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THE REMOTE SENSING LABORATORY OF THE UNITED STATES DEPARTMENT OF ENERGY

EG&G SURVEY REPORT
NRC-8106
JUNE 1981

AN AERIAL RADIOLOGICAL SURVEY OF

HEMATITE, MISSOURI

AND SURROUNDING AREA

DATES OF SURVEY: 11-15 JULY 1980

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APPROVED FOR DISTRIBUTION

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This Document is UNCLASSIFIED

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Classification Officer

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ABSTRACT

An aerial radiological survey was conducted over a 15 km^2 area centered on the Combustion Engineering facility at Hematite, Missouri during 11-15 July 1980. The facility was formerly Gulf United Nuclear. Computer-generated isoradiation contours were overlaid on an aerial photograph of the surveyed area to show the distribution of radiation exposure rates throughout the area. These results showed one area of localized activity directly over the site with an estimated exposure rate range of 17-45 μR/h, compared to a typical terrestrial background of 4-12 μR/h. The above values do not include cosmic ray contributions (approximately 4 μR/h) to the total external exposure rate. Spectral analysis of the data obtained over the site indicated the presence of protactinium-234: this implies the presence of uranium-238 in its separated form (^{226}Ra and daughters removed).

CONTENTS

1.0 INTRODUCTION

The United States Department of Energy (DOE) maintains an aerial surveillance operation called the Aerial Measuring Systems (AMS), which is operated for the DOE by EG&G. This continuing nationwide program, started in 1958, involves surveys to monitor and document background radiation levels throughout the United States. At the request of the DOE, or other federal and state agencies (such as the United States Nuclear Regulatory Commission), the AMS is deployed for various aerial survey operations. This survey was requested by the Nuclear Regulatory Commission for the Combustion Engineering facility located at Hematite, Missouri.

Aerial radiological detection systems average the radiation levels due to gamma-emitting radionuclides existing over an area of several acres. The systems are capable of detecting anomalous gamma count rates and determining the specific radionuclides causing the anomalies; however, because of averaging, they tend to underestimate the magnitude of localized sources as compared with ground-based readings. As such, the indicated radiation levels in the vicinity of anomalies are not definitive. Ground surveys are required for accurate definition of the extent and intensity of such anomalies.

The results of the survey are reported as radiation exposure rates in microroentgens per hour (μR/h) at 1 meter above the ground surface. Approximate annual radiation dose levels expressed as millirem per year (mrem/y) are obtained by multiplying μR/h by 8.76. This conversion number applies only to the external radiation dose component.

Natural background radiation originates from radioactive elements present in the earth and cosmic rays entering the earth's atmosphere from space. The terrestrial gamma rays originate primarily from the uranium decay chain, the thorium decay chain, and radioactive potassium. Local concentrations of these radionuclides produce radiation levels at the surface of the earth in the range 1 to 15 μR/h (9 to 130 mrem/y).

Some areas with high uranium and thorium concentrations in surface minerals exhibit even higher radiation levels, especially in the western states. For example, in the Colorado Plateau area the average radiation level is above 200 mrem/y. At some locations in Brazil and India, the natural radiation level is above 1000 mrem/y. One member of each of the uranium and thorium decay chains is a noble gas which can both diffuse through soil and be borne by air to other locations. Thus, the level of this airborne radiation depends on the meteorological conditions, the mineral content of the soil, the soil permeability, and other conditions existing at each location at any particular time. The airborne radiation contributes from 1 to 10% of the natural background radiation levels.

Cosmic rays (the space component) interact in a complicated manner with the elements of the earth's atmosphere and the soil. These interactions produce an additional natural source of gamma radiation. Radiation levels due to cosmic rays vary with altitude and geomagnetic latitude: they range from 3.7 to 23 μR/h (up to 200 mrem/y).[1]

2.0 SITE OPERATION AND BOUNDARIES

Combustion Engineering (formerly Gulf United Nuclear) occupies several acres near the town of Hematite, Missouri. The facility was purchased from Gulf in 1974; its processes include converting uranium hexaflouride (UF_6) to uranium dioxide (UO_2) pellets to be utilized by commercial power reactors. The uranium on site is about 3 percent enriched. Several tons of UF_6 are stored on site and is available for processing; a similar quantity of processed $U0_2$ pellets is stored and prepared for shipping to various commercial power reactors.[2]

The area surrounding the site is moderately hilly and covered with a variety of vegetation, predominantly trees of various types. The area is sparsely populated.

3.0 SURVEY PROCEDURE AND EQUIPMENT

An aerial photograph was used to define the area to be surveyed. Parallel lines spaced at 76 m (250 feet) intervals were flown at an altitude of 76 m.

The detectors and electronic systems that accumulate and record the data are described briefly here. They are described in detail in previous reports.[3,4]

The survey platform (a Hughes H-500 helicopter) carried a pilot, an equipment operator and a

lightweight version of a specialized data recording system. Two detector pods were mounted on the sides of the helicopter; each pod contained ten sodium iodide NaI (Tl) detectors.

The crystal in each detector was 12.7 cm in diameter and 5.1 cm in height. Gamma ray signals from the twenty detectors were summed and routed through an analog-to-digital converter into a pulse height analyzer. Gamma ray counting rates and energy spectral data were accumulated in 1-second intervals and recorded on magnetic tape.

The helicopter position was established with two systems: a Microwave Ranging System (MRS) and a radar altimeter. The MRS master station, mounted in the helicopter, interrogated two remote transceivers mounted at stationary positions overlooking the survey area. By measuring the round trip propagation time between the master and remote stations, the distance between each was computed by the master unit. These distances were also recorded on magnetic tape each second. In subsequent computer processing, they were converted to position coordinates.

A radar altimeter was employed to determine the altitude of the aircraft above the ground level. These data were also recorded on magnetic tape so that any variations in gamma signal strength caused by altitude fluctuation could be compensated accurately.

Data processing was done primarily with a computer based analysis laboratory mounted in a mobile van. An extensive collection of software routines was available for data processing. The first data processing that was accomplished produced total exposure rate isoradiation contours. These contours were constructed from gross count rate numbers, which refer to integral count rates in that portion of the gamma ray energy spectrum between 0.05 and 3.0 MeV. These count rates were converted to exposure rates at 1 m above the ground using a factor of 940 counts per second per μR/h, a number obtained from calibration data over a test range. The exposure rate isoradiation contours shown in Figure 1 are from terrestrial sources only. The total exposure rate can be obtained by adding an average cosmic ray value of 4 μR/h.

4.0 DISCUSSION AND RESULTS

The isoradiation contours of Figure 1 show the terrestrial exposure rate distribution over the surveyed area. Cosmic ray contributions were not included. Total exposure rate values can be obtained by adding a value of approximately 4 μR/h for cosmic rays to the values in Figure 1. Typical background exposure rates vary from 4-12 μR/h, a combination of B and C level ranges. The anomalous activity encountered directly over the Combustion Engineering facility was 17-45 μR/h (E level), about 3 to 4 times typical background. Figure 2 is a spectrum typical of the natural background gamma ray emitters. Figure 3 is a channel-by-channel difference between a spectrum collected over the site and the typical background spectrum. The prominent photopeaks in this spectrum are due to protactinium-234m, an isotope of separated uranium (radium-226 and daughters removed).

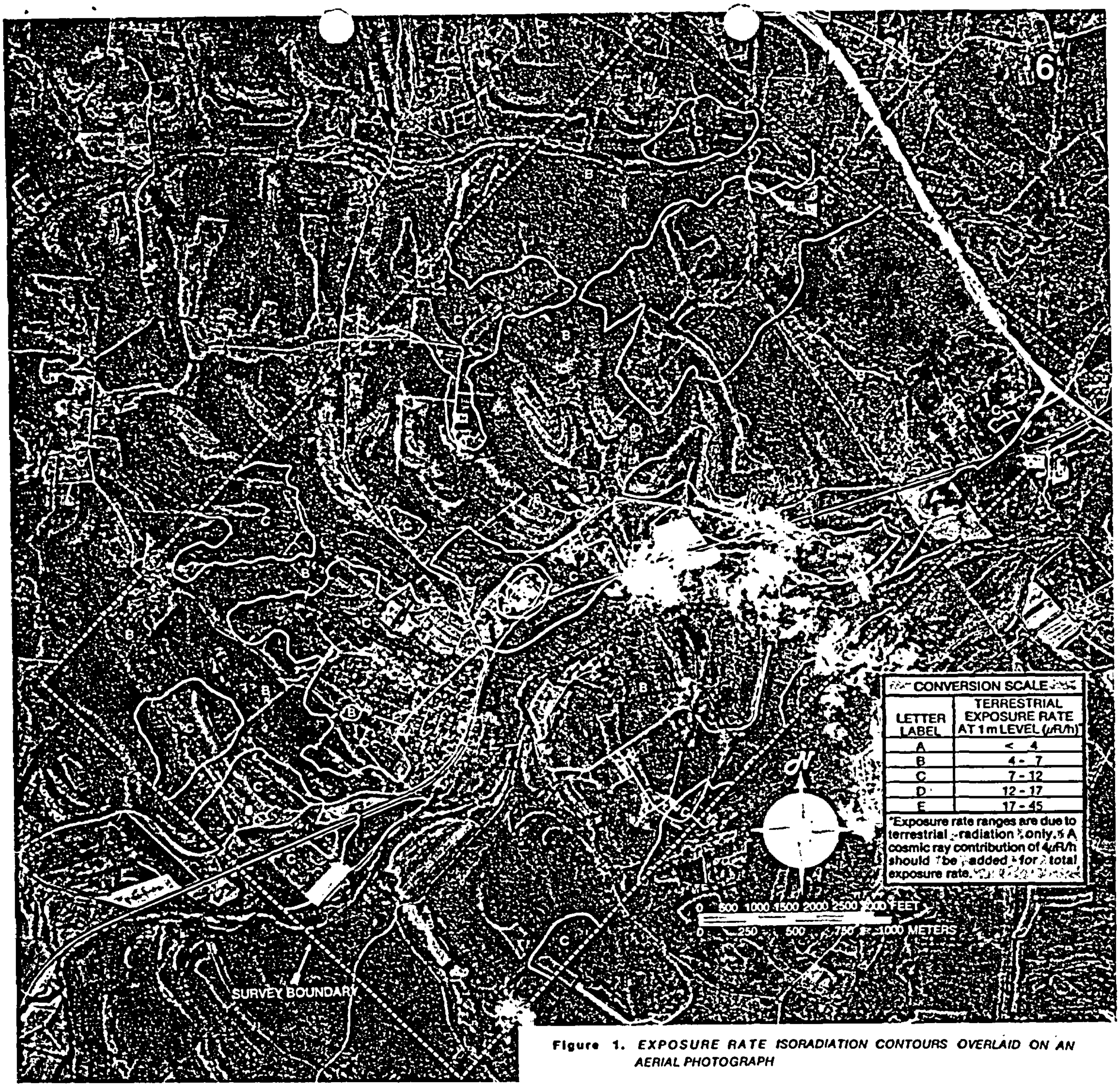

Figure 1. *EXPOSURE RATE ISORADIATION CONTOURS OVERLAID ON AN AERIAL PHOTOGRAPH*

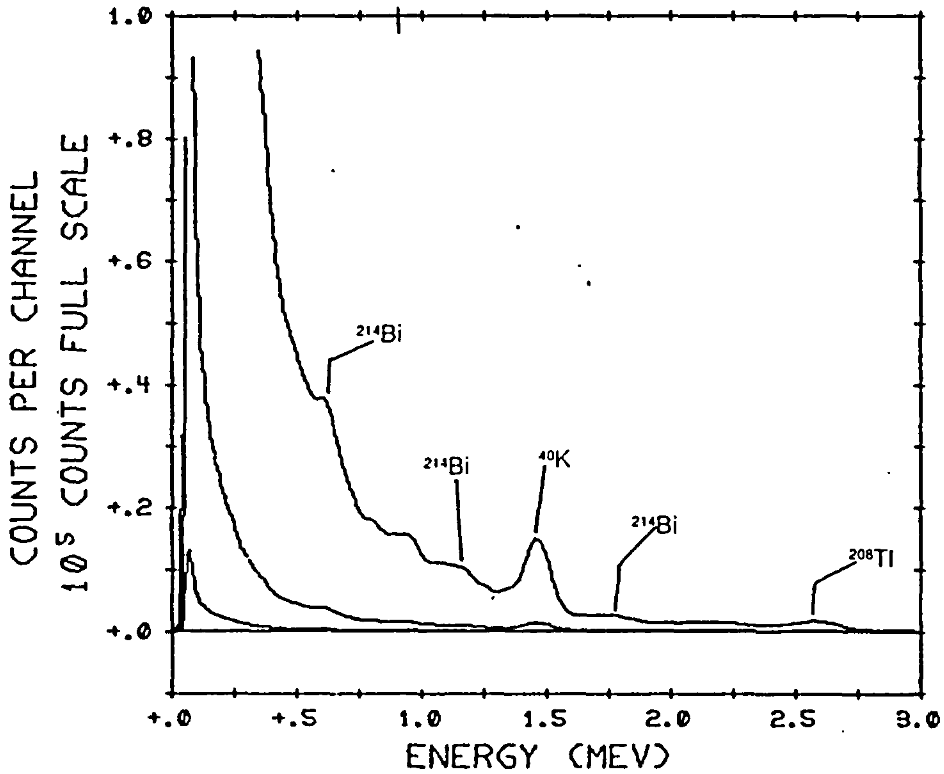

Figure 2. *GAMMA RAY PULSE HEIGHT SPECTRUM TYPICAL OF NATURAL BACKGROUND*

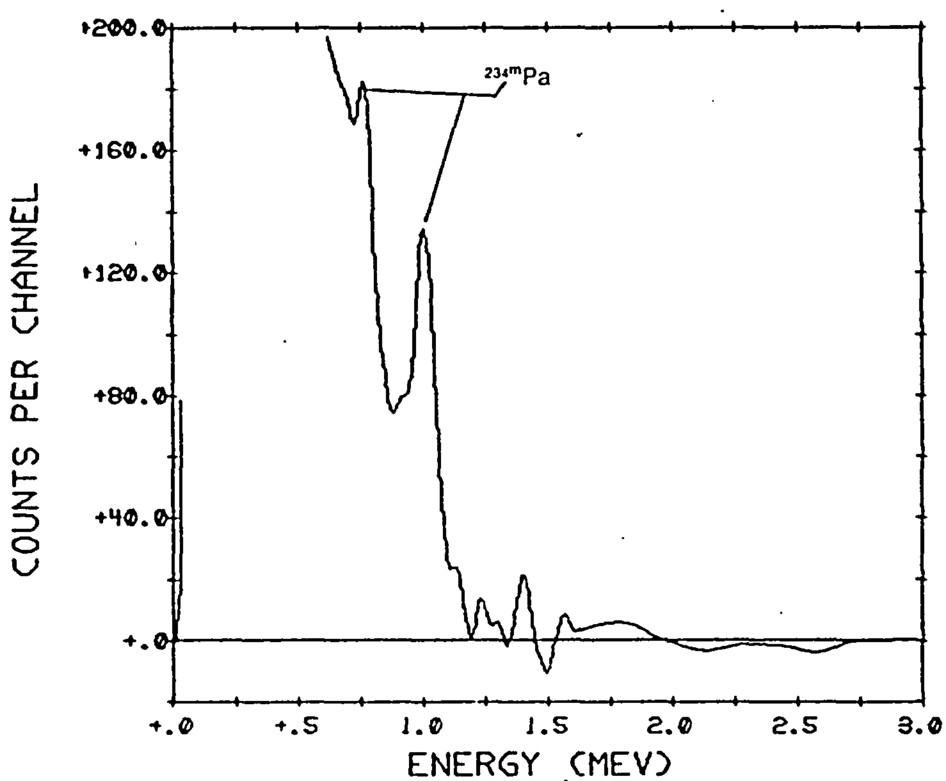

Figure 3. *GAMMA RAY PULSE HEIGHT SPECTRUM OBTAINED OVER THE FACILITY. Dominant photopeaks are from protactinium, indicating the presence of separated uranium.*

APPENDIX: SURVEY PARAMETERS

Location:	Hematite, Missouri
Survey Coverage:	15 km^2
Survey Date:	11-15 July 1980
Project Scientist:	E. L. Feimster
Survey Altitude:	76 m (250 feet)
Line Spacing:	76 m (250 feet)
Detector Array:	20 NaI (Tl)
Acquisition System:	REDAR III
Aircraft:	Hughes H-500 Helicopter

Data Processing:

A. Gross Counts

Window: 0.05 - 3.0 MeV

Conversion Factor: 940 cps/μR/h

Cosmic ray contribution: 4 μR/h (not included in Figure 1)

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