UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Preliminary thorium daughter contour map and profiles of the Hicks Dome area, Hardin County, Illinois

by

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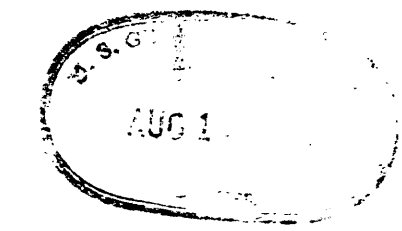

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This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

Contents

List of Illustrations

Introduction

The thorium daughter contour map and profiles described in this report were obtained from an airborne gamma-ray spectrometry survey made in May 1970 of the Hicks Dome area, Hardin County, Ill. (fig. 1).

Purpose

The purpose of the survey was to locate outcrops of thorium-rich breccias which might have associated mineralization (fluorite, as well as barium, beryllium, niobium, and titanium minerals). It was anticipated that mafic alkalic diatremes, dikes, and associated clastic dikes, known to be radioactive compared to the limestone and black shale in which they occur (Heyl and others, 1965, p. B10-B11.), might also be detected. In fact, preliminary ground surveys had shown some intrusions to be more radioactive than the rocks which contained them, even when the intrusions lay within black shales (A. V. Heyl, written commun., 1970).

Method

The natural gamma radiation detected in airborne surveys is that produced by the radioisotopes of potassium, uranium, and thorium. Only the uppermost 20 to 30 cm (centimetres) of rock or soil at the earth's surface can be measured by airborne methods, and the isotopic distribution is dependent on orginal bedrock composition, modified by the geologic processes of weathering, solution, and transportation (Pitkin, 1968, p. F7-F8). Examples of some geologic applications of gamma-ray spectrometry may be found in reports by Darnley, Bristow, and Donhoffer (1969), Darnley (1972), Davis and Guilbert (1973), and Schwarzer and Adams (1973).

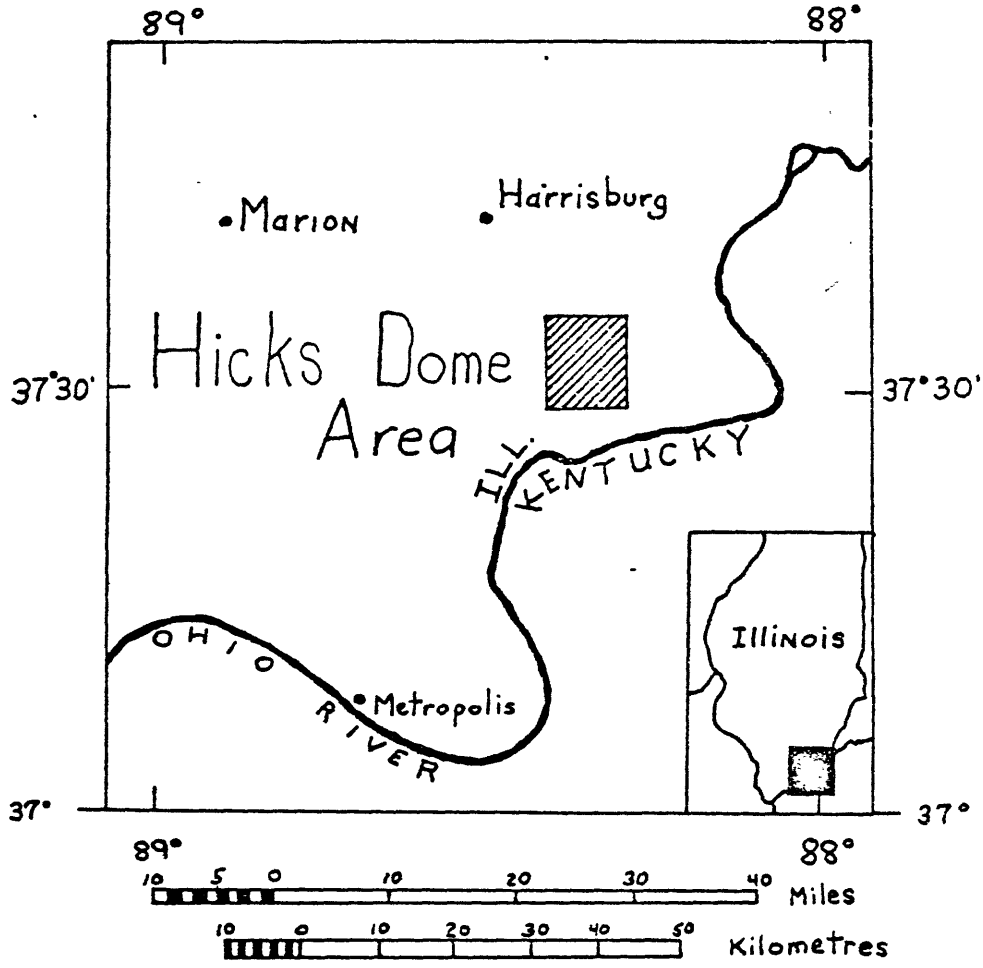

Figure 1.--Index map showing location of the Hicks Dome area, Hardin County, Ill.

System

The spectrometer used in this study detected gamma energy impinging on four thallium-activated sodium iodide crystals 10 cm thick and 12.5 cm in diameter. The detected energy was electronically sorted into four measurements of natural radioactivity: (1) total gamma activity; (2) K^{40}; (3) Bi^{214} daughter of U^{238}; (4) Tl^{208} daughter of Th^{232}. Only the Tl^{208} daughter measurements are discussed in this report. These measurements are thought to be an accurate indicator of ground abundance of Th^{232} despite a complex decay scheme which includes a gaseous daughter, Rn^{220}, with a 56-second half-life.

Survey

The airborne survey of Hicks Dome, Ill. was conducted on May 11 and 12, 1970. It consisted of 37 north-south flight lines of 9 km (kilometre) in length spaced 220 m (metre) apart; line 16 crossed the approximate center of the dome (pl. I-B). The survey was flown from a deHavilland Beaver aircraft at an average speed of 180 km/hr (kilometre per hour) and an average altitude of 130 m above ground. The spectrometry data and flight altitude were continuously recorded on a strip chart recorder. The films of the survey flight paths were recovered from a 35 mm (millimetre) frame camera actuated at 1.5 second intervals by an intervalometer clock. The strip chart recorder and camera were synchronized using a manually-operated fiducial edgemark system. At the surveying altitude of 130 m, the spectrometer detects gamma energy from an area approximately 275 m wide along the flight path. Integrating time constants of 1 second, corresponding to a ground distance of 50 m, were used for recording of the spectrometry data during this survey.

Constraints

Corrections normally applied to gamma-ray spectrometry data include background subtraction, altitude normalization, and lag compensation. These corrections were not applied to the data presented with this report, and the lack of lag compensation most seriously affects the thorium daughter data. "Lag", in airborne gamma-ray spectrometry data, is the time delay in measuring changes in ground radioisotope concentration due to the integrating electronics, the speed of the aircraft, and the dimensions of the radiating source. Lag is compensated for during data reduction by moving the radioactive contact, anomaly, or contour intersection some distance opposite the aircraft flight direction. Preliminary calculations indicate that a lag of at least 150 m should be applied to the data for the Hicks Dome area. In conclusion, these data are thought to be in adequate form for preliminary interpretation, but the lack of lag compensation should be kept in mind.

Preliminary results

Plate I shows contoured thorium daughter data for the Hicks Dome area, and plate II shows most of the profile data from which the contour map was prepared. Plate II does not show all of the thorium daughter data obtained during the survey of the Hicks Dome area, but rather a selective sample deemed adequate for this preliminary report.

Geologic data used in the preparation of this report are from Baxter and Desborough (1965), Baxter, Desborough, and Shaw (1967), and Heyl, Brock, Jolly, and Wells (1965).

Examination of the contour map (pl. I-A) shows thorium daughter background to be 6 to 8 cps (counts per second). Within the topographic rise which lies at the center of the dome (pl. I-B), positive anomalies of as much as four times background were registered on flight lines 14 through 18, all near or over known occurrences of radioactive rock. Outside that small central area underlain by Hunton limestone and chert, anomalies of similar amplitude do not occur. However, it is thought that further refinement of the spectrometry data, such as computation of thorium/uranium and thorium/potassium ratios, could enhance subtle features which may have potential relevance to this study.

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