300–500 μR/h were clearly above criteria recommended by the International Commission on Radiological Protection (ICRP).[3] It was estimated that the top three inches of soil on much of the area contained an average of 140 pCi/g of ^{226}Ra and probably higher average concentrations of ^{238}U, ^{230}Th, and ^{227}Ac.

At the request of the U.S. Department of Energy (DOE), a preliminary survey of properties adjacent to and in the vicinity of the former Cotter site at 9200 Latty Avenue was made in September 1983 to determine if contamination was present on any vicinity properties and to evaluate the scope of work required to perform radiological assessment surveys on these properties.[4] Elevated gamma radiation levels were observed on all properties adjacent to 9200 Latty Avenue, especially on those properties to the north, east, and south.

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The potentially contaminated regions identified during the preliminary evaluation were surveyed by ORNL during the period January through April, 1984. This report describes the results of that portion of the survey which included private properties adjacent to and in the vicinity of the former Cotter site, now the Jarboe Realty and Investment Company. The surveyed properties are owned by the General Investment Fund Real Estate Holding Company and the Norfolk and Western Railroad. The results of radiological surveys of Latty Avenue in the vicinity of the former Cotter site and of the perimeter fence line surrounding the site are provided in separate reports.[5,6]

SURVEY METHODS

The radiological survey of this property included: (1) gamma radiation exposure rates at the surface and at 1 m above the surface throughout the site; (2) concentrations of ^{226}Ra, ^{230}Th, and ^{238}U in surface and subsurface soil samples; (3) concentrations of ^{226}Ra, ^{230}Th, and ^{238}U in sediment samples; (4) concentrations of ^{226}Ra, ^{230}Th, ^{238}U and ^{210}Pb in water samples; and, (5) gamma radiation levels at various depths in auger holes drilled on the site. The radiological survey followed a general plan developed at ORNL for vicinity properties in Hazelwood and Berkeley, Missouri.[7] A comprehensive description of the survey methods and instrumentation has been presented in another report.[8]

To provide better definition of contamination, the site was divided into 50 × 50 ft grid blocks as shown in Fig. 1. Accessible areas in each grid block were scanned with a portable gamma scintillation meter, and the range of measurements found within the block was recorded. Additionally, soil samples were taken from the surface at systematically selected locations and from auger holes drilled in regions of suspected contamination. Additionally, water and sediment samples were collected from surface waters receiving drainage from the site. The soil, sediment, and water samples were analyzed for ^{238}U, ^{226}Ra, and ^{230}Th content.

SURVEY RESULTS

Applicable federal guidelines for radiation exposure to the general public from residual contaminants in soil are given in Table 1. Typical background radiation levels for the St. Louis area are presented in Table 2. These data are provided for purposes of comparison with the survey results reported in this section.

All measurements presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background concentrations have not been subtracted from radionuclide concentrations in soil samples.

GAMMA EXPOSURE RATE MEASUREMENTS

Results of grid point measurements of gamma exposure rates at the surface and at 1 m above the surface and the range of gamma radiation levels detected during the

gamma scan of grid blocks are given in Table 3. The maximum gamma exposure rate on this site was 900 μR/h at the ground surface as determined during the scan of the grid blocks. Grid point measurements at the ground surface ranged from 7 to 680 μR/h and averaged 21 μR/h. The gamma exposure rates at 1 m above the ground surface at grid points ranged from 8 to 560 μR/h with a mean of about 19 μR/h.

SURFACE SOIL SAMPLES

Surface soil samples were collected from systematic locations at a depth of 0 to 15 cm to provide representative sampling of the site. In addition, samples were collected from selected locations showing elevated gamma radiation levels and are designated as "biased" samples. Sample locations are shown on Fig. 2 and the results of soil analysis are given in Table 4. Concentrations of ^{226}Ra in systematic samples ranged from 0.99 to 250 pCi/g and averaged 7.2 pCi/g; ^{238}U concentrations ranged from 1.0 to 210 pCi/g and averaged 5.9 p/Ci/g. Mean concentrations of ^{226}Ra and ^{238}U exceeded background levels by factors of about 7.5 and 6.5, respectively. Concentrations of ^{230}Th in systematic samples ranged from 2.5 to 8800 pCi/g with a mean of 220 pCi/g. The maximum concentration of each of the radionuclides was found in sample number 7 collected near the fence at the east side of the former Cotter site.

In biased samples, concentrations of ^{226}Ra ranged from 1.0 to 270 pCi/g, averaging 100 pCi/g; ^{238}U concentrations ranged from 1.0 to 220 pCi/g with a mean of 75 pCi/g. Concentrations of ^{230}Th in biased samples ranged from 18 to 13,000 pCi/g and averaged 3800 pCi/g.

SUBSURFACE SOIL SAMPLES AND GAMMA LOGGING OF AUGER HOLES

One or more soil samples were collected from each of the auger holes which were drilled at the locations shown on Fig. 3. The sampling depths chosen usually included the region of maximum gamma radiation level as indicated by the gamma log. At selected locations, Shelby tubes and/or split-spoon samplers were used to collect subsurface samples at known depths. The results of radionuclide analysis are given in Table 5.

Concentrations of ^{226}Ra and ^{238}U in soil samples from auger holes ranged from 0.7 to 1400, and 0.35 to 990 pCi/g, respectively. Concentrations of ^{230}Th ranged from less than 0.5 to 81,000 pCi/g. The maximum concentration of each radionuclide was found in a sample taken from hole number 7 at a depth of 15 to 30 cm.

Each of the auger holes was "logged" using a gamma scintillation detector. A plastic pipe (PVC Schedule 40) with a 4-in inside diameter was placed in the hole, and a NaI scintillation probe was lowered inside the pipe. The probe was encased in a lead shield with a horizontal row of collimating slits on the side. This collimation allows measurement of gamma radiation intensities resulting from contamination within small fractions of the hole depth. Measurements were usually made at 15- or 30-cm intervals. Logging of the auger holes was done to determine the extent of subsurface contamination at each location. Profiles of gamma intensity as a function of depth are presented in the Appendix.

The gamma logging used here is not radionuclide specific. However, the logging data, in conjunction with the soil analyses data, may be used to estimate the region of contamination in the auger holes. It appears from a comparison of these data that a reading of 1000 cpm or greater using the shielded scintillator indicates the presence of elevated concentrations of ^{226}Ra and/or ^{238}U. Consequently, soil giving rise to 1000 cpm or greater on the scintillator, or containing radionuclide concentrations above criteria (Table 1) as determined from soil analysis, was considered as contaminated soil. Using these criteria, an estimate of the region of contamination in each hole was made. These data are listed in Table 6. A word of caution should be added in the interpretation of the data presented in Table 6. Only those holes yielding a positive indication of contamination, using the previously stated criteria, are listed as having a region of contamination; an entry of "none" opposite a location means only that no positive indication of contamination was observed using the "logging" and sampling procedures employed on this site. Because of the difficulty of detecting ^{230}Th with this in-situ hole logging device, concentrations of ^{230}Th in the absence of ^{226}Ra considerably in excess of 5 pCi/g may have gone undetected.

The maximum depth at which contamination was measured was 2 m. In general, radionuclide concentrations decreased with increase in depth. The maximum contamination was measured at an average depth of 0.1 m.

SEDIMENT AND WATER SAMPLES

Water and sediment samples were collected from surface waters receiving drainage from the site. Samples were taken from drainage ditches, outfalls, and streams, as well as from Coldwater Creek. Sampling locations are shown in Fig. 4 and results of radionuclide analyses are listed in Table 7. Concentrations of ^{226}Ra, ^{238}U, ^{230}Th and ^{210}Pb in water samples were well below the concentration guides for water for unrestricted use (10 CFR 20). However, concentrations of ^{226}Ra, ^{238}U, and ^{230}Th were elevated in some sediment samples, ranging as high as 170, 190, and 8100 pCi/g, respectively. Although no radiological surveys were performed on properties north of the drainage ditch and east of Coldwater Creek, elevated concentrations of radionuclides found in sediment samples collected from the banks of these streams may be indicative of possible contamination on adjacent properties. Sample number 9, collected from the east bank of Coldwater Creek adjacent to the Hutter property, showed a concentration of 700 pCi of ^{230}Th per gram of soil. Contamination was evident at locations both north and south of the surveyed area.

SIGNIFICANCE OF FINDINGS

A summary of measurement results of the radiological survey conducted on this site is provided in Table 8. Radioactive contamination was found to some extent over most of the surveyed area. Gamma exposure rates measured during the scan ranged from 7 to 900 μR/h at the ground surface while grid point measurements averaged 19 and 21 μR/h at 1 m and at the surface, respectively. Typical background for the St. Louis area ranges from 5 to 8 μR/h, averaging 6 μR/h. In general, gamma levels were highest near the fence line surrounding the Jarboe property, especially on the east side.

The results of soil analysis establish the presence of radionuclides in elevated concentrations over most of the site. The major contaminant is ^{230}Th with ^{226}Ra and ^{238}U occuring in lesser amounts. Concentrations of ^{230}Th exceeded the DOE guideline of 5 pCi/g for surface soil in 63 of 70 representative samples. The average concentration in those samples, 220 pCi/g, is ~45 times that guideline. Of the 86 auger holes drilled, 64 contained ^{226}Ra and/or ^{230}Th concentrations exceeding one or both of the DOE guidelines of 5 and 15 pCi/g for surface and subsurface soil, respectively. The maximum concentrations of ^{226}Ra, ^{230}Th, and ^{238}U in soil were 1400, 81,000, and 990 pCi/g, respectively, and were found in a sample taken from a depth of 15 to 30 cm. The maximum depth at which contamination was measured was 2 m. On the average, the region of maximum contamination was found at 0.1 m. In general, the activity of ^{226}Ra and ^{238}U was roughly equal in the soil samples, indicating secular equilibrium which is characteristic of uranium ore material. However, this relationship was not as constant in some samples collected from near the south end of the Jarboe property. In those samples (B1, B3, and samples from auger holes 12–18) ^{226}Ra concentrations predominated.

Although radionuclide concentrations in water samples retrieved from drainage streams and Coldwater Creek were well below permissible levels for unrestricted use, migration of the radioactive materials was evident. Concentrations of ^{226}Ra, ^{238}U, and ^{230}Th were elevated above typical background values in sediment samples collected from drainage areas both north and south of the properties. The maximum concentrations of ^{226}Ra and ^{230}Th (170 and 8100 pCi/g, respectively) exceed the DOE guideline for surface soil (5 pCi/g) by factors of 34 and >1600. The elevated concentrations of ^{230}Th observed in the majority of soil and sediment samples are typical of the wastes and residues which had been stored at the site.

REFERENCES

1. Nuclear Regulatory Commission I&E Investigation Report No. 76-01, August 20, 1976.
2. Nuclear Regulatory Commission (NRC), *Standards for Protection Against Radiation*, 10 CFR 20.105 (November 17, 1960).
3. International Commission on Radiological Protection, *Recommendations of the International Commission on Radiological Protection*, ICRP Publication 26, Permagen Press, Elmsford, New York (1977).
4. W. D. Cottrell to B. A. Berven, Report on Trip to the Latty Avenue Site, Hazelwood, Missouri (September 27, 1983).
5. W. D. Cottrell, *Radiological Survey of Latty Avenue in the Vicinity of the Former Cotter Site, Hazelwood/Berkeley, Missouri (LM001)*, Oak Ridge National Laboratory, ORNL/TM-10006 (in press).
6. R. F. Carrier and W. D. Cottrell, *Radiological Survey of the Perimeter Fence Line of the Former Cotter Site, Hazelwood, Missouri (LM002)*, Oak Ridge National Laboratory, ORNL/TM-10007 (December 1986).
7. *Radiological Survey Plan for Vicinity Properties in Hazelwood and Berkeley, Missouri*, letter from B. A. Berven, ORNL/RASA, to A. J. Whitman, DOE/HQ (October 1983).
8. T. E. Myrick, B. A. Berven, W. D. Cottrell, W. A. Goldsmith, and F. F. Haywood, *Procedures Manual for the Remedial Action Survey and Certification Activities (RASCA) Program*, Oak Ridge National Laboratory, ORNL/TM-8600 (September 1982).
9. T. E. Myrick, B. A. Berven, and F. F. Haywood, *State Background Radiation Levels: Results of Measurements Taken During 1975–1979*, ORNL/TM-7343 (November 1981).

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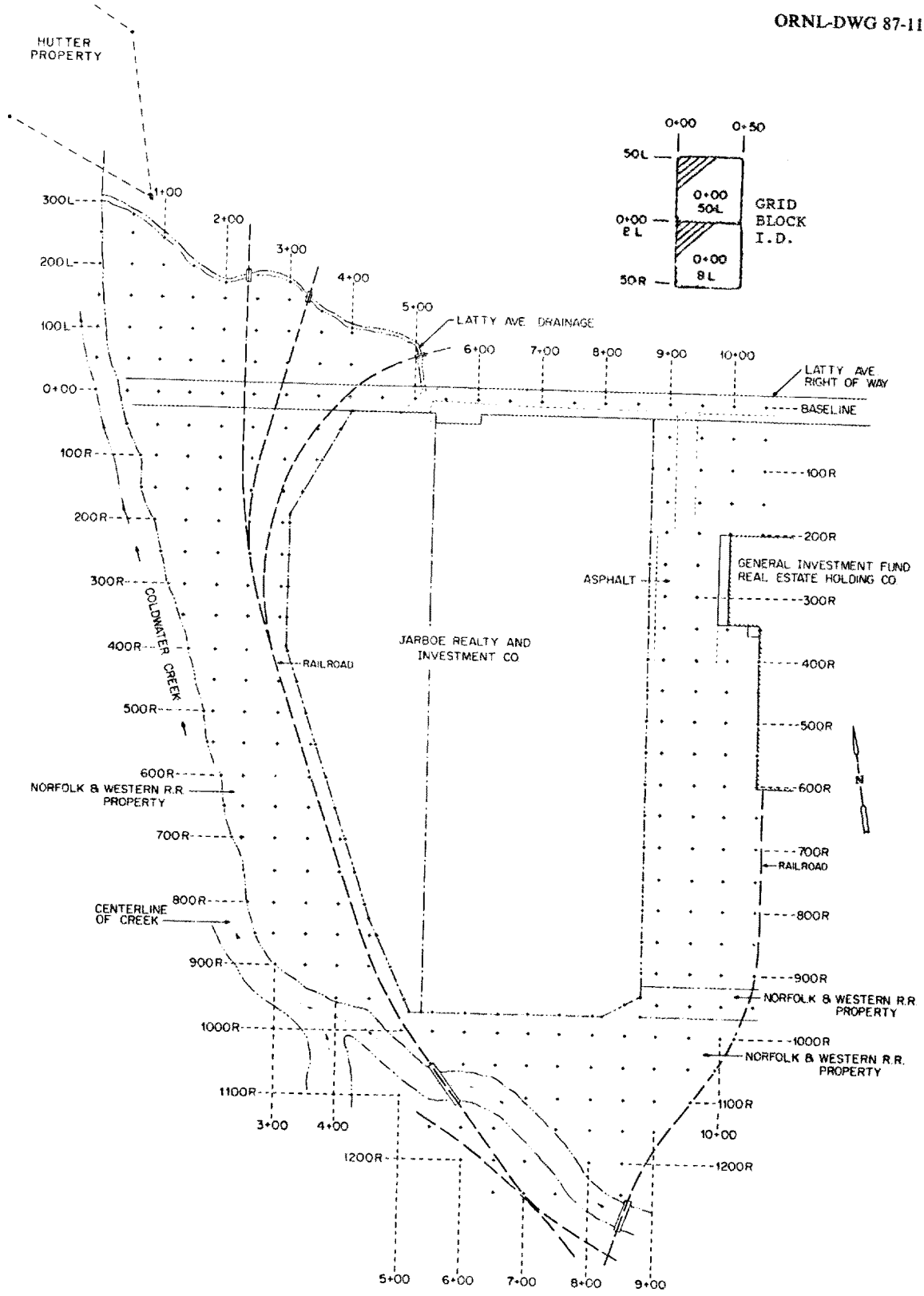

Fig. 1. Diagram showing grid system used at vicinity properties LM003.

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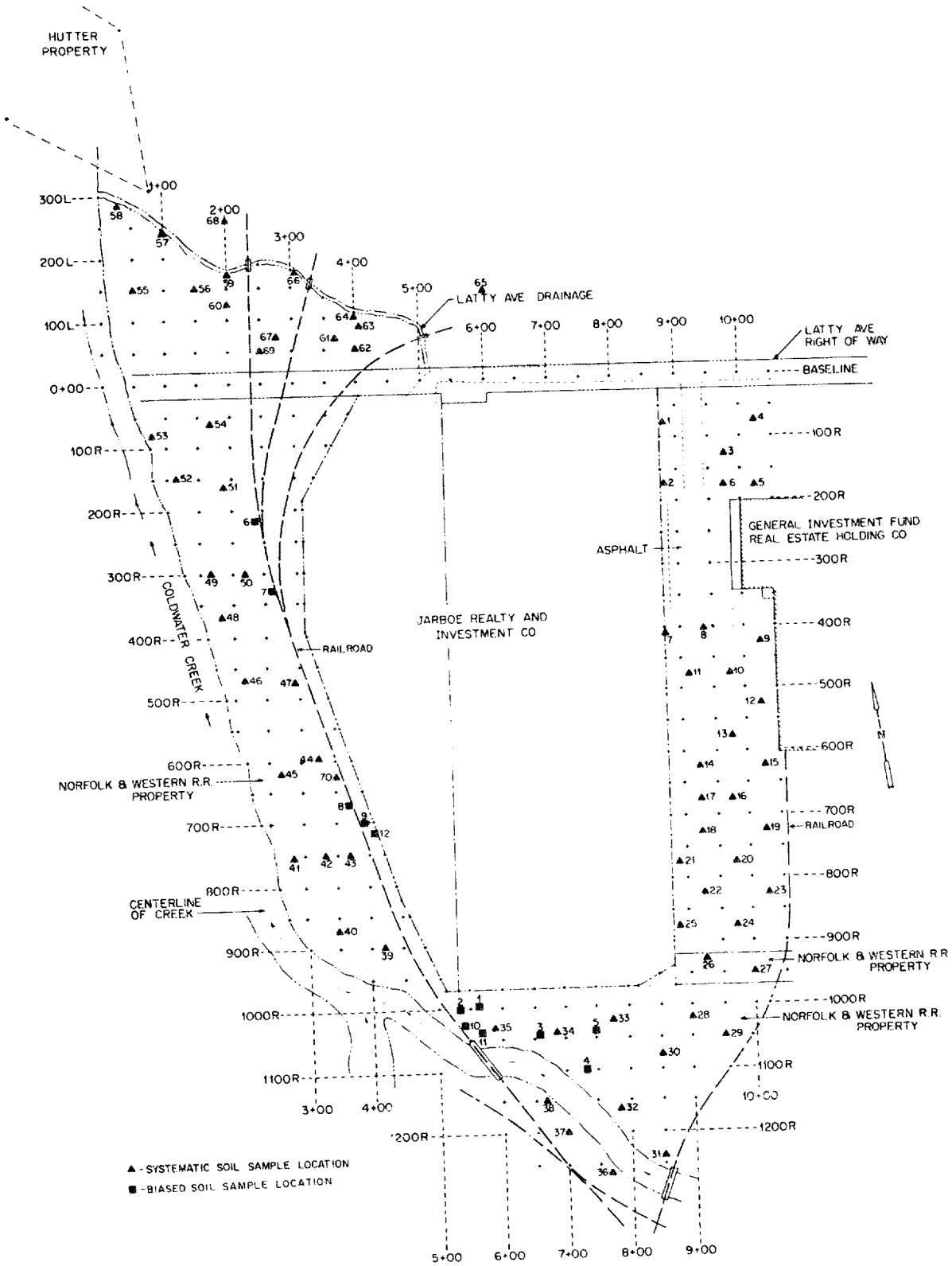

Fig. 2. Locations of surface soil samples taken at vicinity properties LM003.

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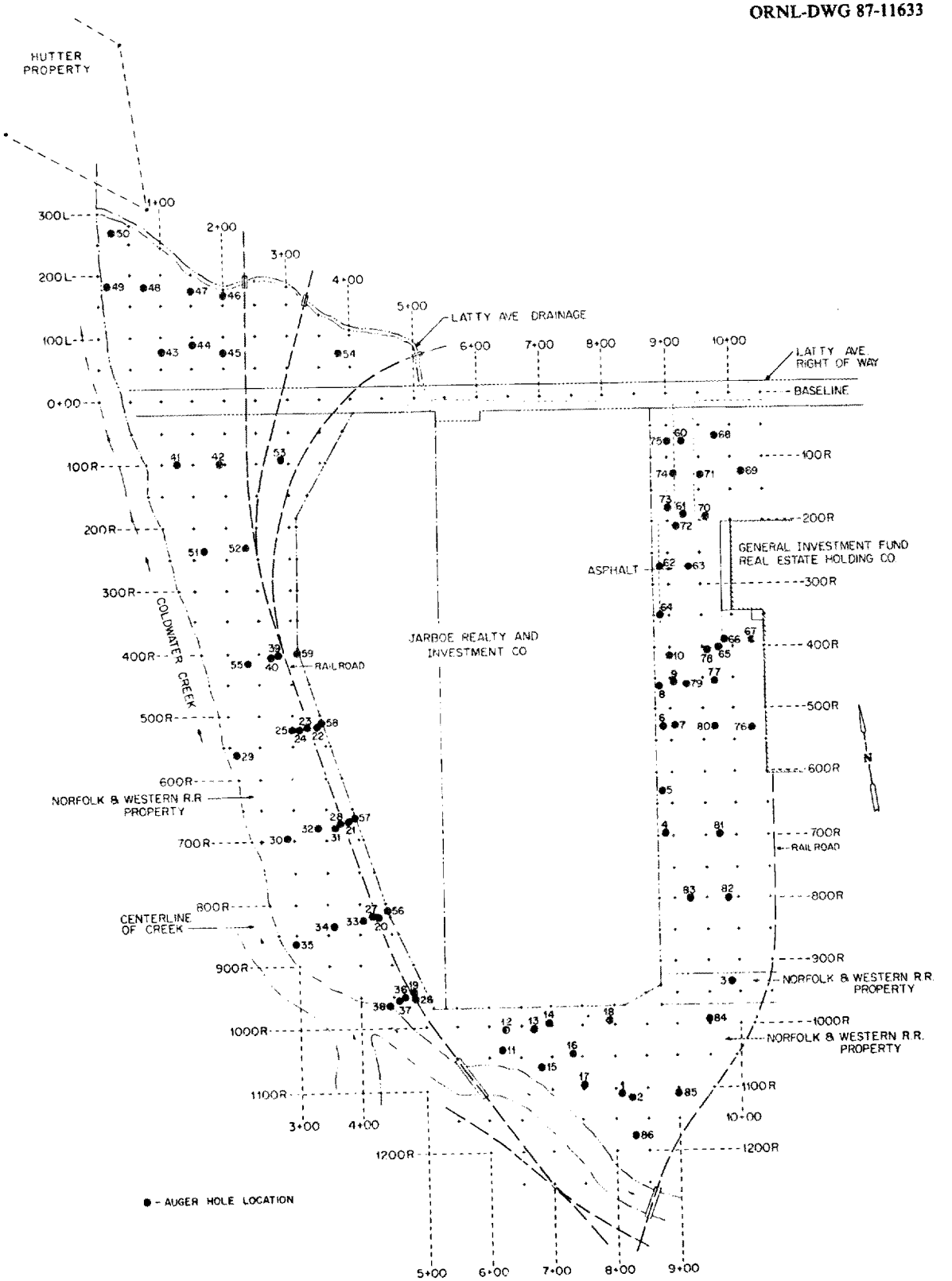

Fig. 3. Locations of auger holes at vicinity properties LM003.

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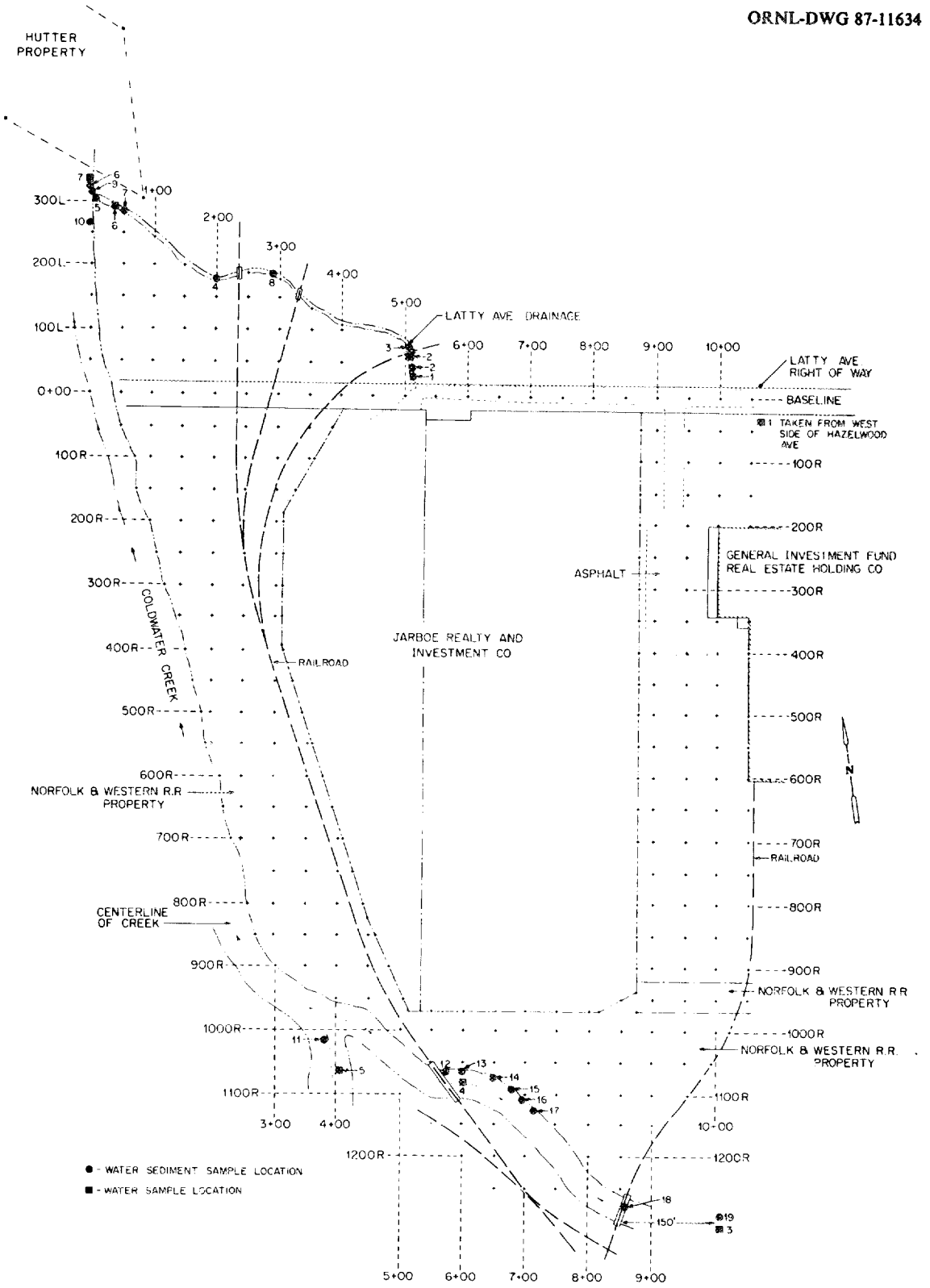

Fig. 4. Locations of sediment and water samples taken at vicinity properties LM003.

Table 1. Applicable guidelines for protection against radiation

Mode of exposure	Exposure conditions	Guideline value	Guideline source
Radionuclide concentrations in soil	Maximum permissible concentration of the following radionuclides in soil above background levels averaged over 100 m^2 area ^{232}Th ^{230}Th ^{228}Ra ^{226}Ra	5 pCi/g averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over 15-cm-thick soil layers, more than 15 cm below the surface	U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management
Radionuclides in water	Maximum permissible concentration of the following radionuclides in water for unrestricted use ^{238}U ^{230}Th ^{226}Ra ^{210}Pb	 4×10^4 pCi/L 2×10^3 pCi/L 30 pCi/L 100 pCi/L	NRC 10 CFR 20.106 Appendix B, Table II
	Maximum contaminant level combined ^{226}Ra and ^{228}Ra in drinking water	5 pCi/L	EPA-National Primary Drinking Water Regulations (40 CFR 141)

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Table 2. Background radiation levels in the St. Louis area

Type of radiation measurement or sample	Radiation level or radionuclide concentration	
	Range	Average
Gamma exposure rate at 1 m above floor or ground surface (μR/h)	5–8	6
Concentration of radionuclides in soil (pCi/g)		
^{238}U	0.33–1.2	0.91
^{226}Ra	0.31–1.3	0.96
^{230}Th[a]	0.33–1.2	0.91

[a] ^{230}Th assumed to be in equilibrium with ^{238}U.

Table 3. Results of gamma exposure rate measurements taken at vicinity properties LM003

Grid location[a]	Grid point measurements[b] (μR/h)		Range of gamma exposure rates during scan of grid block[c] (μR/h)
	Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
0+50, BL	9	9	7–9
1+00, BL	10	10	9–11
1+50, BL	9	10	8–11
2+00, BL	12	12	11–20
2+50, BL	10	10	12–16
3+00, BL	12	12	8–13
3+50, BL	13	13	–
8+50, BL	20	20	22–76
9+00, BL	15	15	10–30
9+50, BL	12	12	16–20
10+00, BL	12	12	15–17
0+50, 50R	9	10	7–10
1+00, 50R	11	10	9–10
1+50, 50R	11	11	8–10
2+00, 50R	12	12	12–20
2+50, 50R	15	16	12–16
3+00, 50R	15	15	8–30
3+50, 50R	11	11	10–12
8+50, 50R	36	36	24–240
9+00, 50R	24	24	10–28
9+50, 50R	24	24	16–24
10+00, 50R	20	20	17–20
10+50, 50R	16	16	–
0+50, 100R	9	10	7–10
1+00, 100R	10	11	9–11
1+50, 100R	11	11	8–10
2+00, 100R	11	12	12–20
2+50, 100R	11	11	11–16
3+00, 100R	14	15	9–20
3+50, 100R	14	15	–
8+50, 100R	150	120	30–400
9+00, 100R	36	34	10–40
9+50, 100R	26	28	24–30
10+00, 100R	20	20	16–20
10+50, 100R	15	15	–
0+50, 150R	9	10	7–10
1+00, 150R	10	11	9–11

Table 3 (continued)

Grid location[a]	Grid point measurements[b] (μR/h)		Range of gamma exposure rates during scan of grid block[c] (μR/h)
	Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
1+50, 150R	10	10	8–11
2+00, 150R	13	14	10–16
2+50, 150R	12	10	11–15
3+00, 150R	11	11	9–12
8+50, 150R	580	740	40–400
9+00, 150R	48	44	16–160
9+50, 150R	32	32	10–50
10+00, 150R	22	22	16–22
10+50, 150R	20	18	–
0+50, 200R	10	9	7–9
1+00, 200R	11	11	9–11
1+50, 200R	11	11	8–11
2+00, 200R	12	12	12–40
2+50, 200R	11	9	9–15
3+00, 200R	11	12	9–12
8+50, 200R	130	200	80–600
9+00, 200R	124	180	20–180
9+50, 200R	24	24	16–24
10+00, 200R	20	22	–
10+50, 200R	14	14	–
0+50, 250R	d	d	–
1+00, 250R	11	11	9–11
1+50, 250R	11	10	11–13
2+00, 250R	12	12	12–14
2+50, 250R	11	11	10–15
3+00, 250R	10	11	10–12
8+50, 250R	100	84	40–600
9+00, 250R	52	48	20–48
9+50, 250R	24	24	14–24
10+00, 250R	13	13	–
10+50, 250R	d	d	–
0+50, 300R	d	d	–
1+24, 300R	10	10	9–11
1+50, 300R	12	12	11–13
2+00, 300R	12	12	12–14
2+50, 300R	10	10	14–30
3+00, 300R	10	10	10–24
8+50, 300R	d	d	40–900
9+00, 300R	32	28	16–40

Table 3 (continued)

Grid location[a]	Grid point measurements[b] (μR/h)		Range of gamma exposure rates during scan of grid block[c] (μR/h)
	Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
9+50, 300R	24	24	16–24
10+00, 300R	14	14	8–16
10+50, 300R	d	d	–
1+00, 350R	d	d	–
1+50, 350R	10	11	12–14
2+00, 350R	13	14	10–14
2+50, 350R	16	20	16–22
3+00, 350R	10	10	11–22
8+50, 350R	d	d	20–500
9+00, 350R	48	48	10–80
9+50, 350R	20	20	16–30
10+00, 350R	20	18	8–18
10+48, 350R	9	9	–
0+50, 400R	d	d	–
1+00, 400R	d	d	–
1+50, 400R	d	d	11–13
2+00, 400R	12	13	8–14
2+50, 400R	18	20	16–22
3+00, 400R	20	20	18–30
8+50, 400R	d	d	60–900
9+00, 400R	48	96	14–96
9+50, 400R	12	10	14–40
10+00, 400R	18	18	12–18
10+48, 400R	18	18	–
1+00, 450R	d	d	–
1+50, 450R	d	d	10–12
2+00, 450R	12	12	8–12
2+50, 450R	14	15	14–18
3+00, 450R	18	18	14–40
8+50, 450R	d	d	40–500
9+00, 450R	90	72	13–72
9+50, 450R	20	18	14–20
10+00, 450R	16	16	11–16
10+48, 450R	12	13	–
1+50, 500R	d	d	10–12
2+00, 500R	12	12	8–12
2+50, 500R	13	13	12–16
3+00, 500R	20	20	13–40
3+46, 500R	16	22	–

Table 3 (continued)

Grid location[a]	Grid point measurements[b] (μR/h)		Range of gamma exposure rates during scan of grid block[c] (μR/h)
	Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
3+50, 500R	d	d	16–30
8+50, 500R	d	d	24–200
9+00, 500R	44	44	14–480
9+50, 500R	18	18	16–20
10+00, 500R	15	15	12–15
10+48, 500R	12	12	–
1+50, 550R	d	d	10
2+00, 550R	12	12	8–12
2+50, 550R	12	13	12–16
3+00, 550R	14	13	12–20
3+50, 550R	24	26	16–26
8+50, 550R	d	d	200–800
9+00, 550R	36	36	13–36
9+50, 550R	18	18	16–20
10+00, 550R	16	16	9–16
10+48, 550R	12	14	–
2+00, 600R	10	10	9–12
2+50, 600R	12	12	12–16
3+00, 600R	13	13	11–22
3+50, 600R	15	15	12–80
8+50, 600R	d	d	16–200
9+00, 600R	24	24	11–24
9+50, 600R	16	16	12–16
10+00, 600R	14	14	9–14
10+48, 600R	11	11	–
2+00, 650R	d	d	7–9
2+50, 650R	11	11	11–13
3+00, 650R	12	12	11–16
3+50, 650R	14	14	12–300
8+50, 650R	d	d	16–200
9+00, 650R	24	20	11–20
9+50, 650R	15	15	12–16
10+00, 650R	14	14	9–14
10+50, 650R	10	10	–
2+50, 700R	11	10	11–13
3+00, 700R	10	12	10–13
3+50, 700R	12	12	12–250
4+00, 700R	60	46	8–160
8+50, 700R	d	d	14–800

Table 3 (continued)

Grid location[a]	Grid point measurements[b] (μR/h)		Range of gamma exposure rates during scan of grid block[c] (μR/h)
	Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
9+00, 700R	16	16	12–16
9+50, 700R	14	14	11–14
10+00, 700R	12	12	9–12
10+50, 700R	9	11	–
2+55, 750R	11	11	10–12
3+00, 750R	10	10	10–12
3+50, 750R	14	14	10–20
4+00, 750R	14	15	10–160
8+50, 750R	60	260	60–260
9+00, 750R	18	16	10–16
9+50, 750R	14	14	11–14
10+00, 750R	12	12	8–12
10+50, 750R	10	10	–
2+50, 800R	d	d	10–12
3+00, 800R	11	11	9–11
3+50, 800R	10	11	8–12
4+00, 800R	14	14	10–120
8+50, 800R	d	d	16–40
9+00, 800R	14	14	10–14
9+50, 800R	12	13	11–13
10+00, 800R	13	12	8–12
10+50, 800R	10	10	–
4+50, 817R	44	60	14–60
2+50, 850R	d	d	10–12
3+00, 850R	10	10	9–11
3+50, 850R	10	10	10–12
4+00, 850R	12	12	12–14
4+50, 850R	16	14	10–60
8+50, 850R	d	d	12–24
9+00, 850R	13	13	11–14
9+50, 850R	12	12	10–12
10+00, 850R	12	12	8–12
10+50, 850R	9	9	–
3+00, 895R	10	10	–
3+00, 900R	d	d	9–11
3+50, 900R	11	10	9–12
4+00, 900R	12	12	12–14
4+50, 900R	12	12	10–400
8+50, 900R	d	d	12–16

Table 3 (continued)

Grid location[a]	Grid point measurements[b] (μR/h)		Range of gamma exposure rates during scan of grid block[c] (μR/h)
	Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
9+00, 900R	14	14	11–14
9+50, 900R	12	12	10–12
10+00, 900R	11	11	8–11
10+50, 900R	8	8	–
3+50, 937R	10	10	–
4+00, 950R	12	12	12–14
4+50, 950R	13	13	10–120
5+50, 950R	d	d	20–260
6+00, 950R	d	d	40–360
6+50, 950R	d	d	150–800
7+00, 950R	d	d	200–800
7+50, 950R	d	d	20–60
8+00, 950R	d	d	14–18
8+50, 950R	d	d	12–16
9+00, 950R	12	13	11–13
9+50, 950R	11	12	10–12
10+00, 950R	10	11	8–11
10+50, 950R	10	10	–
4+50, 1000R	d	d	10–12
5+00, 1000R	12	12	8–200
5+50, 1000R	140	92	20–260
6+00, 1000R	84	84	20–260
6+50, 1000R	90	72	60–200
7+00, 1000R	560	680	40–680
7+50, 1000R	64	64	40–64
8+00, 1000R	24	18	12–18
8+50, 1000R	14	14	9–14
9+00, 1000R	13	12	11–12
9+50, 1000R	10	10	9–12
10+00, 1000R	10	10	8–10
10+21, 1000R	9	9	–
5+00, 1050R	d	d	–
5+50, 1050R	16	12	–
6+00, 1050R	20	184	22–40
6+50, 1050R	60	52	140–200
7+00, 1050R	48	30	16–100
7+50, 1050R	40	68	120–68
8+00, 1050R	14	16	12–16

Table 3 (continued)

Grid location[a]	Grid point measurements[b] (μR/h)		Range of gamma exposure rates during scan of grid block[c] (μR/h)
	Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
8+50, 1050R	12	12	9–12
9+00, 1050R	13	12	10–12
9+50, 1050R	10	10	–
10+00, 1050R	10	10	–
6+00, 1100R	12	13	12–16
6+50, 1100R	d	d	10–14
7+00, 1100R	16	14	12–16
7+50, 1100R	36	38	10–40
8+00, 1100R	13	13	11–13
8+50, 1100R	12	12	9–12
9+00, 1100R	10	10	10–12
9+50, 1100R	10	9	–
6+50, 1150R	15	16	10–20
7+00, 1150R	d	d	8–16
7+50, 1150R	12	12	10–12
8+00, 1150R	12	12	10–13
8+50, 1150R	12	11	9–12
9+00, 1150R	10	10	–
7+00, 1200R	11	11	8–10
7+50, 1200R	d	d	10–12
8+00, 1200R	10	11	10–12
8+50, 1200R	10	10	–
8+00, 1226R	10	11	–
7+50, 1250R	10	9	–
8+00, 1250R	d	d	8–12
8+50, 1250R	9	8	–
8+00, 1300R	9	10	–
0+00, 50L	9	9	9–11
0+50, 50L	9	10	9–11
1+00, 50L	10	10	9–11
1+50, 50L	10	10	10–12
2+00, 50L	8	8	9–14
2+50, 50L	11	11	12–15
0+00, 100L	9	9	9–11
0+50, 100L	10	11	9–11
1+00, 100L	9	10	8–11
1+50, 100L	10	10	9–12
2+00, 100L	8	8	8–13

Table 3 (continued)

Grid location[a]	Grid point measurements[b] (μR/h)		Range of gamma exposure rates during scan of grid block[c] (μR/h)
	Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
2+50, 100L	10	11	12–16
3+00, 100L	10	11	8–15
3+50, 100L	8	7	8–16
4+00, 100L	16	18	16–30
3+50, 133L	9	9	8–20
0+00, 150L	9	9	9–10
0+50, 150L	10	10	9–11
1+00, 150L	10	10	9–11
1+50, 150L	9	9	9–12
2+00, 150L	9	8	8–14
2+50, 150L	12	12	14–20
3+00, 150L	9	10	11–20
2+00, 176L	8	9	8–14
3+00, 178L	12	15	13–24
2+50, 189L	9	10	14–20
0+00, 200L	9	9	9–11
0+50, 200L	9	9	9–10
1+00, 200L	9	9	8–10
1+50, 200L	10	10	8–10
1+00, 243L	9	9	8–11
0+00, 250L	9	10	9–11
0+50, 250L	9	9	8–10
0+50, 279L	9	9	8–10
0+00, 300L	9	9	9–11

[a]Grid location shown on Fig. 1.
[b]Grid point measurements are discrete measurements at each grid point.
[c]Grid block measurements are obtained by a gamma scan of the entire block.
[d]Inaccessible.

Table 4. Results of analyses of surface soil samples taken at vicinity properties LM003

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)		
			^{226}Ra[b]	^{230}Th[c]	^{238}U[d]
		Systematic samples[e]			
S1	8+85, 75R	0–15	2.6 ±0.4	64	2.5
S2	8+88, 170R	0–15	63 ±2	2300	44
S3	9+75, 125R	0–15	3.0 ±0.1	54	2.5
S4	10+25, 75R	0–15	2.6 ±0.1	62	2.2
S5	10+25, 175R	0–15	2.8 ±0.06	64	2.4
S6	9+75, 175R	0–15	7.3 ±0.2	290	6.1
S7	8+75, 406R	0–15	250 ±20	8800	210
S8	9+40, 403R	0–15	18 ±2	650	14
S9	10+25, 425R	0–15	2.7 ±0.2	85	2.9
S10	9+75, 475R	0–15	1.1 ±0.2	19	1.2
S11	9+15, 475R	0–15	2.4 ±0.2	120	2.2
S12	10+25, 525R	0–15	4.1 ±0.1	7.2	4.0
S13	9+75, 575R	0–15	1.3 ±0.2	3.7	1.2
S14	9+25, 625R	0–15	1.4 ±0.08	15	1.7
S15	10+25, 625R	0–15	1.6 ±0.08	29	1.6
S16	9+75, 675R	0–15	1.1 ±0.2	2.9	1.1
S17	9+25, 675R	0–15	0.99 ±0.1	5.1	1.1
S18	9+25, 725R	0–15	1.0 ±0.04	4.2	1.1
S19	10+25, 725R	0–15	1.4 ±0.3	21	1.3
S20	9+75, 775R	0–15	1.3 ±0.2	15	1.2
S21	8+88, 775R	0–15	8.3 ±1	190	3.7
S22	9+25, 825R	0–15	1.7 ±0.4	10	1.1
S23	10+25, 825R	0–15	1.3 ±0.2	6.5	1.2
S24	9+75, 875R	0–15	1.5 ±0.1	5.5	1.2
S25	8+88, 875R	0–15	1.8 ±0.1	39	1.3
S26	9+25, 925R	0–15	1.7 ±0.07	27	1.5
S27	10+00, 950R	0–15	1.4 ±0.2	5.9	1.2
S28	9+00, 1020R	0–15	1.7 ±0.2	16	1.3
S29	9+50, 1050R	0–15	1.5 ±0.3	7.5	1.2
S30	8+50, 1081R	0–15	1.6 ±0.08	20	1.2
S31	8+50, 1240R	0–15	1.3 ±0.1	23	1.1
S32	7+88, 1165R	0–15	2.1 ±1	47	1.3
S33	7+77, 1026R	0–15	1.8 ±0.04	14	1.2
S34	6+93, 1044R	0–15	7.7 ±0.3	53	2.3
S35	5+85, 1034R	0–15	2.4 ±0.2	100	1.9
S36	7+66, 1266R	0–15	1.2 ±0.3	120	1.0
S37	7+00, 1200R	0–15	1.3 ±0.09	44	1.1
S38	6+67, 1150R	0–15	1.4 ±0.08	2.9	1.3

Table 4 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)		
			^{226}Ra[b]	^{230}Th[c]	^{238}U[d]
S39	4+22, 900R	0–15	1.5±0.1	5.7	1.3
S40	3+50, 875R	0–15	1.5±0.2	10	1.2
S41	2+80, 752R	0–15	1.4±0.09	5.0	1.3
S42	3+31, 750R	0–15	1.7±0.3	33	1.6
S43	3+67, 750R	0–15	3.0±0.3	24	2.8
S44	3+27, 595R	0–15	2.1±0.2	22	2.2
S45	2+68, 619R	0–15	1.6±0.1	16	1.5
S46	2+18, 469R	0–15	1.2±0.04	2.5	1.2
S47	2+94, 477R	0–15	6.5±0.07	4.1	6.0
S48	1+89, 371R	0–15	1.9±0.04	41	1.9
S49	1+64, 300R	0–15	1.7±0.1	44	1.6
S50	2+20, 300R	0–15	2.2±0.3	46	2.2
S51	1+92, 158R	0–15	1.6±0.3	19	1.6
S52	1+17, 150R	0–15	1.7±0.05	15	1.5
S53	0+82, 86R	0–15	1.5±0.2	19	1.5
S54	1+70, 65R	0–15	2.0±0.1	24	1.8
S55	0+50, 150L	0–15	1.8±0.2	17	1.8
S56	1+50, 150L	0–15	1.8±0.09	23	1.7
S57	1+00, 243L	0–15	1.7±0.2	32	1.6
S58	0+29, 287L	0–15	1.5±0.2	23	1.5
S59	2+00, 176L	0–15	2.2±0.2	60	1.9
S60	2+00, 123L	0–15	1.8±0.2	28	2.4
S61	3+59, 64L	0–15	2.3±0.1	92	3.1
S62	4+00, 50L	0–15	3.2±0.2	89	3.2
S63	4+08, 84L	0–15	11 ±0.7	430	8.1
S64	4+00, 100L	0–15	9.4±0.5	480	7.5
S65	6+00, 144L	0–15	2.5±0.3	52	2.5
S66	3+02, 178L	0–15	6.2±0.5	180	4.5
S67	2+77, 72L	0–15	2.5±0.2	33	2.5
S68	2+00, 260L	0–15	1.7±0.06	73	1.7
S69	2+50, 50L	0–15	3.8±0.2	3.5	3.3
S70	3+50, 626R	0–15	5.1±0.3	19	4.6
		Biased samples[f]			
B1	5+58, 997R	0–15	240 ±10	6800	140
B2	5+44, 1000R	0–15	230 ±10	9200	190
B3A	6+58, 1041R	0–15	6.1±0.4	160	5.3
B3B	6+58, 1041R	15–30	270 ±9	9700	74
B4	7+33, 1100R	0–15	17 ±0.2	480	5.5
B5	7+50, 1042R	0–15	20 ±0.9	590	3.1
B6	2+44, 217R	0–15	32 ±1	1200	37

Table 4 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)		
			^{226}Ra[b]	^{230}Th[c]	^{238}U[d]
B7	2+57, 334R	0–15	7.1 ± 0.2	18	6.6
B8	3+70, 665R	0–15	92 ± 4	3300	100
B9	3+97, 700R	0–15	250 ± 8	13000	220
B10	5+45, 1025R	0–15	1.0 ± 0.03	38	1.0
B11	5+62, 1037R	0–15	13 ± 0.4	340	12
B12	4+11, 717R	0–15	170 ± 10	4200	180

[a]Locations of soil samples are shown on Fig. 2.

[b]Indicated counting error is at the 95% confidence level ($\pm$ 2σ).

[c]The error of the reported radionuclide concentration is less than $\pm$ 5% (95% confidence level).

[d]Analytical error of measurement results is less than $\pm$ 3% (95% confidence level).

[e]Systematic samples are taken at grid locations irrespective of gamma exposure.

[f]Biased samples are taken from areas shown to have elevated gamma exposure rates.

Table 5. Results of analyses of subsurface soil samples taken at vicinity properties LM003

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{226}Ra[c]	^{230}Th[d]	^{238}U[e]
		Auger samples[f]			
1A	8+09, 1107R	0–15	1.3±0.1	<4.1	1.0
B		15–30	1.4±0.09	<4.1	1.0
C		30–60	1.3±0.3	<2.7	1.1
2A	8+43, 1011R	0–15	1.5±0.1	<2.3	0.35
B		15–30	1.4±0.1	<1.4	1.1
C		30–60	1.4±0.2	<4.5	1.1
3A	9+90, 925R	0–15	1.7±0.05	22	1.3
B		15–30	1.4±0.1	<4.1	1.1
C		30–60	1.2±0.2	<1.4	1.0
4A	8+89, 695R	015	4.3±0.3	95	3.5
B		15–30	6.2±0.3	170	5.4
C		30–45	2.1±0.3	25	1.7
D		45–60	1.4±0.09	12	1.2
5A	8+88, 630R	0–15	7.3±0.3	210	7.4
B		15–30	3.5±0.1	86	4.5
C		30–60	1.7±0.2	20	1.9
D		60–75	1.1±0.1	2.3	1.1
E		75–90	1.3±0.2	1.2	1.1
F		90–120	1.2±0.2	1.3	1.1
G		120–145	1.5±0.09	1.3	1.1
H		145–165	1.5±0.2	1.6	1.1
6A	8+91, 528R	0–15	33 ±1	1,200	32
B		15–30	13 ±1	360	15
C		30–45	1.4±0.4	18	3.0
D		45–60	1.1±0.2	<3.2	1.2
7A	9+12, 528R	0–15	290 ±20	16,000	230
B		15–30	1400 ±60	81,000	990
C		30–45	590 ±50	32,000	430
D		45–60	45 ±1	1,700	36
E		60–75	2.7±0.09	55	4.1
F		75–90	2.1±0.1	31	3.6
G		90–120	2.0±1	14	4.7
H		120–145	2.9±0.1	43	2.2
I		145–175	1.6±0.07	1.2	1.1
8A	8+84, 458R	0–15	690 ±30	38,000	230
B		15–30	41 ±0.9	1,700	35
C		30–45	5.5±0.2	190	7.5

Table 5 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{226}Ra[c]	^{230}Th[d]	^{238}U[e]
8D		45–60	1.5 ±0.07	22	3.5
E		60–75	1.2 ±0.2	1.6	1.6
F		75–90	1.5 ±0.09	2.1	1.2
G		90–120	2.3 ±0.09	4.0	1.5
H	8+84, 458R	120–145	1.5 ±0.1	0.90	1.1
I		145–175	1.4 ±0.2	1.6	1.1
J		175–195	3.5 ±0.2	77	2.7
K		195–215	1.1 ±0.3	1.0	0.93
9A	9+03, 455R	0–15	28 ±3	1,400	26
B		15–30	1.7 ±0.09	15	1.4
C		30–60	1.3 ±0.1	5.0	1.2
10A	9+00, 409R	0–15	27 ±0.7	1,400	23
B		15–30	3.6 ±0.06	150	3.3
C		30–60	1.3 ±0.07	1.7	1.2
11A	6+21, 1037R	0–15	3.3 ±0.2	120	2.6
B		15–30	1.5 ±0.1	15	1.1
C		30–60	1.4 ±0.2	22	1.1
D		60–90	1.1 ±0.08	2.0	1.0
E		90–120	1.1 ±0.2	1.9	1.0
F		120–145	0.97 ±0.2	9.6	0.99
G		145–175	1.2 ±0.09	1.9	0.97
H		175–195	1.1 ±0.06	2.1	1.0
I		195–225	1.1 ±0.2	1.1	1.1
12A	6+26, 1005R	0–15	580 ±10	12,000	230
B		15–30	1300 ±90	21,000	310
C		30–45	150 ±8	4,500	54
D		45–60	5.8 ±0.3	190	16
E		60–75	2.3 ±0.08	1.3	10
F		75–90	21 ±0.9	600	13
G		90–105	9.0 ±0.7	210	12
H		105–120	1.4 ±0.1	26	3.8
I		120–145	4.3 ±0.05	95	3.7
J		145–175	1.6 ±0.3	3.5	2.1
13A	6+26, 1006R	0–15	4.2 ±0.4	72	1.2
B		15–30	1.4 ±0.2	15	1.0
C		30–45	1.9 ±0.08	23	1.1
D		45–60	2.2 ±0.2	54	1.7
E		60–90	1.4 ±0.2	7.1	1.1
F		90–120	1.4 ±0.2	8.9	1.1

Table 5 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{226}Ra[c]	^{230}Th[d]	^{238}U[e]
13G		120–145	1.1 ± 0.1	1.4	0.94
H		145–175	1.1 ± 0.2	6.3	0.94
14A	6+95, 998R	0–15	210 ± 9	2,700	21
B		15–30	20 ± 1	590	3.8
C		30–45	22 ± 1	680	3.2
D		45–60	5.8 ± 0.1	170	1.5
E		60–75	5.3 ± 0.1	140	1.7
F		75–90	6.7 ± 0.3	200	1.6
14G	6+95, 998R	90–120	1.6 ± 0.09	13	1.0
H		120–145	22 ± 0.6	430	2.4
I		145–175	1.2 ± 0.2	<1.0	0.99
15A	6+84, 1065R	0–30	250 ± 7	4,500	41
B		30–45	11 ± 0.2	290	4.8
C		45–60	3.0 ± 0.1	63	2.1
D		60–75	5.4 ± 0.3	130	7.1
E		75–90	9.6 ± 0.6	220	13
F		90–120	1.6 ± 0.1	21	2.7
G		120–145	1.4 ± 0.2	4.9	1.3
H		145–175	1.3 ± 0.08	2.0	1.5
16A	7+32, 1046R	0–30	65 ± 1	1,800	8.3
B		30–45	2.2 ± 0.2	44	1.2
C		45–60	1.4 ± 0.2	20	1.1
D		60–90	1.1 ± 0.2	1.6	0.97
E		90–120	1.1 ± 0.1	2.7	1.1
F		120–145	3.0 ± 0.1	66	1.3
G		145–175	1.2 ± 0.3	1.9	1.0
17A	7+51, 1097R	0–30	5.7 ± 0.1	130	2.3
B		30–45	1.9 ± 0.09	38	1.2
C		45–60	1.5 ± 0.1	17	1.2
D		60–90	1.2 ± 0.2	3.5	1.1
E		90–120	1.3 ± 0.2	2.1	1.0
F		120–145	1.1 ± 0.1	3.0	0.96
G		145–175	1.0 ± 0.1	0.81	0.92
18A	7+41, 993R	0–30	15 ± 0.3	450	3.5
B		30–45	4.0 ± 0.2	90	1.8
C		45–60	5.3 ± 0.2	120	3.0
D		60–90	2.3 ± 0.09	26	1.2
E		90–120	2.3 ± 0.1	30	1.2
F		120–145	1.6 ± 0.03	7.1	1.1
G		145–175	1.4 ± 0.06	3.9	1.2

Table 5 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{226}Ra[c]	^{230}Th[d]	^{238}U[e]
19A	4+86, 944R	0–30	300 ±8	17,000	300
B		30–45	17 ±0.5	860	14
C		45–60	1.6 ±0.1	17	1.9
20A	4+37, 819R	0–30	4.0 ±0.09	120	4.2
B		30–60	1.1 ±0.2	3.7	1.2
21A	3+83, 670R	0–30	260 ±6	15,000	220
B		30–60	7.2 ±0.2	230	9.2
C		60–90	1.1 ±0.2	1.9	1.1
D		90–120	1.2 ±0.2	2.7	1.1
E		120–145	1.5 ±0.07	1.0	1.1
F		145–175	1.3 ±0.2	1.4	1.0
22A	3+34, 513R	0–30	4.7 ±0.2	190	3.6
B		30–60	1.3 ±0.2	<3.2	1.1
23A	3+25, 515R	0–30	3.0 ±0.2	59	2.3
B		30–60	1.1 ±0.1	17	0.99
C		60–90	1.2 ±0.07	0.70	1.1
D		90–120	1.3 ±0.1	1.3	1.1
E		120–145	1.2 ±0.2	0.62	1.1
F		145–175	1.3 ±0.1	0.76	1.0
24A	3+18, 517R	0–30	2.2 ±0.3	4.4	1.8
B		30–60	2.2 ±0.1	<3.2	2.6
25A	3+02, 523R	0–30	2.7 ±0.3	15	2.5
B		30–60	1.2 ±0.1	<3.6	1.1
26A	4+79, 948R	0–30	10 ±0.6	420	9.3
B		30–60	0.93 ±0.3	<3.2	1.0
27A	4+24, 820R	0–30	1.6 ±0.1	32	1.5
B		30–60	1.1 ±0.2	<3.2	1.1
28A	3+75, 674R	0–30	2.6 ±0.2	77	2.6
B		30–60	1.1 ±0.07	<3.6	1.1
29A	2+15, 557R	0–30	1.4 ±0.2	5.9	1.1
B		30–60	1.4 ±0.1	4.2	1.1
30A	2+94, 698R	0–30	1.8 ±0.2	19	1.6
B		30–60	1.3 ±0.3	4.3	1.2
31A	3+66, 699R	0–30	3.7 ±0.1	7.7	3.5
B		30–60	1.2 ±0.04	<3.2	1.2
32A	3+44, 684R	0–30	1.5 ±0.1	6.8	1.4
B		30–60	1.2 ±0.1	<4.1	1.1
33A	4+05, 826R	0–30	5.2 ±0.4	4.3	4.6
B		30–60	1.2 ±0.2	<4.1	1.3

Table 5 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{226}Ra[c]	^{230}Th[d]	^{238}U[e]
34A	3+55, 842R	0–15	1.6±0.1	15	1.2
B		15–30	1.5±0.1	6.8	1.3
C		30–60	1.2±0.1	<2.7	1.1
35A	3+00, 862R	0–30	1.3±0.09	8.1	1.2
B		30–60	1.3±0.2	6.3	1.1
36A	4+74, 950R	0–30	1.1±0.06	11	1.3
B		30–60	1.2±0.2	<3.6	1.1
37A	4+65, 956R	0–30	5.5±0.6	<2.7	4.9
B		30–60	2.3±0.1	<3.2	2.4
38A	4+41, 970R	0–30	1.5±0.1	6.8	1.2
B		30–60	1.7±0.1	23	1.4
C		60–90	1.4±0.2	7.8	1.3
D		90–120	1.2±0.2	<0.50	1.0
39A	2+85, 402R	0–30	1.3±0.09	320	7.3
B		30–60	8.5±0.4	<4.1	1.1
40A	2+73, 407R	0–30	4.4±0.3	5.4	4.3
B		30–60	1.5±0.1	<3.2	1.5
41A	1+23, 100R	0–30	1.6±0.2	19	1.3
B		30–60	1.3±0.1	<4.1	1.1
42A	1+92, 100R	0–30	1.2±0.2	5.4	1.2
B		30–60	1.2±0.08	<2.7	1.1
43A	1+00, 77L	0–15	1.3±0.1	8.1	1.2
B		15–30	1.2±0.3	<4.1	1.1
C		30–60	1.1±0.1	<2.3	1.1
44A	1+50, 83L	0–15	1.2±0.2	5.0	1.1
B		15–30	1.1±0.2	<3.2	1.0
C		30–60	1.1±0.1	<3.6	1.0
45A	2+00, 74L	0–15	1.5±0.2	21	1.4
B		15–30	1.2±0.04	<4.1	1.1
C		30–60	1.2±0.04	<3.6	1.1
46A	2+00, 161L	0–15	1.4±0.5	16	1.4
B		15–30	1.2±0.2	9.9	1.2
C		30–60	1.1±0.08	<2.3	0.99
47A	1+50, 175L	0–15	1.2±0.2	6.3	1.1
B		15–30	1.1±0.1	<3.2	1.1
C		30–60	1.3±0.08	4.5	1.2
48A	0+72, 180L	0–15	1.5±0.1	12	1.4
B		15–30	1.2±0.1	<4.0	1.2
C		30–60	1.3±0.2	<0.90	1.3

Table 5 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{226}Ra[c]	^{230}Th[d]	^{238}U[e]
49A	0+13, 183L	0–15	1.3±0.1	<1.8	1.1
B		15–30	1.2±0.04	<2.7	0.97
C		30–60	1.3±0.4	3.5	1.2
50A	0+23, 270L	0–15	1.4±0.07	5.9	1.3
B		15–30	1.2±0.2	4.5	1.2
C		30–60	1.2±0.3	0.71	1.2
51A	1+67, 237R	0–15	1.3±0.1	1.5	1.1
B		15–30	1.3±0.1	1.0	1.1
C		30–60	1.4±0.2	3.0	1.1
52A	2+33, 234R	0–15	2.9±0.08	6.9	2.7
B		15–30	2.4±0.3	5.8	2.3
C		30–60	2.5±0.4	1.9	2.3
53A	2+87, 97R	0–15	1.5±0.2	9.8	1.3
B		15–30	1.2±0.2	0.71	1.1
C		30–60	1.4±0.1	1.3	1.1
54A	3+79, 70L	0–15	2.4±0.2	55	2.7
B		15–30	1.0±0.2	1.9	1.0
C		30–60	1.1±0.2	1.7	1.0
55A	2+32, 417R	0–15	1.6±0.1	14	1.4
B		15–30	1.3±0.1	5.3	1.1
C		30–60	1.3±0.07	0.90	1.2
56A	4+51, 814R	0–15	2.3±0.03	26	3.0
B		15–30	4.1±0.1	84	5.9
C		30–60	3.7±0.04	36	7.5
D		60–90	1.6±0.08	4.6	5.8
E		90–120	1.5±0.2	0.60	1.1
F		120–145	1.3±0.1	0.84	1.0
G		145–175	1.4±0.1	1.6	1.1
57A	3+95, 665R	0–15	17 ±0.2	860	18
B		15–30	14 ±0.5	580	16
C		30–60	3.5±0.1	49	10
D		60–90	1.3±0.2	1.2	1.8
E		90–120	1.4±0.2	1.0	2.0
F		120–145	1.2±0.1	2.2	1.9
G		145–175	1.2±0.1	1.8	1.3
58A	3+43, 510R	0–15	6.4±0.4	69	6.7
B		15–30	1.5±0.09	1.4	2.1
C		30–60	1.3±0.3	3.6	1.7

Table 5 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{226}Ra[c]	^{230}Th[d]	^{238}U[e]
59A	3+02, 400R	0–15	2.1 ±0.08	47	2.0
B		15–30	1.3 ±0.1	0.80	1.1
C		30–60	1.4 ±0.1	1.6	1.1
60A	9+24, 73R	0–10	1.1 ±0.1	27	1.1
B		10–30	1.1 ±0.1	0.92	1.0
C		30–60	0.90±0.1	5.4	0.90
61A	9+23, 189R	0–5	2.5 ±0.2	120	2.0
B		5–30	1.0 ±0.07	9.5	1.0
C		30–60	1.1 ±0.2	1.8	1.1
62A	8+89, 273R	0–8	2.0 ±0.3	120	1.6
B		8–23	1.0 ±0.1	9.8	1.2
C		23–60	1.3 ±0.2	0.84	1.2
63A	9+34, 273R	0–10	2.3 ±0.1	130	1.9
B		10–30	0.92±0.04	10	0.99
C		30–60	1.4 ±0.09	2.3	1.1
64A	8+89, 350R	0–8	1.3 ±0.08	58	1.6
B		8–20	1.0 ±0.1	2.4	1.3
C		20–30	1.2 ±0.1	1.4	1.5
D		30–60	1.3 ±0.1	0.93	1.1
65A	9+77, 399R	0–8	1.3 ±0.06	26	1.3
B		8–30	0.70±0.09	1.8	0.79
C		30–60	1.4 ±0.5	1.0	1.1
66A	9+86, 385R	0–15	7.8 ±0.1	300	6.4
B		15–30	1.5 ±0.1	8.5	1.2
C		30–60	1.4 ±0.2	4.6	1.1
67A	10+34, 386R	0–15	1.5 ±0.06	14	1.3
B		15–30	1.2 ±0.2	17	1.1
C		30–60	1.3 ±0.1	34	1.1
D		60–90	1.4 ±0.3	1.2	1.1
E		90–120	1.3 ±0.1	1.2	1.0
68A	9+75, 68R	0–15	2.5 ±0.1	52	2.2
B		15–30	1.2 ±0.3	4.8	1.2
C		30–60	1.2 ±0.2	4.1	1.2
69A	10+15, 124R	0–15	1.7 ±0.1	23	1.7
B		15–30	1.3 ±0.2	2.5	1.3
C		30–60	1.3 ±0.2	4.3	1.1
70A	9+61, 192R	0–15	11 ±0.2	510	9.7
B		15–30	1.2 ±0.05	2.1	1.3
C		30–60	1.3 ±0.04	1.2	1.2

Table 5 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{226}Ra[c]	^{230}Th[d]	^{238}U[e]
71A	9+52, 125R	0–15	2.2 ±0.05	23	2.4
B		15–30	1.3 ±0.1	15	1.2
C		30–60	1.3 ±0.1	4.6	1.2
72A	9+11, 210R	0–10	17 ±0.06	1,000	21
B		10–25	3.1 ±0.3	130	3.8
C		25–60	1.2 ±0.1	5.3	1.1
73A	9+00, 177R	0–15	72 ±4	3,300	69
B		15–30	4.1 ±0.2	250	5.4
C		30–60	1.2 ±0.1	1.7	1.2
74A	9+12, 126R	0–15	4.1 ±0.3	98	4.3
B		15–30	1.4 ±0.05	7.6	1.4
C		30–60	1.1 ±0.2	7.7	1.2
75A	9+00, 78R	0–15	1.7 ±0.1	24	1.6
B		15–30	1.2 ±0.05	3.4	1.2
C		30–60	0.99 ±0.2	4.8	1.0
76A	10+29, 531R	0–15	1.6 ±0.2	8.0	1.3
B		15–30	1.2 ±0.2	2.4	1.1
C		30–60	1.2 ±0.2	0.81	1.1
77A	9+67, 454R	0–15	1.3 ±0.2	1.5	1.1
B		15–30	1.3 ±0.07	0.89	1.1
C		30–60	1.3 ±0.2	6.8	1.1
78A	9+56, 406R	0–15	13 ±0.4	360	10
B		15–30	1.7 ±0.1	26	1.7
C		30–60	1.3 ±0.2	3.1	1.2
79A	9+20, 457R	0–15	1.2 ±0.2	4.9	1.1
B		15–30	1.1 ±0.2	2.0	1.1
C		30–60	1.3 ±0.2	1.0	1.1
80A	9+65, 529R	0–15	1.2 ±0.2	2.6	1.1
B		15–30	1.3 ±0.07	1.1	1.1
C		30–60	1.4 ±0.1	1.2	1.1
81A	9+69 698R	0–15	1.2 ±0.2	4.1	1.1
B		15–30	1.5 ±0.2	1.7	1.1
C		30–60	1.3 ±0.1	3.5	1.1
82A	9+85, 800R	0–15	1.2 ±0.2	3.5	1.1
B		15–30	1.1 ±0.04	1.3	1.2
C		30–60	1.2 ±0.1	0.89	1.2
83A	9+24, 800R	0–15	1.4 ±0.08	1.4	1.2
B		15–30	1.1 ±0.2	1.8	1.1
C		30–60	1.2 ±0.2	3.4	1.2

Table 5 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{226}Ra[c]	^{230}Th[d]	^{238}U[e]
84A	9+50, 994R	0–15	1.3±0.09	1.3	1.1
B		15–30	1.4±0.08	0.71	1.1
C		30–60	1.3±0.2	1.2	1.1
D		60–90	1.2±0.1	0.81	1.2
E		90–120	1.3±0.2	0.39	1.1
85A	9+00, 1103R	0–15	1.1±0.2	2.2	1.0
B		15–30	1.1±0.1	<0.50	0.95
C		30–60	1.1±0.2	<0.50	1.1
D		60–90	1.2±0.1	<0.50	1.1
E		90–120	1.2±0.2	1.4	1.1
86A	8+29, 1173R	0–15	1.3±0.3	0.91	1.1
B		15–30	1.3±0.2	1.6	1.1
C		30–60	1.4±0.1	1.2	1.1
D		60–90	1.2±0.3	<0.50	1.1
E		90–120	1.3±0.1	0.70	1.1

[a]Locations of soil samples are shown on Fig. 3.

[b]A value preceded by a "<" sign is the minimum detectable activity (MDA) at the 95% confidence level.

[c]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).

[d]The error of the reported radionuclide concentration is less than ($\pm 5\%$ (95% confidence level).

[e]Analytical error of measurement results is less than $\pm 3\%$ (95% confidence level).

[f]Auger samples are those taken from holes drilled to further define the depth and extent of tailings material. Holes may be drilled in either contaminated or uncontaminated regions.

Table 6. Extent of subsurface contamination at vicinity properties LM003 as indicated by scintillation probe loggings and sample analyses

Hole	Location[a]	Depth of hole (m)	Estimated vertical extent of contaminated soil[b] (m)	Region of maximum contamination (m)	Radionuclide concentration in region of maximum contamination[c] (pCi/g)		
					^{226}Ra[d]	^{230}Th[e]	^{238}U[f]
1	8+09, 1107R	2.2	None				
2	8+43, 1011R	2.6	None				
3	9+90, 925R	2.2	0–0.15	0–0.15	1.7±0.05	22	1.3
4	8+89, 695R	1.6	0–0.45	0.15–0.3	6.2±0.3	170	5.4
5	8+88, 630R	1.6	0–0.6	0–0.15	7.3±0.3	210	7.4
6	8+91, 528R	1.8	0–0.45	0–0.15	33 ±1	1,200	32
7	9+12, 528R	1.8	0–1.45	0.15–0.3	1400 ±60	81,000	990
8	8+84, 458R	2.2	0–2	0–0.15	690 ±30	38,000	230
9	9+03, 455R	2.2	0–0.3	0–0.15	28 ±3	1,400	26
10	9+00, 409R	1.8	0–0.3	0–0.15	27 ±0.7	1,400	23
11	6+21, 1037R	2.2	0–0.6	0–0.15	3.3±0.2	120	2.6
12	6+26, 1005R	1.8	0–1.45	0.15–0.3	1300 ±90	21,000	310
13	6+26, 1006R	1.8	0–0.6	0–0.15	4.2±0.4	72	1.2
14	6+95, 998R	1.8	0–1.4	0–0.15	210 ±9	2,700	21
15	6+84, 1065R	1.8	0–1.2	0–0.3	250 ±7	4,500	41
16	7+32, 1046R	1.8	0–1.4	0–0.3	65 ±1	1,800	8.3
17	7+51, 1097R	1.8	0–0.6	0–0.3	5.7±0.1	130	2.3
18	7+41, 993R	1.8	0–1.2	0–0.3	15 ±0.3	450	3.5
19	4+86, 944R	2.6	0–0.6	0–0.3	300 ±8	17,000	300
20	4+37, 819R	2.2	0–0.3	0–0.3	4 ±0.09	120	4.2
21	3+83, 670R	1.8	0–0.6	0–0.3	260 ±6	15,000	220
22	3+34, 513R	1.8	0–1.8	0–0.3	4.7±0.2	190	3.6
23	3+25, 515R	1.8	0–0.6	0–0.3	3.0±0.2	59	2.3
24	3+18, 517R	1.8	0–1.8		(Hole not sampled at region of maximum contamination)		
25	3+02, 523R	1.8	0–0.3	0–0.3	2.7±0.3	15	2.5
26	4+79, 948R	2.6	0–0.3	0–0.3	10 ±0.6	420	9.3
27	4+24, 820R	2.0	0–0.3	0–0.3	1.6±0.1	32	1.5
28	3+75, 674R	1.8	0–0.3	0–0.3	2.6±0.2	77	2.6
29	2+15, 557R	1.2	0–0.3	0–0.3	1.4±0.2	5.9	1.1
30	2+94, 698R	1.8	0–0.3	0–0.3	1.8±0.2	19	1.6
31	3+66, 699R	1.8	0–0.3	0–0.3	3.7±0.1	7.7	3.5
32	3+44, 684R	1.6	0–0.3	0–0.3	1.5±0.1	6.8	1.4
33	4+05, 826R	1.8	0–0.3	0–0.3	5.2±0.4	4.3	4.6
34	3+55, 842R	1.4	0–0.15	0–0.15	1.6±0.1	15	1.2
35	3+00, 862R	1.8	0–0.3	0–0.3	1.3±0.09	8.1	1.2
36	4+74, 950R	2.4	0–0.3	0–0.3	1.1±0.06	11	1.3
37	4+65, 956R	1.2	0–0.3	0–0.3	5.5±0.6	<2.7	4.9
38	4+41, 970R	1.2	0–0.6	0.3–0.6	1.7±0.1	23	1.4
39	2+85, 402R	1.8	0–0.6	0–0.3	1.3±0.09	320	7.3
40	2+73, 407R	1.2	0–0.3	0–0.3	4.4±0.3	5.4	4.3
41	1+23, 100R	1.2	0–0.3	0–0.3	1.6±0.2	19	1.3
42	1+92, 100R	1.2	0–0.3	0–0.3	1.2±0.2	5.4	1.2
43	1+00, 77L	1.2	0–0.15	0–0.15	1.3±0.1	8.1	1.2
44	1+50, 83L	1.2	0–0.15	0–0.15	1.2±0.2	5	1.1
45	2+00, 74L	1.2	0–0.15	0–0.15	1.5±0.2	21	1.4
46	2+00, 161L	1.2	0–0.15	0–0.15	1.4±0.5	16	1.4

Table 6 (continued)

Hole	Location[a]	Depth of hole (m)	Estimated vertical extent of contaminated soil[b] (m)	Region of maximum contamination (m)	Radionuclide concentration in region of maximum contamination[c] (pCi/g)		
					^{226}Ra[d]	^{230}Th[e]	^{238}U[f]
47	1+50, 175L	1.2	0–0.15	0–0.15	1.2±0.2	6.3	1.1
48	0+72, 180L	1.2	0–0.15	0–0.15	1.5±0.1	12	1.4
49	0+13, 183L	1.2	None				
50	0+23, 270L	1.2	0–0.15	0–0.15	1.4±0.07	5.9	1.3
51	1+67, 237R	1.2	None				
52	2+33, 234R	1.8	0–0.15	0–0.15	2.9±0.08	6.9	2.7
53	2+87, 97R	1.8	0–0.15	0–0.15	1.5±0.2	9.8	1.3
54	3+79, 70L	1.2	0–0.15	0–0.15	2.4±0.2	55	2.7
55	2+32, 417R	1.2	0–0.15	0–0.15	1.6±0.1	14	1.4
56	4+51, 814R	1.8	0–0.6	0.15–0.3	4.1±0.1	84	5.9
57	3+95, 665R	1.8	0–0.6	0–0.15	17 ±0.2	860	18
58	3+43, 510R	1.8	0–0.15	0–0.15	6.4±0.4	69	6.7
59	3+02, 400R	1.8	0–0.15	0–0.15	2.1±0.08	47	2
60	9+24, 73R	1.2	0–0.1	0–0.1	1.1±0.1	27	1.1
61	9+23, 189R	1.2	0–0.05	0–0.05	2.5±0.2	120	2
62	8+89, 273R	1.8	0–0.08	0–0.08	2 ±0.3	120	1.6
63	9+34, 273R	1.8	0–0.1	0–0.1	2.3±0.1	130	1.9
64	8+89, 350R	1.6	0–0.08	0–0.08	1.3±0.08	58	1.6
65	9+77, 399R	1.8	0–0.08	0–0.08	1.3±0.06	26	1.3
66	9+86, 385R	1.8	0–0.15	0–0.15	7.8±0.1	300	6.4
67	10+34, 386R	1.2	0–0.6	0.3–0.6	1.3±0.1	34	1.1
68	9+75, 68R	1.2	0–0.15	0–0.15	2.5±0.1	52	2.2
69	10+15, 124R	1.2	0–0.15	0–0.15	1.7±0.1	23	1.7
70	9+61, 192R	1.2	0–0.15	0–0.15	11 ±0.2	510	9.7
71	9+52, 125R	1.2	0–0.3	0–0.15	2.2±0.05	23	2.4
72	9+11, 210R	1.2	0–0.25	0–0.1	17 ±0.6	1,000	21
73	9+00, 177R	1.2	0–0.3	0–0.15	72 ±4	3,300	69
74	9+12, 126R	1.2	0–0.15	0–0.15	4.1±0.3	98	4.3
75	9+00, 78R	1.2	0–0.15	0–0.15	1.7±0.1	24	1.6
76	10+29, 531R	1.2	0–0.15	0–0.15	1.6±0.2	8	1.3
77	9+67, 454R	1.2	None				
78	9+56, 406R	1.2	0–0.3	0–0.15	13 ±0.4	360	10
79	9+20, 457R	1.2	None				
80	9+65, 529R	1.2	None				
81	9+69, 698R	1.2	None				
82	9+85, 800R	1.2	None				
83	9+24, 800R	1.2	None				
84	9+50, 994R	1.2	None				
85	9+00, 1103R	1.2	None				
86	8+29, 1173R	1.2	None				

[a]See Fig. 3 for location.

[b]Contaminated soil is defined as soil having concentrations of ^{226}Ra or ^{230}Th equal to or greater than the criteria given in Table 1; or giving rise to 1,000 cpm or more on the shielded scintillator.

[c]A value preceded by a "<" sign is the minimum detectable activity (MDA) at the 95% confidence level.

[d]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).

[e]The error of the reported radionuclide concentration is less than ±5% (95% confidence level).

[f]The total analytical error is less than ±3% (95% confidence level).

Table 7. Results of analyses of sediment and water samples taken at vicinity properties LM003

Sample[a]	Radionuclide concentration[b]			
	^{210}Pb	^{226}Ra[c]	^{230}Th[d]	^{238}U[e]
	Sediment samples (pCi/g)[f]			
1	g	21 ±2	1100	17
2	g	170 ±10	8100	150
3	g	5.5±0.5	77	2.1
4	g	2.7±0.3	40	1.4
5	g	1.9±0.06	54	1.6
6	g	4.9±0.2	130	2.6
7	g	160 ±20	6800	190
8	g	5.7±0.3	280	4.8
9	g	15 ±0.7	700	11
10	g	1.5±0.1	15	1.3
11	g	1.9±0.1	9.7	1.1
12	g	3.9±0.2	91	5.0
13	g	4.3±0.2	110	4.9
14	g	1.3±0.08	2.9	0.96
15	g	1.2±0.2	1.3	0.95
16	g	8.0±0.4	300	4.5
17	g	1.7±0.2	1.6	0.93
18	g	2.1±0.1	2.2	0.88
19	g	2.5±0.2	3.6	0.99
	Water samples (pCi/L)[f]			
1	7.3 ±4.6	<0.54	1.1±1.9	<0.67
2	1.4 ±3	<0.54	1.1±2.2	<0.67
3	2.7 ±2.7	<0.27	3.2±1.1	<1.67
4	2.7 ±2.7	<0.27	<1.1	<1.33
5	0.27±2.7	<0.27	1.4±2.4	<2
6	1.9 ±3.2	<0.27	1.4±2.4	<2
7	<2.4	<0.27	<1.1	<3

[a]Locations of samples are shown on Fig. 4.

[b]A value preceded by a "<" sign is the minimum detectable activity (MDA) at the 95% confidence level.

[c]Indicated counting error is at the 95% confidence level ($\pm 2\ \sigma$).

[d]The error of the reported radionuclide concentration is ±5% (95% confidence level).

[e]Total error of measurement results is less than ±5% (95% confidence level).

[f]Water and sediment samples are taken at locations irrespective of gamma exposure.

[g]Not analyzed.

Table 8. Summary of measurements and sample results at vicinity properties LM003

Measurement or sample type	Number of measurements/ samples	Range	Mean
Gamma exposure rate at 1 m (μR/h)[a]	235	8–560	19
Gamma exposure rate at surface (μR/h)[a]	235	7–680	21
Scan, gamma exposure rate near surface (μR/h)[b]	–	7–900	–
Concentration of ^{226}Ra in surface soil (pCi/g), systematic locations[c]	70	0.99–250	7.2
Concentration of ^{230}Th in surface soil (pCi/g), systematic locations[c]	70	2.9–8,800	220
Concentration of ^{238}U in surface soil (pCi/g), systematic locations[c]	70	1.0–210	5.9
Concentration of ^{226}Ra in surface soil (pCi/g), biased locations[c]	13	1.0–270	100
Concentration of ^{230}Th in surface soil (pCi/g), biased locations[c]	3	18–13,000	3,800
Concentration of ^{238}U in surface soil (pCi/g), biased locations[c]	3	1.0–220	75
Maximum ^{226}Ra concentration in soil from auger holes, (pCi/g)[d]	86	1.1–1,400	–
Maximum ^{230}Th concentration in soil from auger holes, (pCi/g)[d]	86	1.3–81,000	–
Maximum ^{238}U concentration in soil from auger holes, (pCi/g)[d]	86	1.1–990	–
Concentration of ^{226}Ra in sediment, (pCi/g)[e]	19	1.2–170	22

Table 8 (continued)

Measurement or sample type	Number of measurements/ samples	Range	Mean
Concentration of ^{230}Th in sediment, (pCi/g)[e]	19	1.3–8,100	940
Concentration of ^{238}U in sediment, (pCi/g)[e]	19	0.88–190	21
Concentration of ^{226}Ra in drainage water, (pCi/L)[e]	7	<0.27–<0.54	0.35
Concentration of ^{230}Th in drainage water, (pCi/L)[e]	7	<1.1–3.2	1.5
Concentration of ^{238}U in drainage water, (pCi/L)[e]	7	<0.67–3	1.6
Concentration of ^{210}Pb in drainage water, (pCi/L)[e]	7	0.27–7.3	2.7

[a]At grid points.
[b]Scan of entire property.
[c]Systematic and biased samples, Table 4.
[d]Auger hole samples, Table 5.
[e]Water and sediment samples, Table 7.

APPENDIX

GAMMA PROFILE GRAPHS OF AUGER HOLES AT PROPERTY LM003

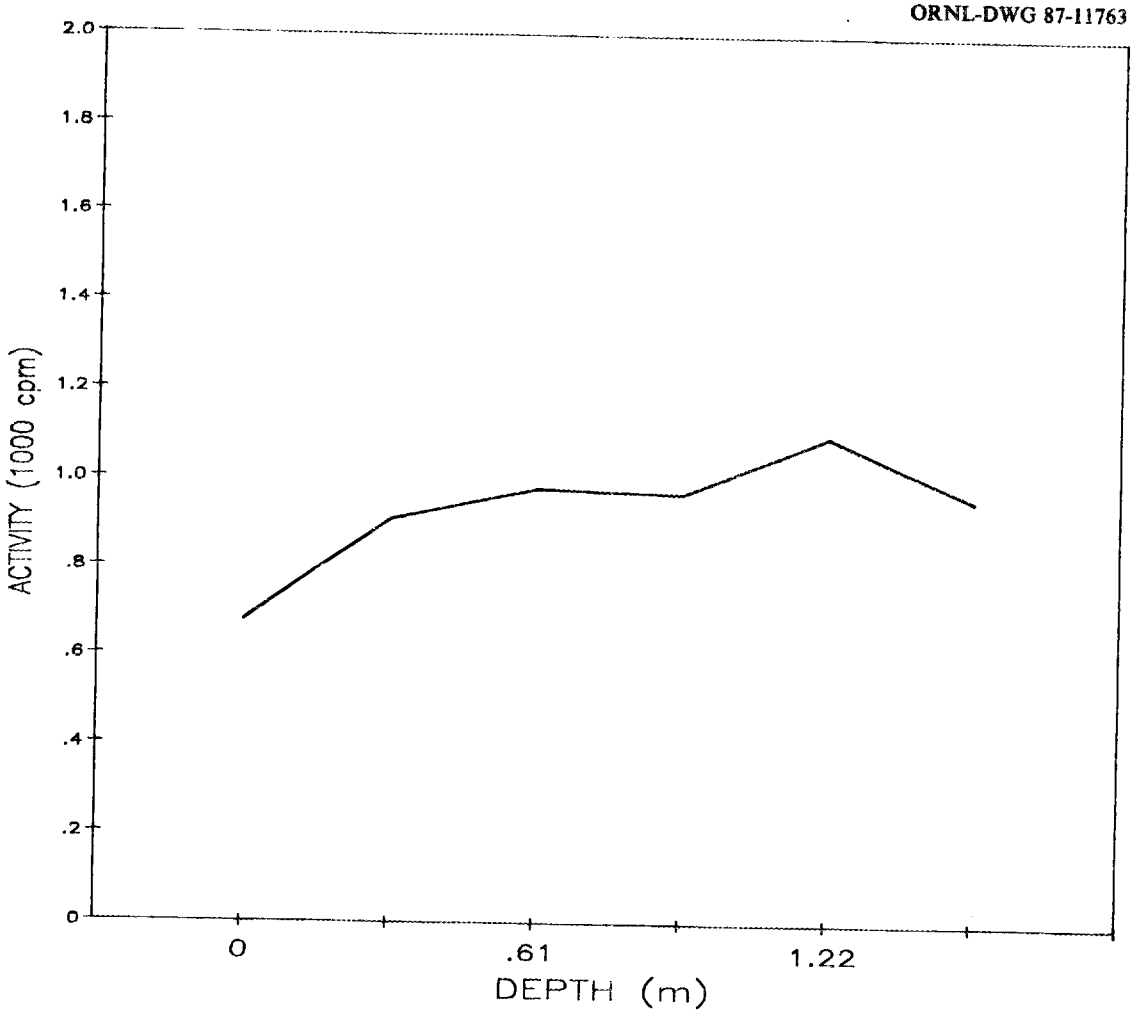

Fig. A.1. Gamma profile of auger hole 1.

ORNL-DWG 87-11764

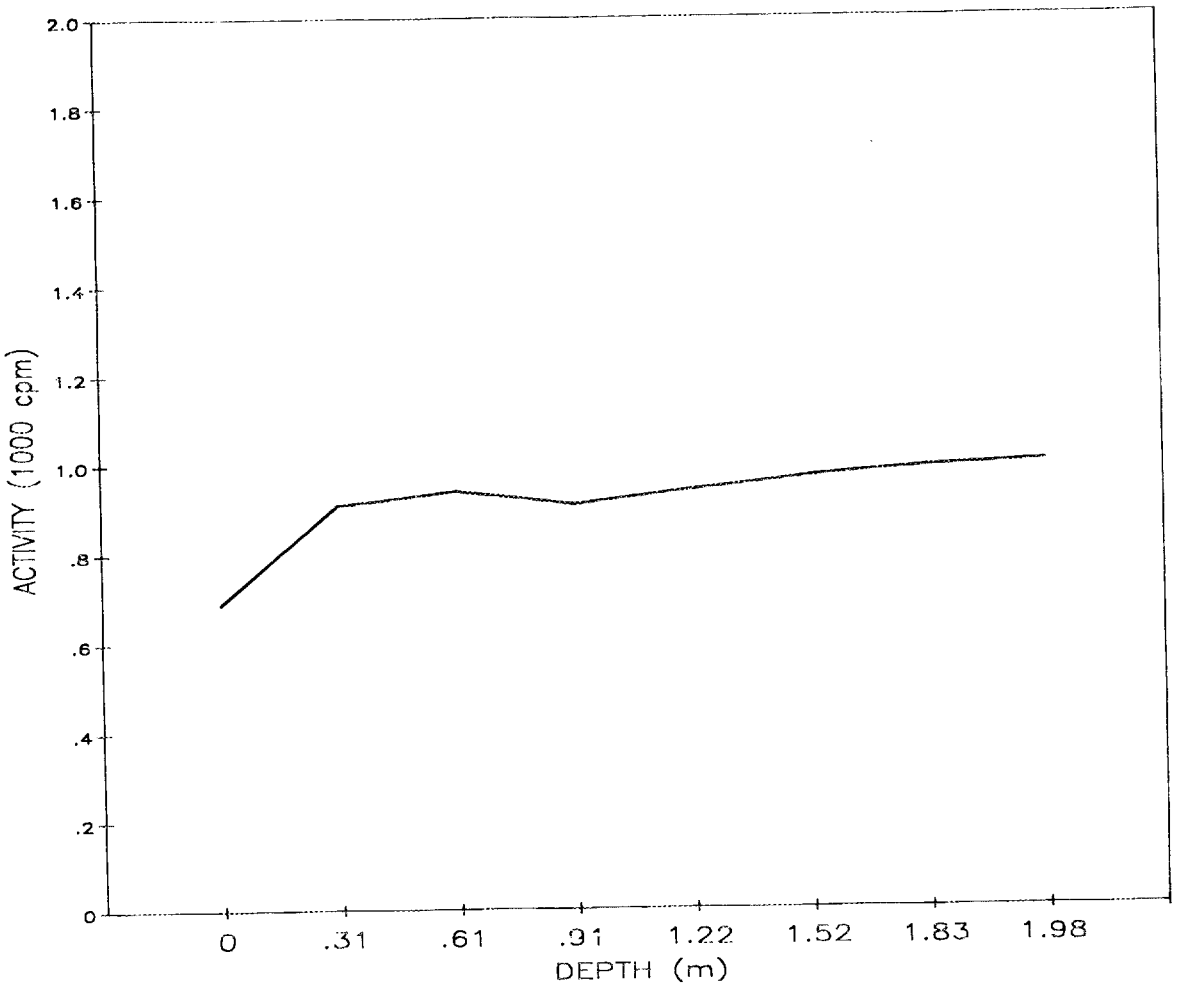

Fig. A.2. Gamma profile of auger hole 2.

ORNL-DWG 87-11765

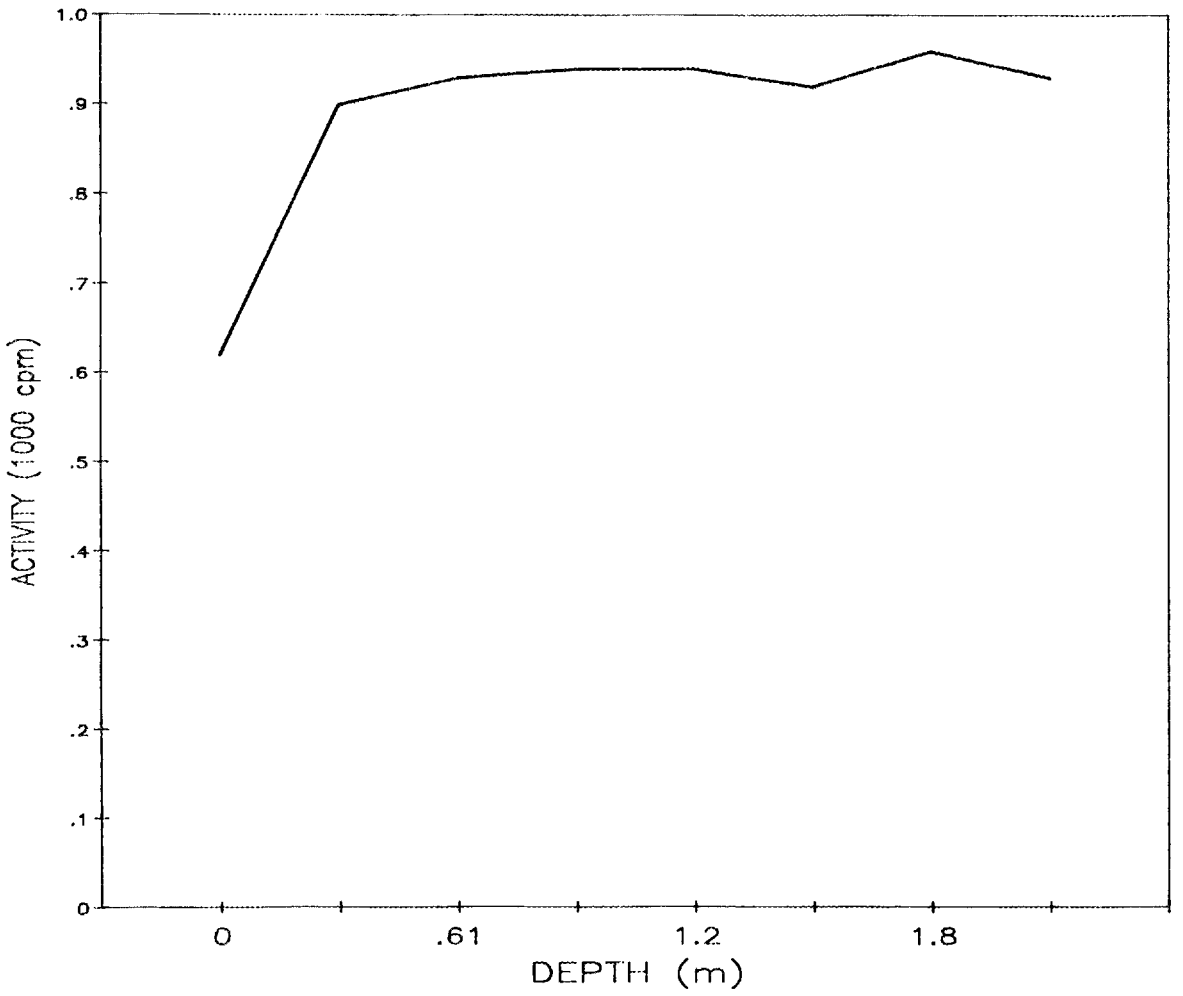

Fig. A.3. Gamma profile of auger hole 3.

ORNL-DWG 87-11766

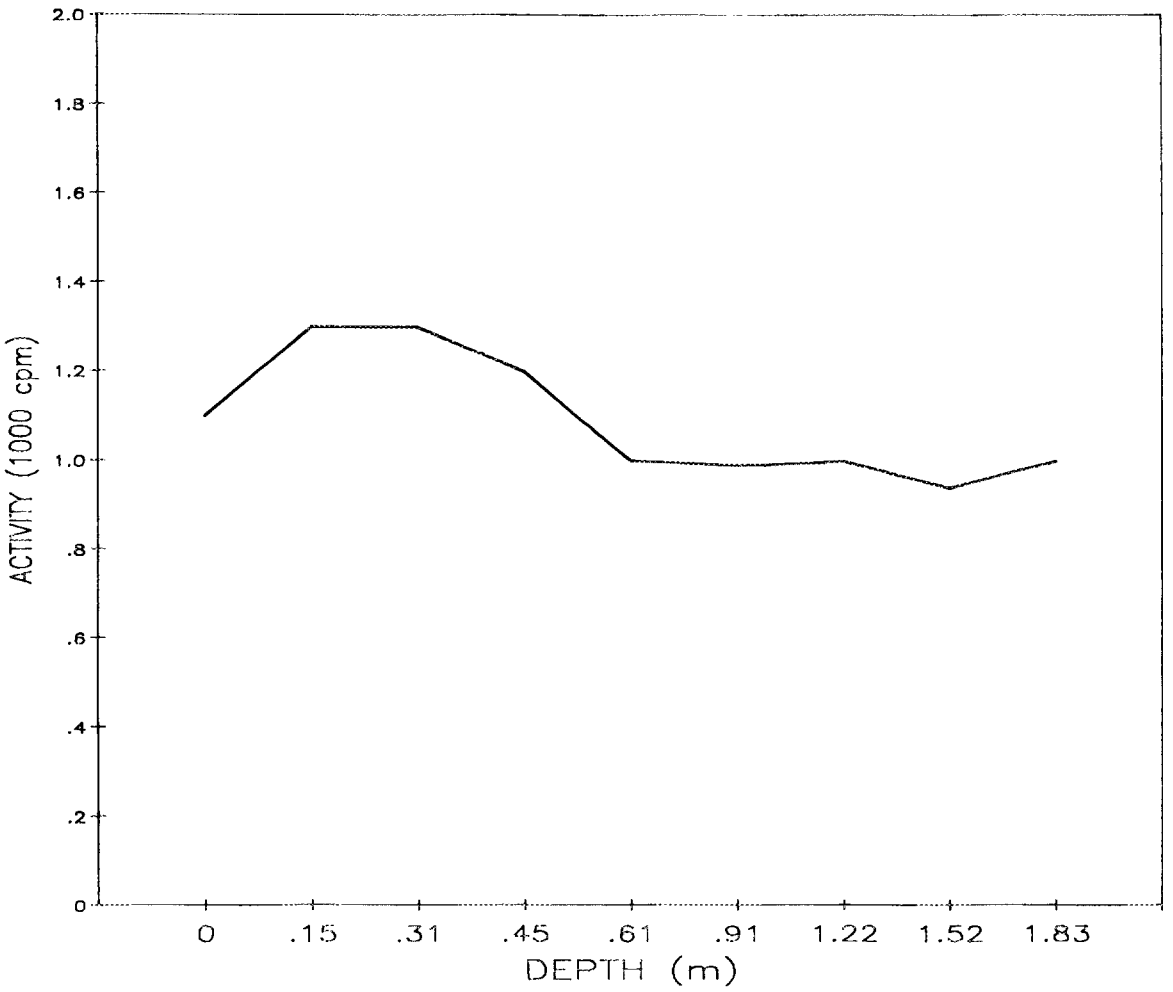

Fig. A.4. Gamma profile of auger hole 4.

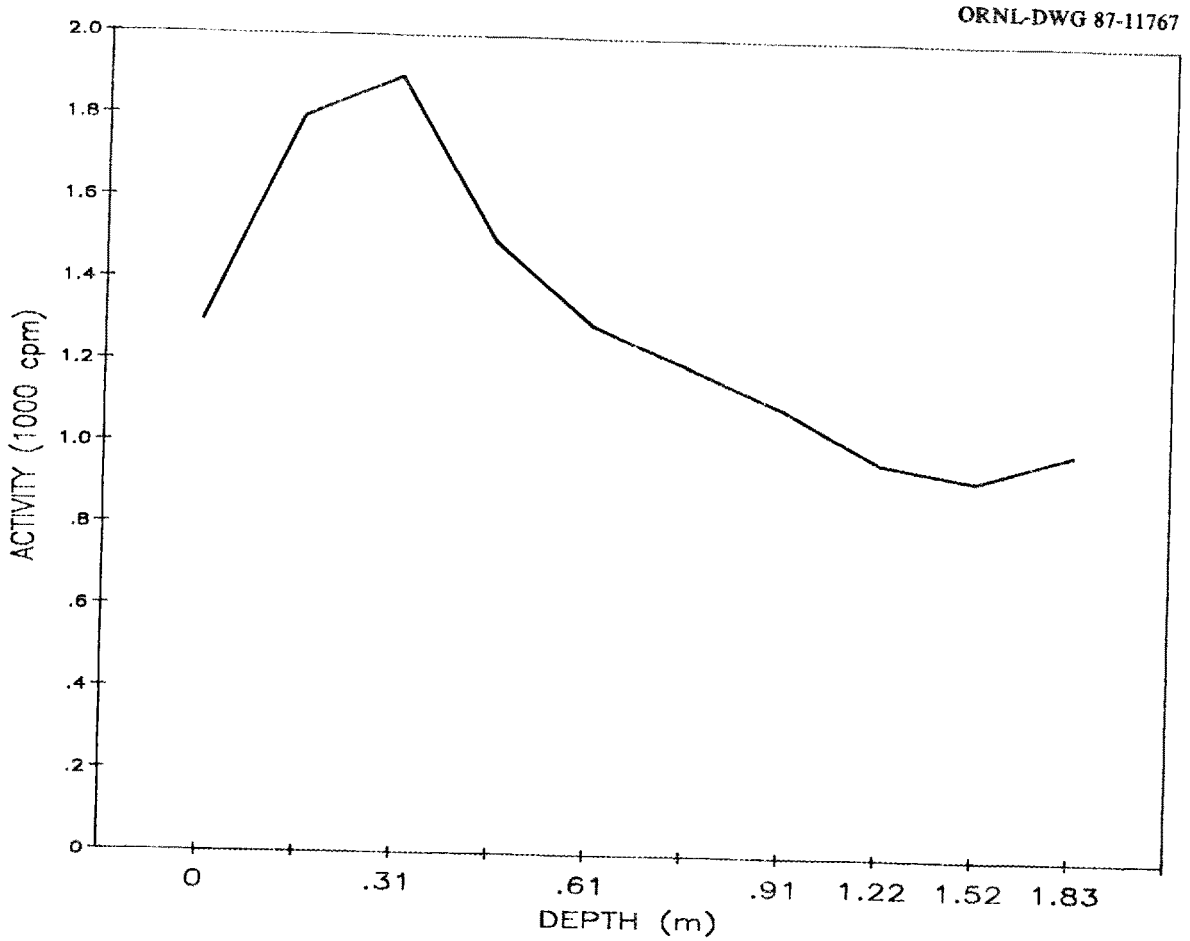

Fig. A.5. Gamma profile of auger hole 5.

ORNL-DWG 87-11768

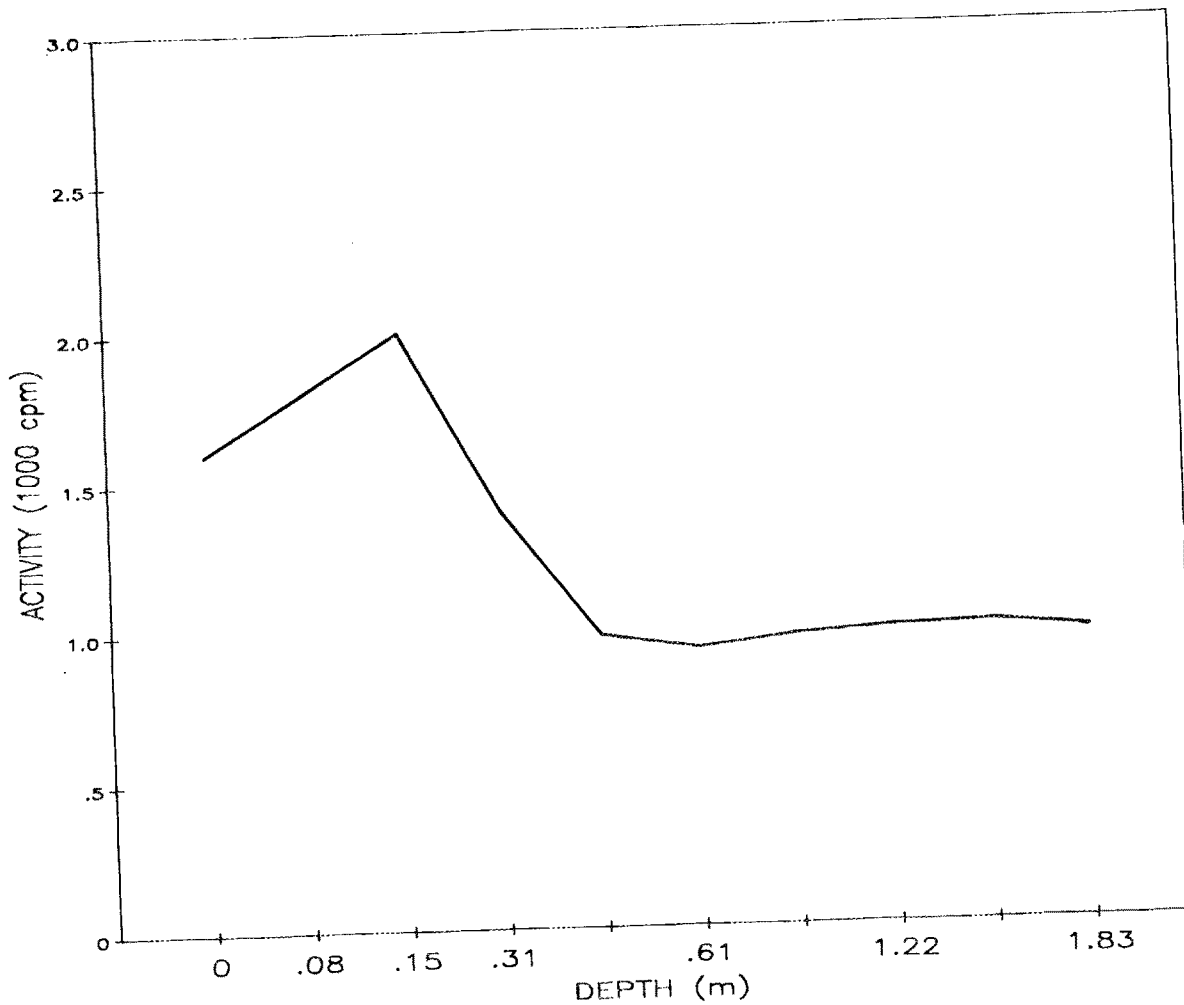

Fig. A.6. Gamma profile of auger hole 6.

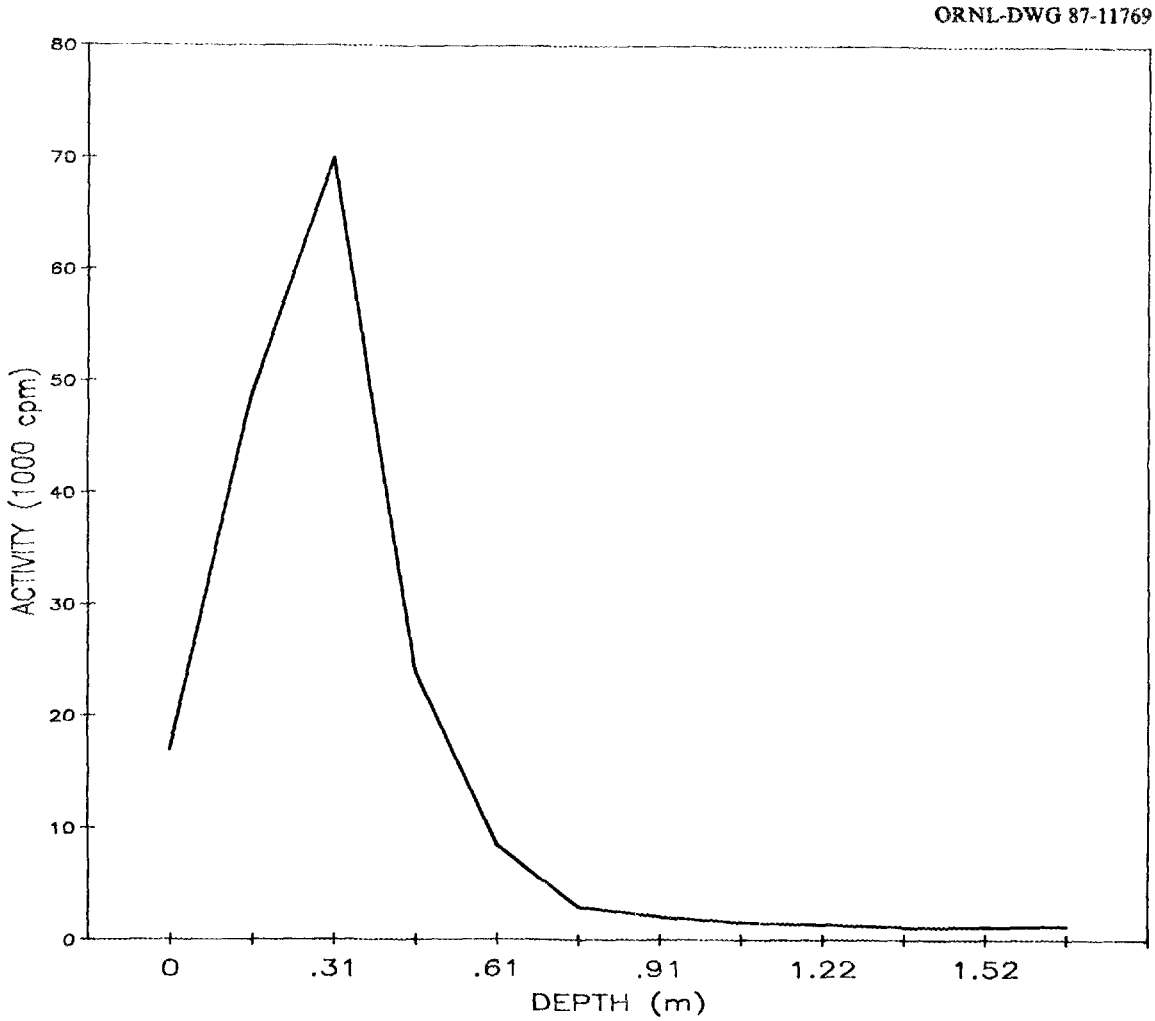

Fig. A.7. Gamma profile of auger hole 7.

ORNL-DWG 87-11770

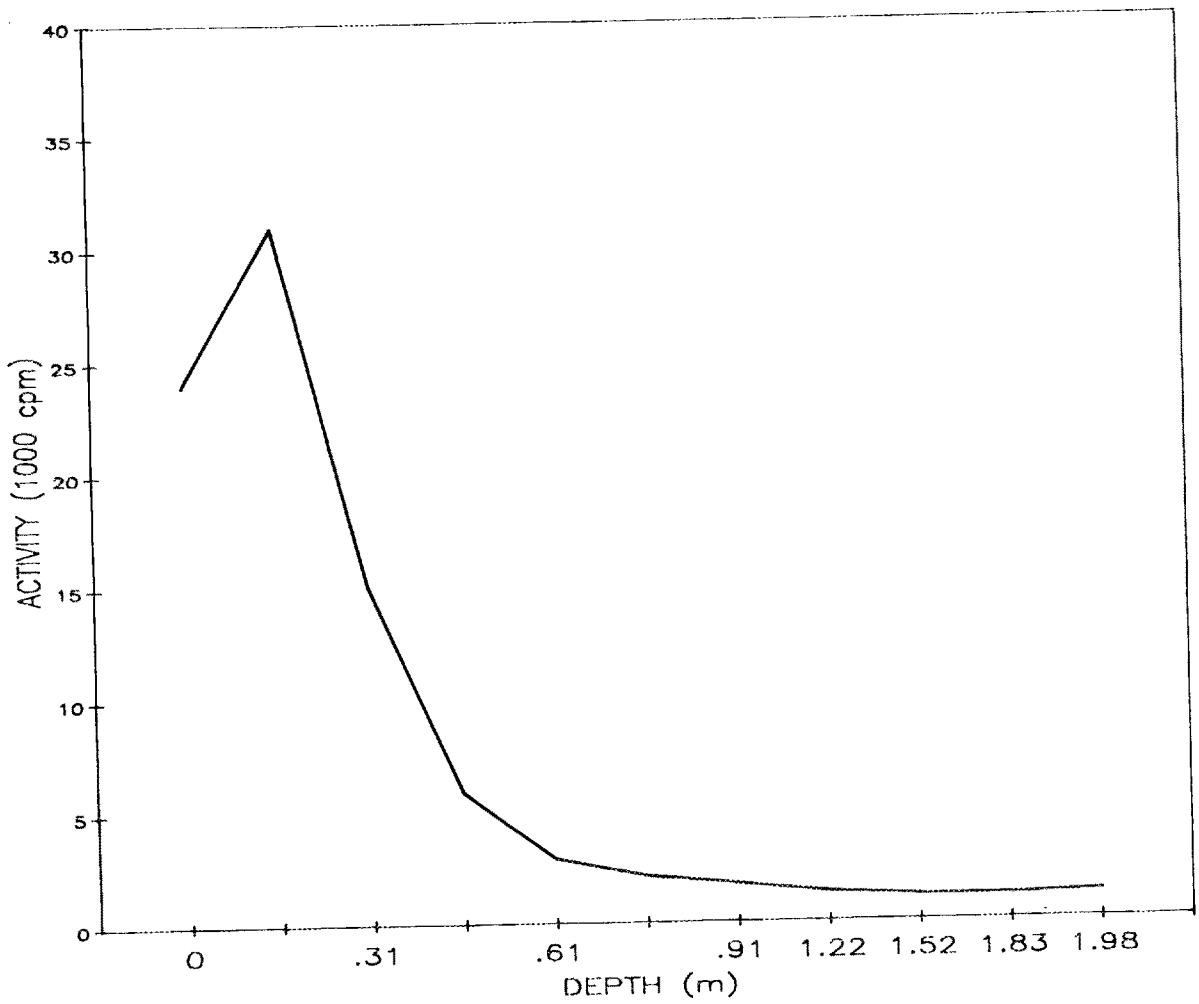

Fig. A.8. Gamma profile of auger hole 8.

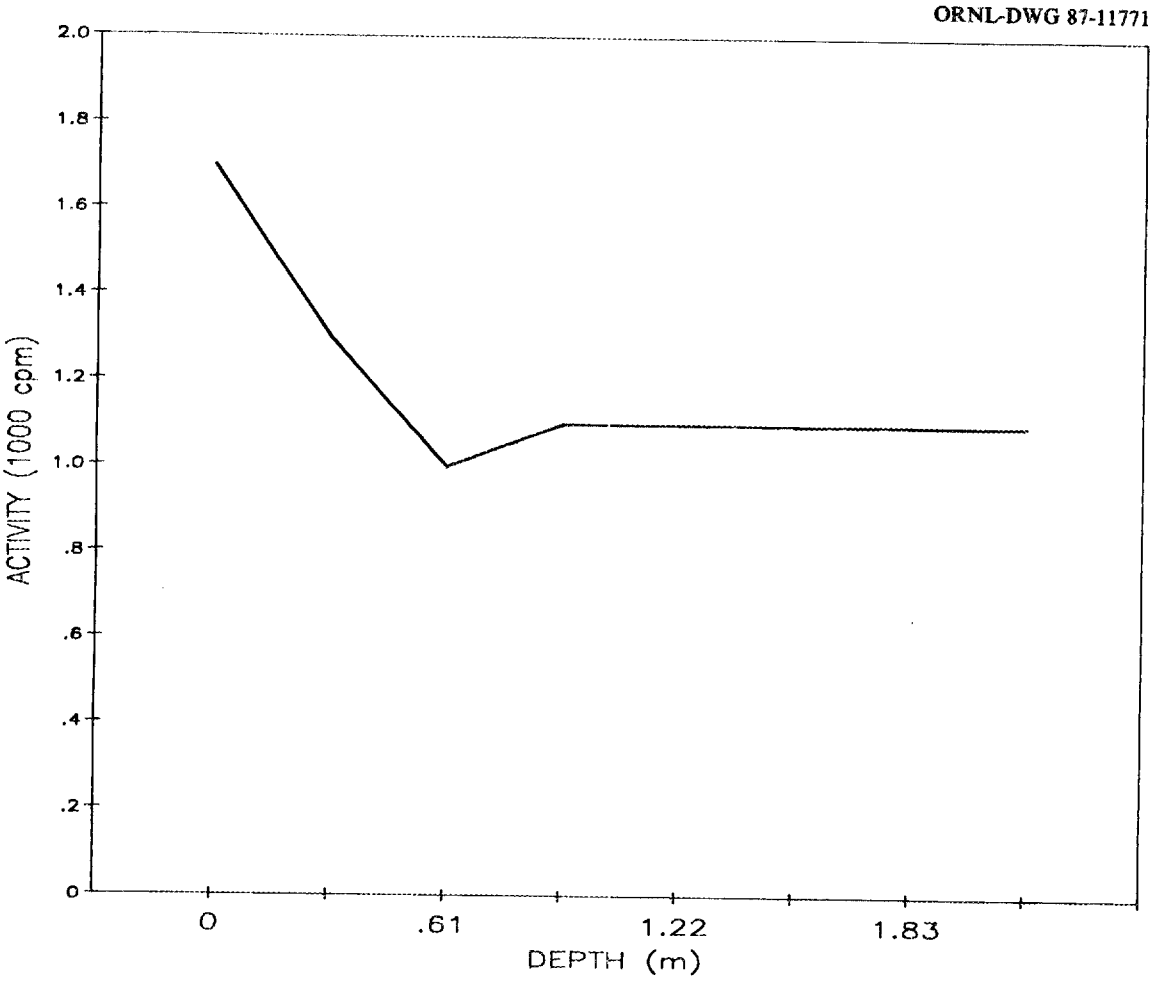

Fig. A.9. Gamma profile of auger hole 9.

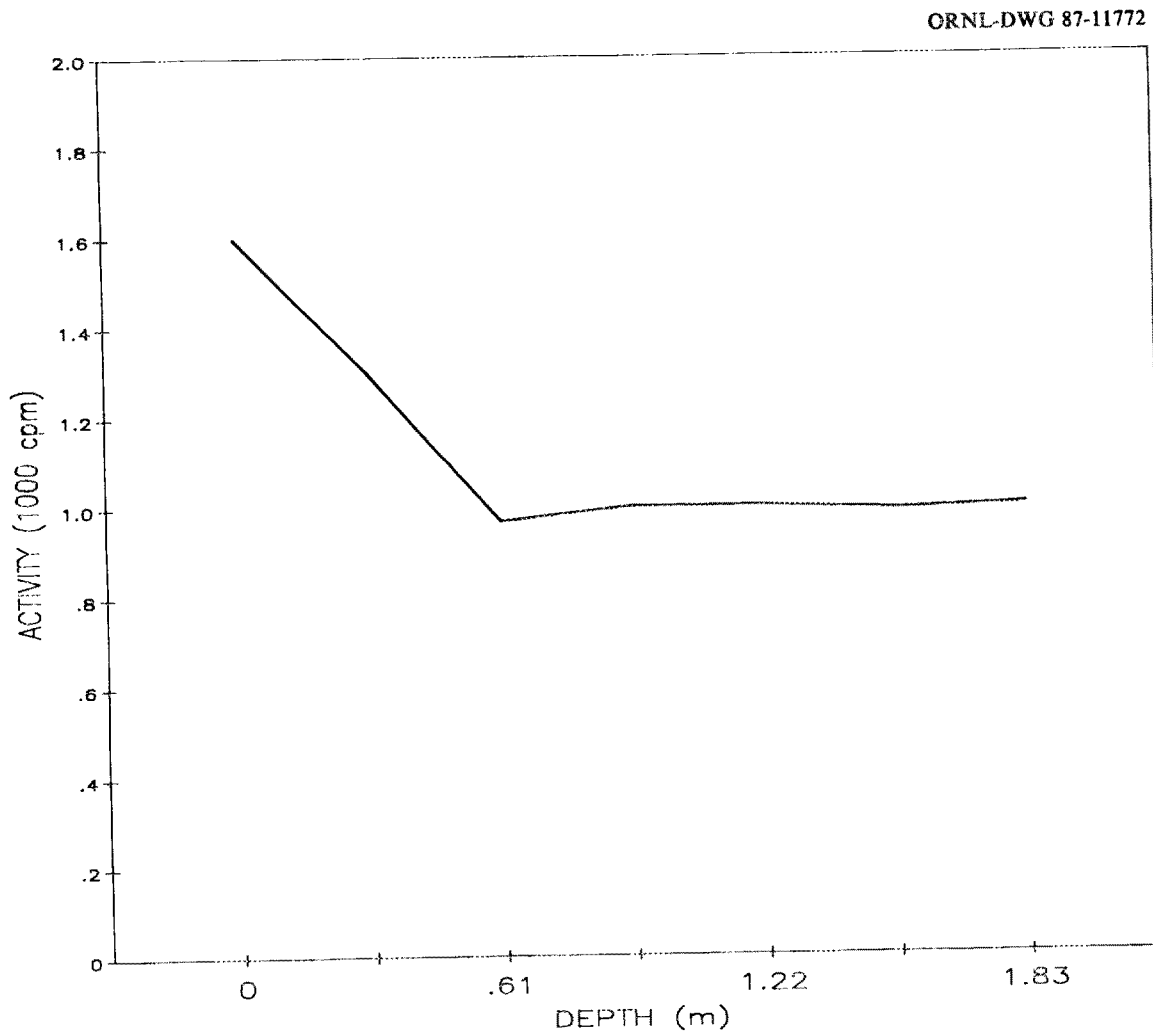

Fig. A.10. Gamma profile of auger hole 10.

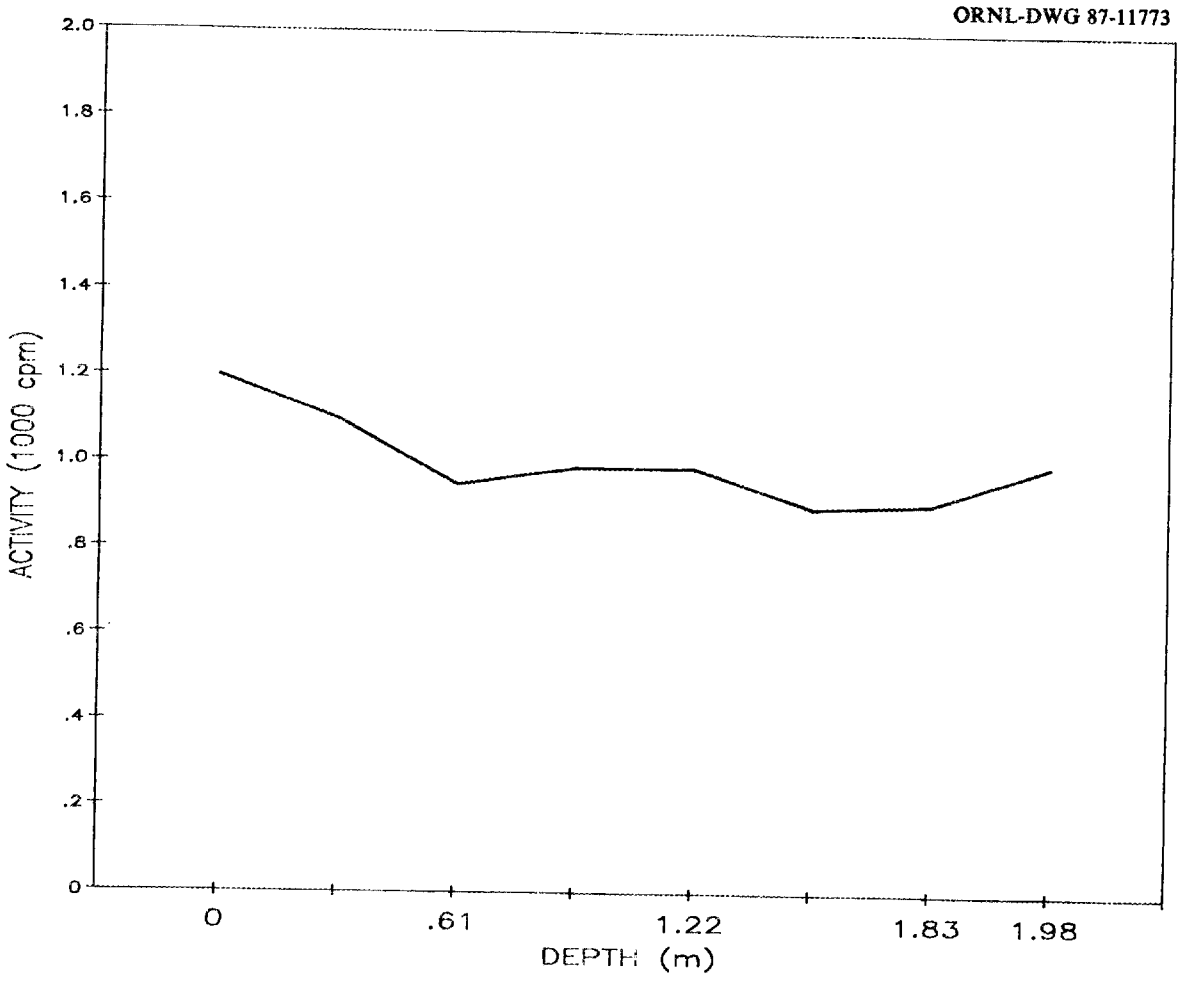

Fig. A.11. Gamma profile of auger hole 11.

ORNL-DWG 87-11774

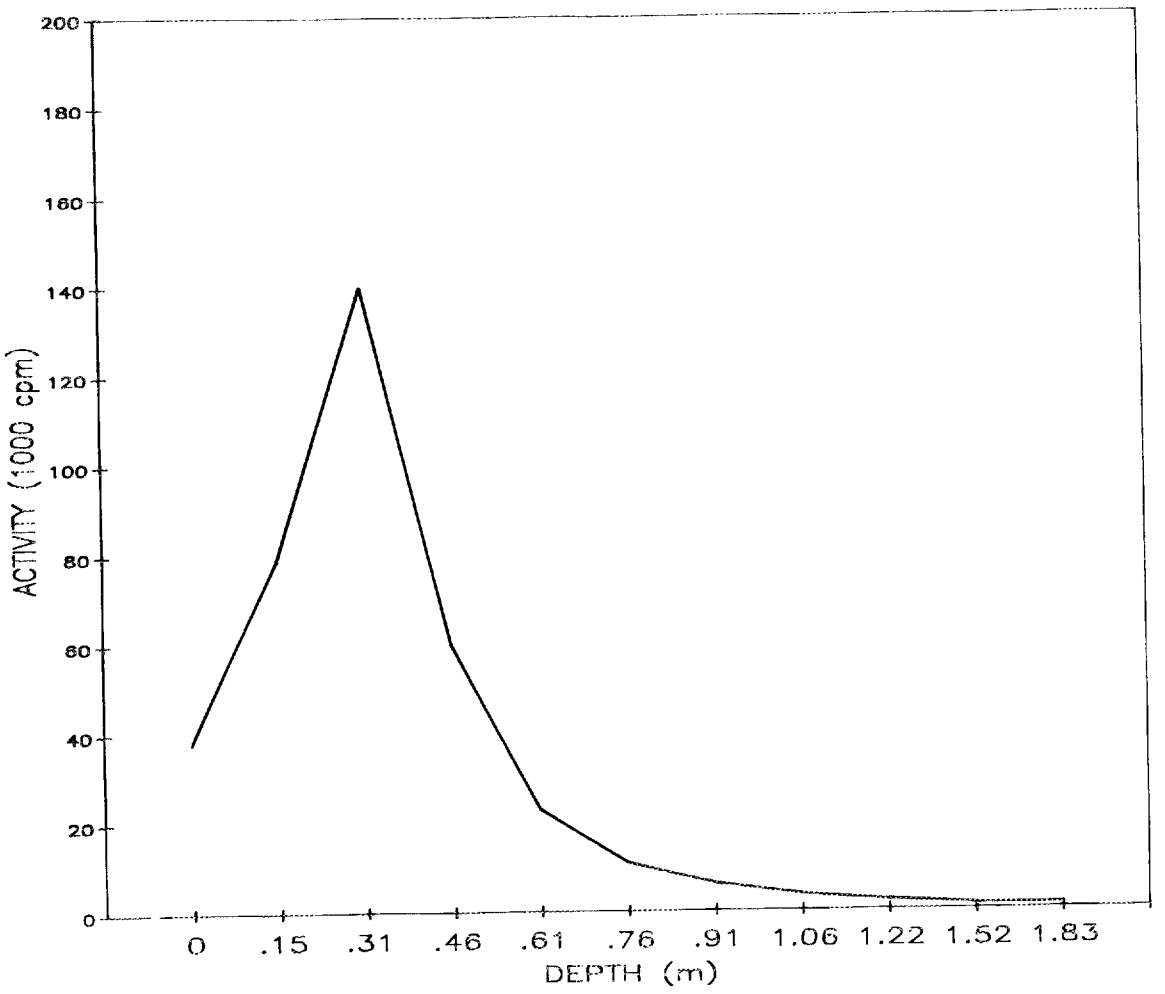

Fig. A.12. Gamma profile of auger hole 12.

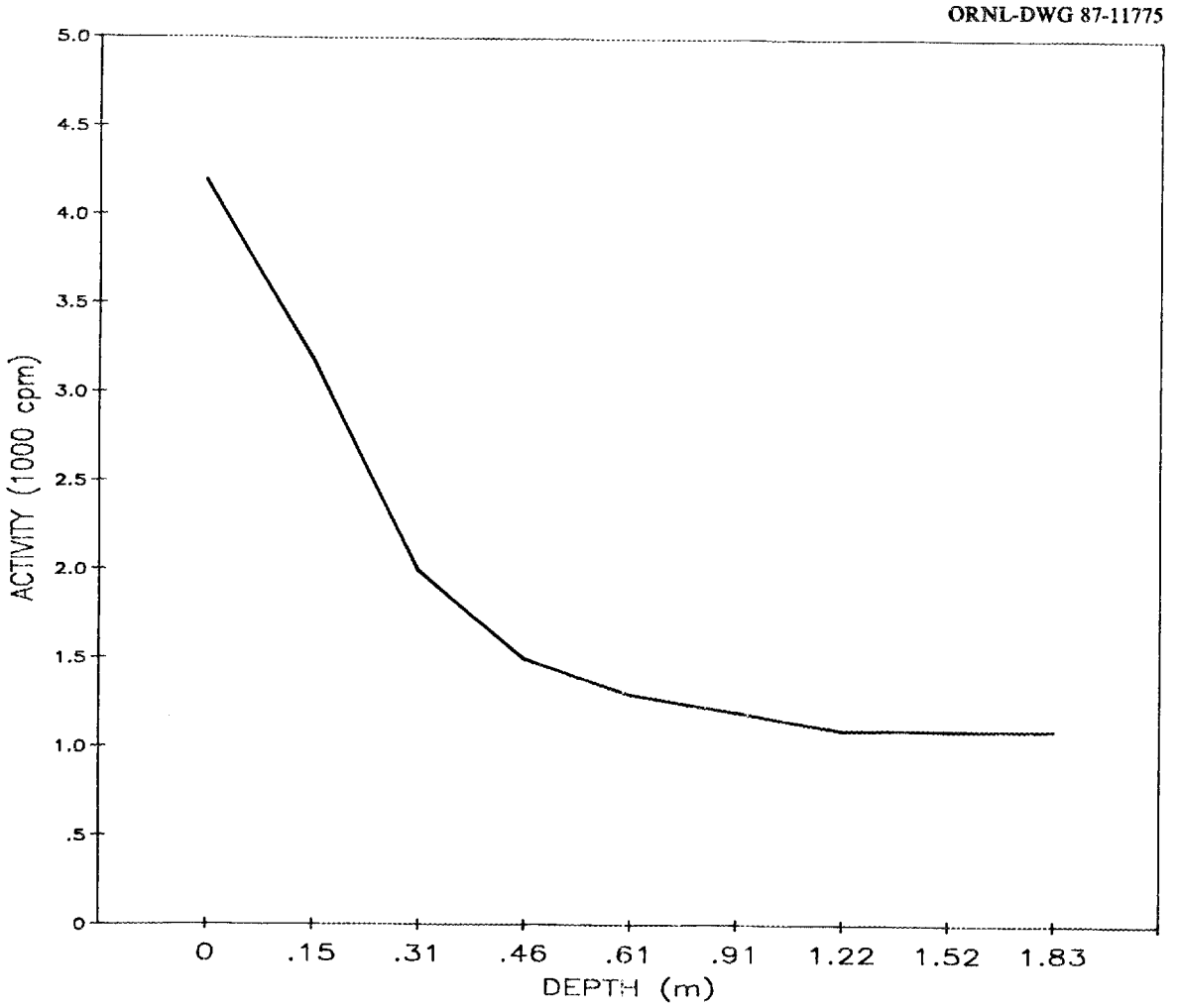

Fig. A.13. Gamma profile of auger hole 13.

ORNL-DWG 87-11776

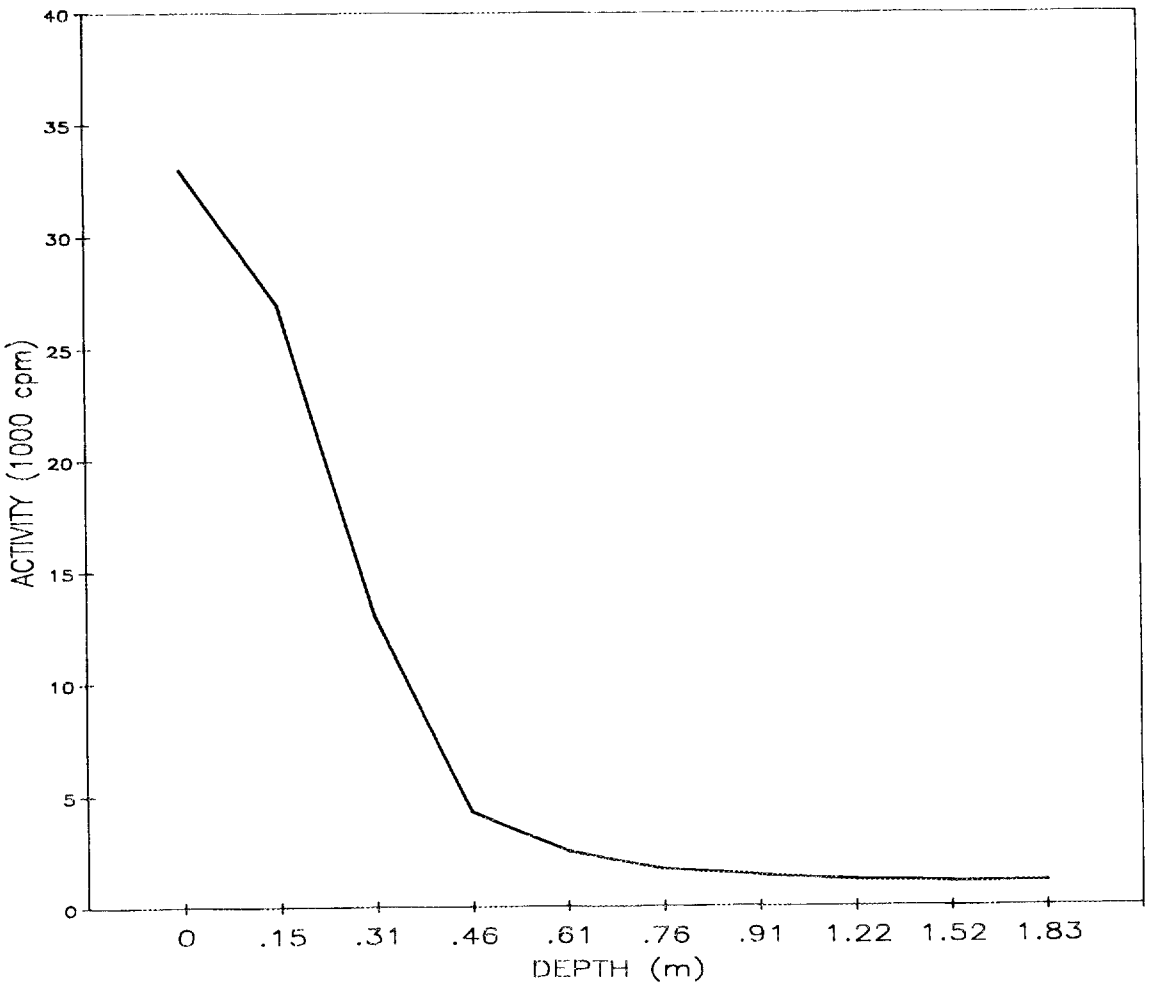

Fig. A.14. Gamma profile of auger hole 14.

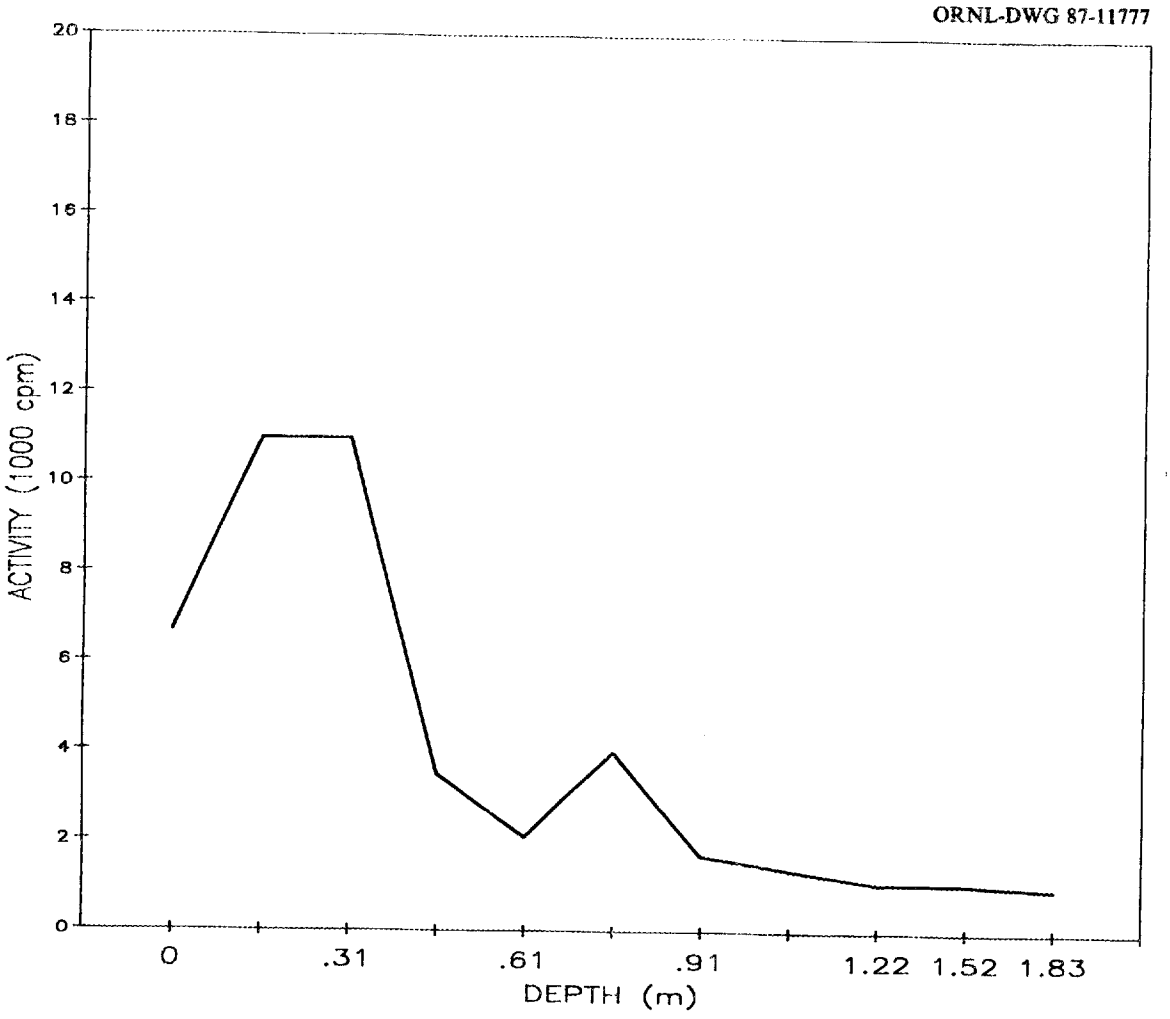

Fig. A.15. Gamma profile of auger hole 15.

ORNL-DWG 87-11778

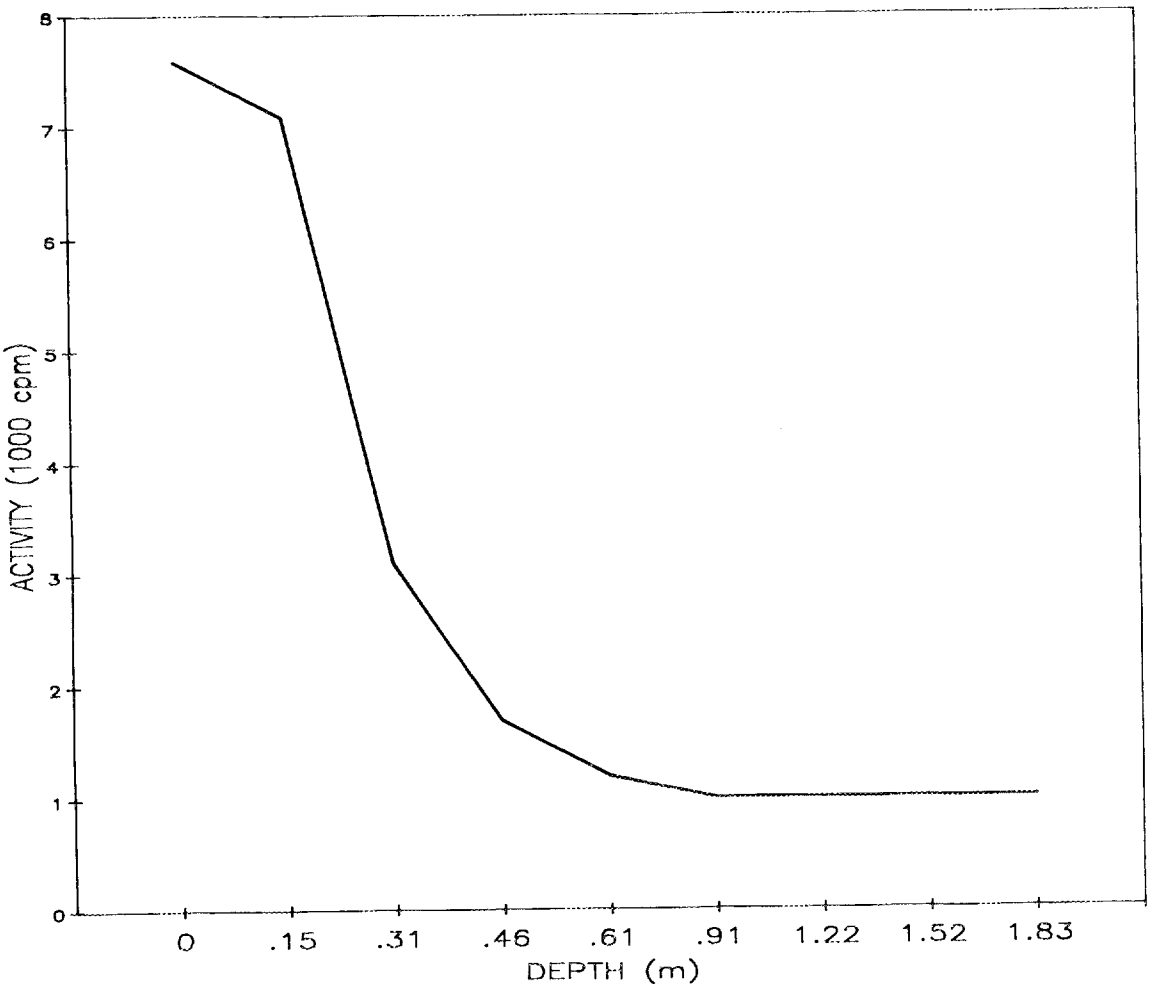

Fig. A.16. Gamma profile of auger hole 16.

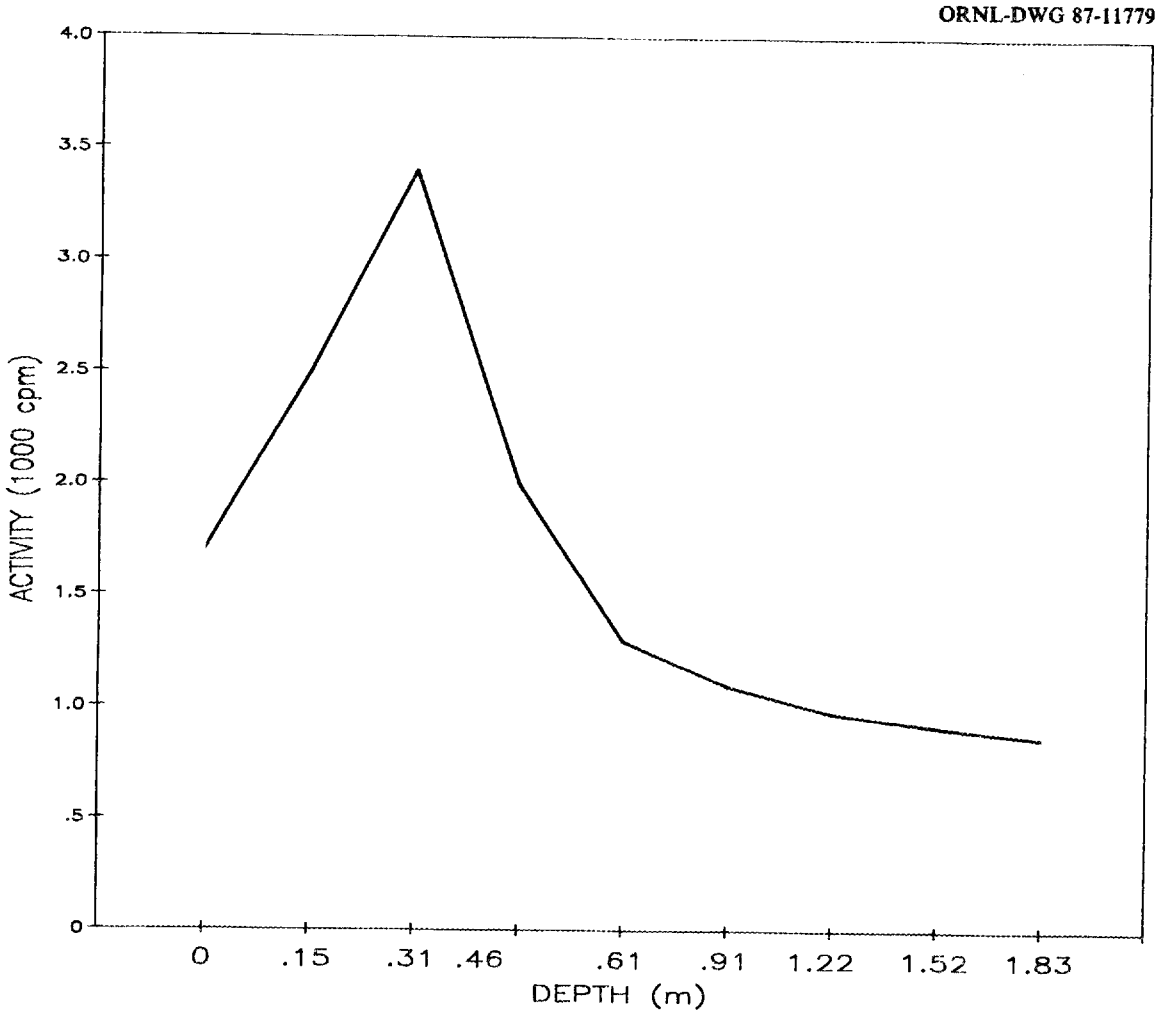

Fig. A.17. Gamma profile of auger hole 17.

ORNL-DWG 87-11780

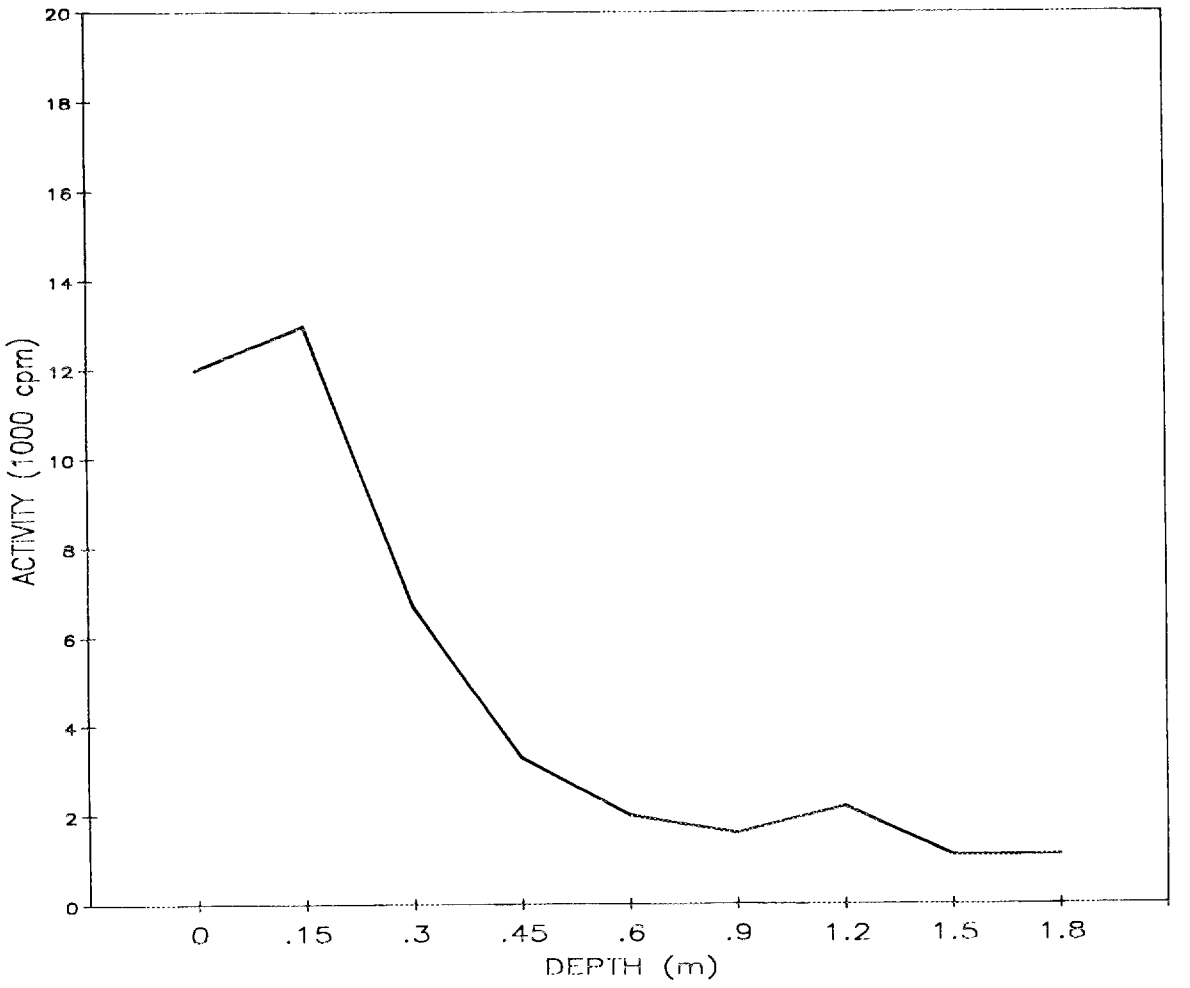

Fig. A.18. Gamma profile of auger hole 18.

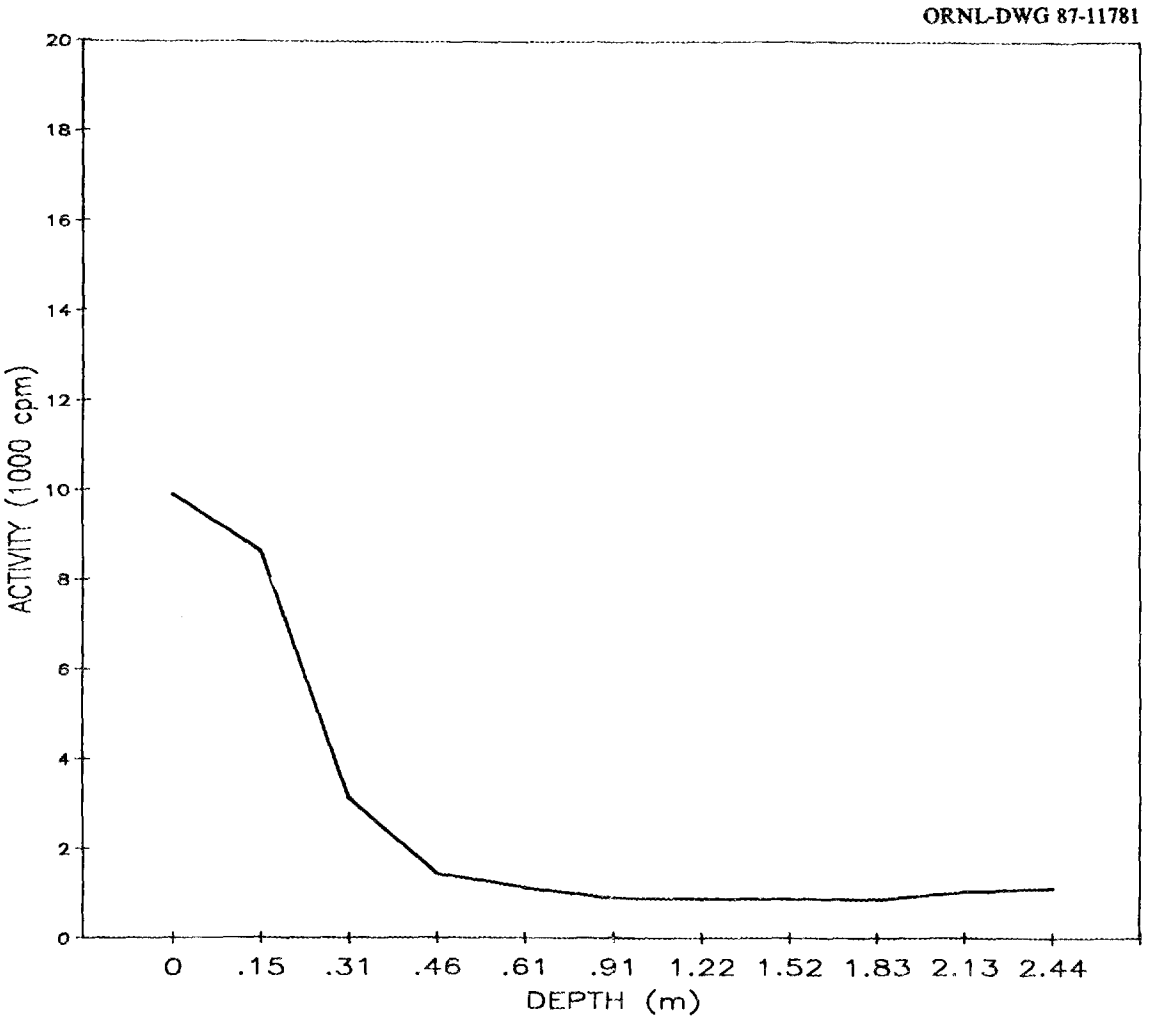

Fig. A.19. Gamma profile of auger hole 19.

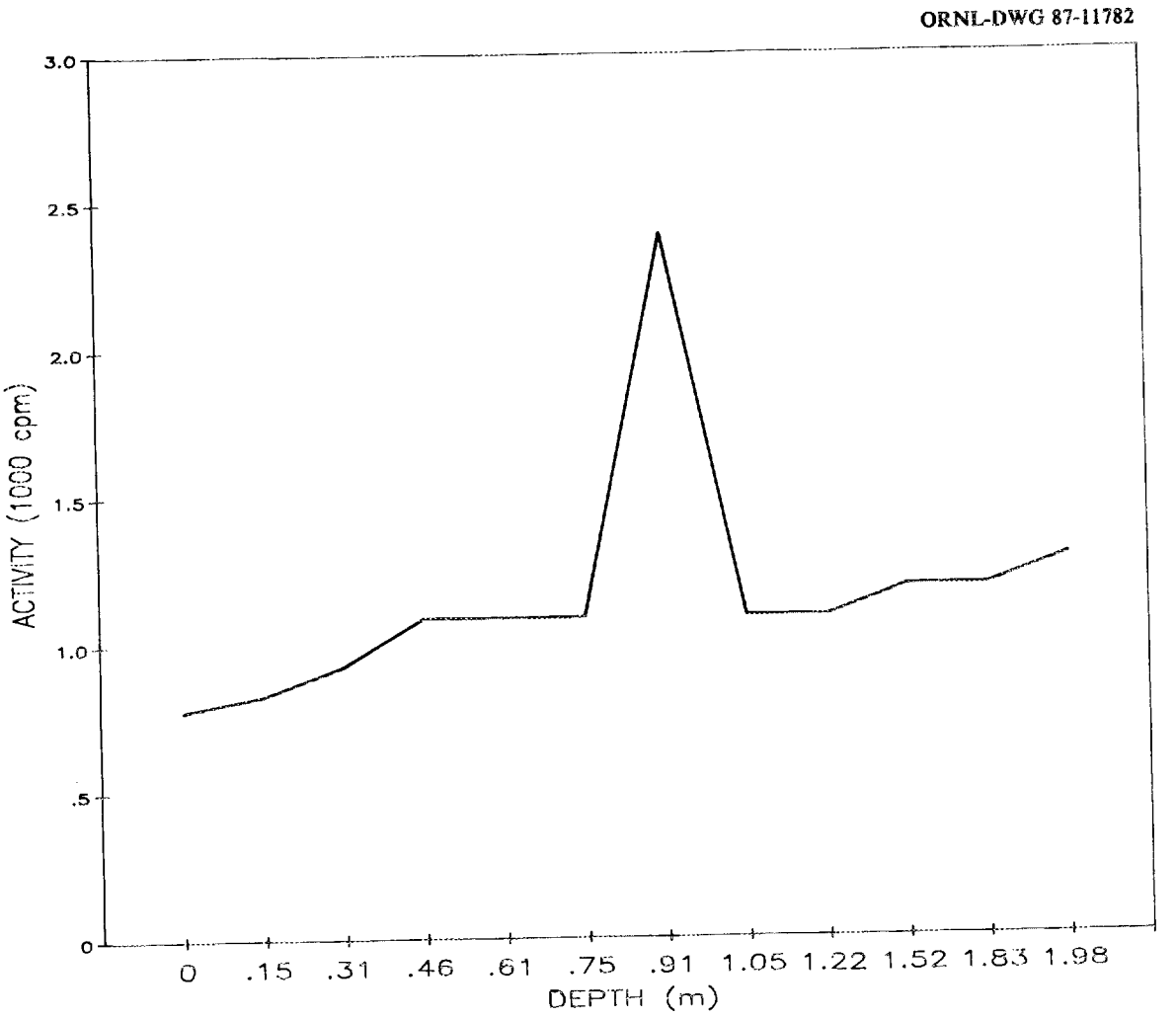

Fig. A.20. Gamma profile of auger hole 20.

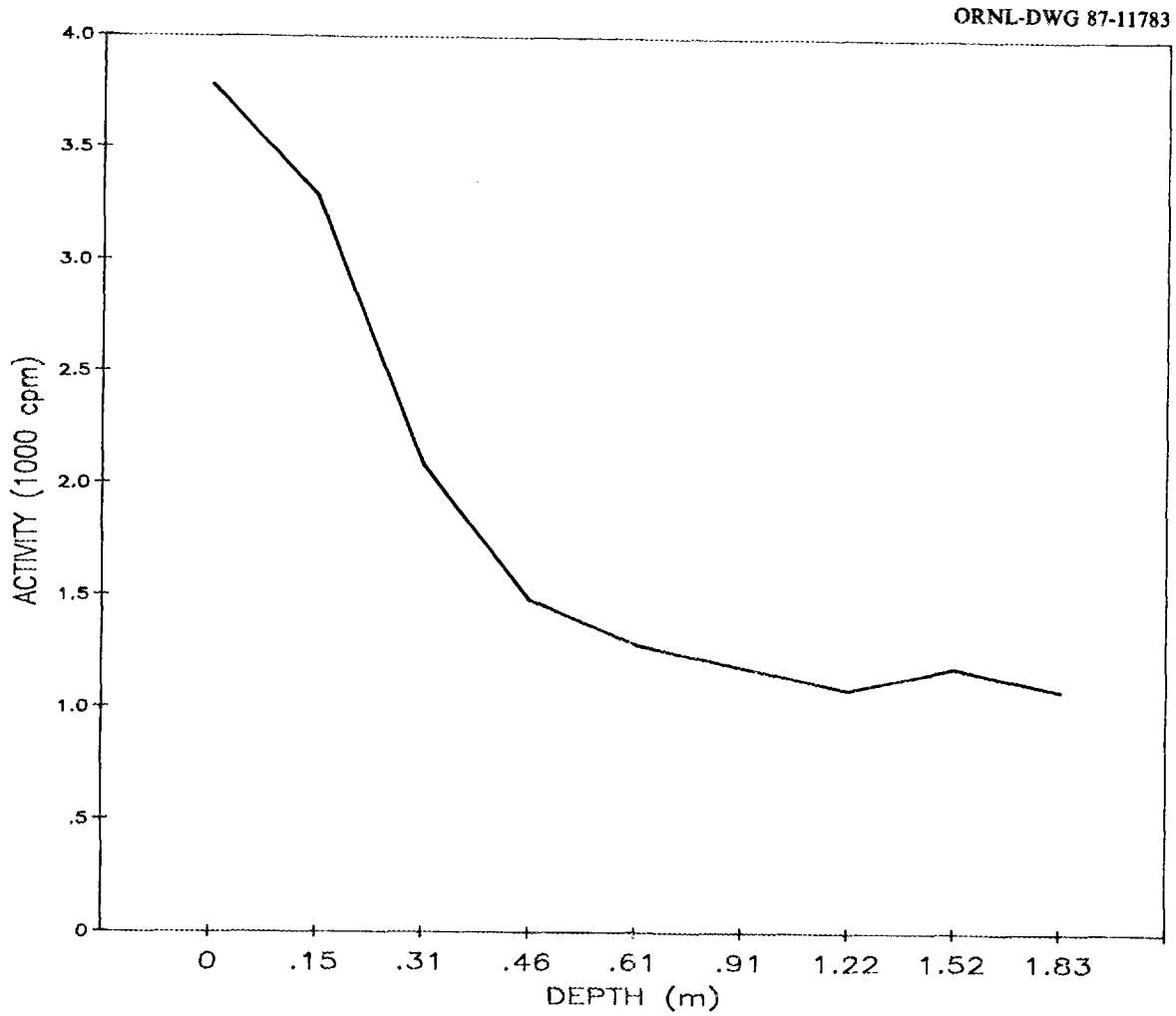

Fig. A.21. Gamma profile of auger hole 21.

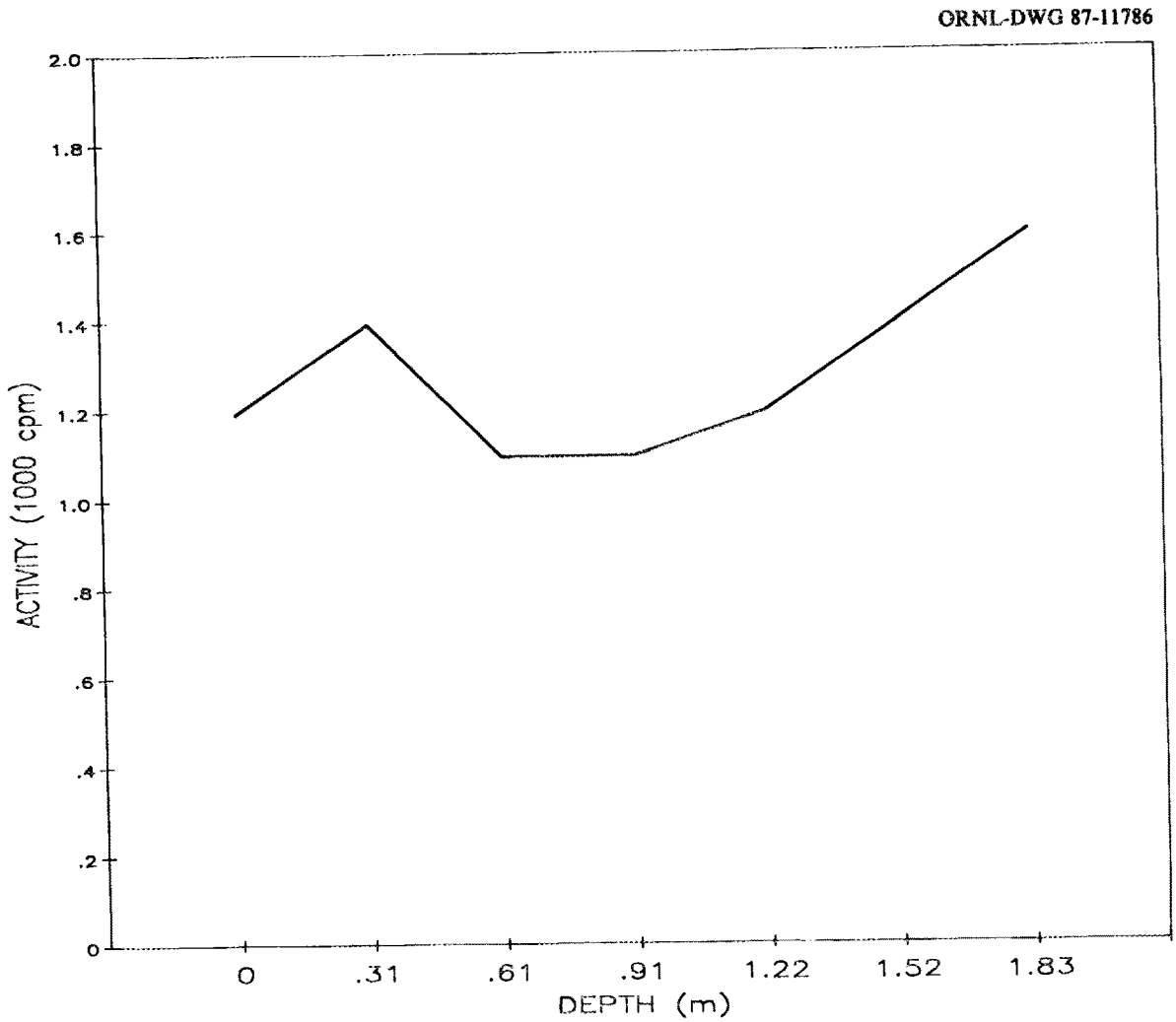

Fig. A.24. Gamma profile of auger hole 24.

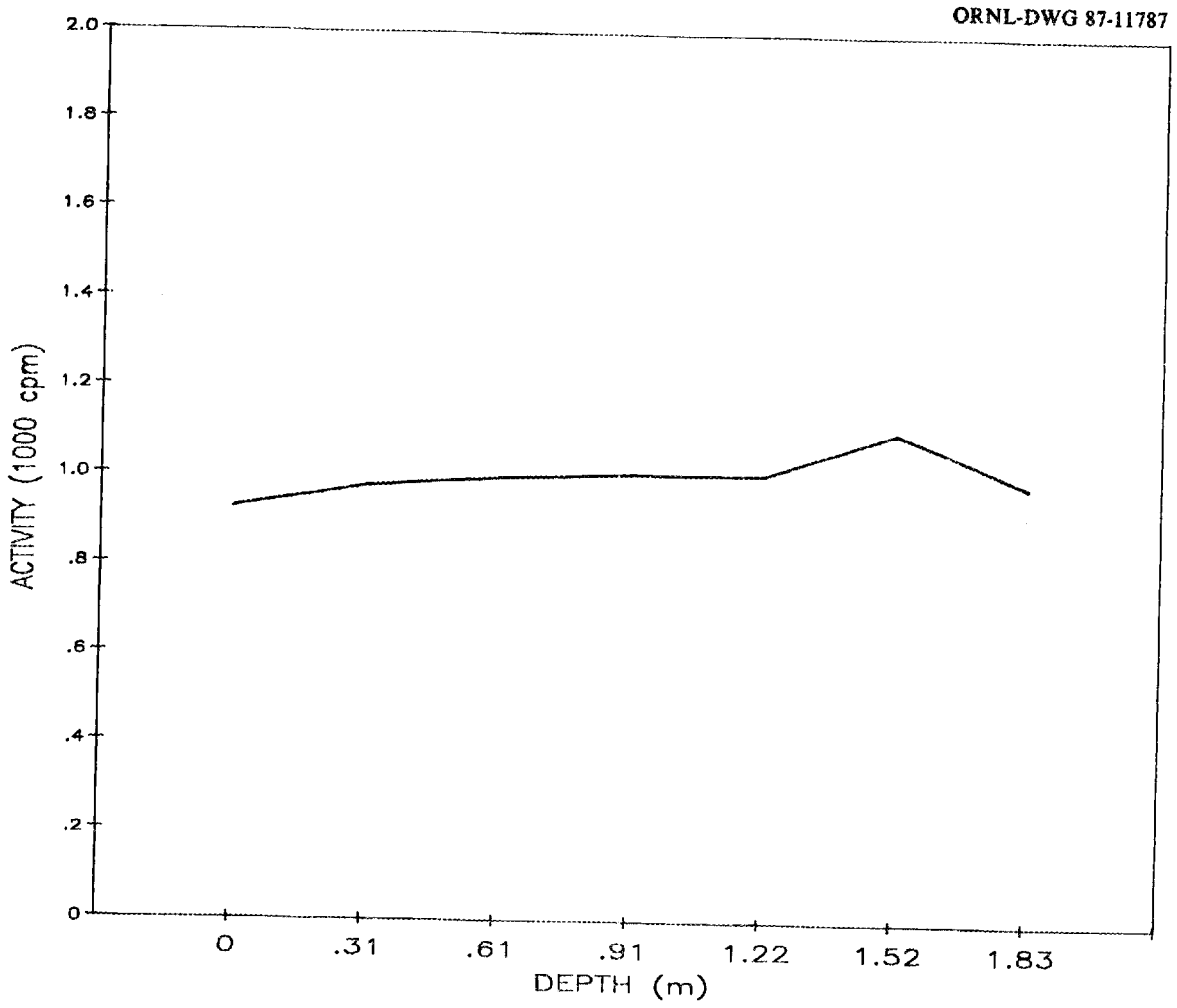

Fig. A.25. Gamma profile of auger hole 25.

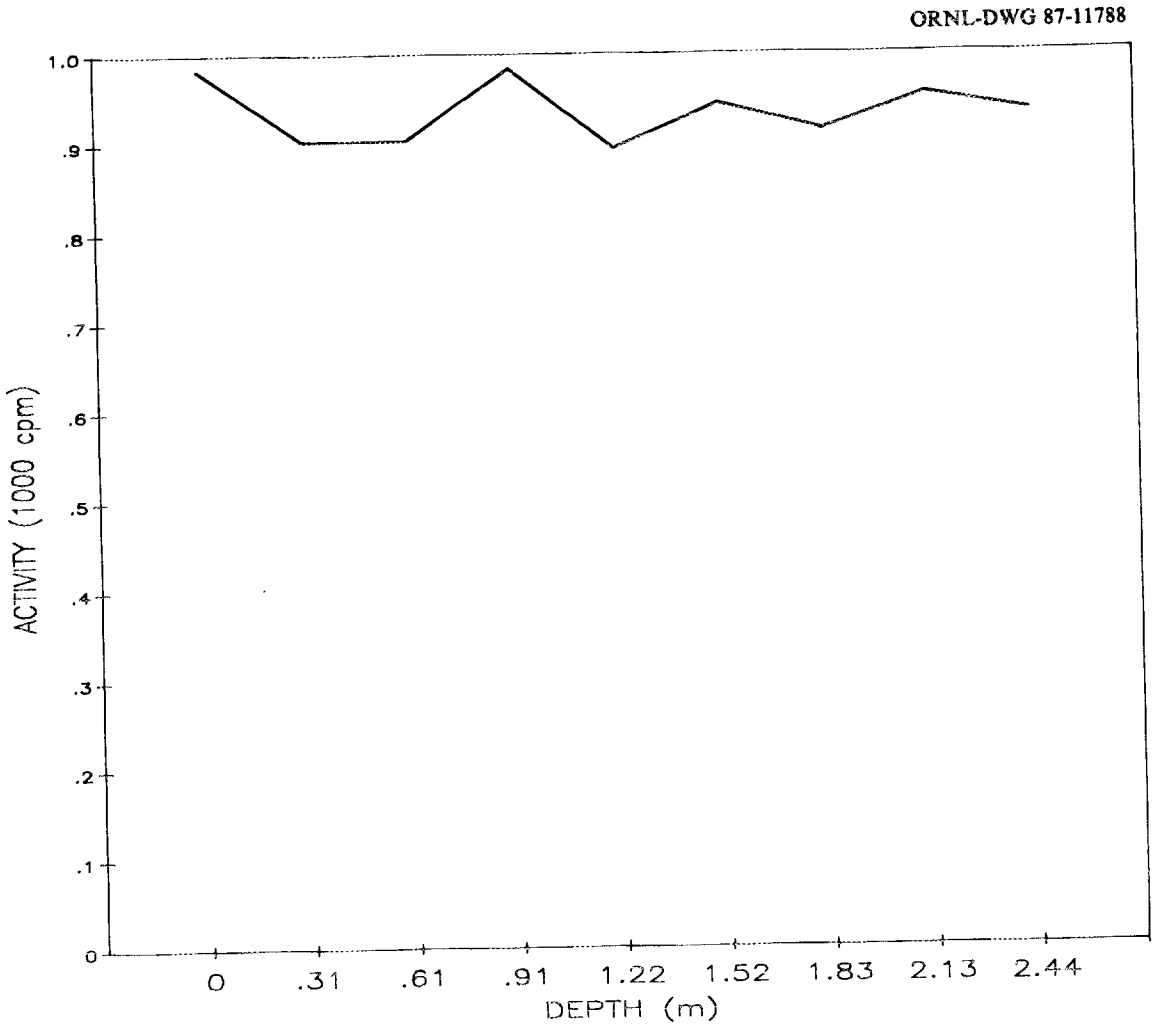

Fig. A.26. Gamma profile of auger hole 26.

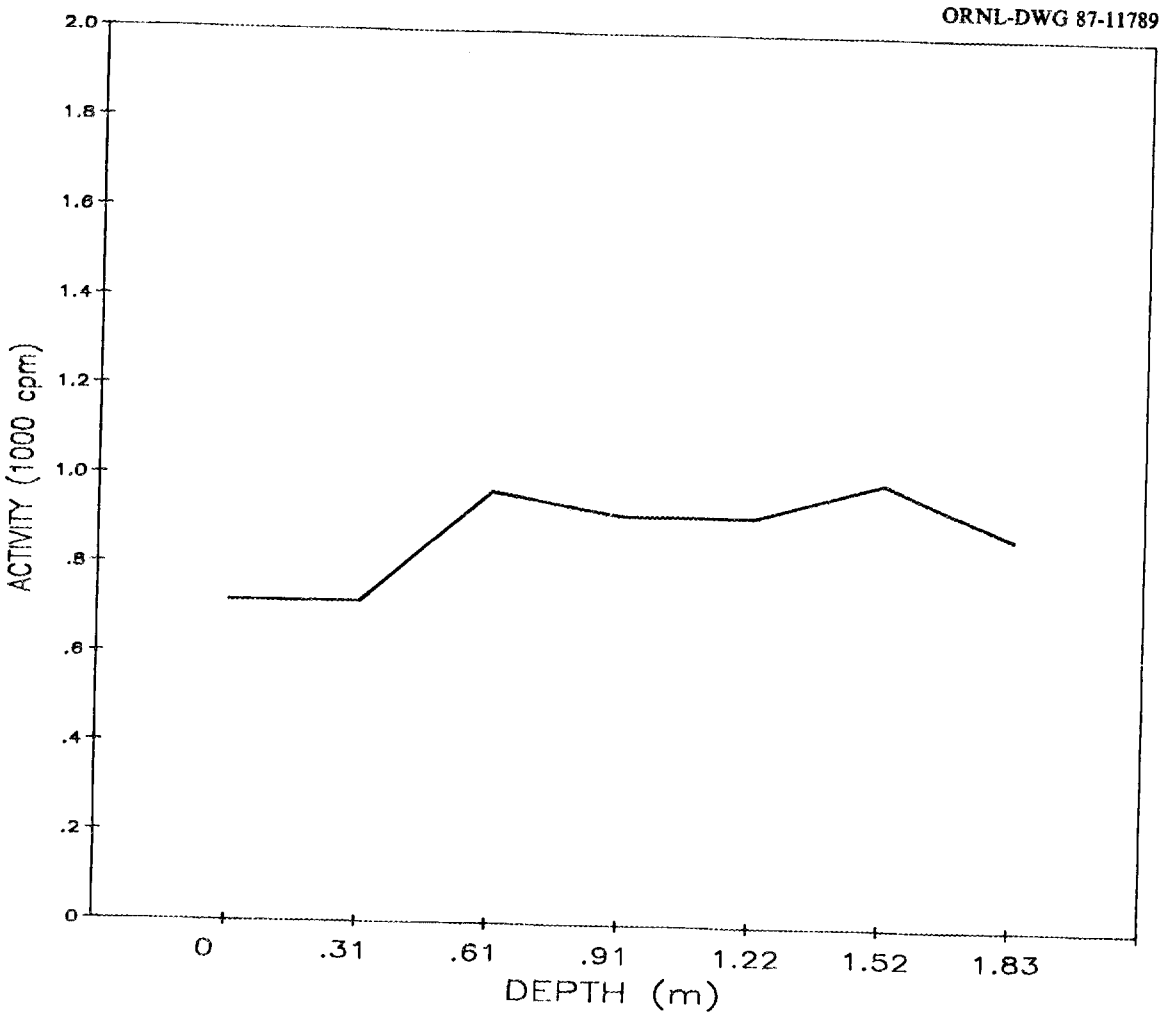

Fig. A.27. Gamma profile of auger hole 27.

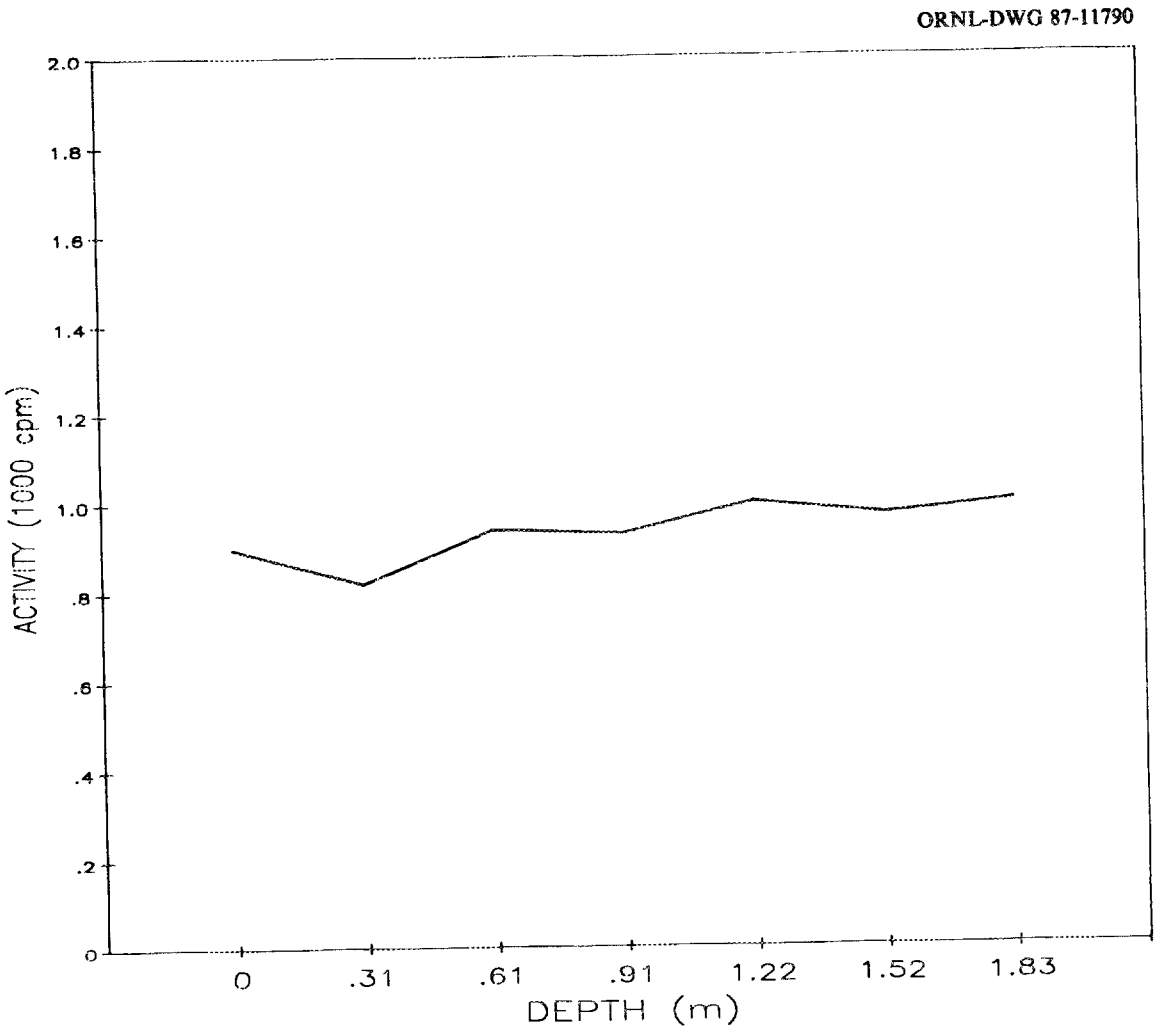

Fig. A.28. Gamma profile of auger hole 28.

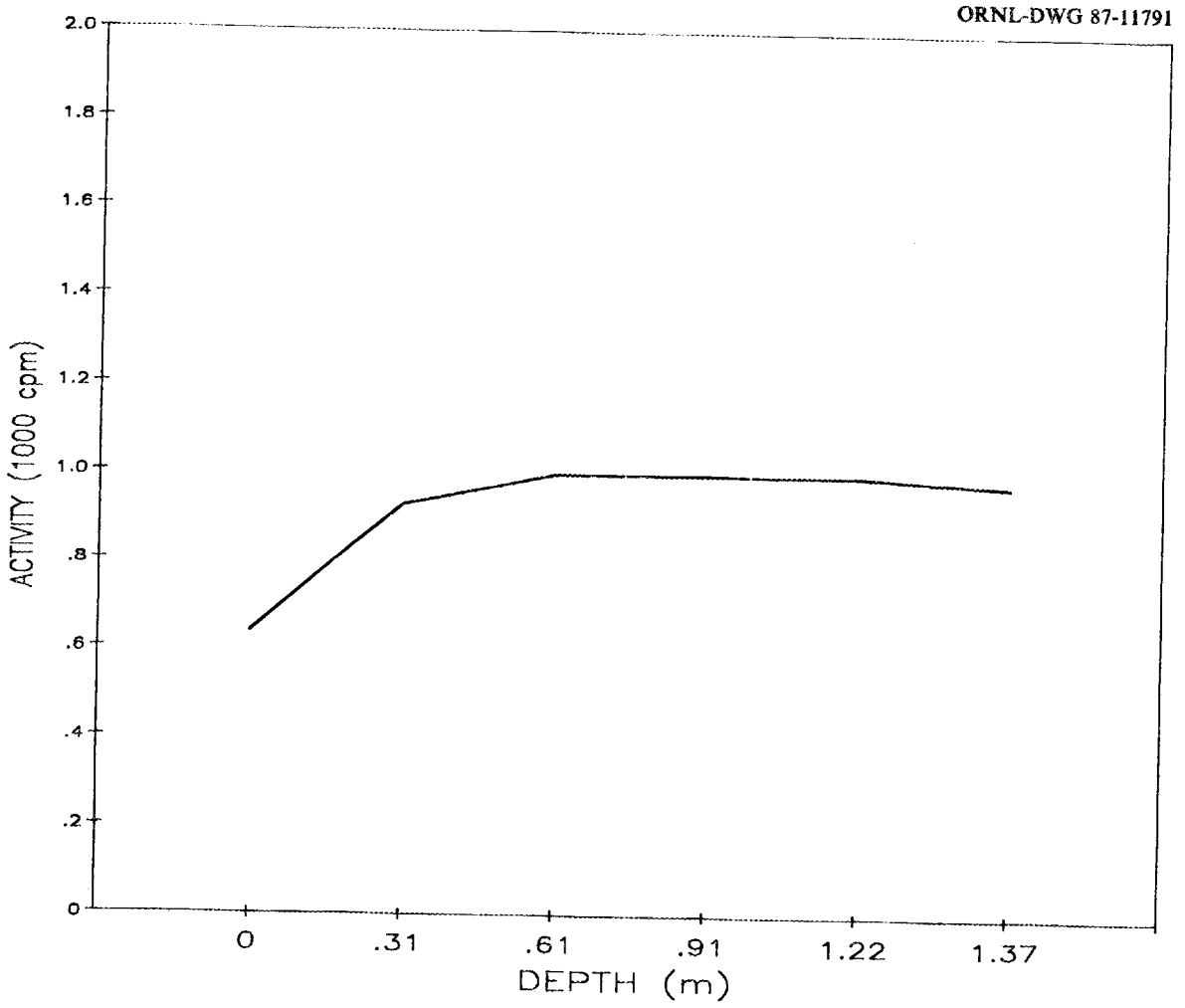

Fig. A.29. Gamma profile of auger hole 29.

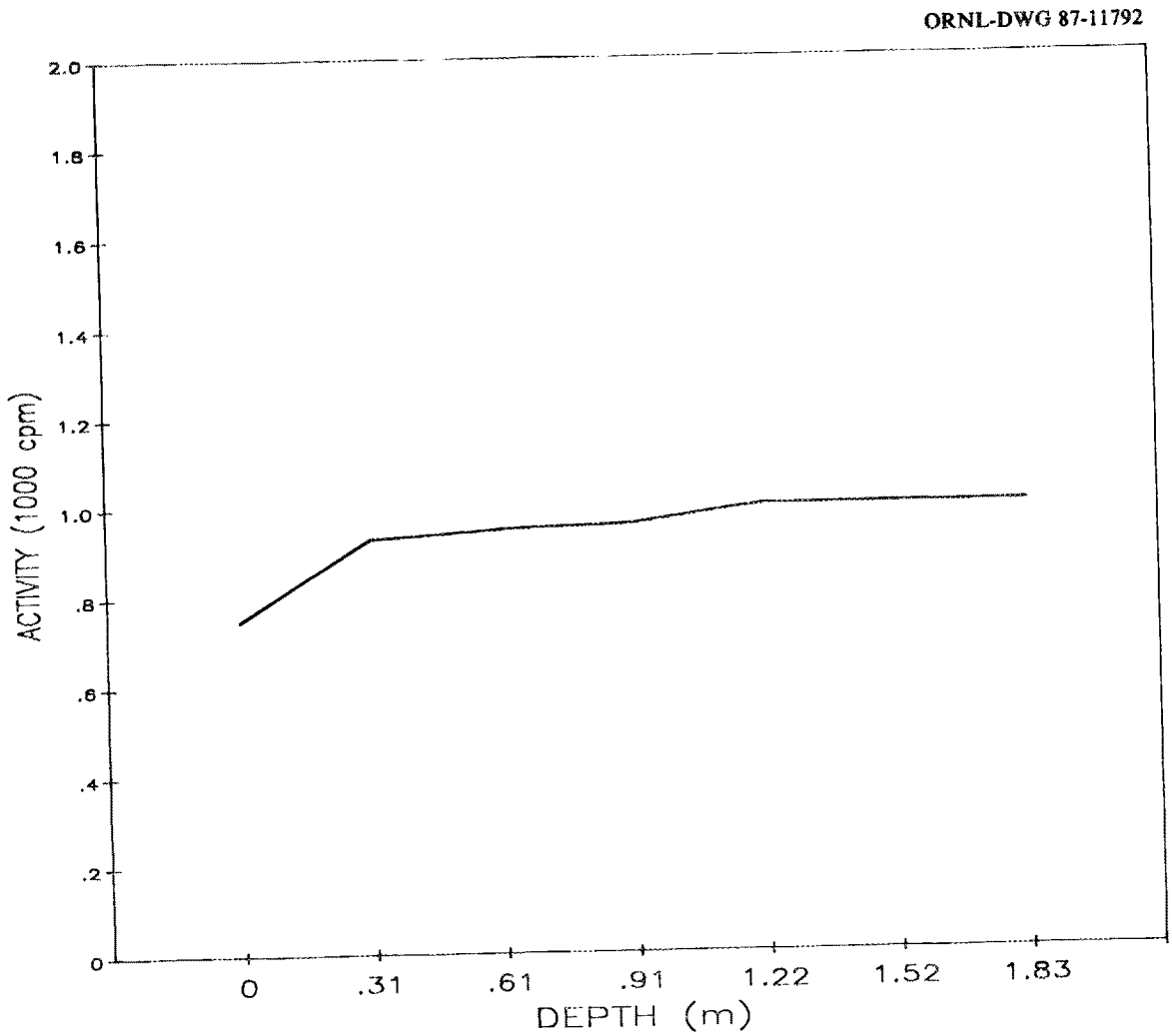

Fig. A.30. Gamma profile of auger hole 30.

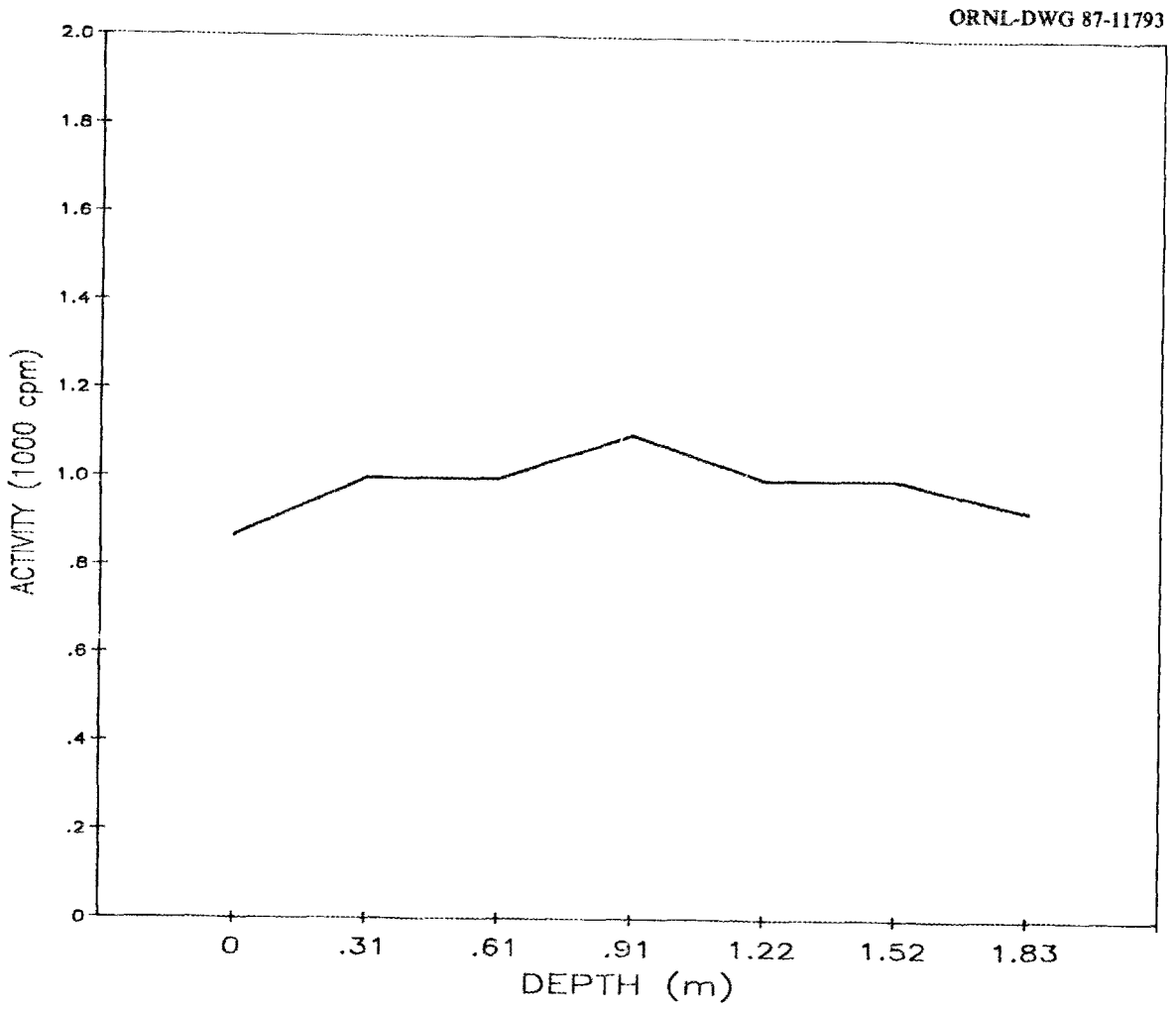

Fig. A.31. Gamma profile of auger hole 31.

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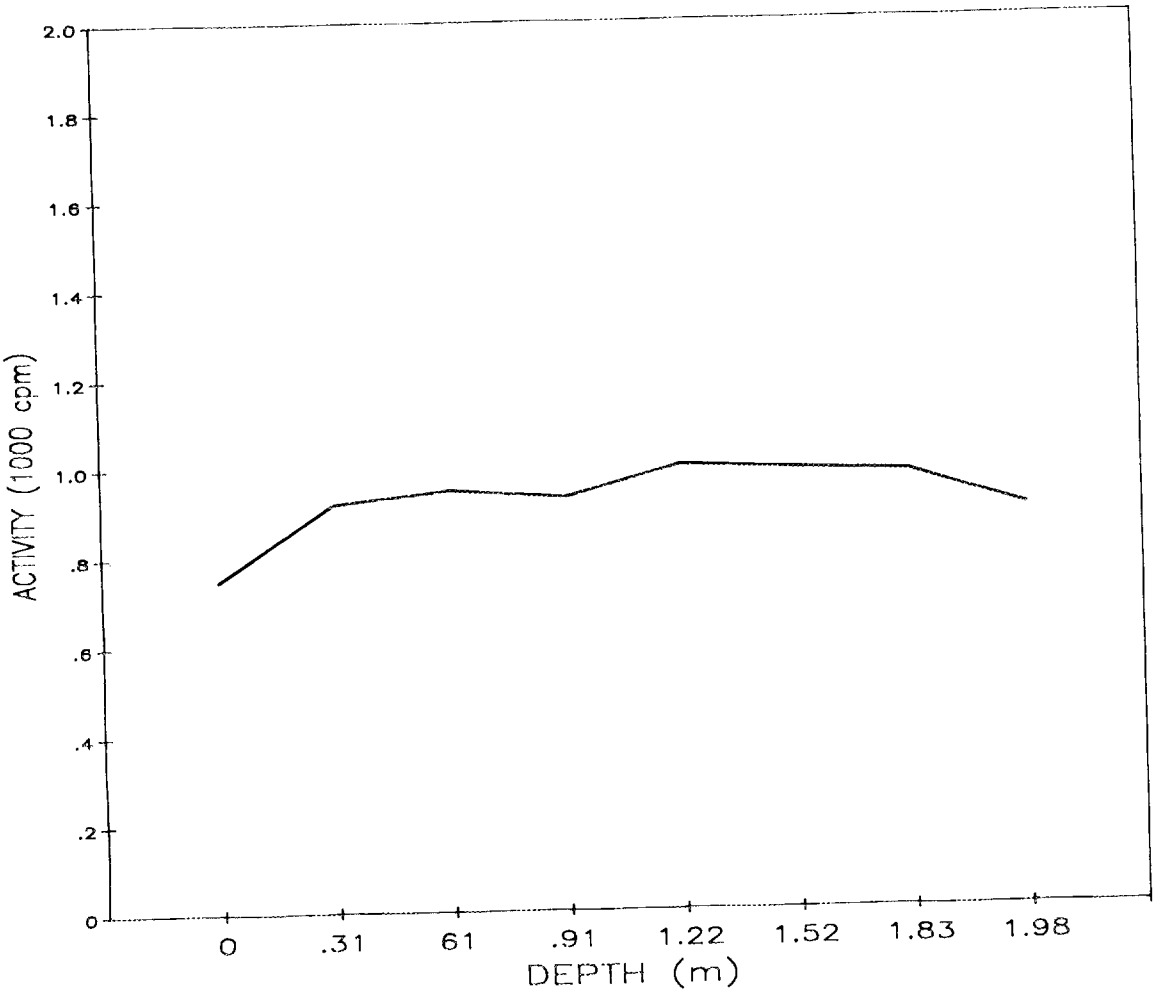

Fig. A.32. Gamma profile of auger hole 32.

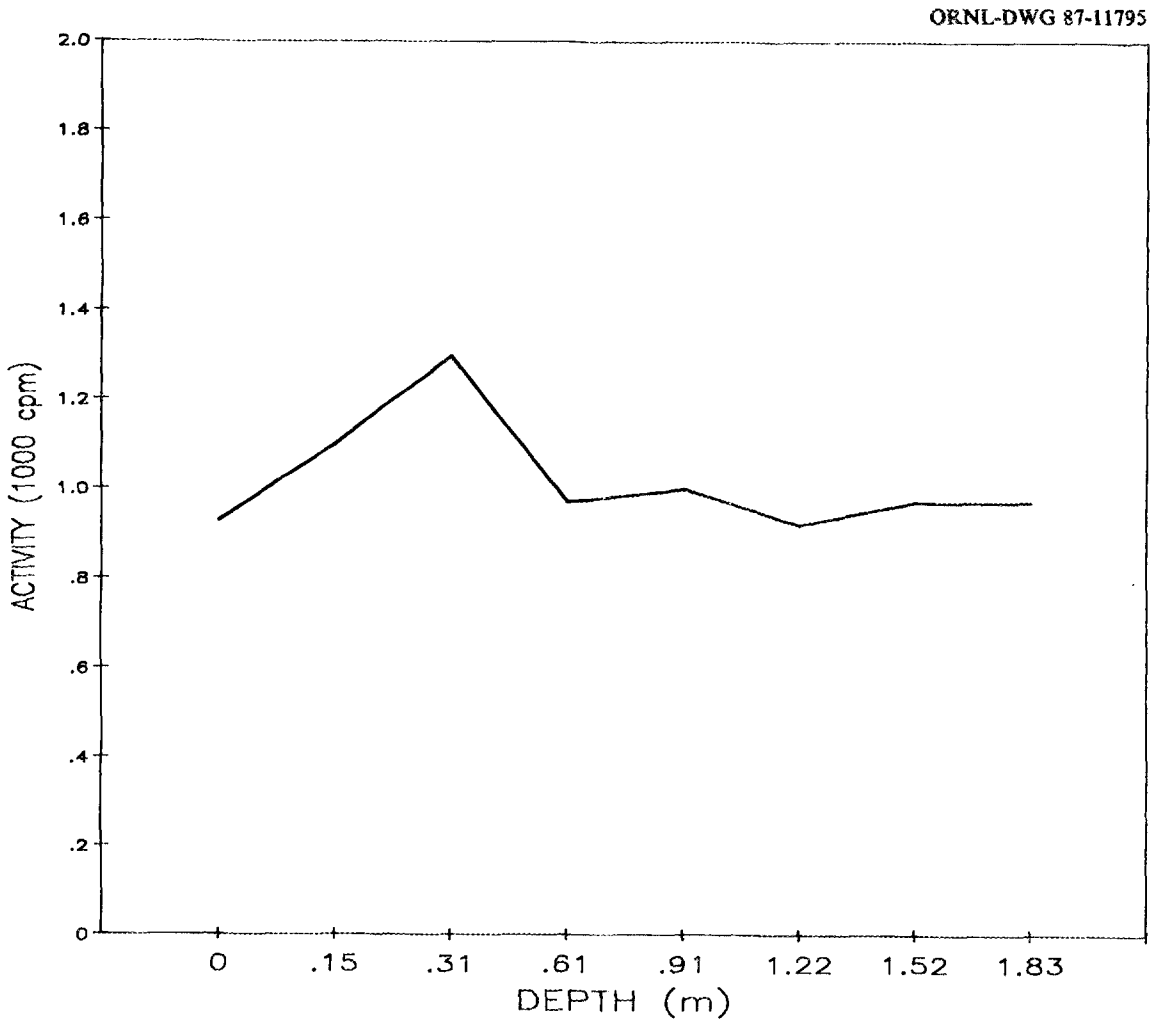

Fig. A.33. Gamma profile of auger hole 33.

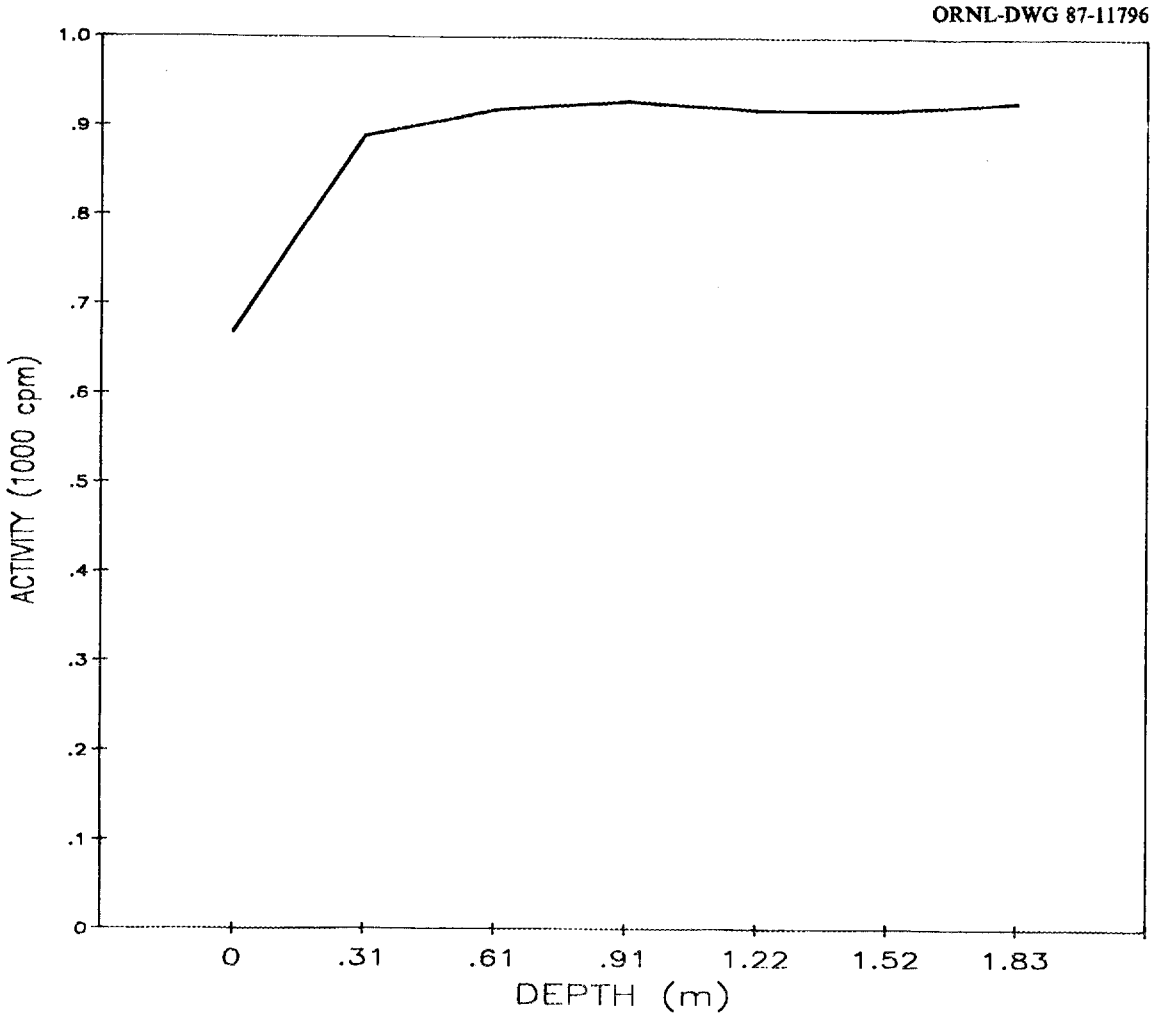

Fig. A.34. Gamma profile of auger hole 34.

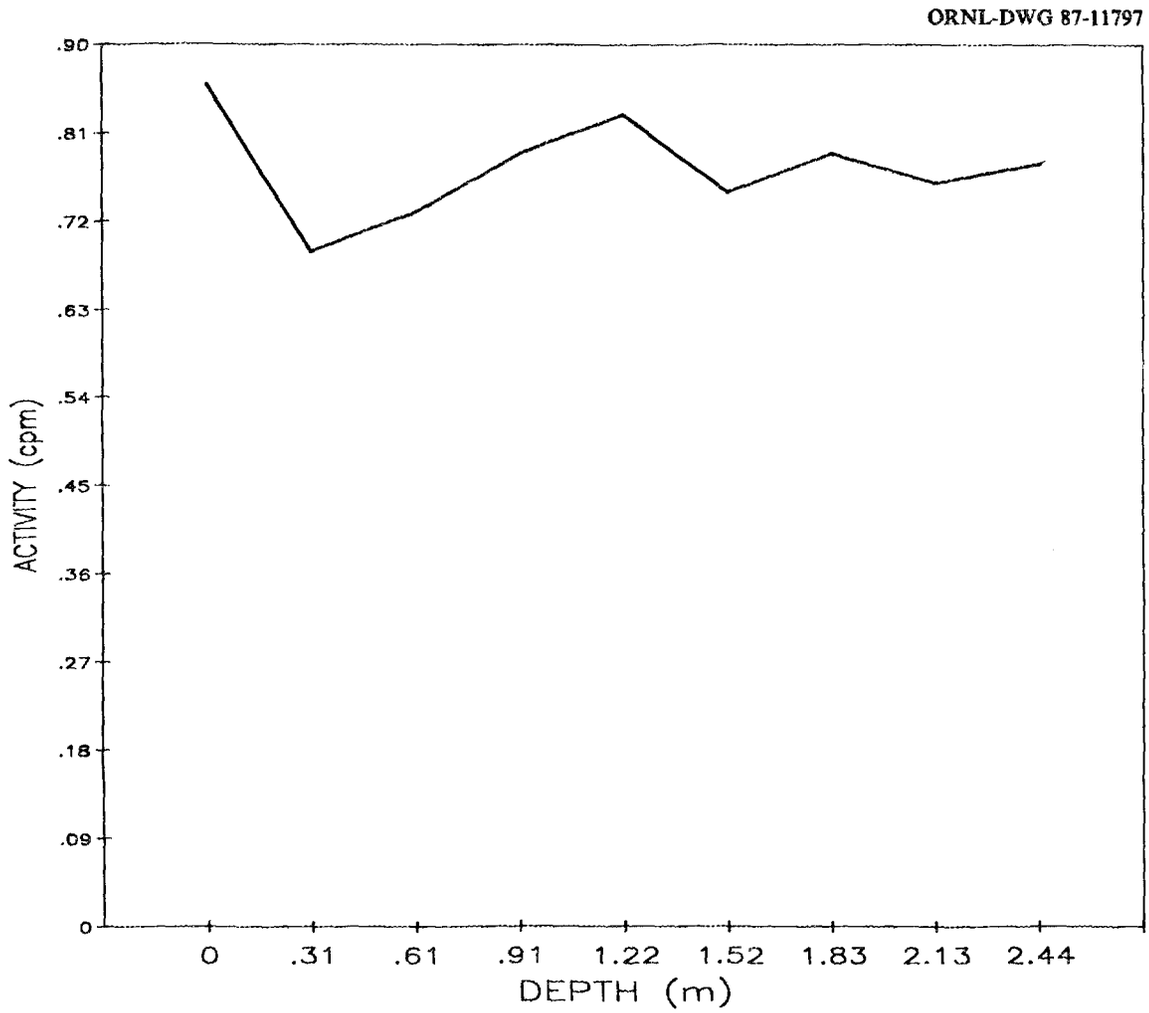

Fig. A.35. Gamma profile of auger hole 36.

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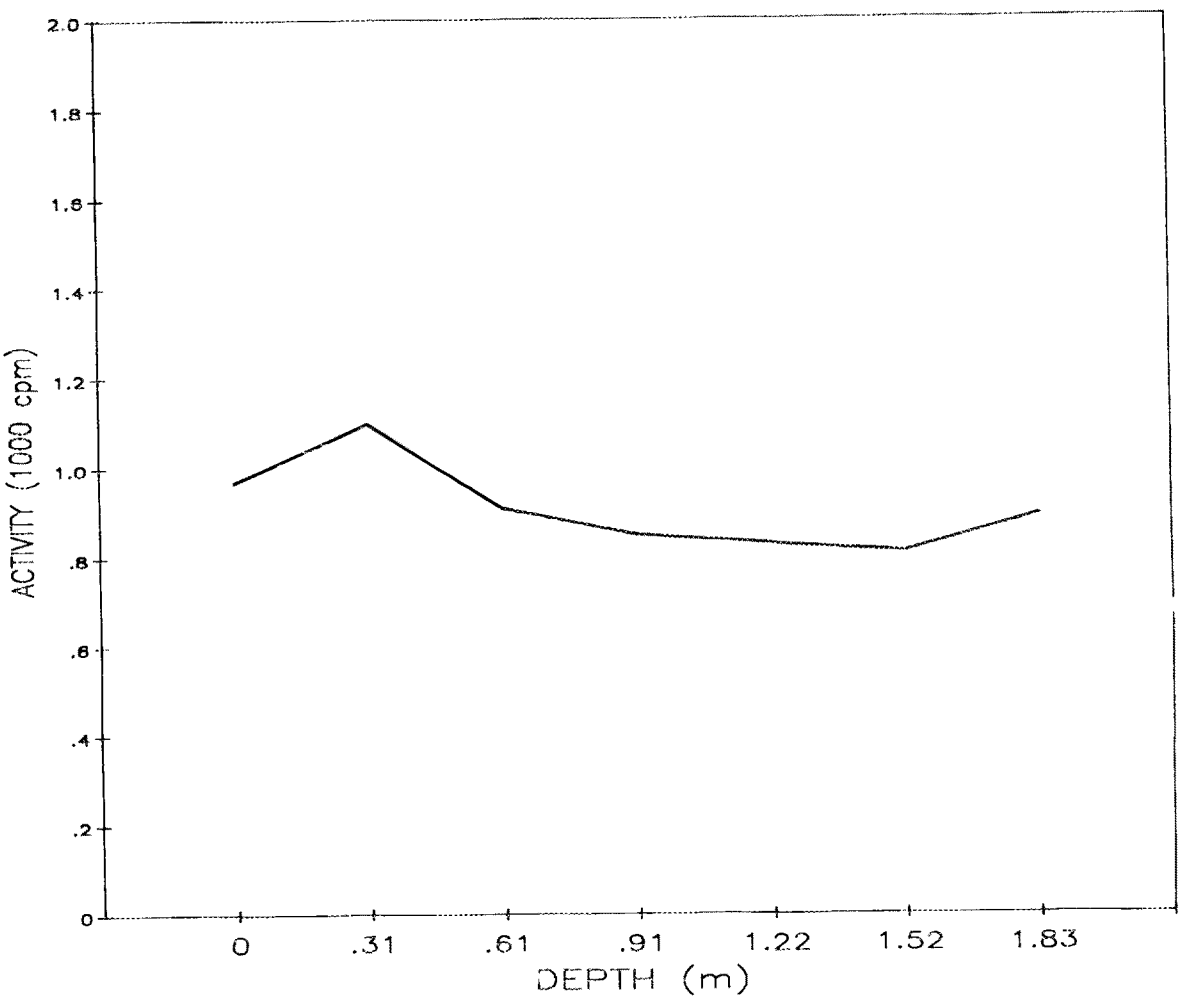

Fig. A.36. Gamma profile of auger hole 39.

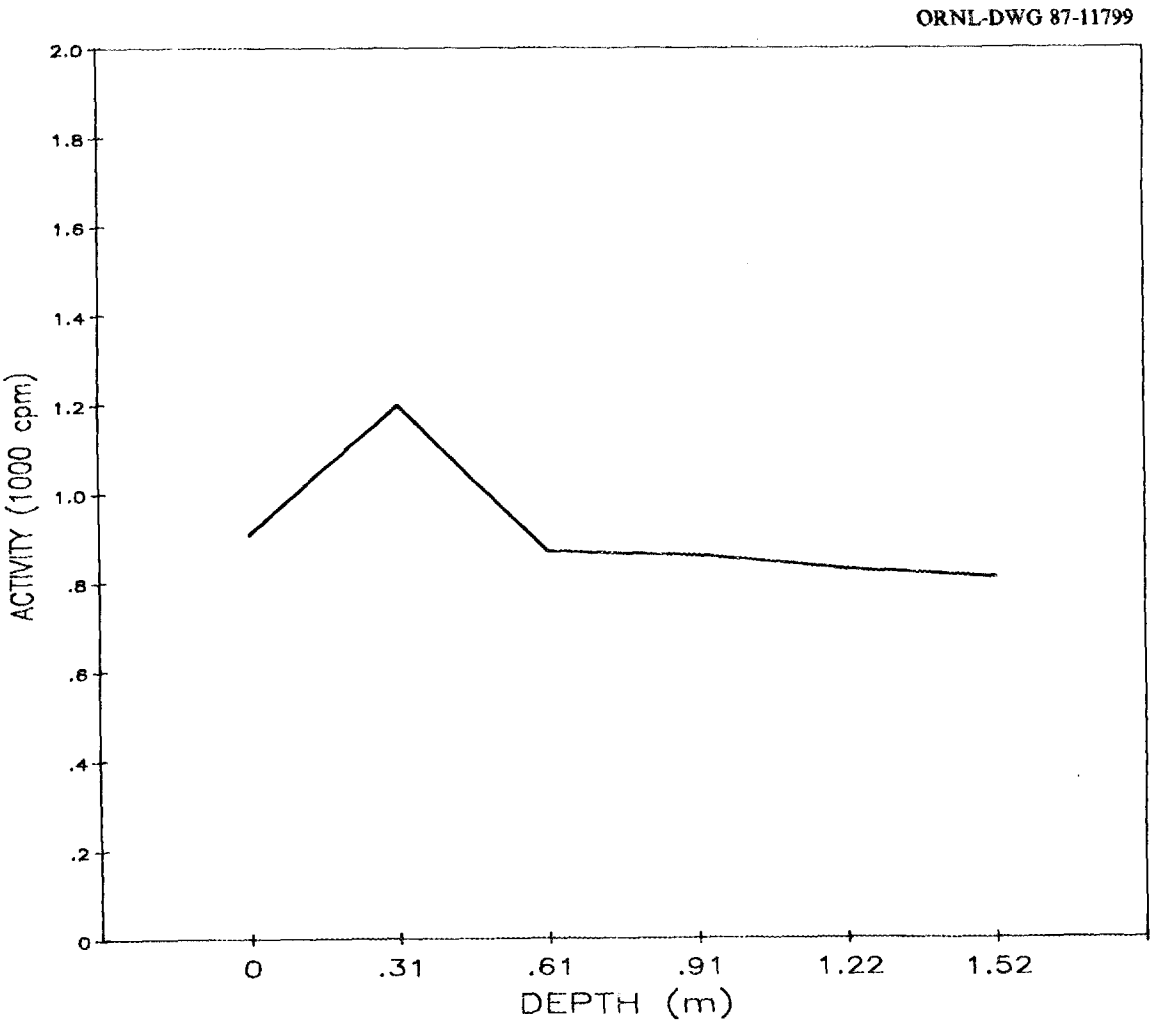

Fig. A.37. Gamma profile of auger hole 40.

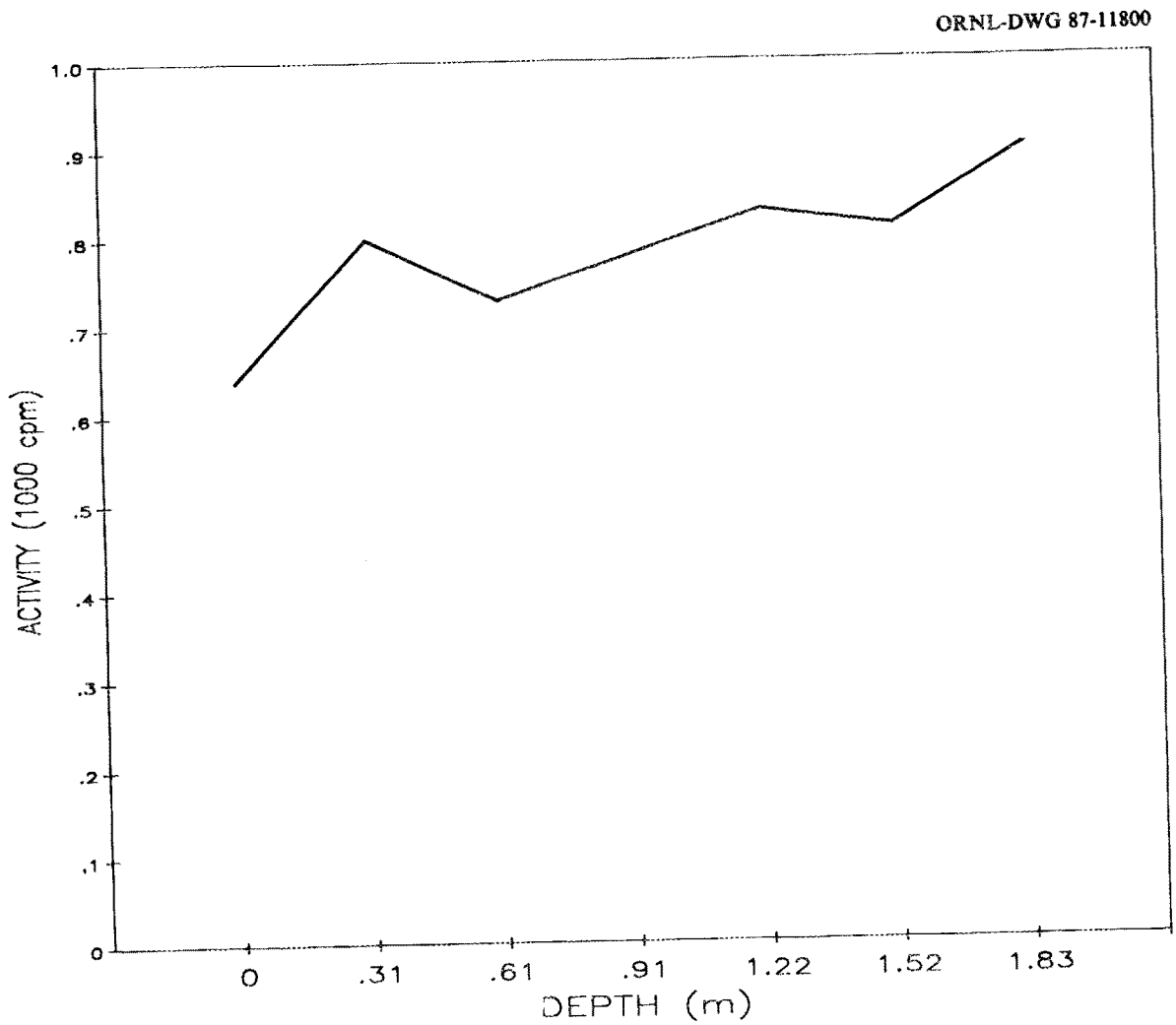

Fig. A.38. Gamma profile of auger hole 52.

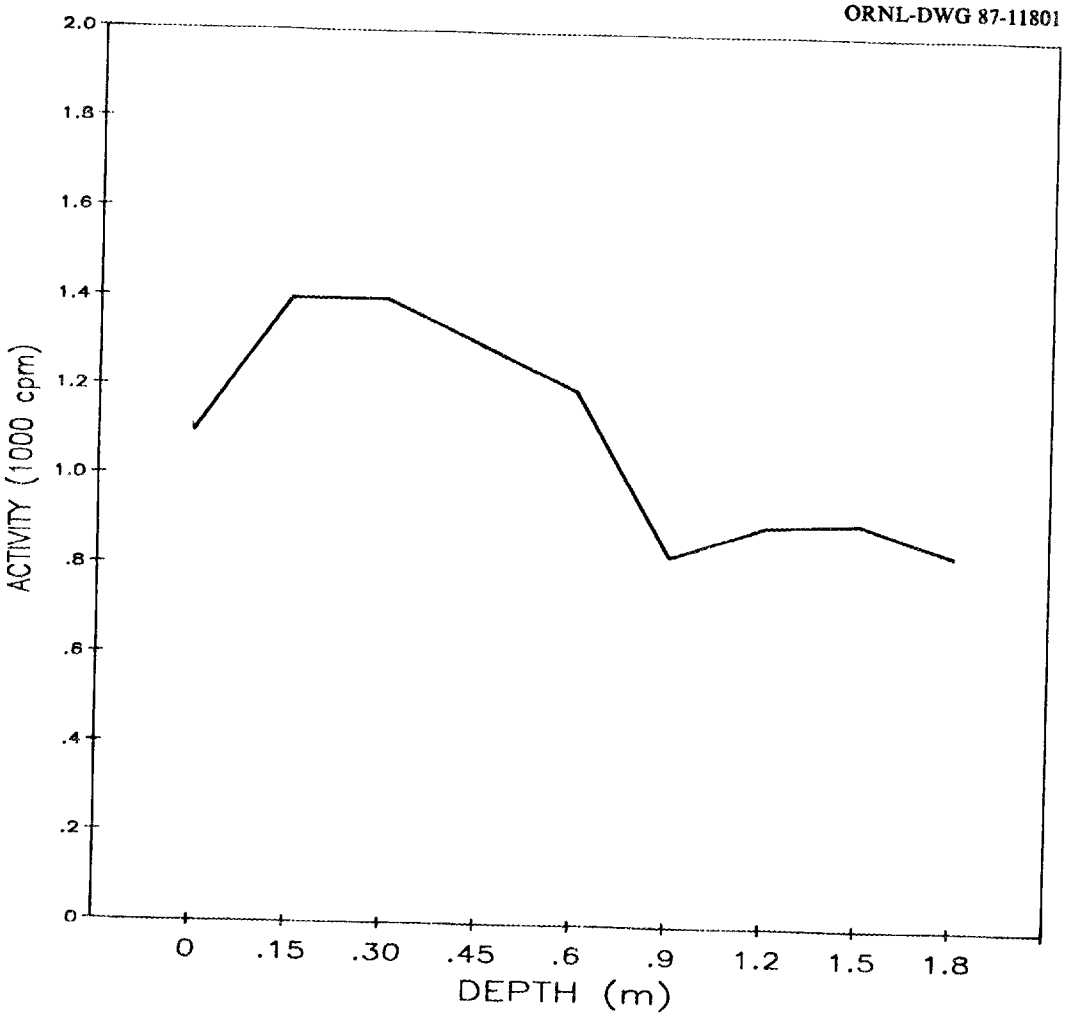

Fig. A.39. Gamma profile of auger hole 56.

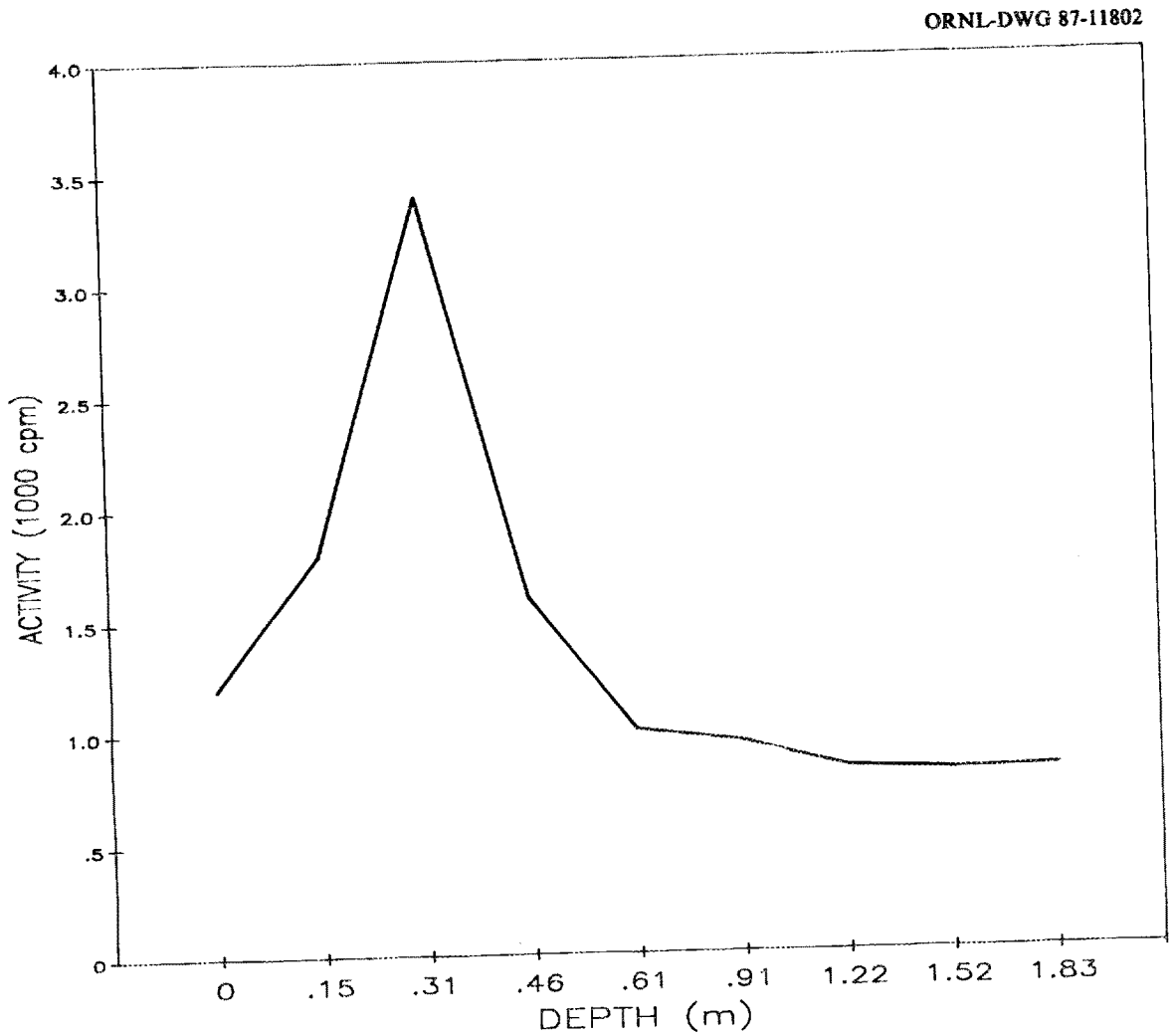

Fig. A.40. Gamma profile of auger hole 57.

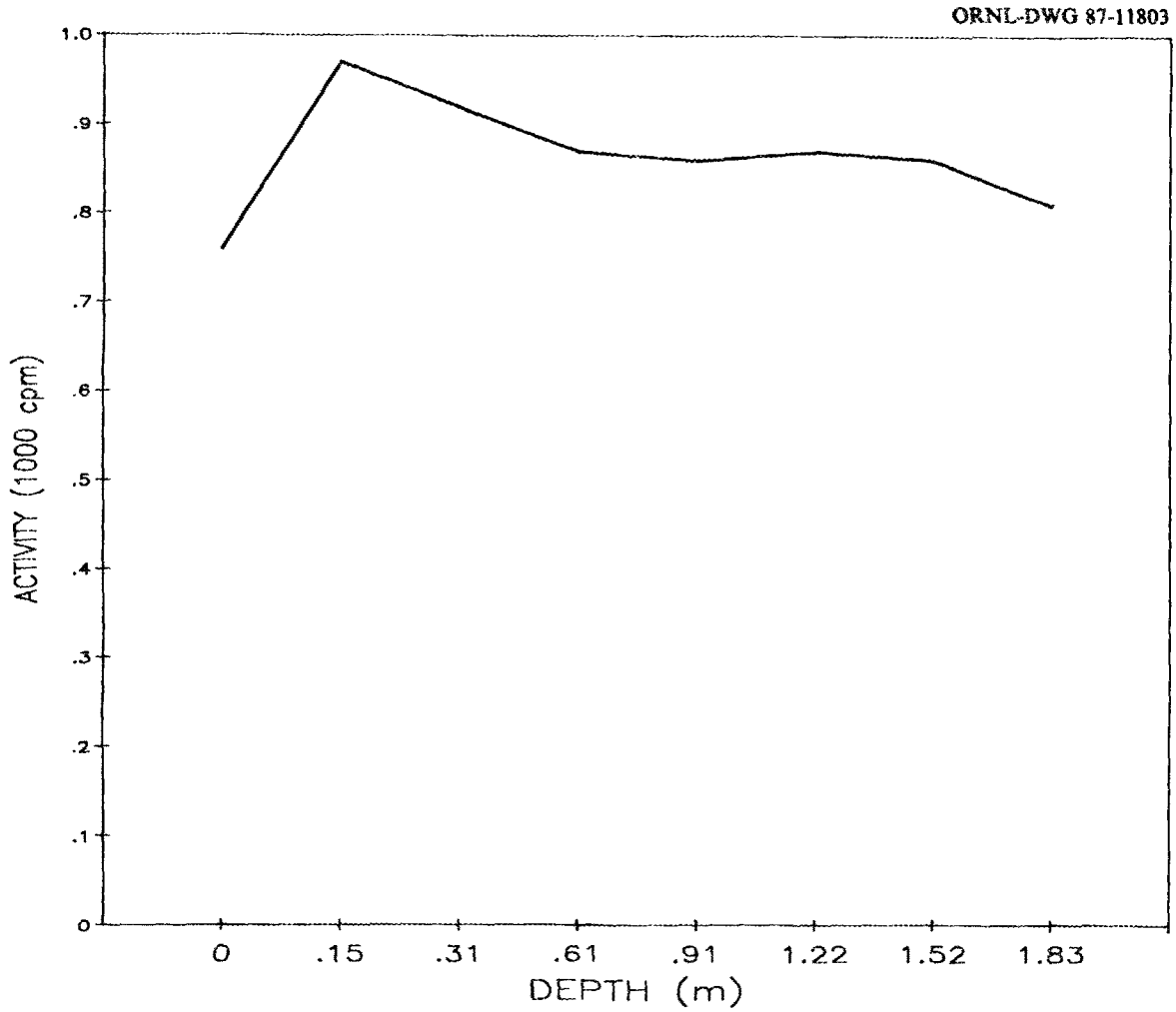

Fig. A.41. Gamma profile of auger hole 58.

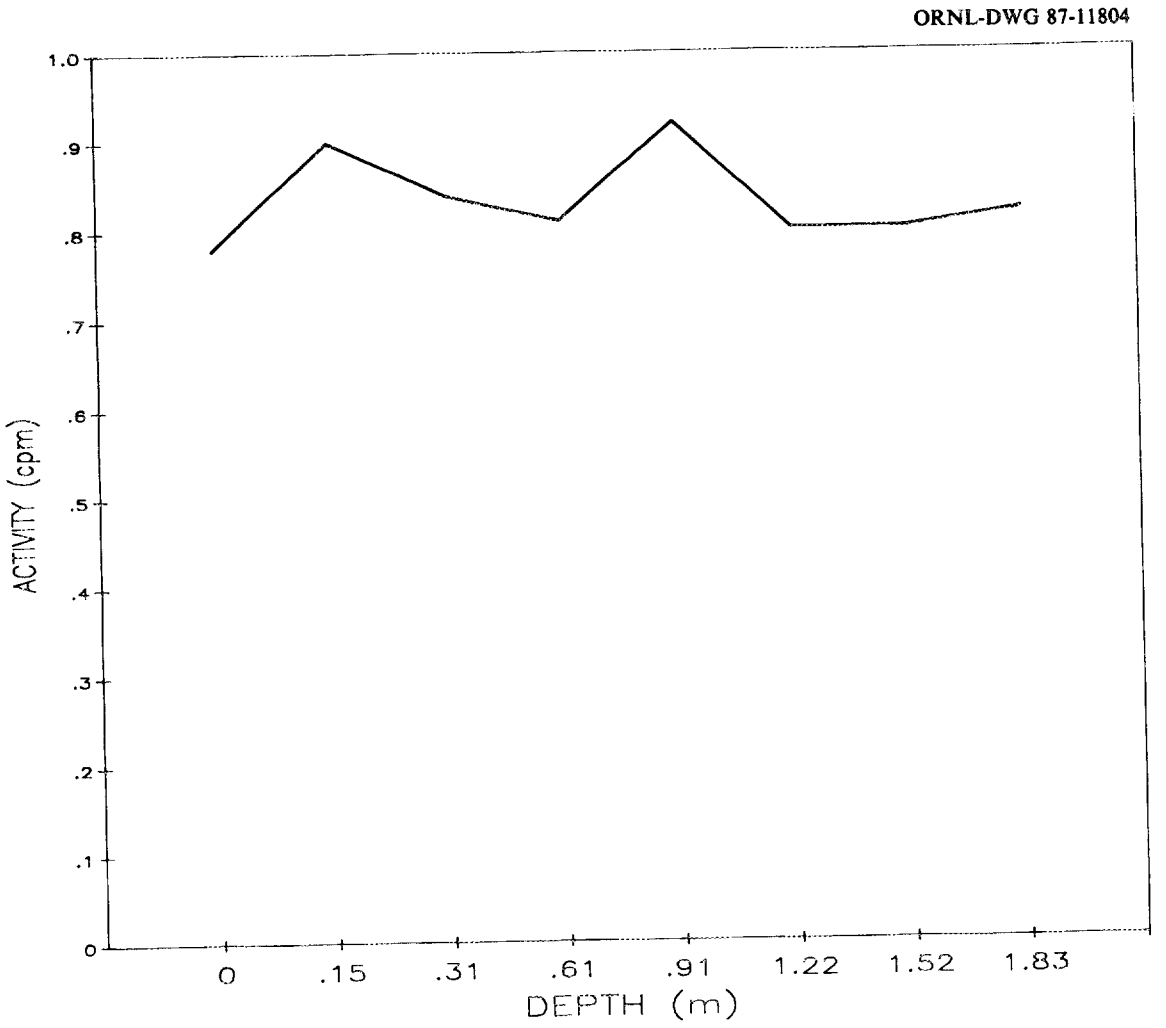

Fig. A.42. Gamma profile of auger hole 59.

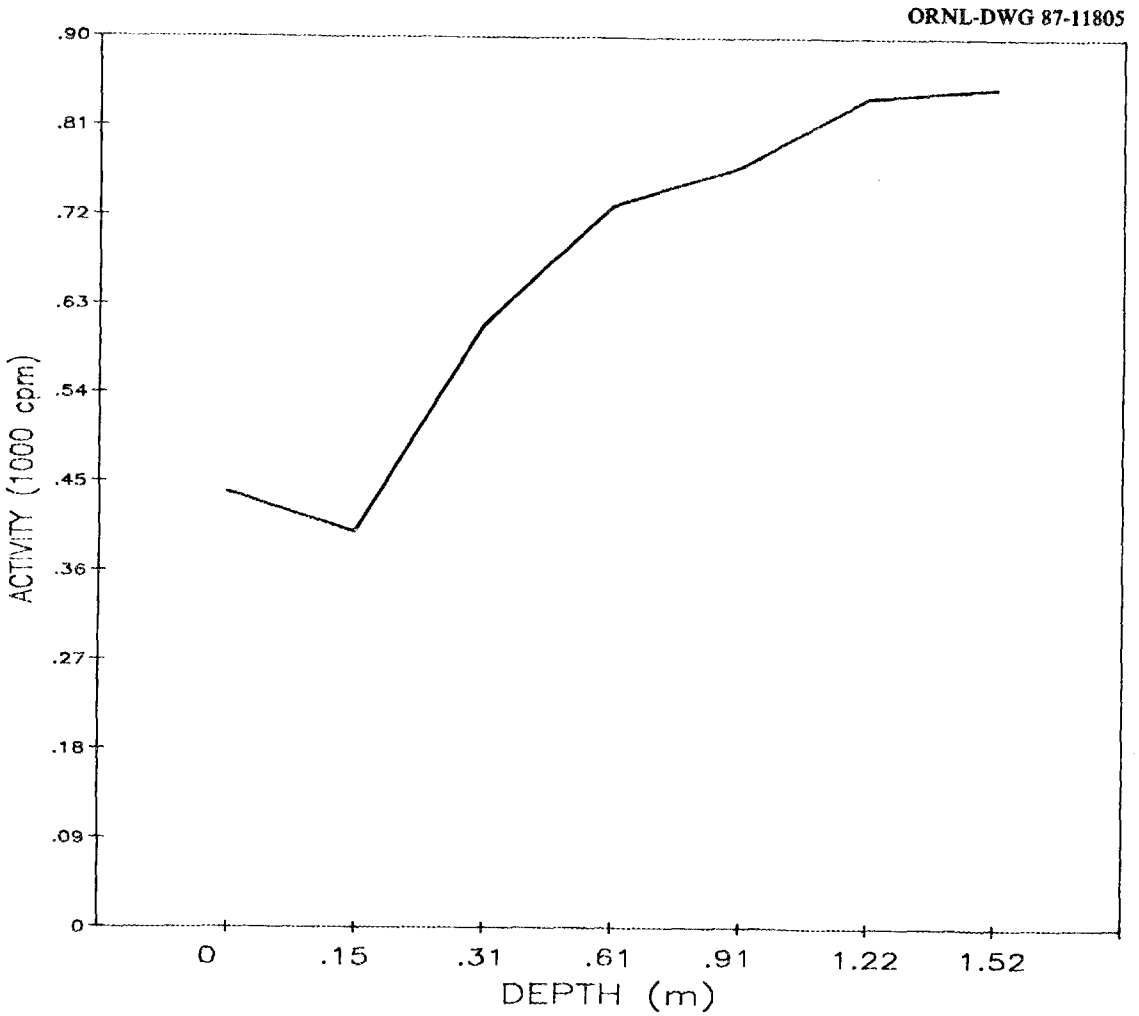

Fig. A.43. Gamma profile of auger hole 60.

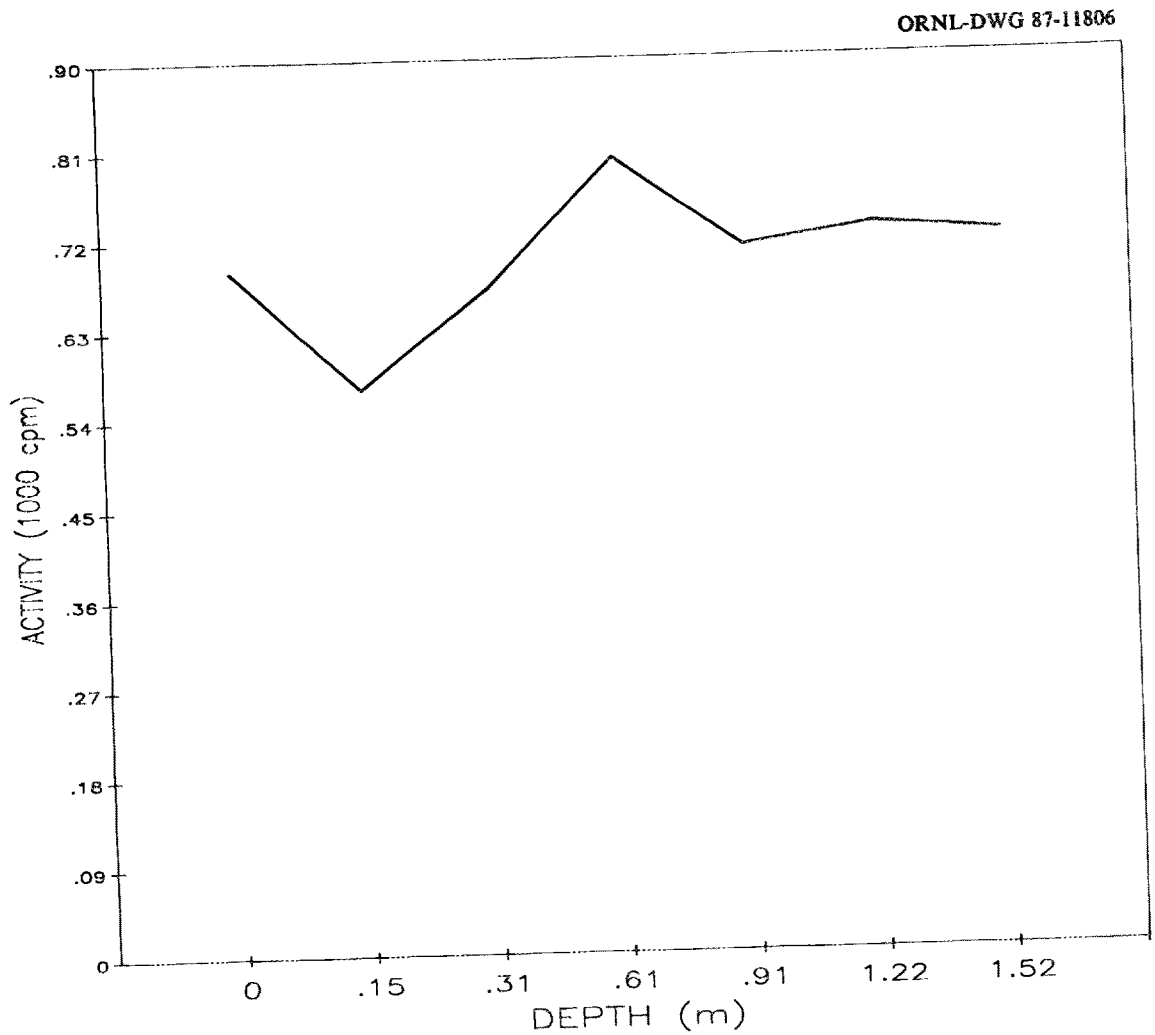

Fig. A.44. Gamma profile of auger hole 61.

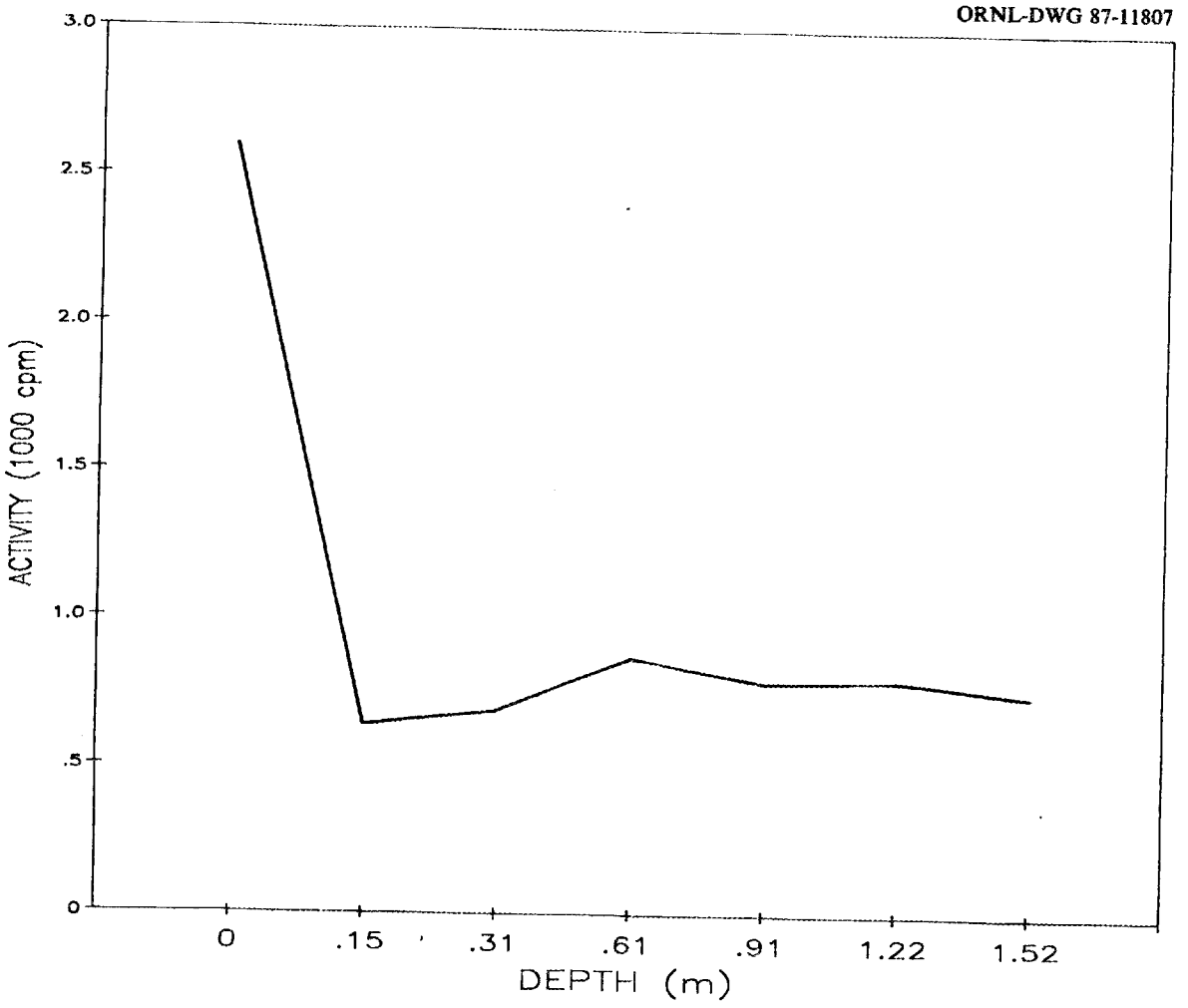

Fig. A.45. Gamma profile of auger hole 62.

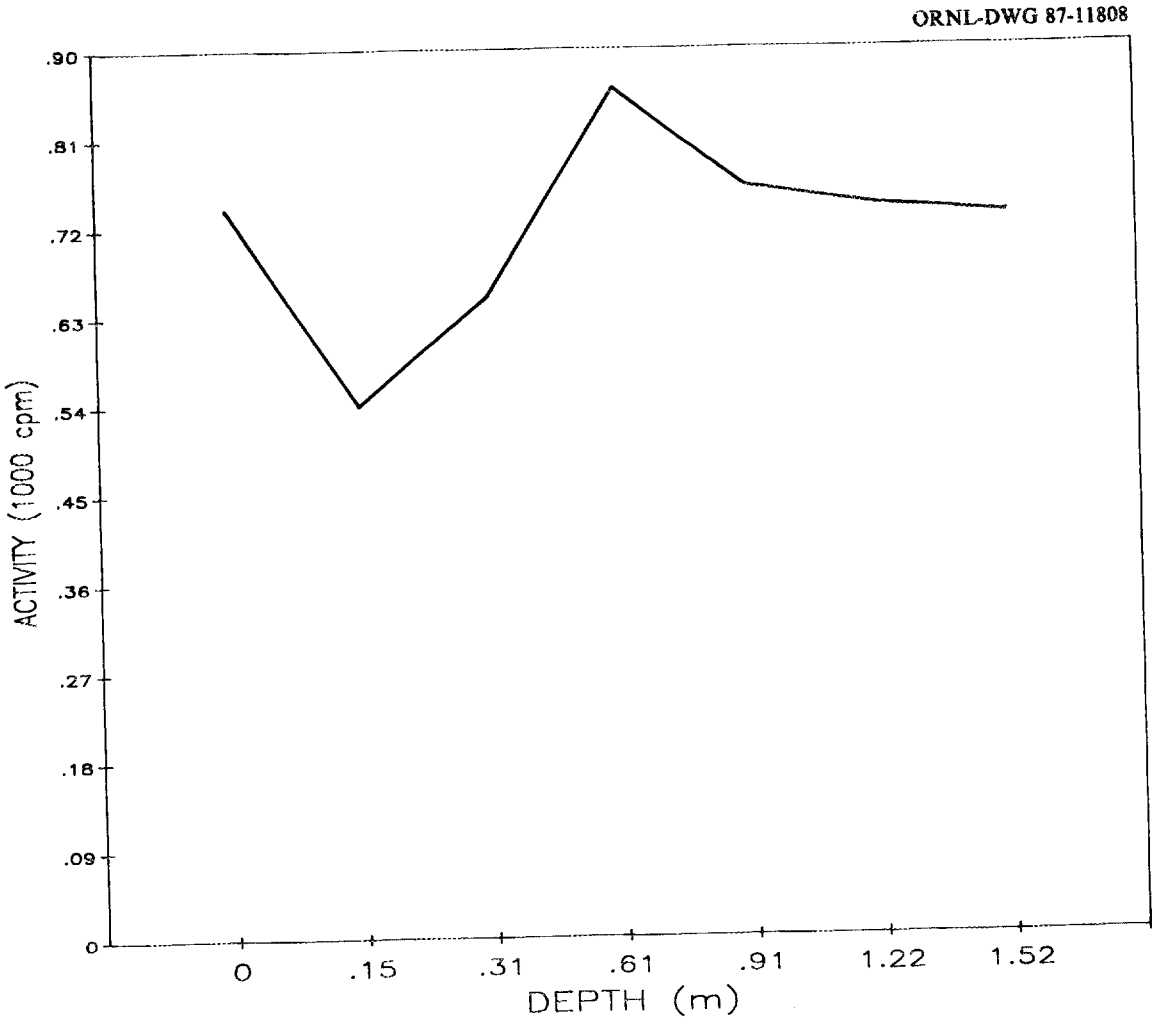

Fig. A.46. Gamma profile of auger hole 63.

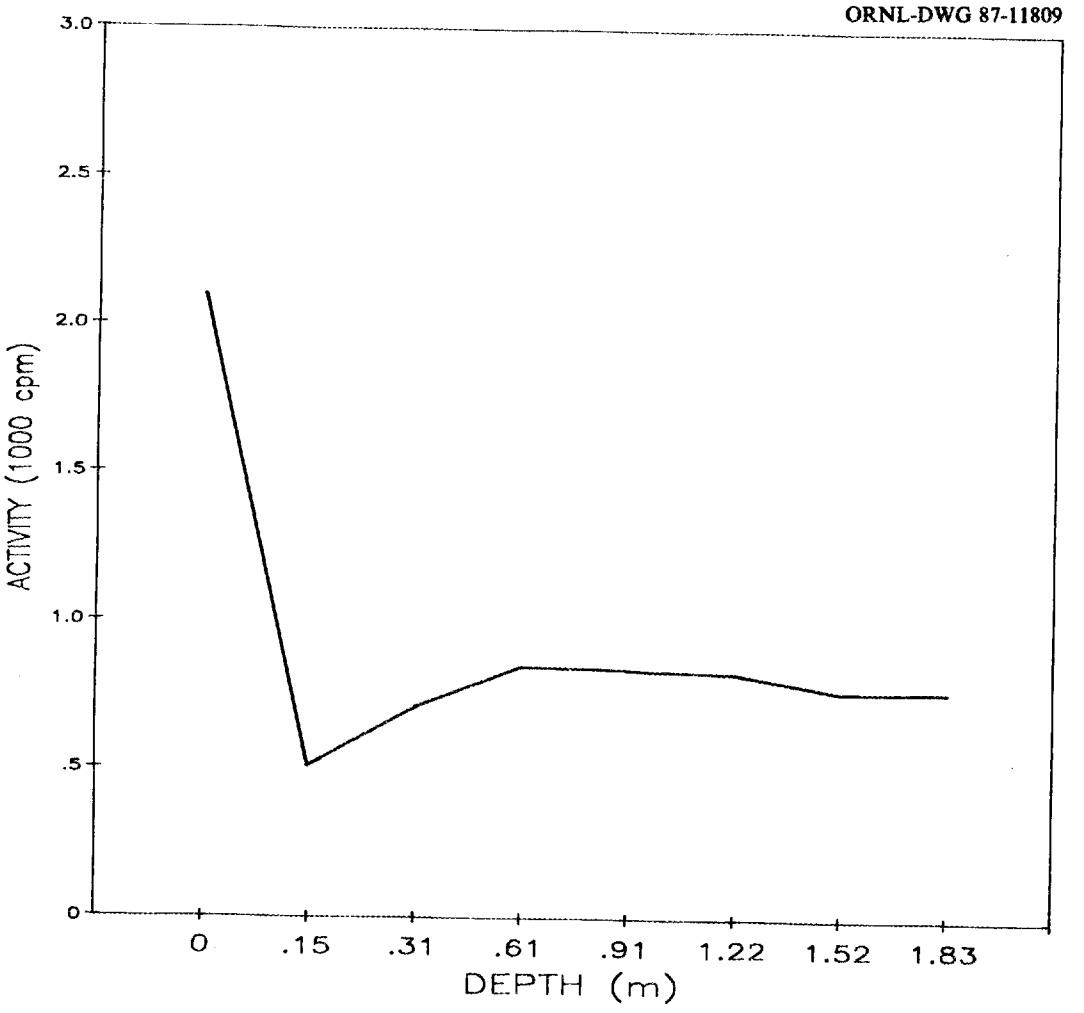

Fig. A.47. Gamma profile of auger hole 64.

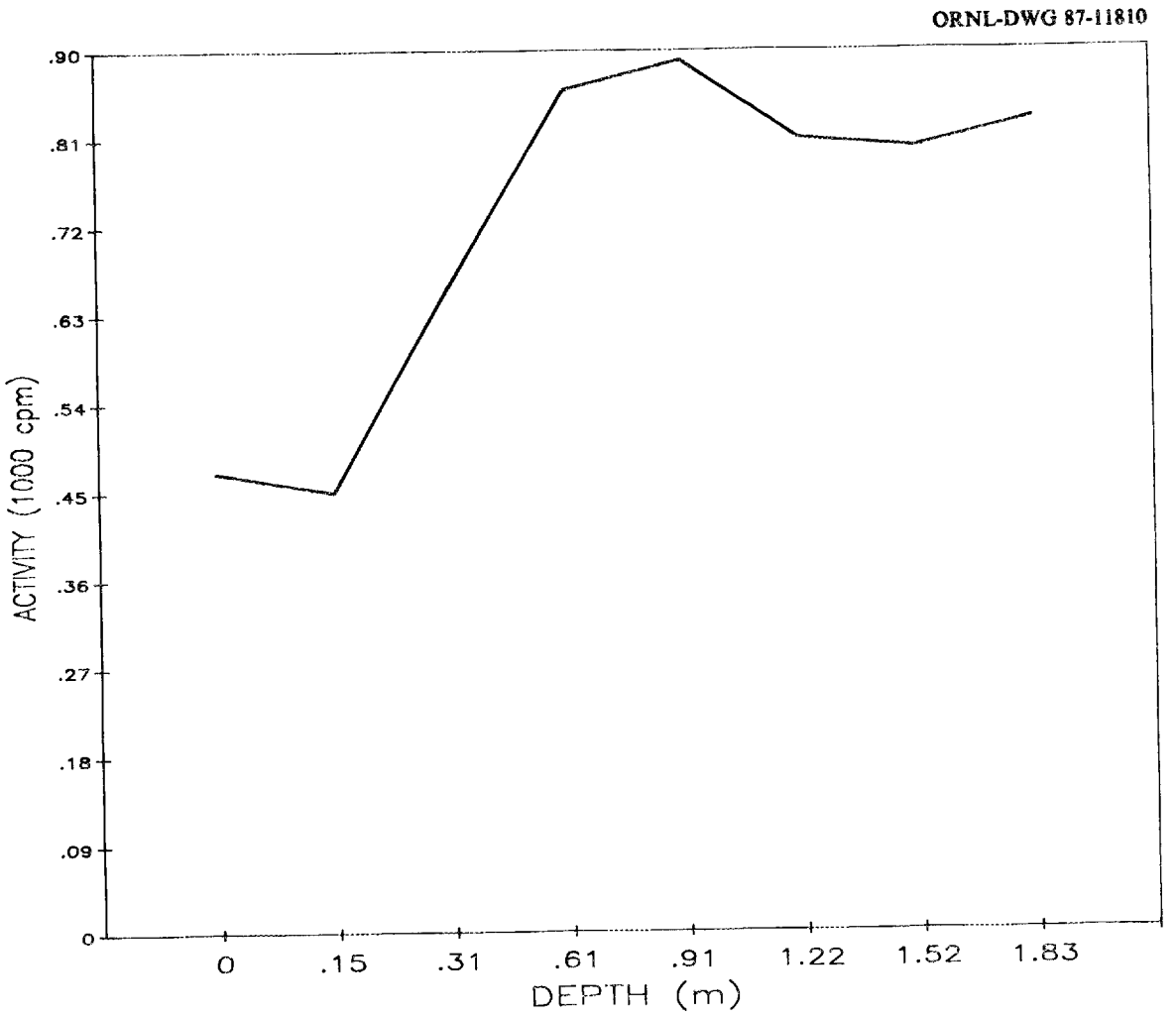

Fig. A.48. Gamma profile of auger hole 65.

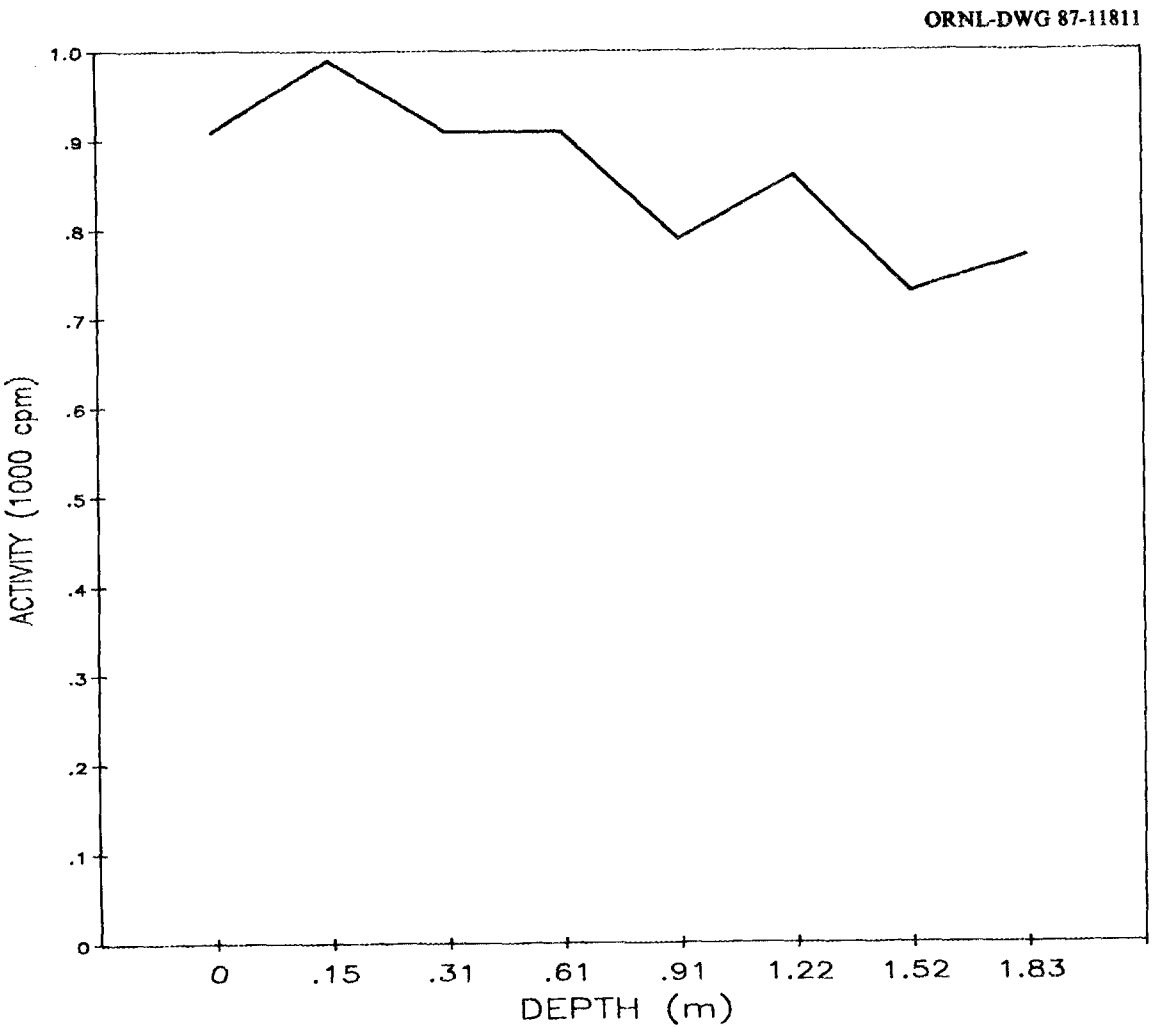

Fig. A.49. Gamma profile of auger hole 66.

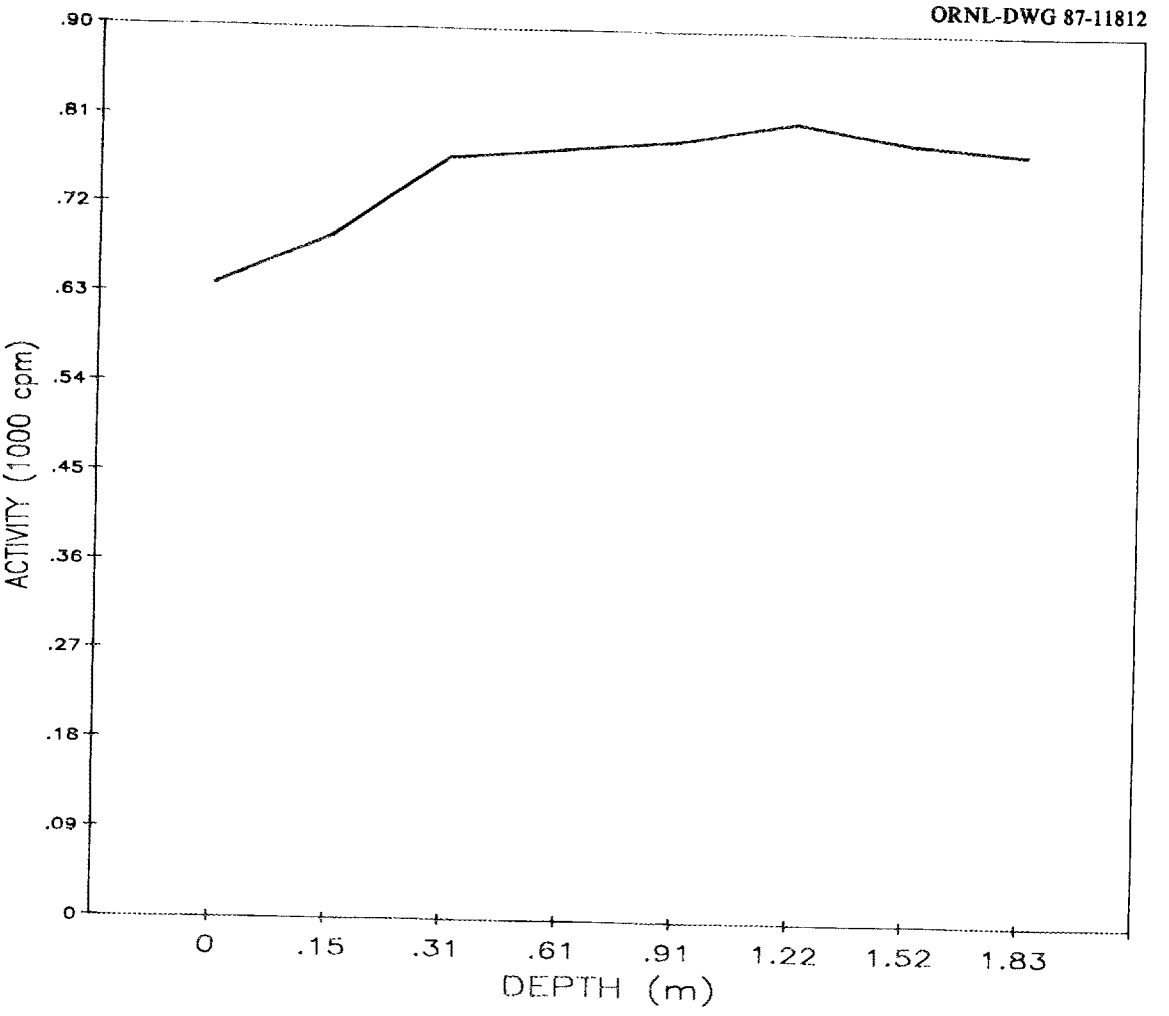

Fig. A.50. Gamma profile of auger hole 67.

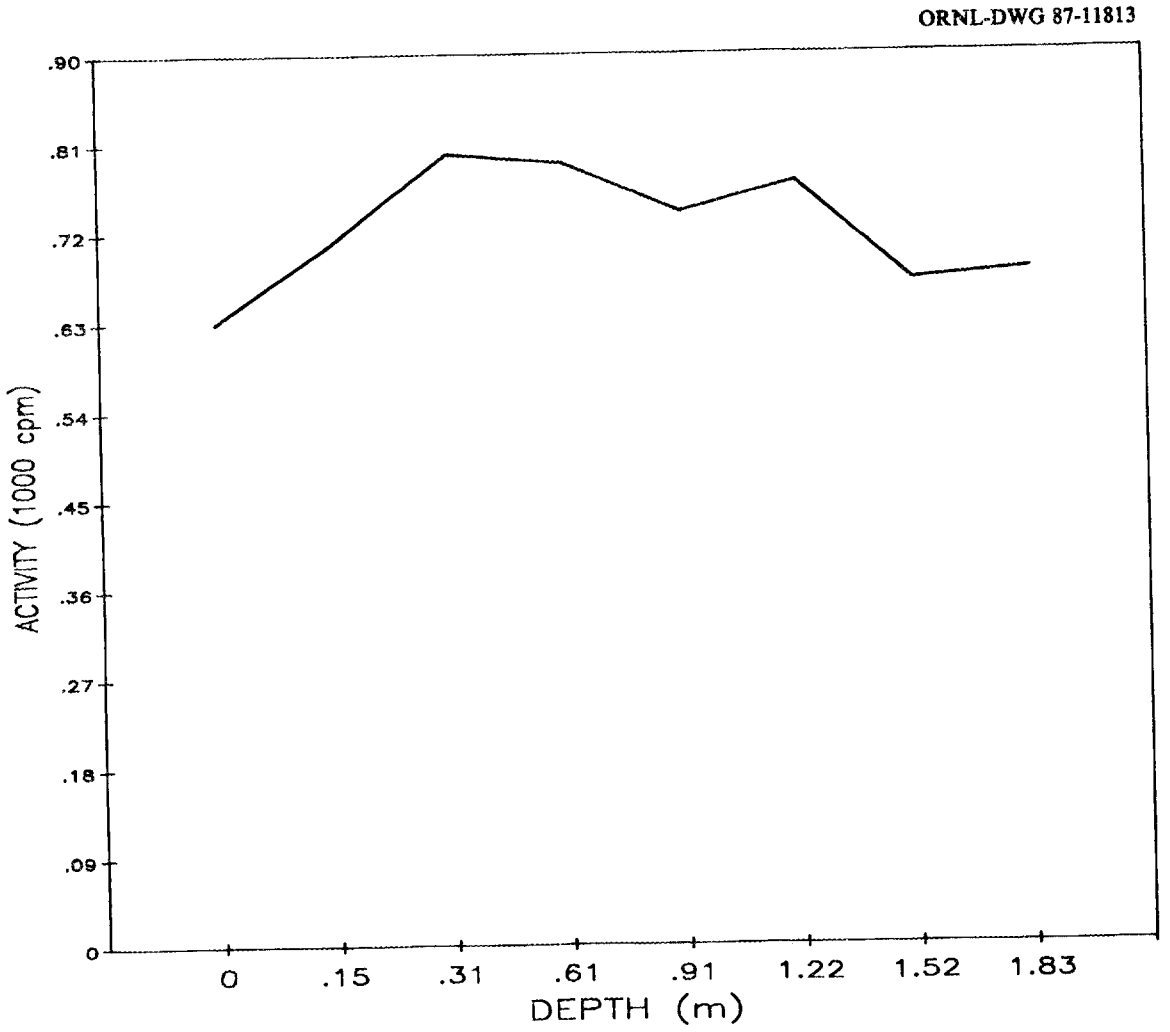

Fig. A.51. Gamma profile of auger hole 68.

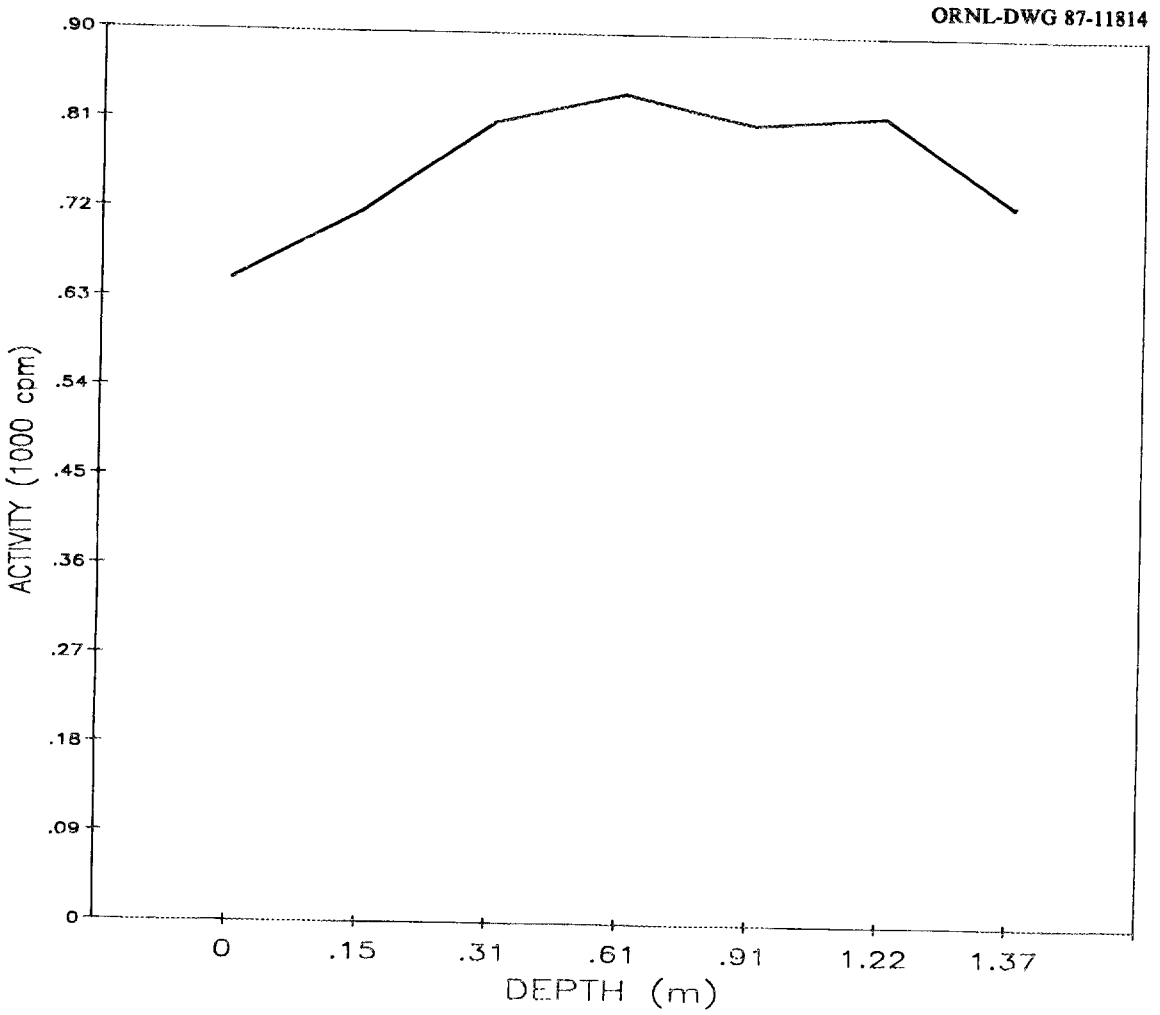

Fig. A.52. Gamma profile of auger hole 69.

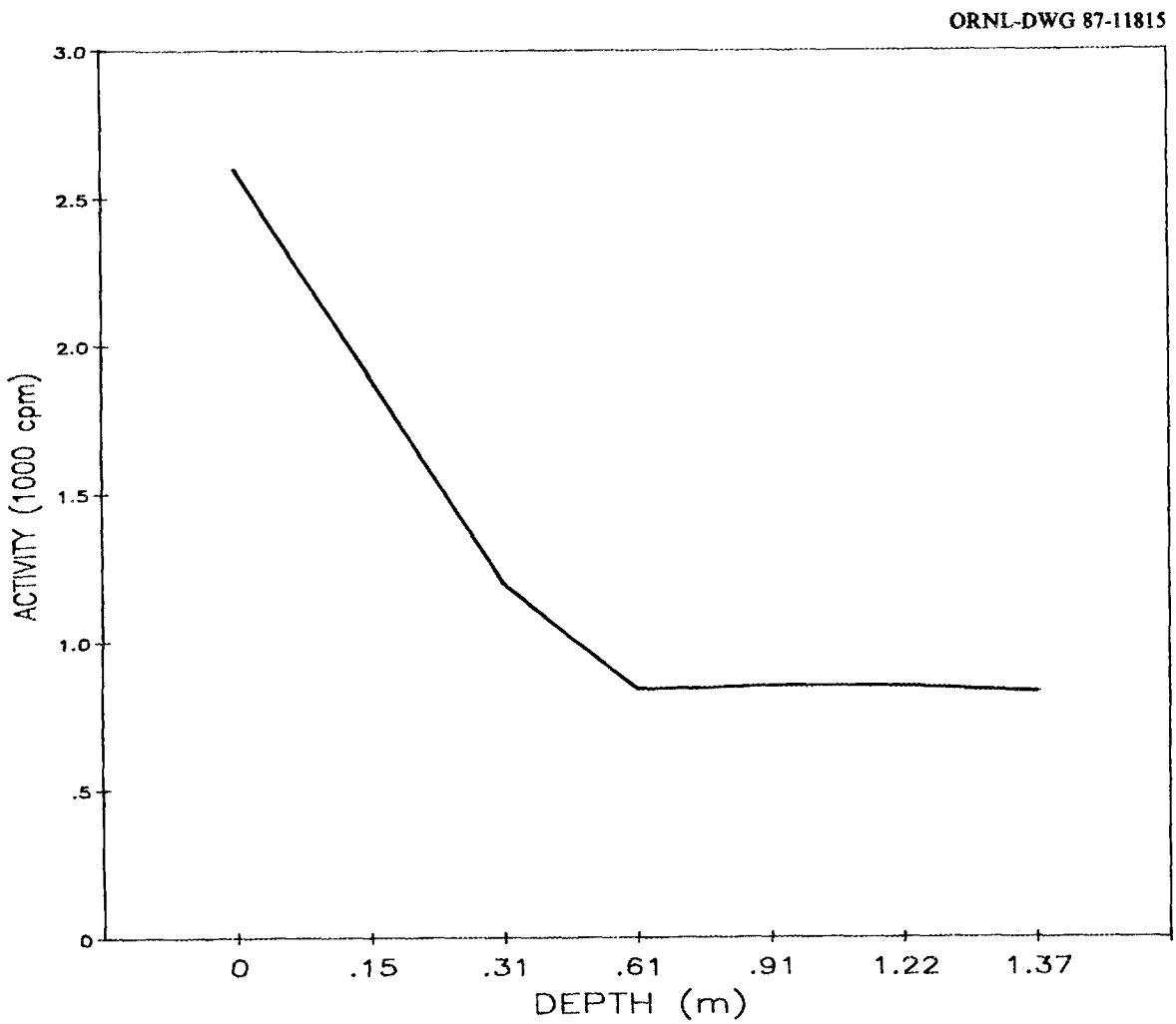

Fig. A.53. Gamma profile of auger hole 70.

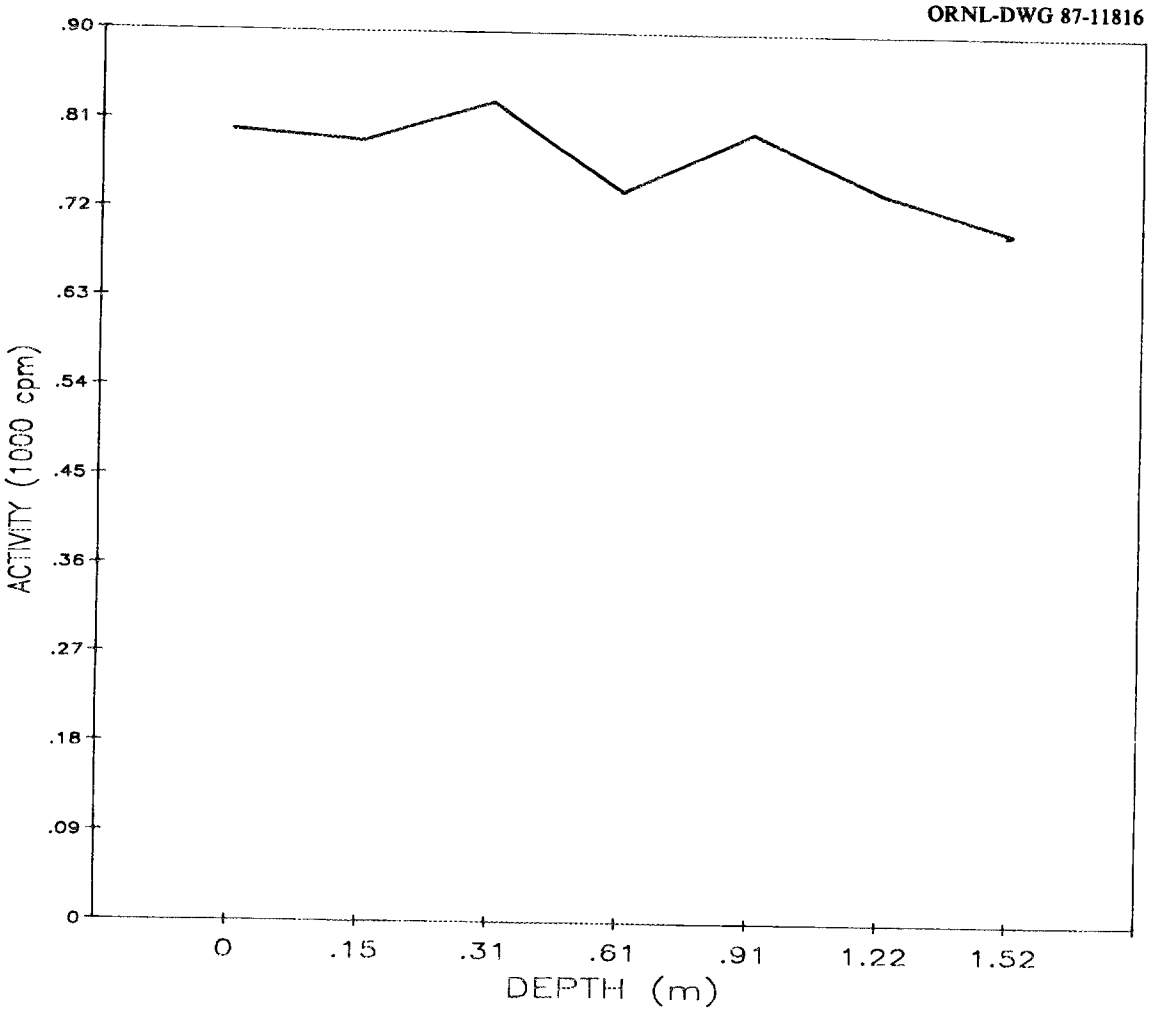

Fig. A.54. Gamma profile of auger hole 71.

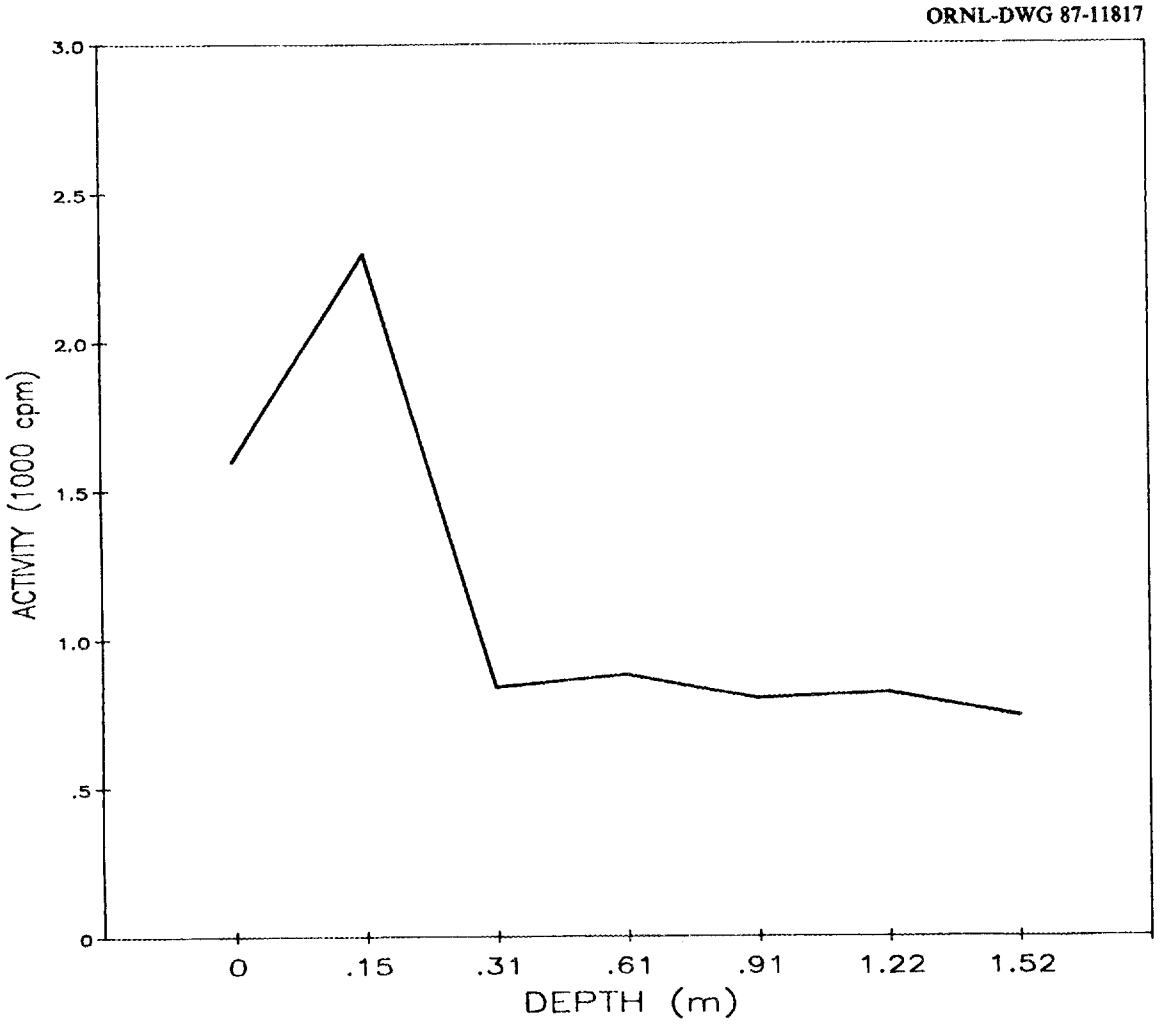

Fig. A.55. Gamma profile of auger hole 72.

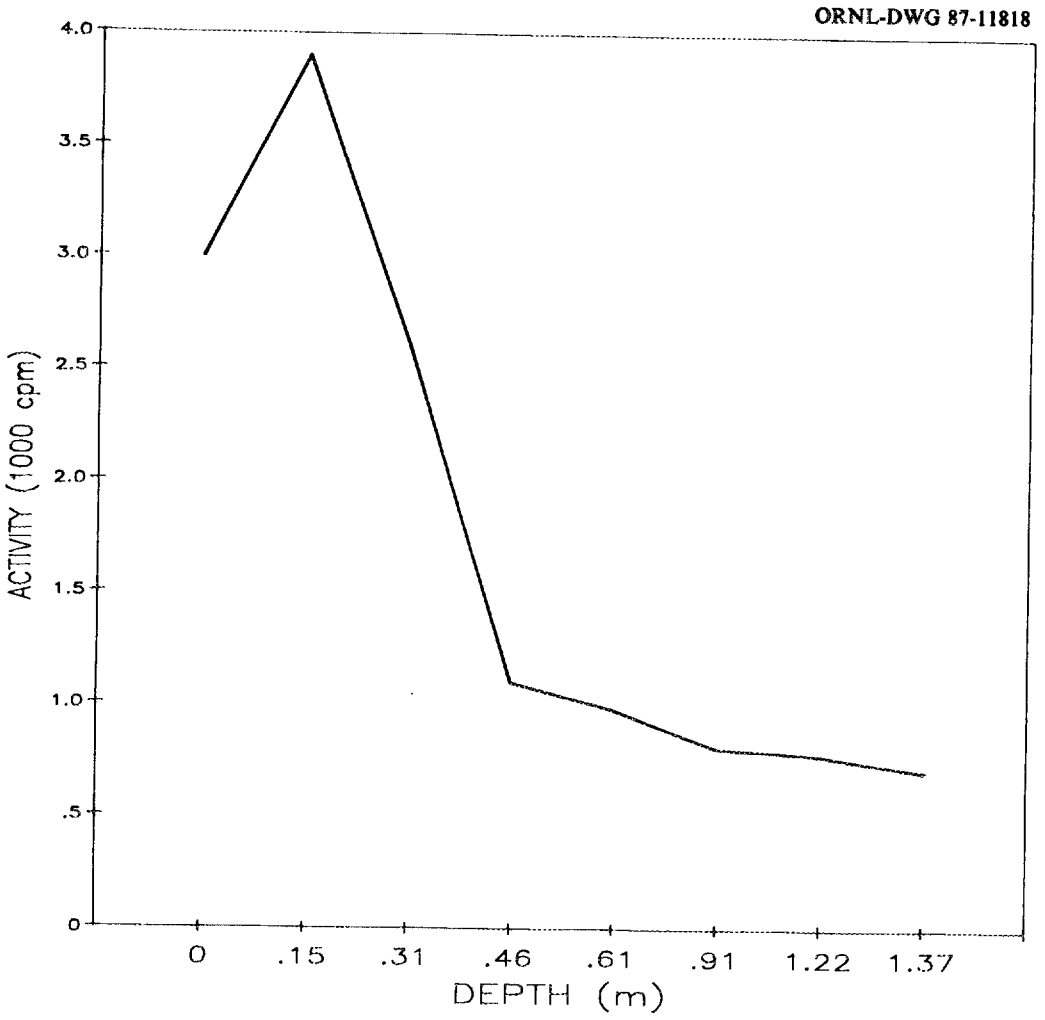

Fig. A.56. Gamma profile of auger hole 73.

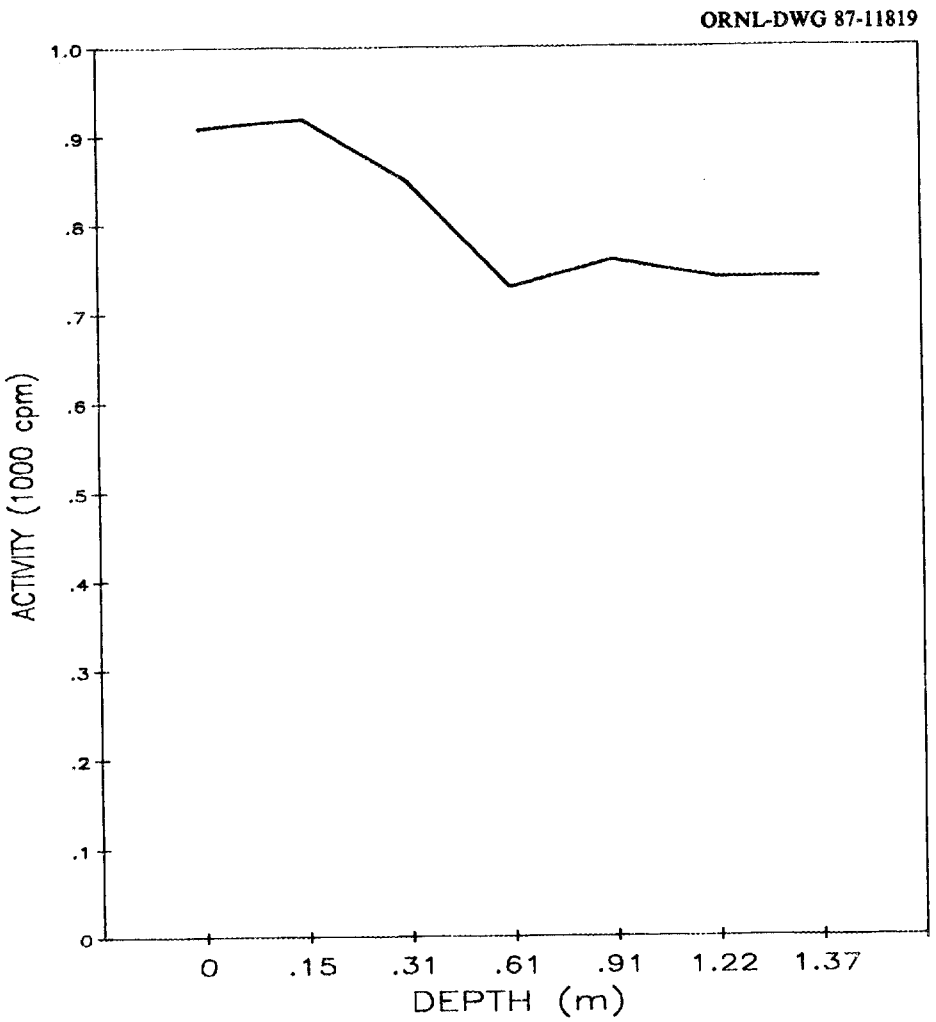

Fig. A.57. Gamma profile of auger hole 74.

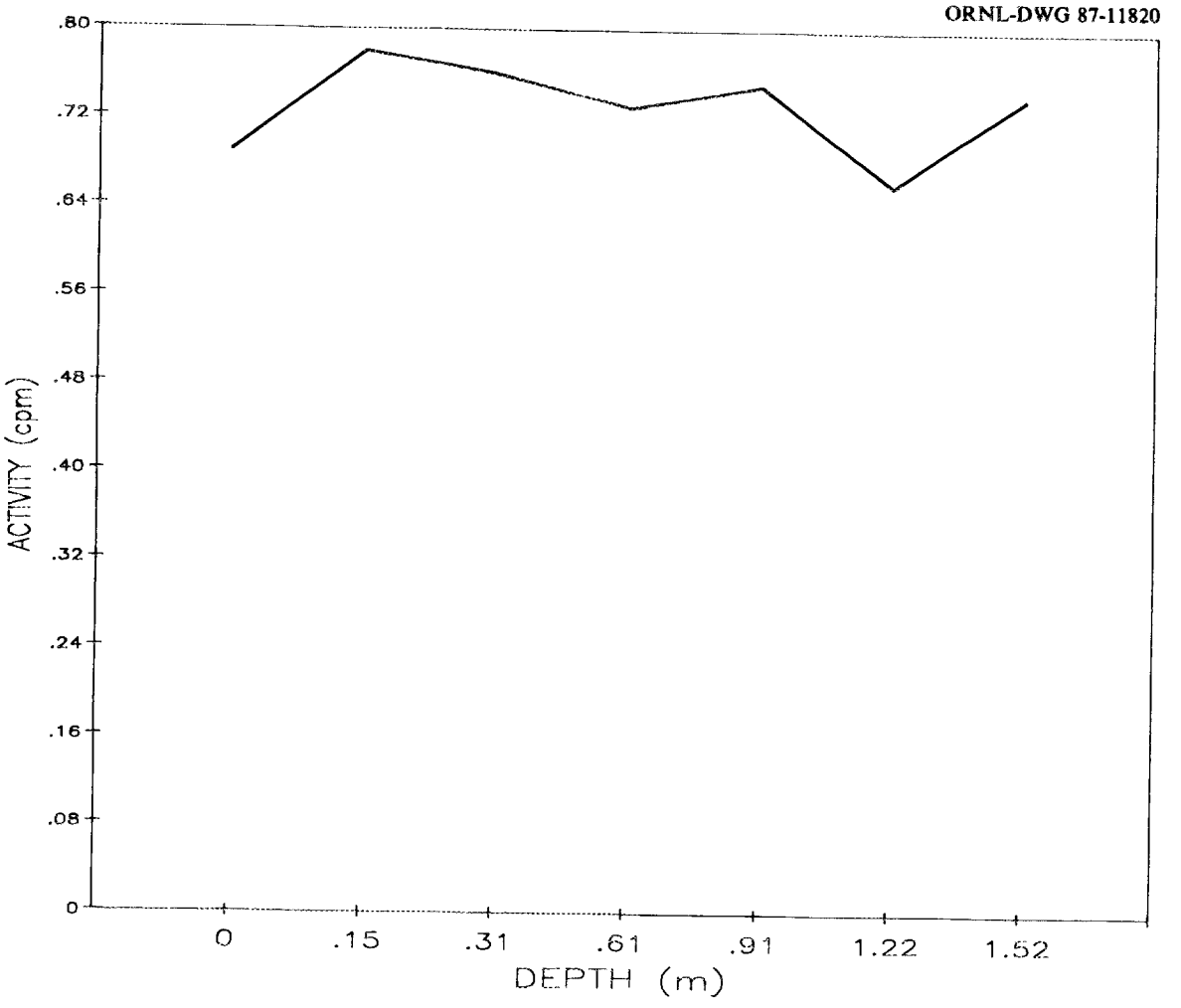

Fig. A.58. Gamma profile of auger hole 75.

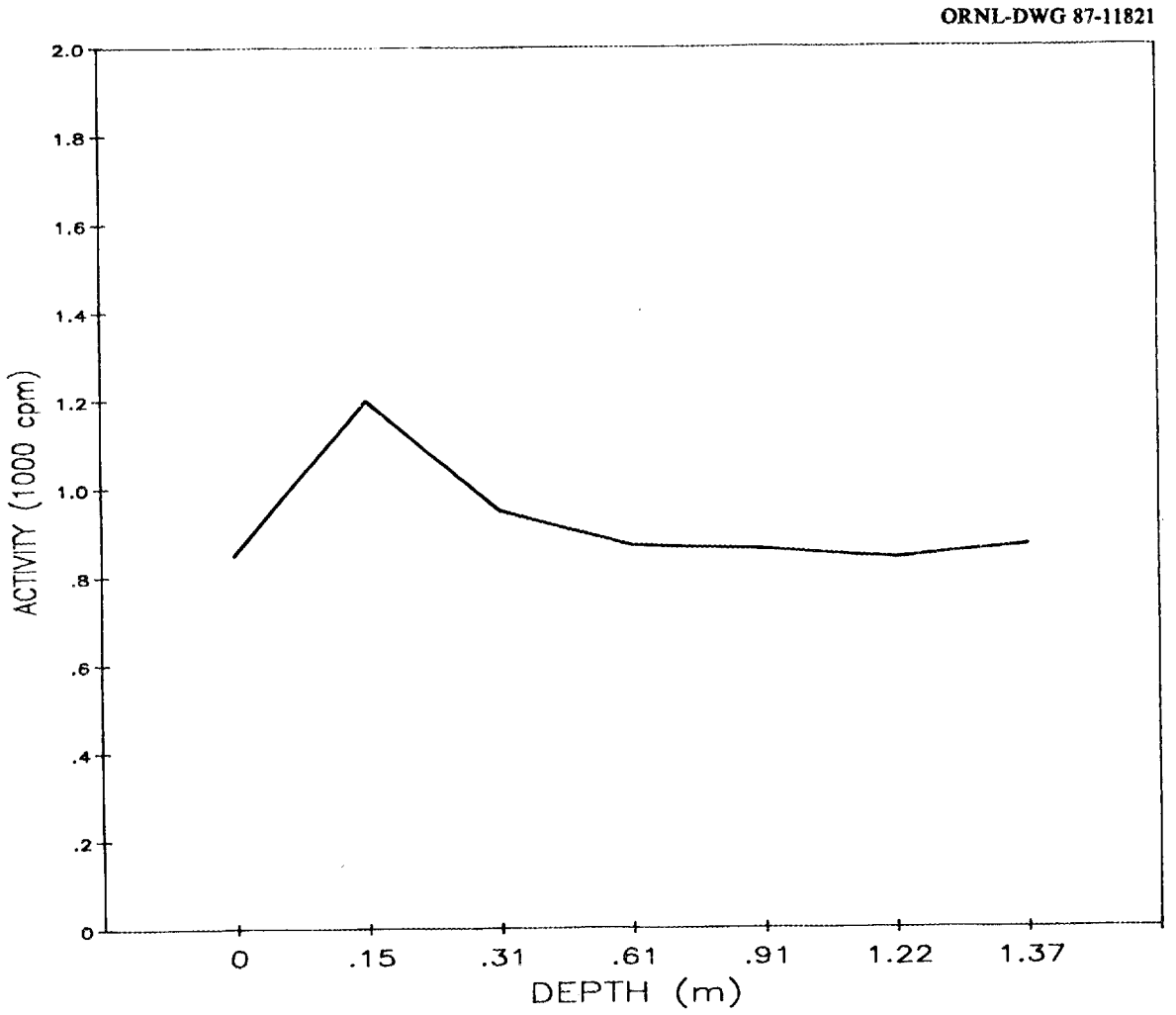

Fig. A.59. Gamma profile of auger hole 78.

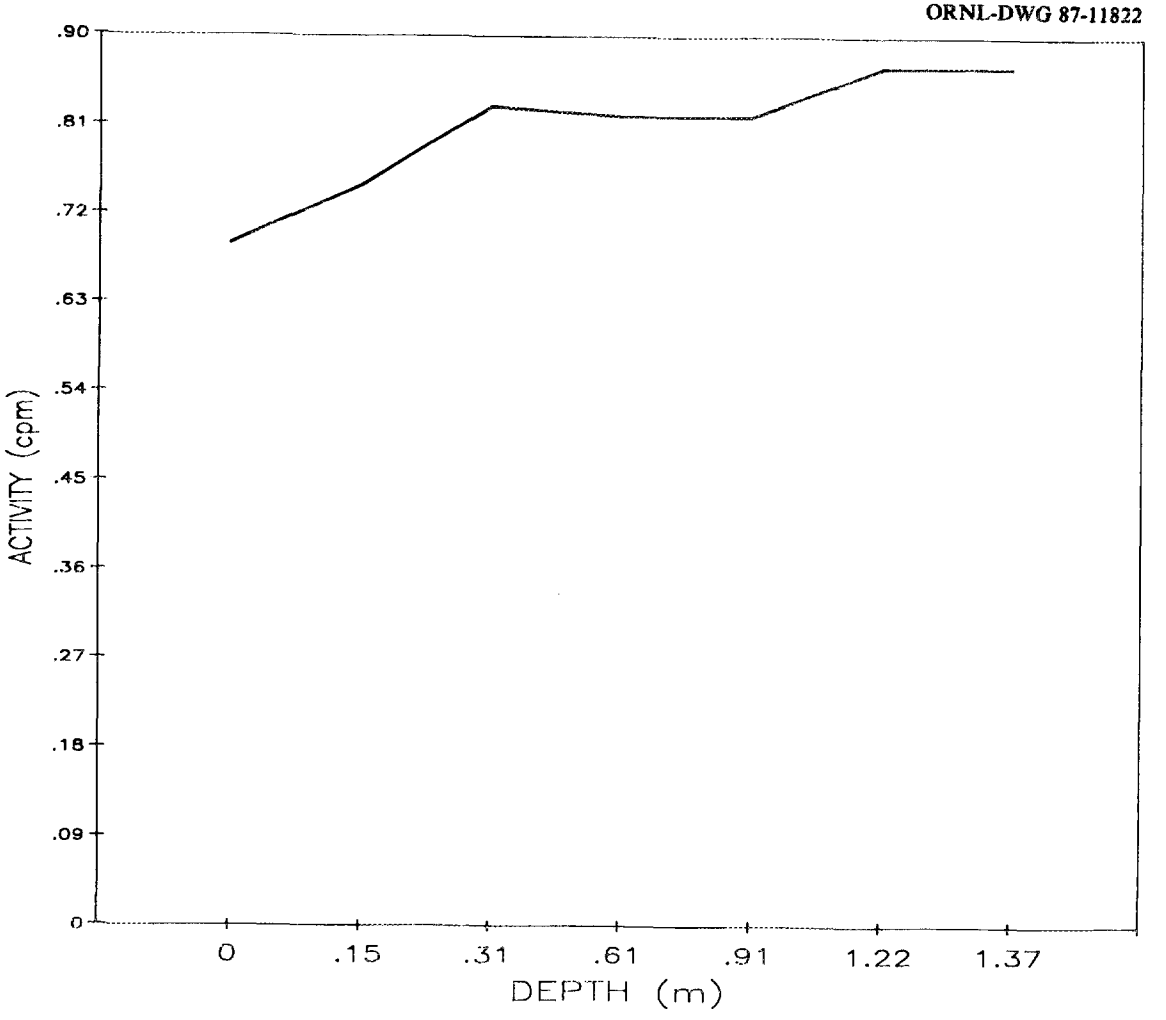

Fig. A.60. Gamma profile of auger hole 79.

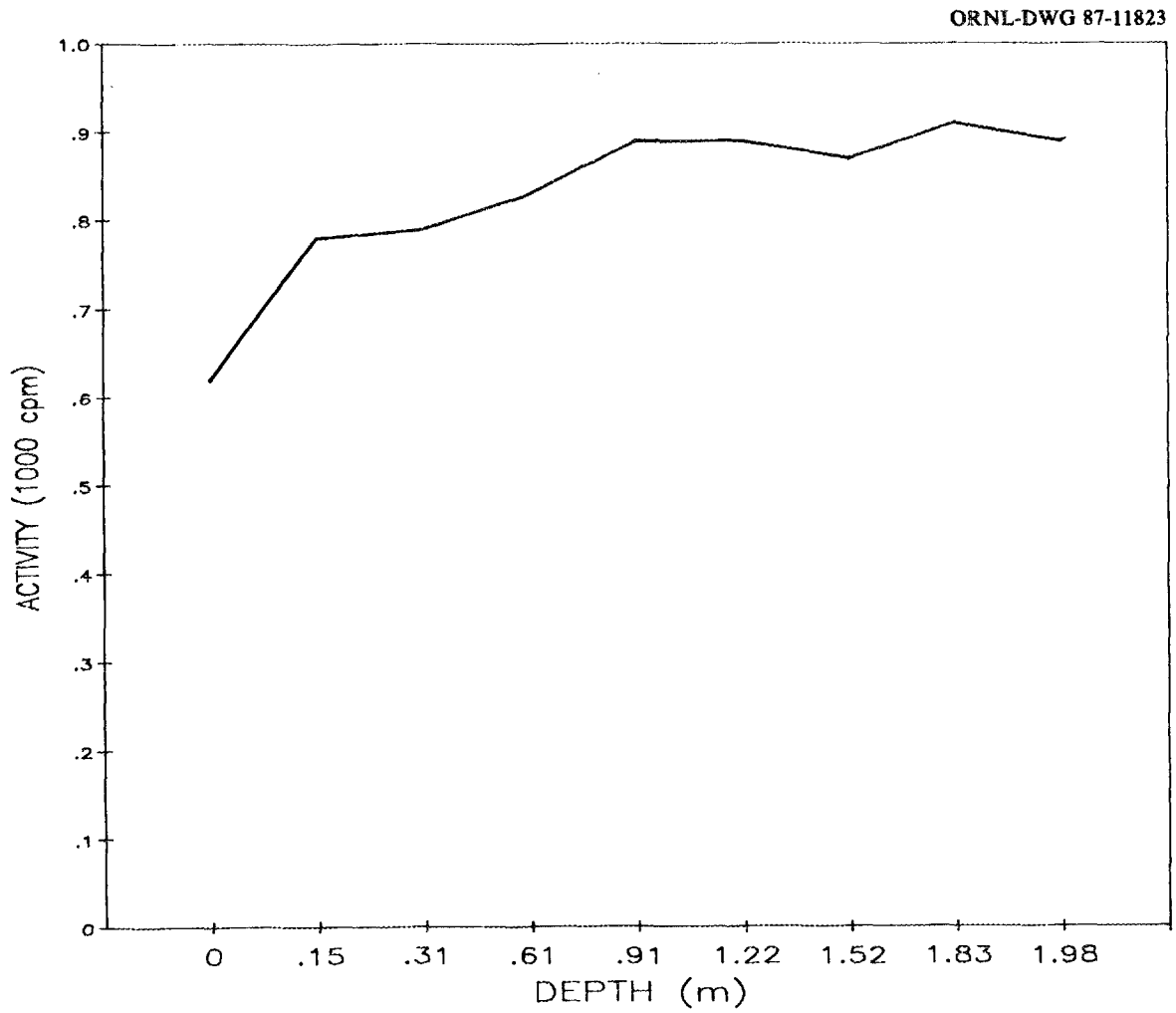

Fig. A.61. Gamma profile of auger hole 84.

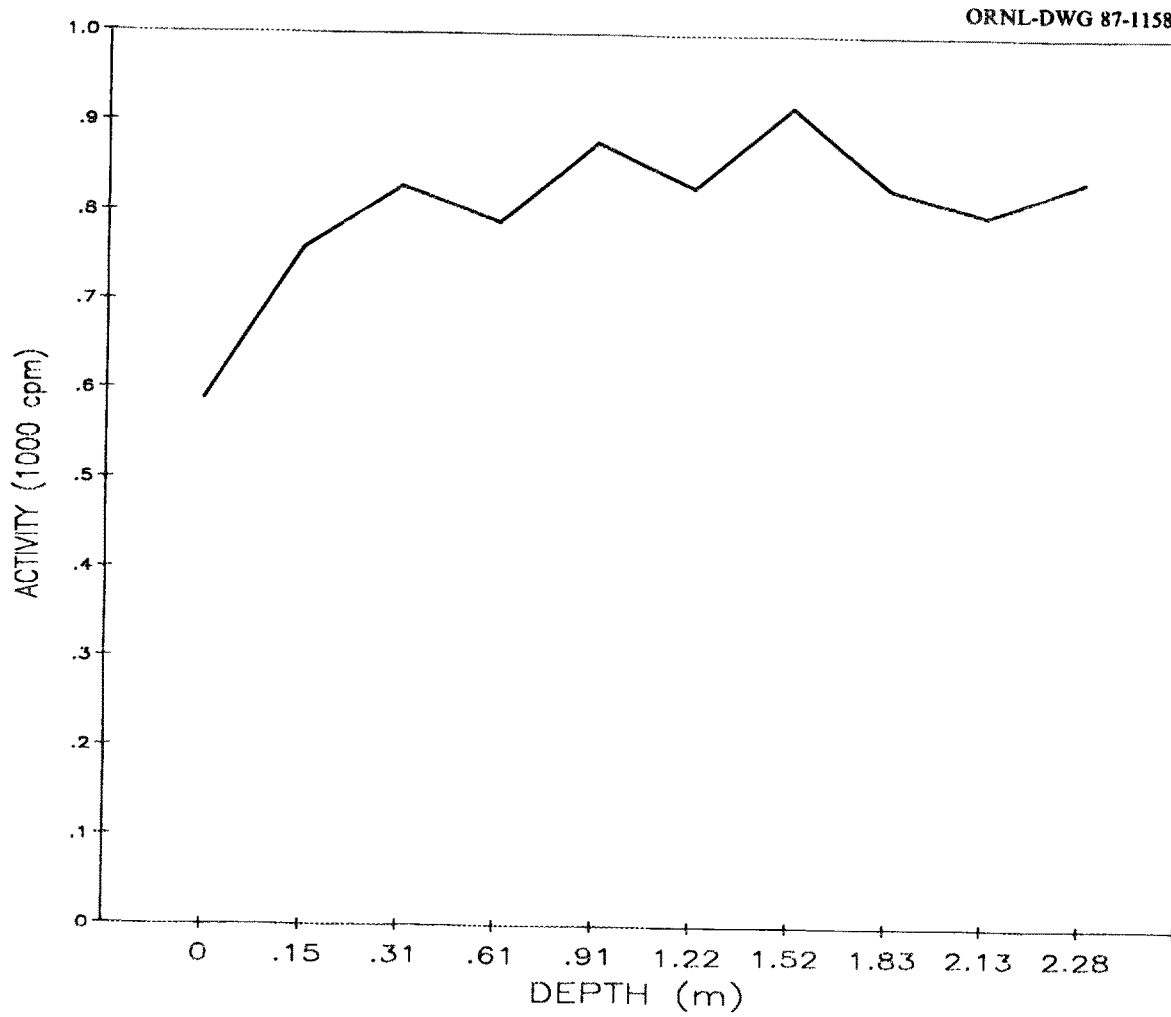

Fig. A.62. Gamma profile of auger hole 85.

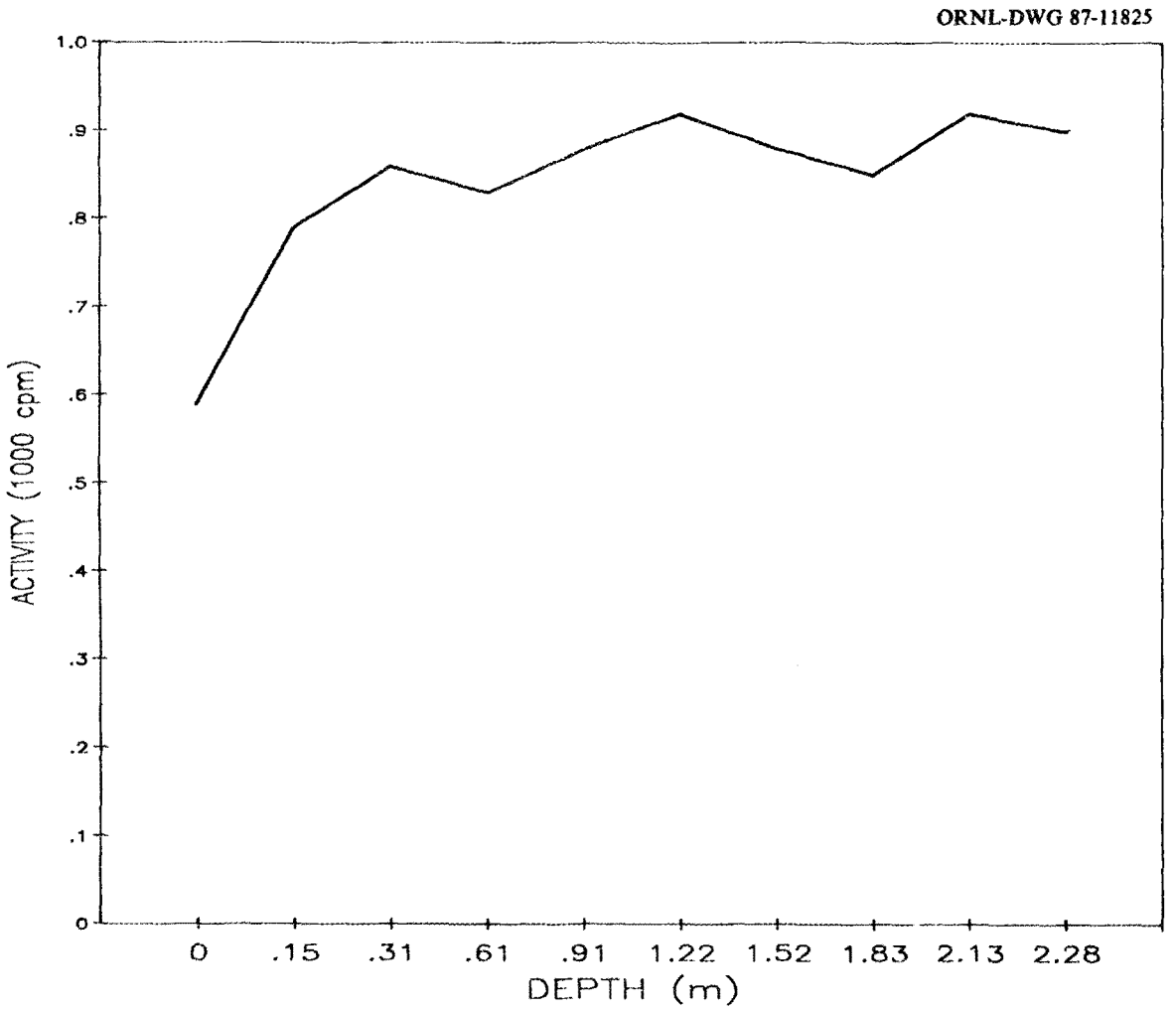

Fig. A.63. Gamma profile of auger hole 86.

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