(200)
T67r
No. 83

FOR OFFICIAL USE ONLY

THIS DOCUMENT CONSISTS OF 8 PAGE(S)
NO. 16 OF 25 COPIES, SERIES A

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON

PROGRESS ON DETECTION OF RADIOACTIVITY BY AIRBORNE EQUIPMENT

by
Frank W. Stead
September 1949

Trace Elements Investigations Report 83

U. S. GOVERNMENT PRINTING OFFICE 858002

FOR OFFICIAL USE ONLY

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

PROGRESS ON DETECTION OF RADIOACTIVITY BY AIRBORNE EQUIPMENT

by

Frank W. Stead

September 1949

Trace Elements Investigations Report 83

FOR OFFICIAL USE ONLY

USGS - TEI Rept. 83
Consisting of 8 pages
Copy No. 16 of 25 copies
Series B
Issued to (see below)

The distribution (Series B) of this report is as follows:

Copies 1 and 2 .... AEC, Washington (J. C. Johnson)

Copies 3 through 8 .... AEC, New York (P. L. Merritt)

Copy 9 .... AEC, Denver, Colorado (C. C. Towle, Jr.)

Copy 10 .... AEC, Spokane, Washington (E. E. Thurlow)

Copy 11 .... AEC, Grand Junction, Colorado (W. G. Fetzer)

Copies 12 through 25 .... U. S. Geological Survey

1 Master copy (mat) for TEPCO Files

Contents

Illustrations
(at end of report)

PROGRESS ON DETECTION OF RADIOACTIVITY BY AIRBORNE EQUIPMENT

by

Frank W. Stead

Abstract

Coincidence and anti-coincidence counting rate meters and also an air conductivity meter have been installed in a transport plane to measure gamma radiation from ground sources. Materials containing 0.01 percent uranium can be detected at 500 feet and at an airspeed of 150 miles per hour.

Introduction

The detection of radioactivity by airborne equipment has followed two principal lines of investigation; the first, a technique of measuring directly the gamma radiation from ground sources, the second, a technique of measuring ionization of the atmosphere caused by cosmic radiation and gamma radiation from ground and airborne sources. The objective has been to develop techniques of measurement capable of detecting at a distance of 500 feet raw materials containing approximately 0.01 percent uranium oxide. In accordance with this objective, a flight strip was selected that offered materials containing 0.01 percent uranium oxide along a flight line with a minimum of topographic relief; strong artificial sources, such as stockpiles and operating plants, were not considered of value in the late stage of development.

Equipment

The equipment for measuring radioactivity is installed in the Geological Survey's plane, a Douglas DC-3, with a cruising speed of 150 miles per hour. The present units are a dual-channel radiation detector and an air conductivity meter.

The dual-channel radiation detector is a counting rate type which continuously records both the cosmic or coincident count, the C channel, and the soft gamma or total-minus-coincident count, the T-C channel. The detector contains an hexagonal array of nineteen Geiger-Mueller tubes of the self-quenching type. The primary power source for the detector is the nominal 26.5 volts D.C. available in the plane.

The air conductivity meter consists essentially of a cylindrical condenser with the inner coaxial member connected to a vibrating reed electrometer. When air is passed through the cylinder, the ions are collected on the inner member owing to the electric field between the cylinder and the inner member. The ionization current can be made independent of the rate of air flow by operating at a collection voltage below saturation; i.e., only a portion of the ions passing through the cylinder are collected. The power source for the meter is a rotary inverter providing 110 volt. A.C. 60 cycle regulated.

Flight strip

The flight strip is in the Red Desert region of southern Wyoming at an average altitude of 6,500 feet. The region is underlain by 2,000 feet of Tertiary continental sediments consisting mainly of the Green River and Wasatch formations of lower Eocene age. Radioactive lignites and carbonaceous shales occur in the lower part of the Wasatch formation.

The geology of the flight strip, a belt 14 miles long and 2 miles wide with a maximum relief of 150 feet, was mapped on aerial photographs. The radioactivity along the flight strip was measured with car-borne equipment and with hand portable equipment in small areas not accessible by car. Sufficient outcrop samples were taken to establish a correlation between the meter reading of the car-borne equipment and the equivalent uranium content of the radioactive lignites and carbonaceous clays.

Techniques of measurement

The techniques of measurement of radioactivity were developed to utilize the equipment previously installed in the plane for airborne magnetometer surveys.

The installation of equipment for radioactivity measurements is diagrammatically shown in figure 1. All records are synchronized by time signals and key numbers automatically printed on each individual record. By tying together the radar altimeter and the continuous strip-camera with the dual-channel detector and the air conductivity meter, the location of a radioactive anomaly in three dimensions can be precisely determined.

Figure 2 shows the mounting of equipment in the plane. In the foreground are the dual-channel detector and the two Esterline-Angus recorders for the coincidence channel and the total-minus-coincidence channel. The 19 Geiger-Mueller tubes with the power supply and cathode follower amplifier are mounted on the cabin floor back of the trailing edge of the wing. The rotary inverter is mounted over a main wing member.

The air conductivity meter in the foreground of figure 3 receives air flow from a main ventilating duct whose intake is in the nose of the plane. The vibrating reed electrometer is mounted directly on the main condenser. The linear amplifier and Brown recorder for the meter are mounted behind the main condenser. In the background can be seen the control panel for the magnetometer and the radar altimeter recorder.

The car-borne installation used to measure the radioactivity along the flight strip is shown in figure 4. Two 42-inch Geiger tubes in parallel are shock-mounted on the top of the truck.

The amplifier, a modified Victoreen portable survey meter, is shock-mounted in the instrument panel of the truck (fig. 5). Car speeds while measuring the radioactivity in the flight strip varied between 5 and 30 miles per hour. The width of the radioactive outcrops was sufficient that variation in car speed had no appreciable effect on the deflection of the meter.

Shown on figure 6 are the geology along the flight line, the radioactivity at the ground level along the flight line, and the activity at 250 feet along the flight line.

The outcrops of radioactive lignite and carbonaceous shales are shown in the dark pattern. The flight line, 14 miles in length, is the heavy broken line along the center of the flight strip. Deviation from the flight line in repeated runs seldom exceeded 150 feet at the 250-foot level, 200 feet at the 500-foot level, and 300 feet at the 1,000 foot-level.

The activity at the ground level is essentially measured along the flight line although short distances could not be traversed by the car-borne equipment and had to be covered on foot with portable survey meters. The highest peak on the curve represents material of approximately 0.014 percent equivalent uranium. The slightly lower peaks represent approximately 0.012 percent equivalent uranium.

The activity curve at 250 feet is the total-minus-coincidence or T-C channel of the dual-channel detector. The radar altimeter records show that the flight altitudes never departed from the desired 250-foot level by more than 50 feet and usually were within 20 feet of the desired level. It will be noted that the anomalies lag behind the ground control owing to the time constant of the detector, two seconds, and the speed of the plane, 150 miles per hour. The flight direction is indicated by the arrow.

The anomalies measured at the 250-level could be directly related to outcrops of radioactive lignites and shales.

The activity at 500 feet is compared with the ground activity in figure 7. The anomalies are less pronounced than at 250 feet, but they are still recognizable.

The activity at 1,000 feet (fig. 8) does not indicate any definite anomalies that can be tied in with the ground control, although a faint suggestion of anomalies noted at lower levels can be seen.

A comparison of the measured activities at 250, 500, and 1,000 feet (fig. 9) shows that anomalies are almost indistinguishable at 1,000 feet, that anomalies are reasonably well detected at 500 feet, and that anomalies are clearly detectable at 250 feet. A marked similarity of pattern is shown between the 250- and 500-foot level. The anomalies at 250 feet show a close correlation with the outcrops of lignite and carbonaceous shales.

Figures 10 through 13 show the results of measurements with the air conductivity meter. Definite anomalies are reflected at the 250-foot level (fig. 10) with the meter operated at a low sensitivity, 10^{-9} amperes for full-scale deflection, to prevent off-scale deflections.

Figure 11 shows the ionization measurements at 500 feet using a higher sensitivity, 10^{-10} amperes for full-scale deflection. It will be noted that the area of highest deflection is offset to the left in relation to the ground activity. This offset is attributable in part to the time constant of the meter, 1.9 seconds, in part to the wind direction, and in part to the deviation from the flight line and level.

The ionization measured at 1,000 feet (fig. 12) shows a definite anomaly which corresponds to the area of greatest activity, as measured by the total-minus-coincidence circuit at 250 and 500 feet. It is of marked interest that the ionization meter detects an anomaly at 1,000 feet, whereas the total-minus-coincidence circuit cannot delimit the anomaly at this distance.

A comparison of the ionization measurements at 250, 500, and 1,000 feet shows a general correlation of the areas of greatest activities (fig. 13). Although insufficient time was available to plot precisely the position of the plane for the three flight levels, it is interesting to note that the largest anomaly for all three levels has a three-peaked top expanding in width and diminishing in amplitude with increase in altitude.

Summary

To summarize, both the dual-channel radiation detector and the air conductivity meter can satisfactorily detect raw materials containing as little as 0.01 percent uranium oxide at a distance of about 500 feet. At a flying speed of 150 miles per hour, such radioactive materials must extend at least 300 feet along the flight line. Both techniques yield reproducible results for low-level flights when preliminary corrections are made for deviations from the flight line and level, for variations in flying speed, and for wind direction.

Comparing the two techniques, the air conductivity meter offers the greater promise for further development, particularly as anomalies can be resolved at greater distances than seem possible using a Geiger tube array. Although only fragmentary data are available from early morning flights, the concentration of radon beneath inversion layers on calm nights may markedly increase the value of the air conductivity meter.

Investigations now in progress include the following:

1. Selective shielding of the Geiger tube array to cut down the soft component of cosmic radiation. Preliminary results indicate about a four-fold increase in sensitivity.

2. Correction of flight records for deviation from flight line and level, for variation in flying speed, and for wind direction and velocity. This would permit correlation of airborne anomalies with a ground isoradioactivity map to determine the effectiveness of the techniques of measurement.

3. Determination in a test area of the effect and extent of the concentration of radon under inversion layers and the relationship of such concentration to radioactive raw materials.

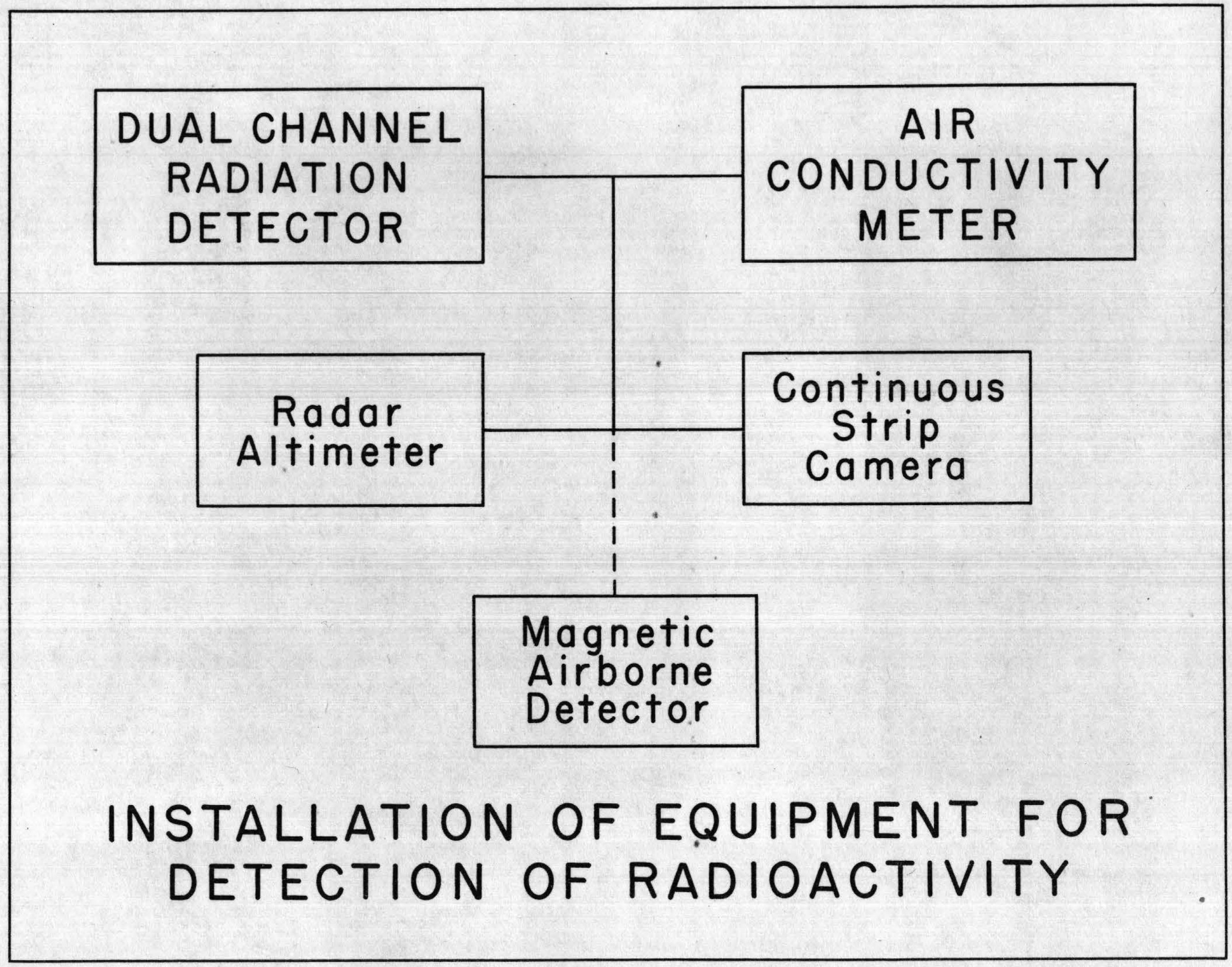

DUAL CHANNEL RADIATION DETECTOR
AIR CONDUCTIVITY METER
Radar Altimeter
Continuous Strip Camera
Magnetic Airborne Detector
INSTALLATION OF EQUIPMENT FOR DETECTION OF RADIOACTIVITY

Figure 1

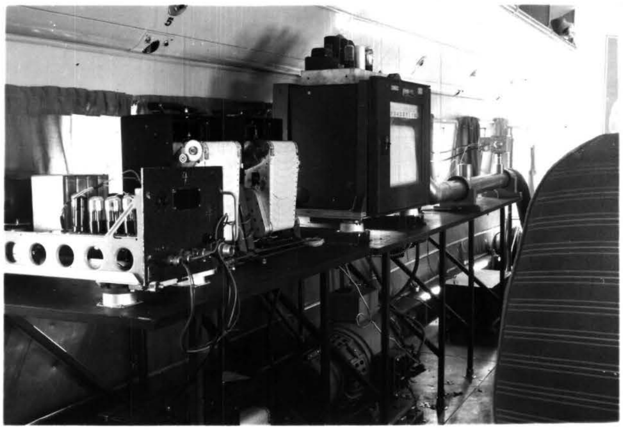
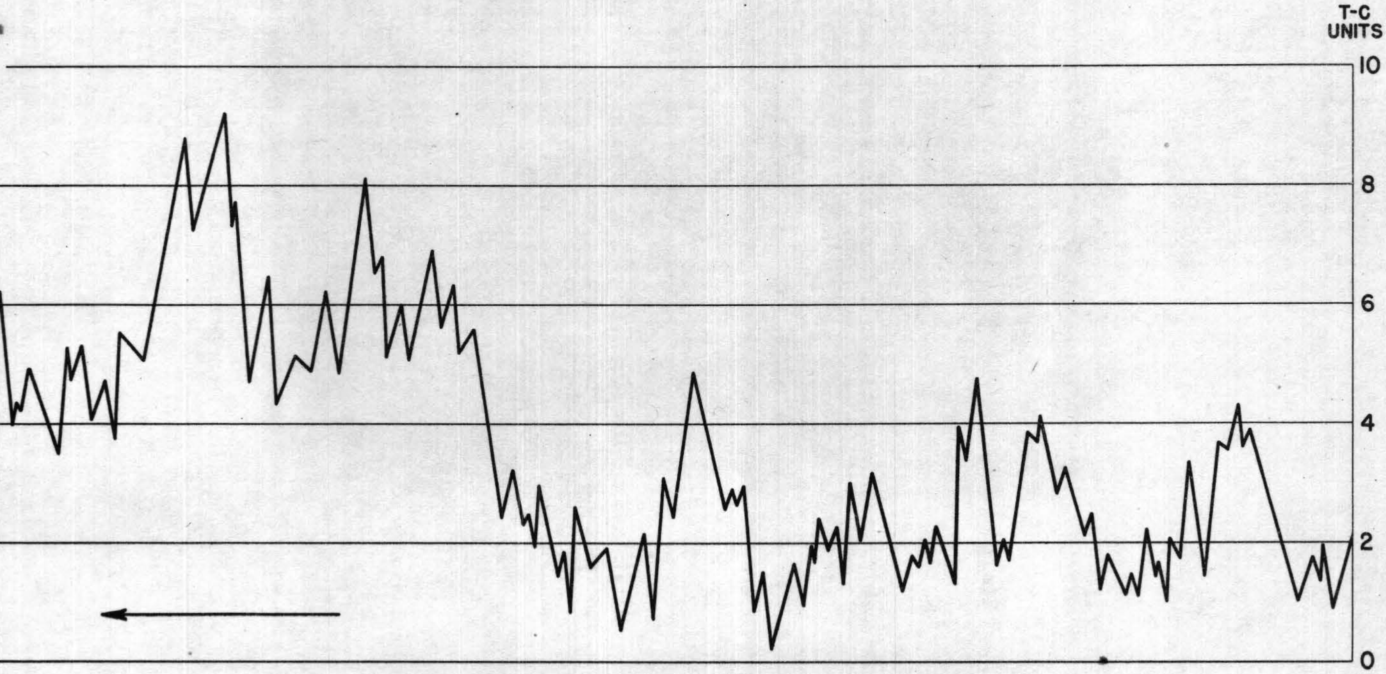


Figure 2.- Installation of equipment looking toward the rear of the plane.

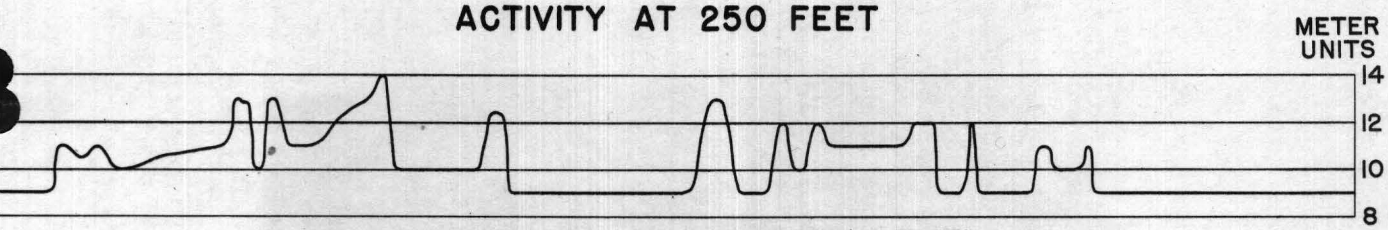
Figure 3.- Installation of equipment looking toward the front of the plane.

Figure 4.- Geiger counters installed on roof of truck.

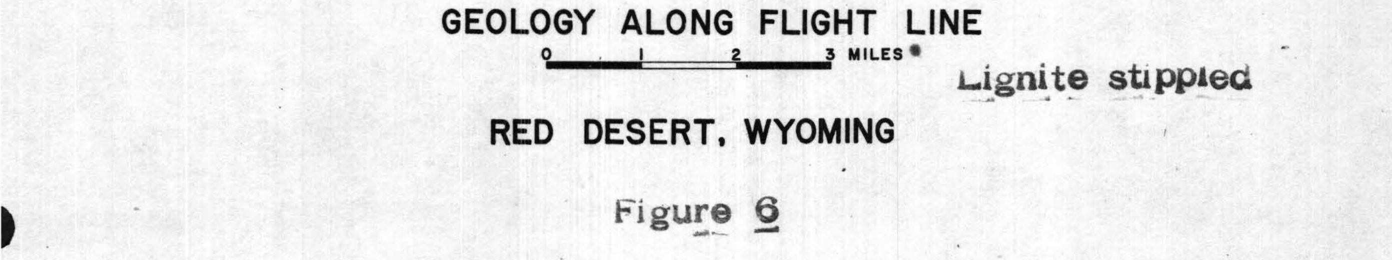
Figure 5.- Counting rate meter installed in the center of instrument panel of truck.



ACTIVITY AT 250 FEET



ACTIVITY AT GROUND LEVEL



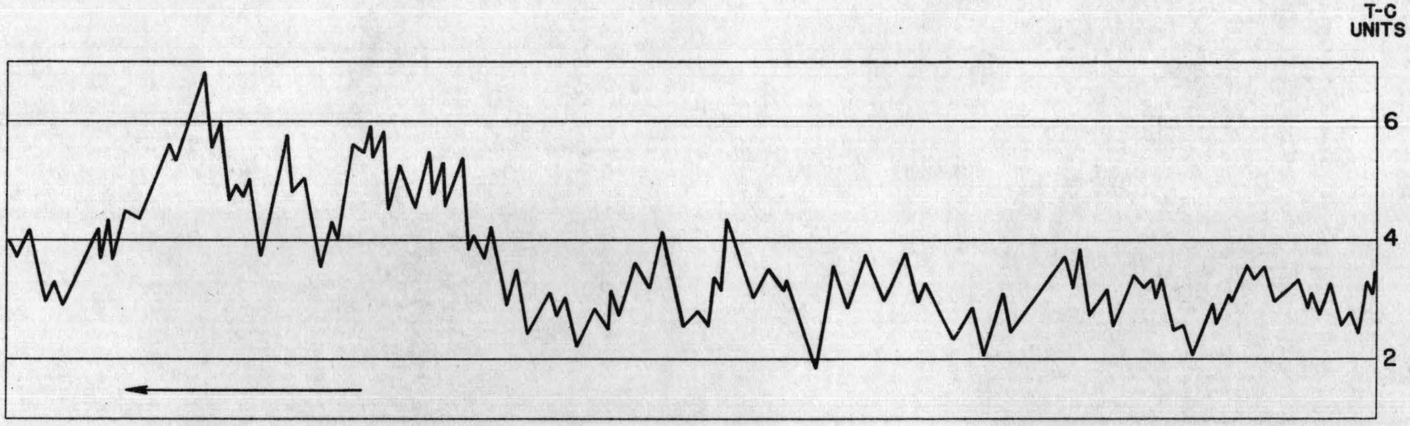
GEOLOGY ALONG FLIGHT LINE

0 1 2 3 MILES

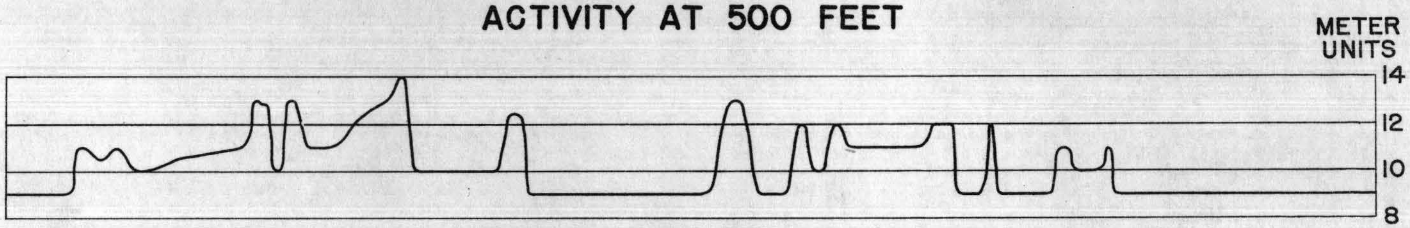
Lignite stippled

RED DESERT, WYOMING

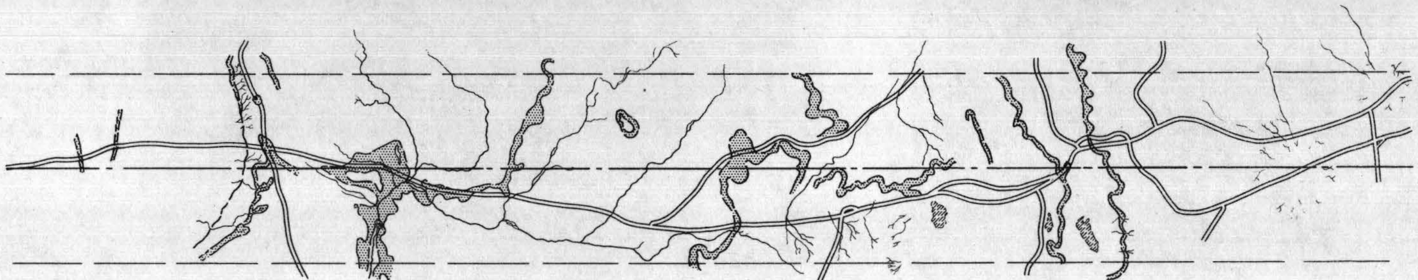
Figure 6



ACTIVITY AT 500 FEET



ACTIVITY AT GROUND LEVEL



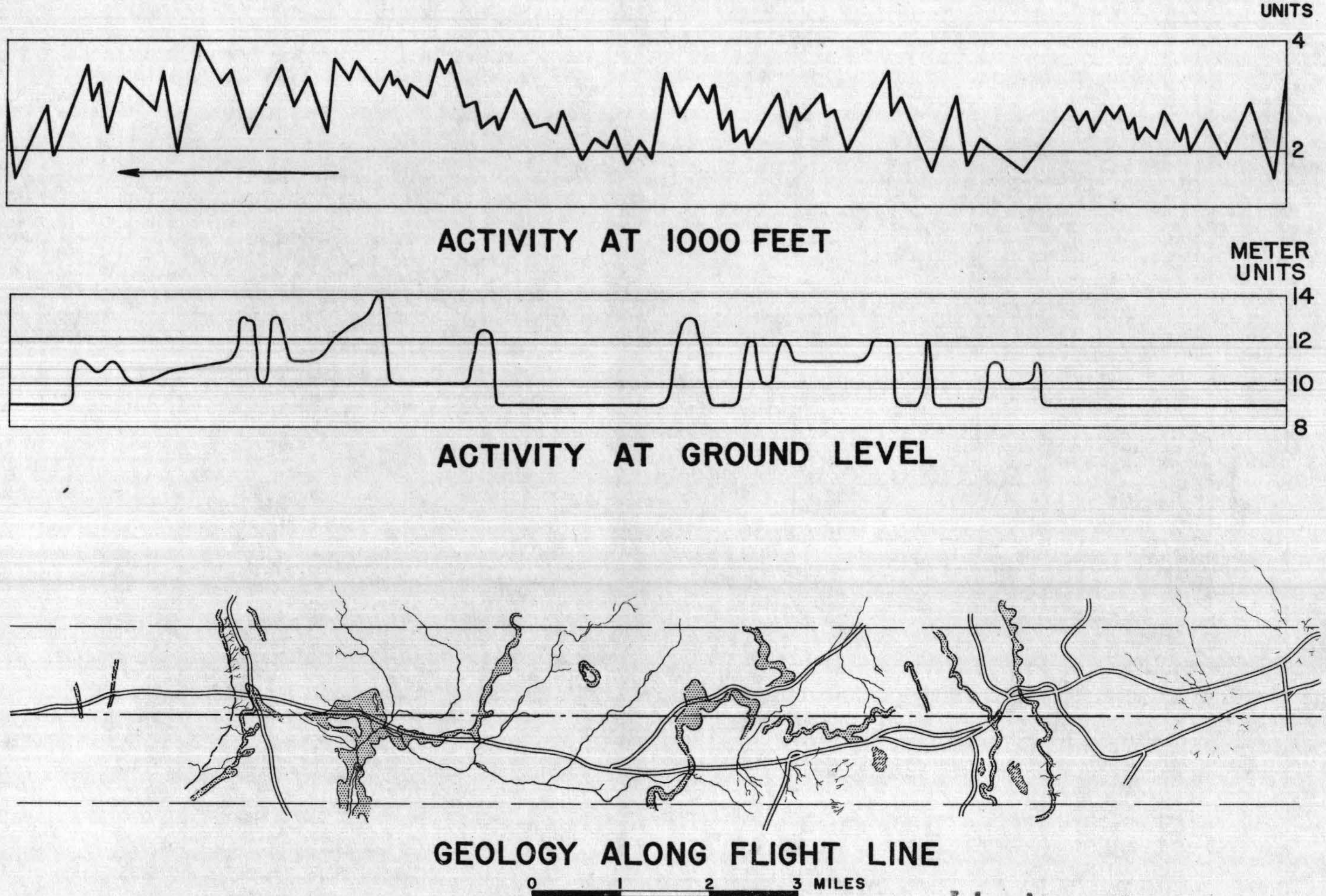
GEOLOGY ALONG FLIGHT LINE

0 1 2 3 MILES

Lignite stippled

RED DESERT, WYOMING

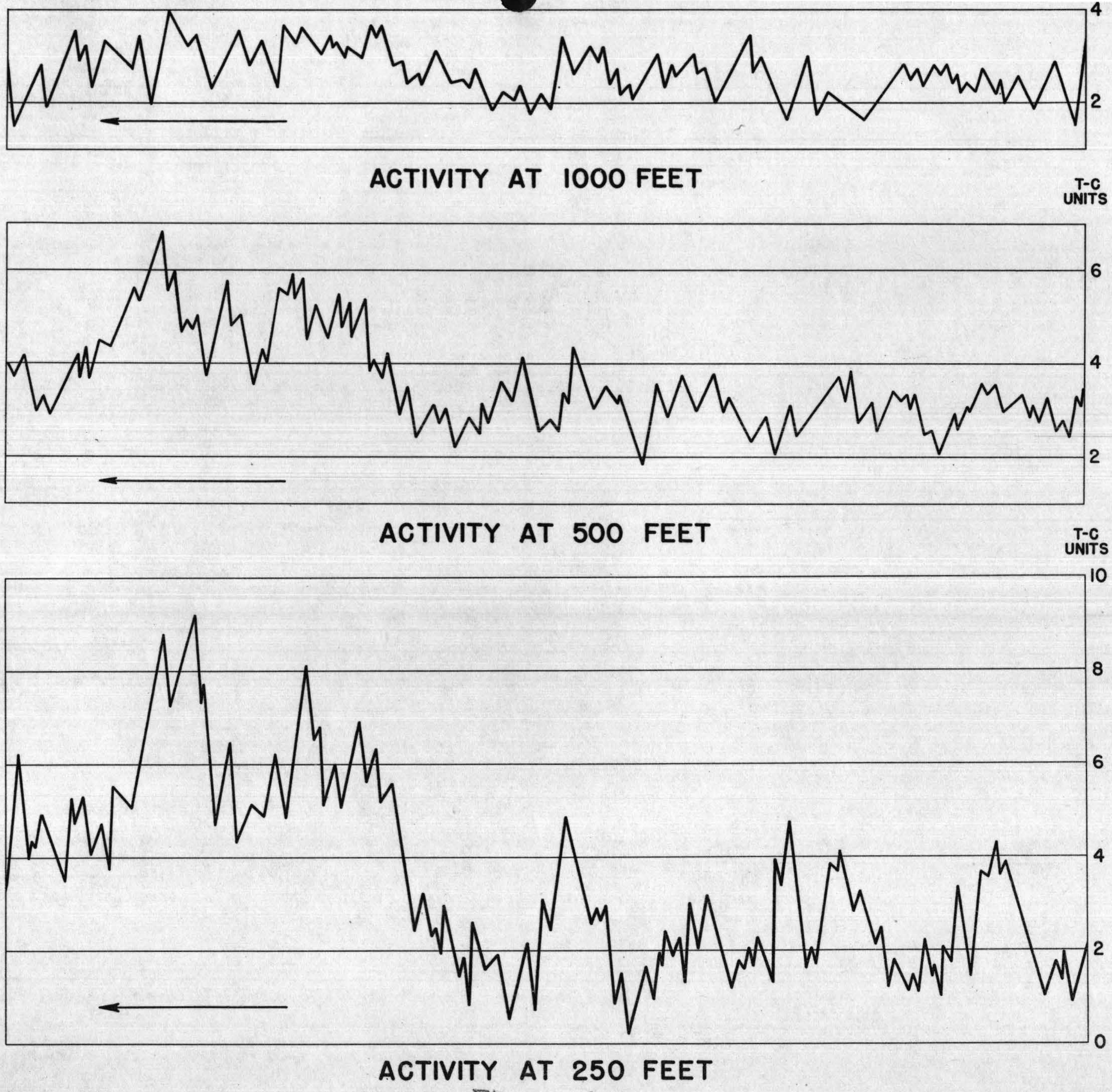
Figure 7



Lignite stippled

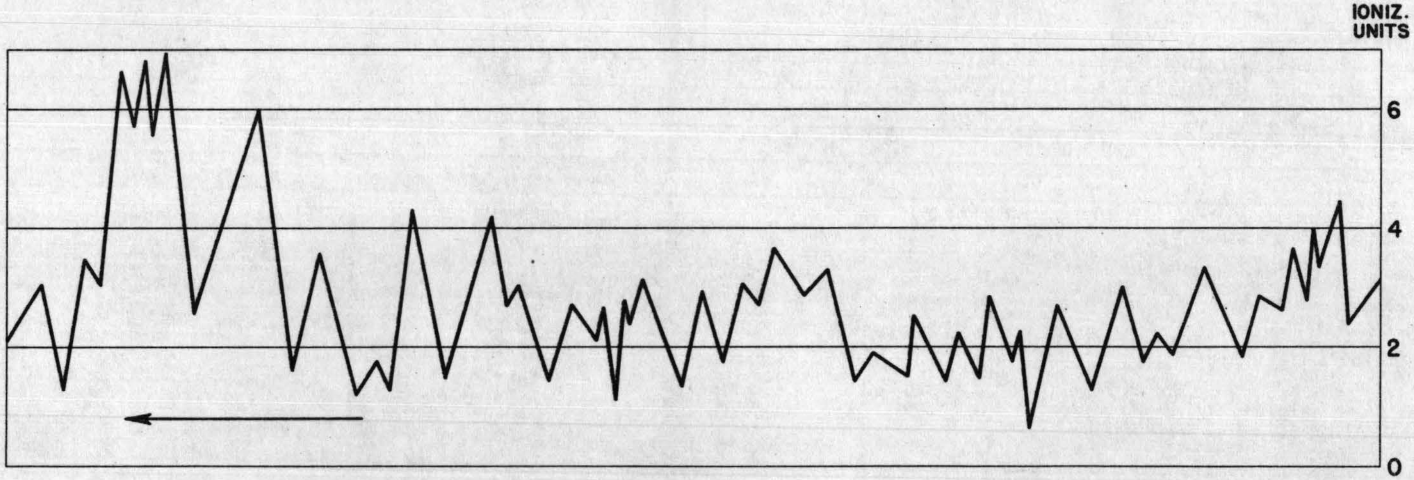
RED DESERT, WYOMING

Figure 8

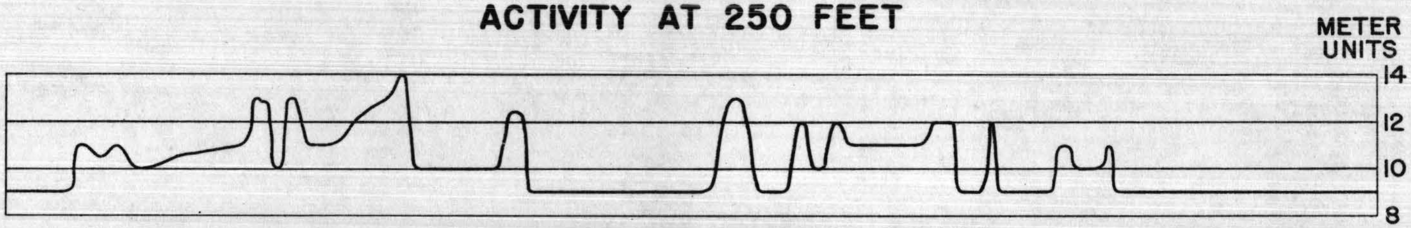


4
2
ACTIVITY AT 1000 FEET
T-C
UNITS
6
4
2
ACTIVITY AT 500 FEET
T-C
UNITS
10
8
6
4
2
0
ACTIVITY AT 250 FEET

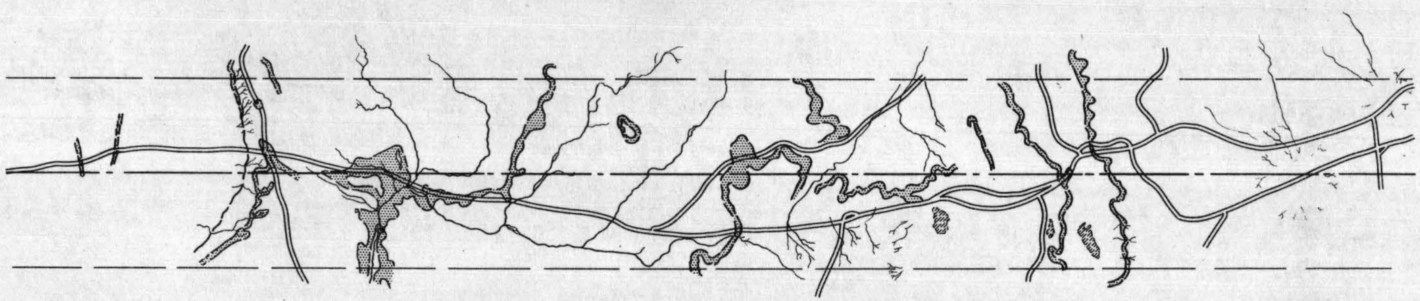
Figure 9



ACTIVITY AT 250 FEET



ACTIVITY AT GROUND LEVEL



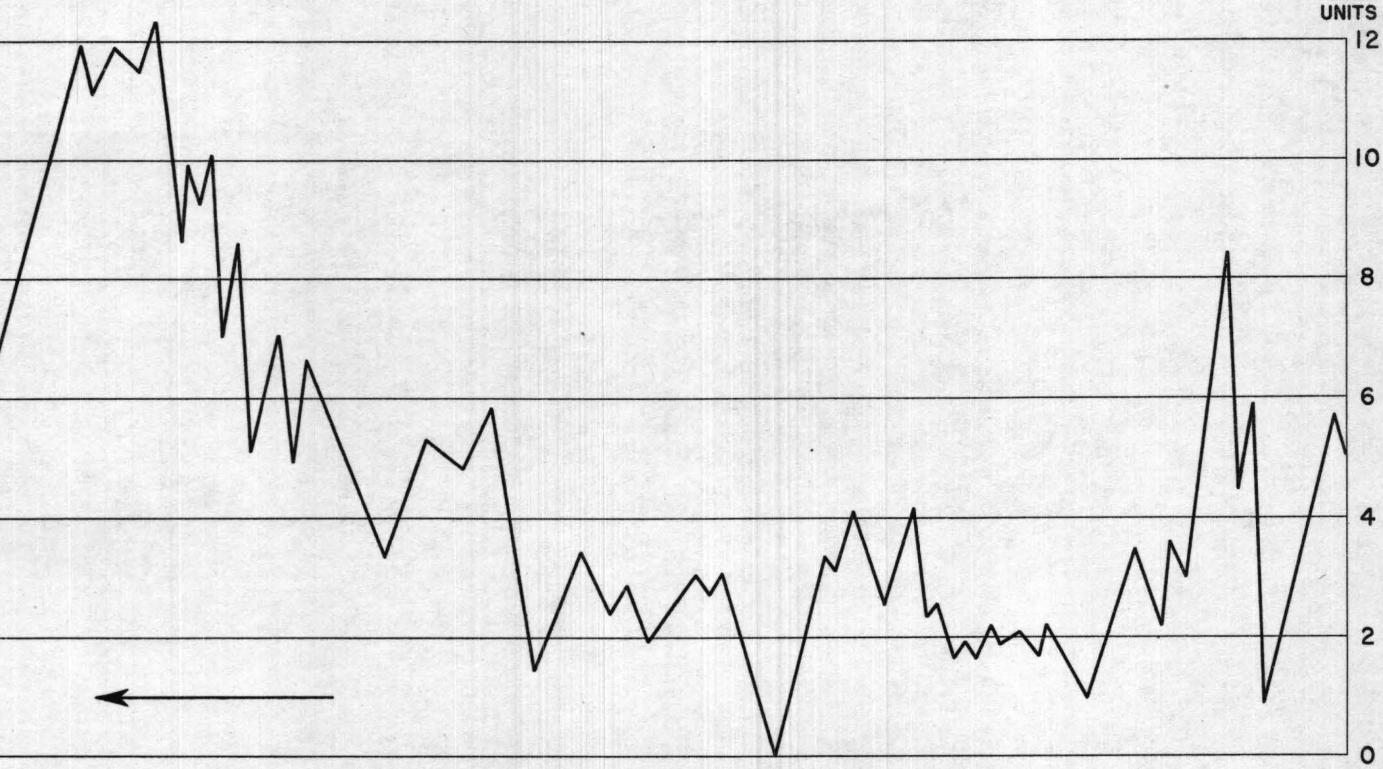
GEOLOGY ALONG FLIGHT LINE

0 1 2 3 MILES

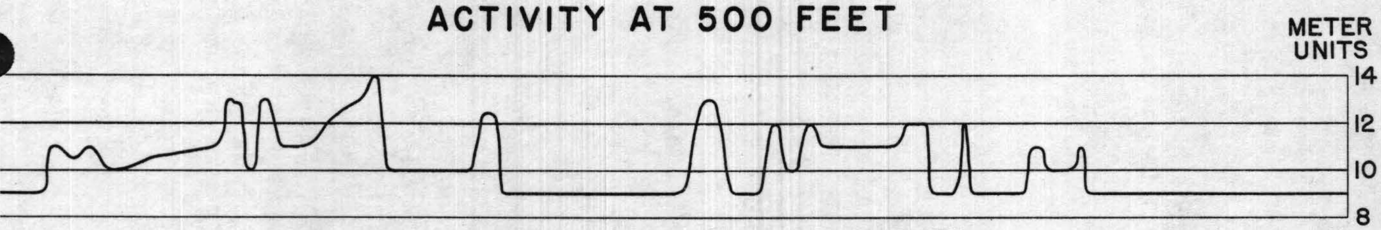
Lignite stippled

RED DESERT, WYOMING

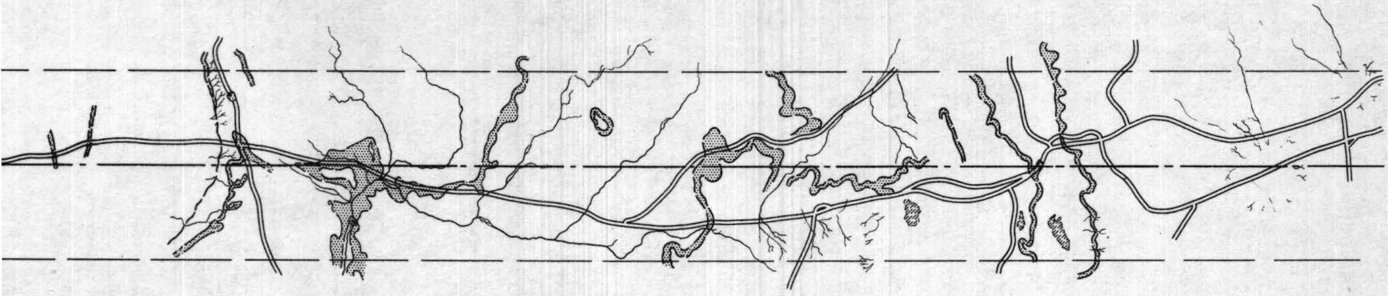
Figure 10



ACTIVITY AT 500 FEET



ACTIVITY AT GROUND LEVEL



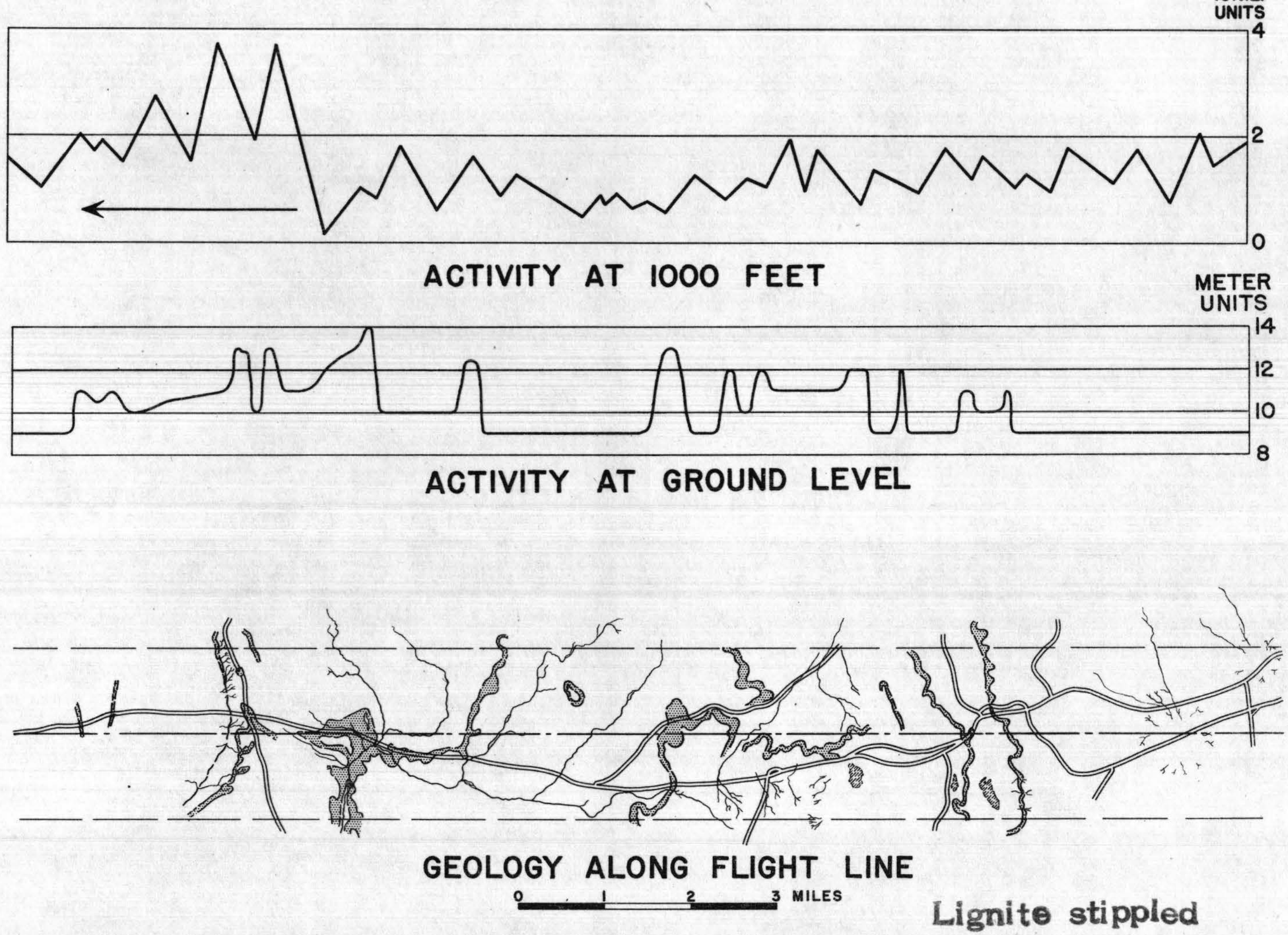
GEOLOGY ALONG FLIGHT LINE

0 1 2 3 MILES

Lignite stippled

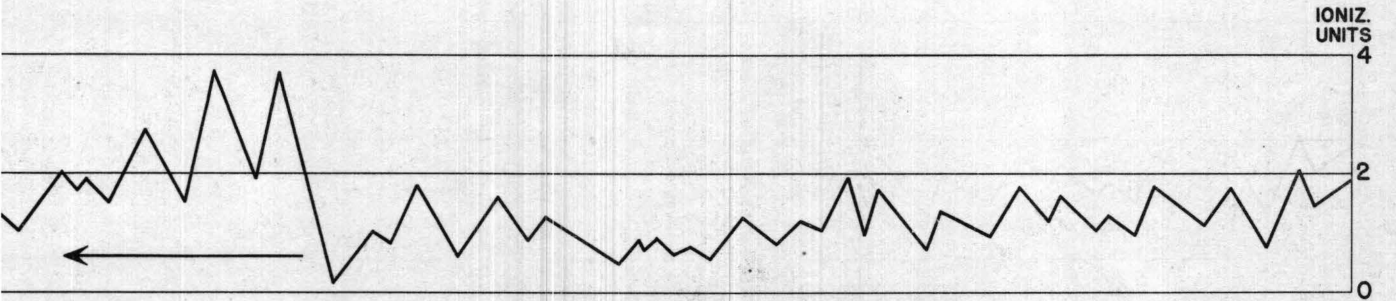
RED DESERT, WYOMING

Figure 11

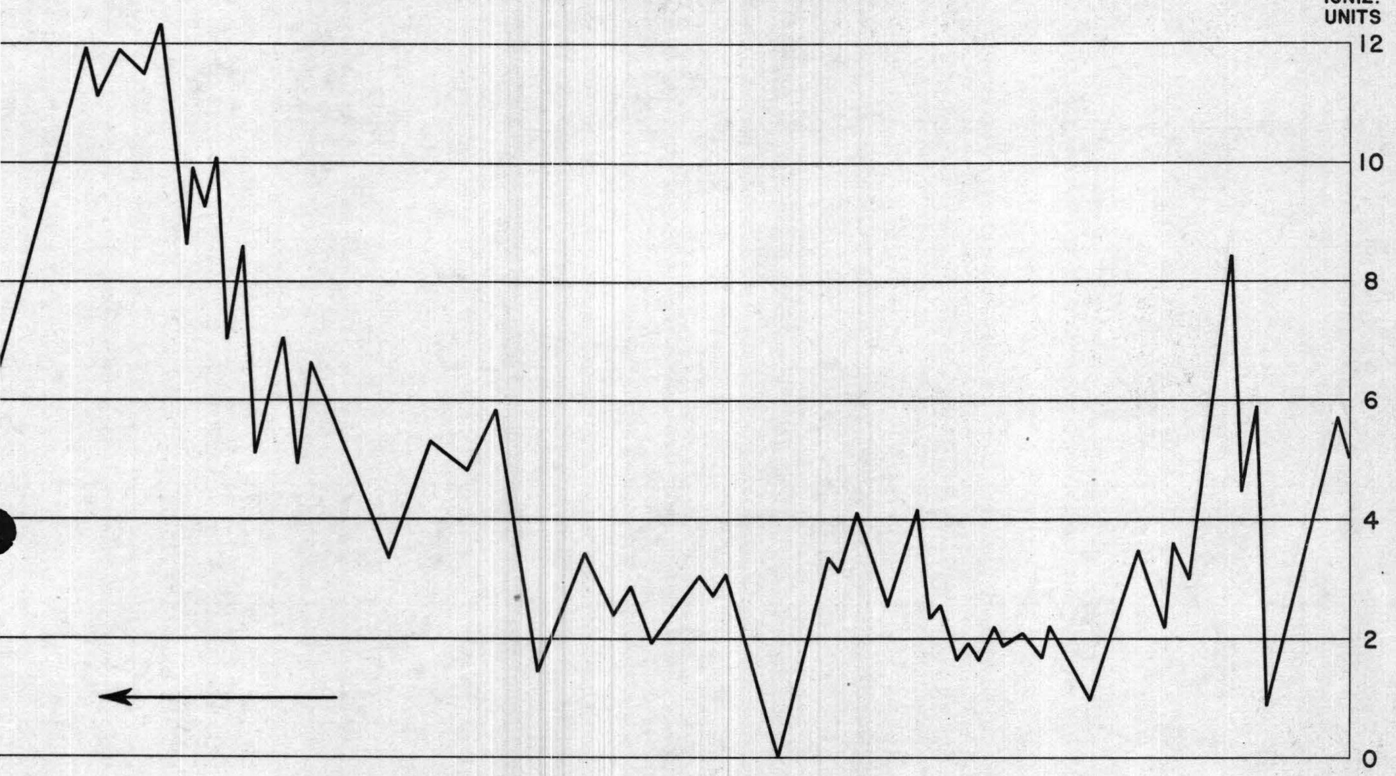


RED DESERT, WYOMING

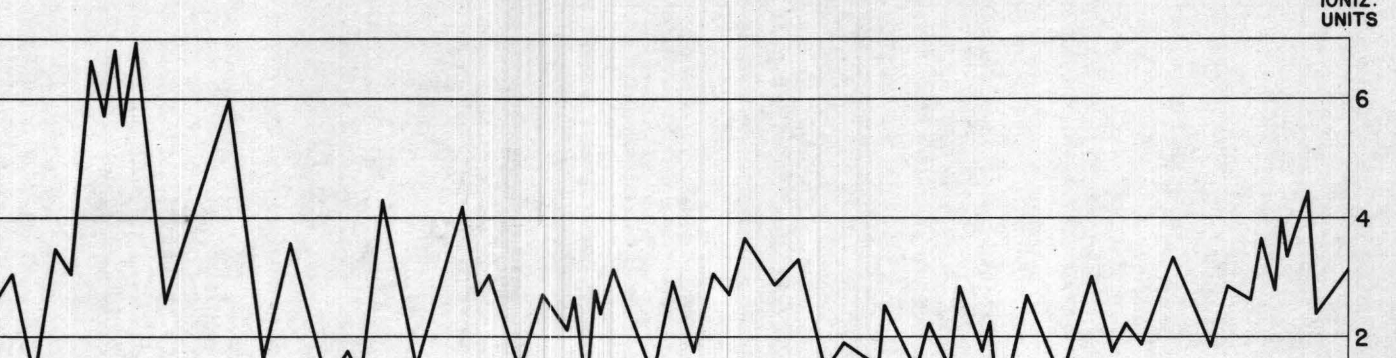
Figure 12



ACTIVITY AT 1000 FEET



ACTIVITY AT 500 FEET



ACTIVITY AT 250 FEET

Figure 13