UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Uranium and Thorium Distribution in Soils and Weathered Bedrock in South Texas

By

Kendell A. Dickinson

Open-File Report 77-764
1977

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

CONTENTS

	Page
Abstract	1
Introduction and summary	1
Previous work	2
Methods	3
Acknowledgments	4
Geologic setting	4
The profiles	6
References cited	17

Illustrations

Page

Figure 1. Generalized geologic map of south Texas------------ 5

2. Map showing locations of profiles------------------ 7

3. Diagrammatic cross section showing stratigraphic positions of profiles------------------------------ 8

4. Profile number 1, located at the Buck Martin road metal pit 10 km west of Tilden, Texas------------ 9

5. Profile number 2, located in a roadcut on State Highway 72, 1.5 km east of Tilden, Texas---------- 12

6. Profile number 3, located on the south ramp of the Pawelek uranium mine, 16 km southwest of Falls City, Texas--------------------------------- 13

7. Profile number 4, located on the north ramp of the Pawelek uranium mine------------------------------ 15

8. Profile number 5, located on the west ramp of the Manka uranium mine, 6 km southwest of Falls City, Texas-- 16

Tables

Page

Table 1. Average values of uranium and thorium, and the thorium-uranium ratio for each profile---------------------- 10

URANIUM AND THORIUM DISTRIBUTION IN SOILS AND WEATHERED BEDROCK IN SOUTH TEXAS

By Kendell A. Dickinson

Abstract

The distribtuion of uranium and thorium in soils and weathered bedrock in areas of calich soil development on various kinds of sedimentary bedrock in south Texas indicates that uranium and thorium are leached from the surface layers and deposited deeper in the soil or weathered bedrock. The data provide field evidence that uranium is mobilized during dry-climate weathering, and suggest that caution be used in the interpretation of airborne radiactive surveys that measure uranium at the surface.

Introduction and Summary

Uranium and thorium were measured by neutron-activation for five weathering profiles in the south Texas uranium area. The studies were made on various kinds of Tertiary bedrock. Certain general conclusions, important to uranium explorers, can be made from the data. First, uranium was leached from the surface in the calichified soil. Second, uranium was deposited deeper in the soil, perhaps adsorbed on clinoptilolite or montmorillonite. Third, the data provide field evidence that the conclusion by Weeks and Eargle (1963) that the uranium was mobilized during periods of dry-climate weathering is correct. Fourth, the data suggest that caution should be used in the interpretation of airborne radioactivity measurements, because these measurements are made on the near surface soil material which has suffered the greatest loss of uranium and thorium by leaching.

The distribution of uranium resembles that of the Sr^{++} and Ba^{++} ions, which are shown for comparison; this resemblance suggests that the uranium was transported as the UO_2^{++} ion. No systematic vertical depositional order, which would be indicated by the layers of maximum concentration, is apparent. If the deposition of the ions was solely by adsorption, the order of deposition might depend on the ionic radii and might be, in ascending order, Sr^{++}, Ba^{++}, and UO_2^{++} or the reverse. Neither of these orders is strictly followed in the profiles (figs. 4-8), suggesting that the actual process is more complicated. The complicating factors may have been differences in the chemical character of the ground water, fluctuations in ground-water movement, the parent material of the soil, or the shapes of the ions.

Thorium, on the other hand, does not form an ion chemically similar to uranium in the oxidizing environment. The distribution of thorium in the profiles does, however, resemble that of uranium, a phenomenon for which no explanation is offered.

Previous Work

The distribution of uranium and thorium in weathered bedrock and soils has been analyzed in some studies, but little of this work applies directly to the present report. Gibbs and McCallum (1955) determined the distribution of radioactive elements in soils developed on various bedrock types in New Zealand and demonstrated that these elements were leached and transported within the soil profiles. Pliler and Adams (1962) estimated that 60 percent of the uranium and 25 percent of the thorium were removed during early weathering stages from rocks within a Pennsylvanian weathering profile developed on Precambrian granodiorite near Boulder, Colo. In this case, however, both elements were reconcentrated in the most weathered parts of the profile, uranium in resistates and thorium in secondary stable minerals. A similar study of weathering of granite in Oklahoma and Georgia by Harriss and Adams (1966) indicated that the distribution of uranium and thorium is also controlled by the distribution of resistates and secondary stable minerals. Hirono (1973) reported that uranium was adsorbed on heulandite, montmorillonite, and carbonaceous materials in a core containing uraninite and coffinite. Masuda and Yamamoto (1971) have shown experimentally that uranium is adsorbed on alluvial, sandy, and volcanic-ash soils. Of the three soils, volcanic ash adsorbed uranium most readily and desorbed it least readily when treated with distilled water or salt solutions.

Methods

Uranium and thorium were measured using a delayed-neutron technique (Millard, 1976). The average coefficient of variation for the uranium determinations is 4 percent, and for the thorium determinations it is 15 percent. For comparative purposes strontium and barium were also plotted on the profiles shown in figures 4-8. These values were determined by six-step semiquantitative spectrographic analyses. Four minerals--calcite, montmorillonite, cristobalite, and clinoptilolite--

were also graphed for each profile. The values plotted for the minerals are X-ray peak heights in centimeters and are intended only to give an approximate quantity of the mineral.

Acknowledgments

The neutron-activation analyses were performed by H. Millard, P. Aruscavage, and A. Bartel. The six-step semiquantitative spectrographic analyses were done by H. Neiman and L. Bradley. All chemical analyses were carried out in analytical laboratories of the U.S. Geological Survey at Denver, Colo. R. Brown and L. Groves of the U.S. Geological Survey energy resources laboratory, also in Denver, did the X-ray analyses.

Geologic Setting

The general geology of the south Texas coastal plain is shown on figure 1. The Tertiary rocks are mostly nonmarine sedimentary types that dip gently to the southeast, at about 1°, into the Gulf coast geosyncline. They also thicken into the geosyncline. Growth faults, generally with small displacements near the surface, extend parallel to the outcrops for many kilometers. The upthrown sides may be to the northwest or southeast, and at some places the faults are in pairs and form wide grabens. Numerous smaller faults are also found in the area (Eargle and others, 1975).

Two formations on which soils and weathering profiles were sampled are the late Eocene Manning and Whitsett Formations of the Jackson Group (Eargle, 1972). The Manning consists mostly of tuffaceous clay,

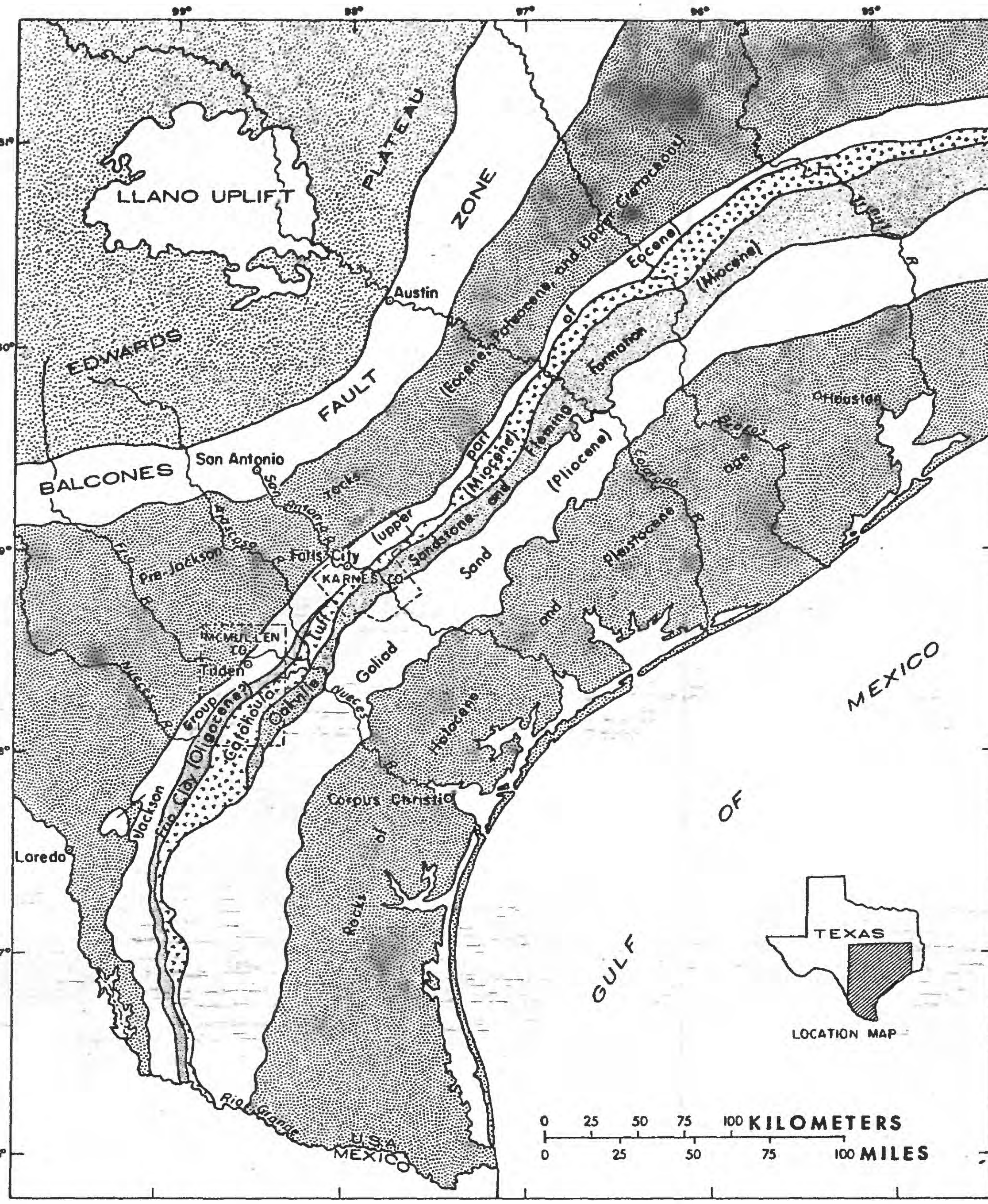


Figure 1.--Generalized geologic map of south Texas.

deposited in lagoonal and flood-plain environments, but also contains a few sandstone and coal beds. The Whitsett consists of alternating members of sandstone formed in marine beaches and claystone formed in lagoons and bays. The third formation sampled is the Miocene Catahoula Tuff, which unconformably overlies the Oligocene(?) Frio Clay in some areas and the Whitsett Formation elsewhere. The Catahoula consists of pink waterlain tuff interbedded with volcanic conglomerate units especially in the south part of the study area. For more comprehensive discussions of the uranium geology, see Eargle and Weeks (1973) and Eargle, Dickinson, and Davis (1975). For more information on the Catahoula, see McBride, Lindemann, and Freeman (1968).

The Profiles

Five weathering profiles, each from different bedrock types, were selected for study. Four of the profiles were in the Jackson Group, two in McMullen County and two in Karnes County; one profile was in the Catahoula Tuff in Karnes County (fig. 2). Figure 3 shows the stratigraphic positions of the profiles and the relation among the various Tertiary units in the coastal plain.

Profile one (fig. 4) is from the Manning Formation. It was sampled in the Buck Martin road metal pit 10 km west of Tilden, Texas. This section consists mostly of nearly white, dense, zeolitized water-lain tuff; it has a black calcareous soil developed in the upper 1 1/2 m. Uranium averaged 4.3 ppm and thorium averaged 14.8 ppm (table 1). Minor leaching of these elements occurred during soil development; but,

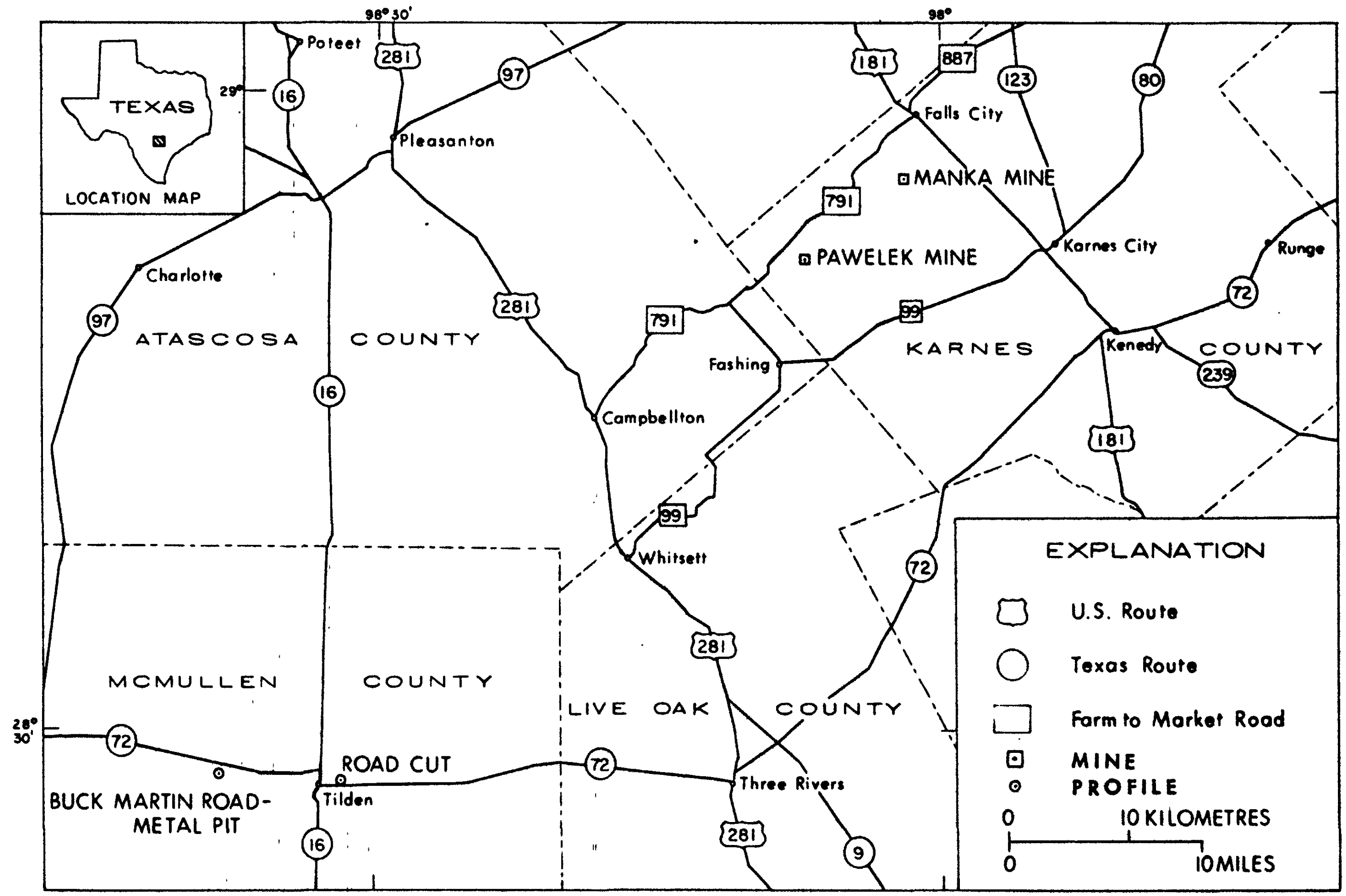


Figure 2.--Map showing locations of profiles.

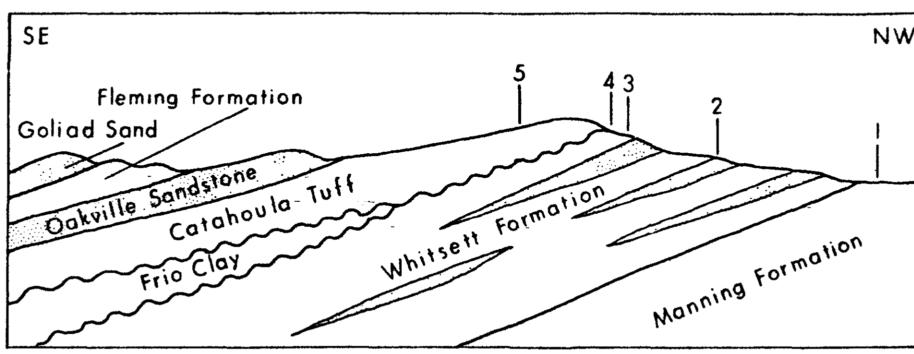


Figure 3.--Diagrammatic cross section showing stratigraphic positions of profiles.

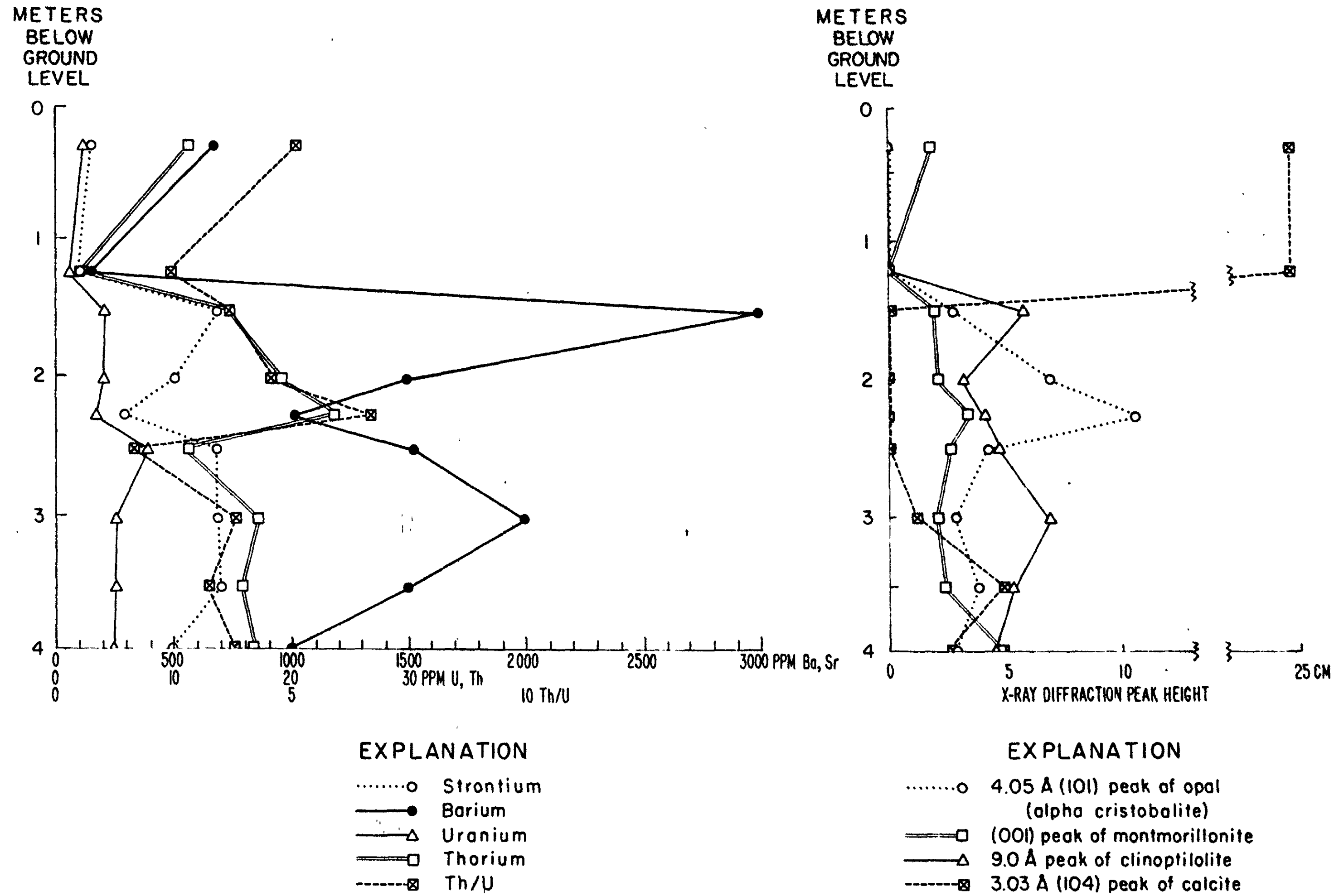


Figure 4.--Profile number 1, located at the Buck Martin road metal pit 10 km west of Tilden, Texas.

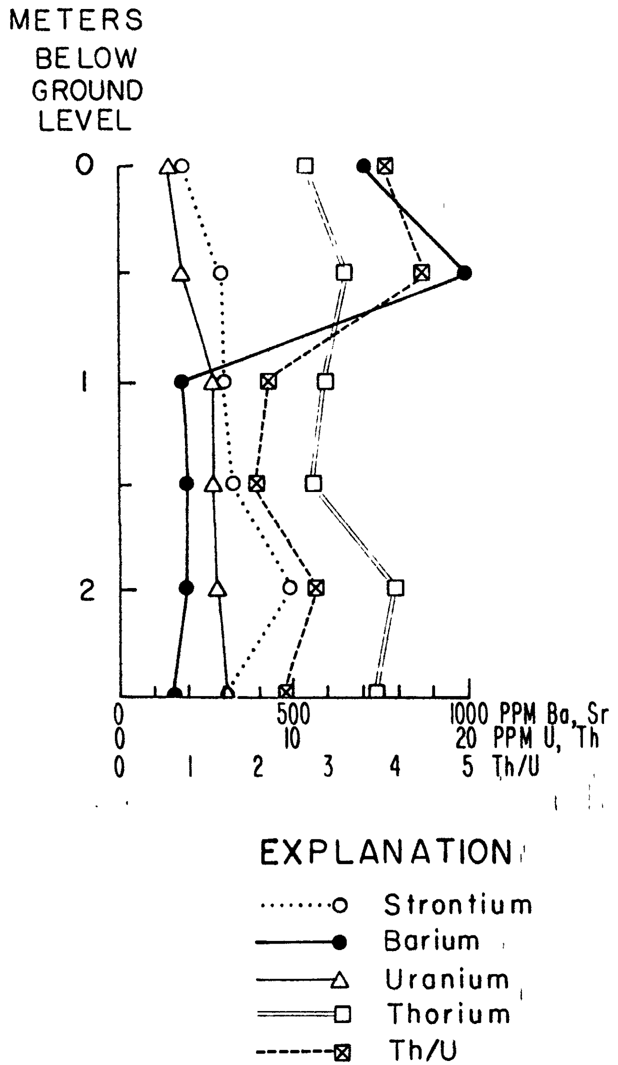
Table 1.--Average values of uranium and thorium, and the thorium-uranium ratio for each profile.

Profile	Formation and location	Uranium ppm	Thorium ppm	Th/U
1----------	Manning Formation Buck Martin road metal pit	4.3	14.8	3.4
2----------	Conquista Clay 1.6 km east of Tilden, Texas	17.3	13.5	.8
3----------	Fashing Clay South ramp Pawelek mine	5.2	13.0	2.5
4----------	Fashing Clay North ramp Pawelek mine	14.5	30.0	2.1
5----------	Catahoula Tuff Manka mine	2.7	14.0	5.1

on the basis of an assumed higher U content of the volcanic parent material, initial loss of uranium before soil development or diagenesis probably occurred.

Profile two (fig. 5) was located in a roadcut 1.5 km east of Tilden in McMullen County. This profile is developed on zeolitized mudstone of the Conquista Clay Member of the Whitsett Formation. The bedrock here is similar to that in the previously described section at the Buck Martin road metal pit, but it has much less cristobalite and montmorillonite and it has scattered diagenetic gypsum crystal clusters in the lower part. Uranium averages 17.3 ppm and thorium averages 13.5 ppm (table 1). The thorium-uranium ratio, 0.8, and a maximum uranium value of 77 ppm indicate uranium enrichment in part of this section. Uranium, thorium, strontium, and barium were apparently leached from the upper, calichified part of the soil profile and concentrated on the zeolitic bedrock material below. The amount of uranium and thorium beneath the zone of concentration, at a depth of about 1.5 m and below, is less than 5 ppm, a value comparable to that found in the upper leached zone. The lower depleted zone probably contains less uranium and thorium than was in the original rock and, if so, may indicate an earlier period of leaching. Alternatively, dilution of the tuffaceous material by non-volcanic sediment may have lowered the original uranium content. The strontium and barium do not fall back to the upper leached values below the zone of absorption.

The third profile (fig. 6) is located on the south ramp of the Pawelek uranium mine and is in the Fashing Clay Member of the Whitsett



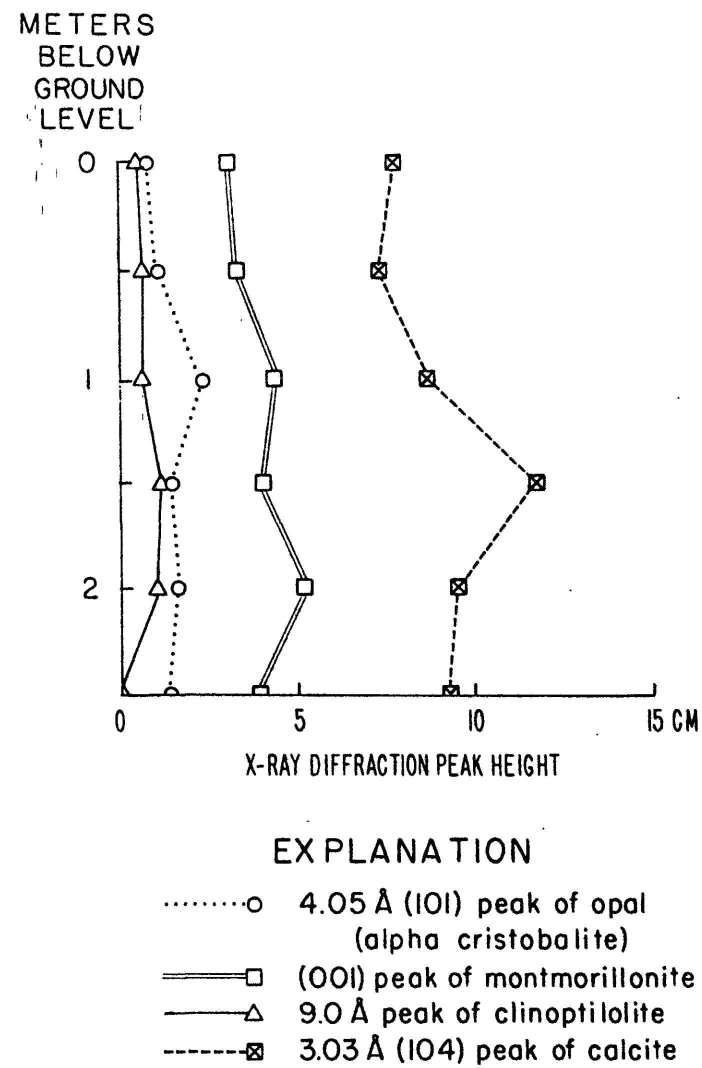


Figure 6.--Profile number 3, located on the south ramp of the Pawelek uranium mine 16 km southwest of Falls City, Texas.

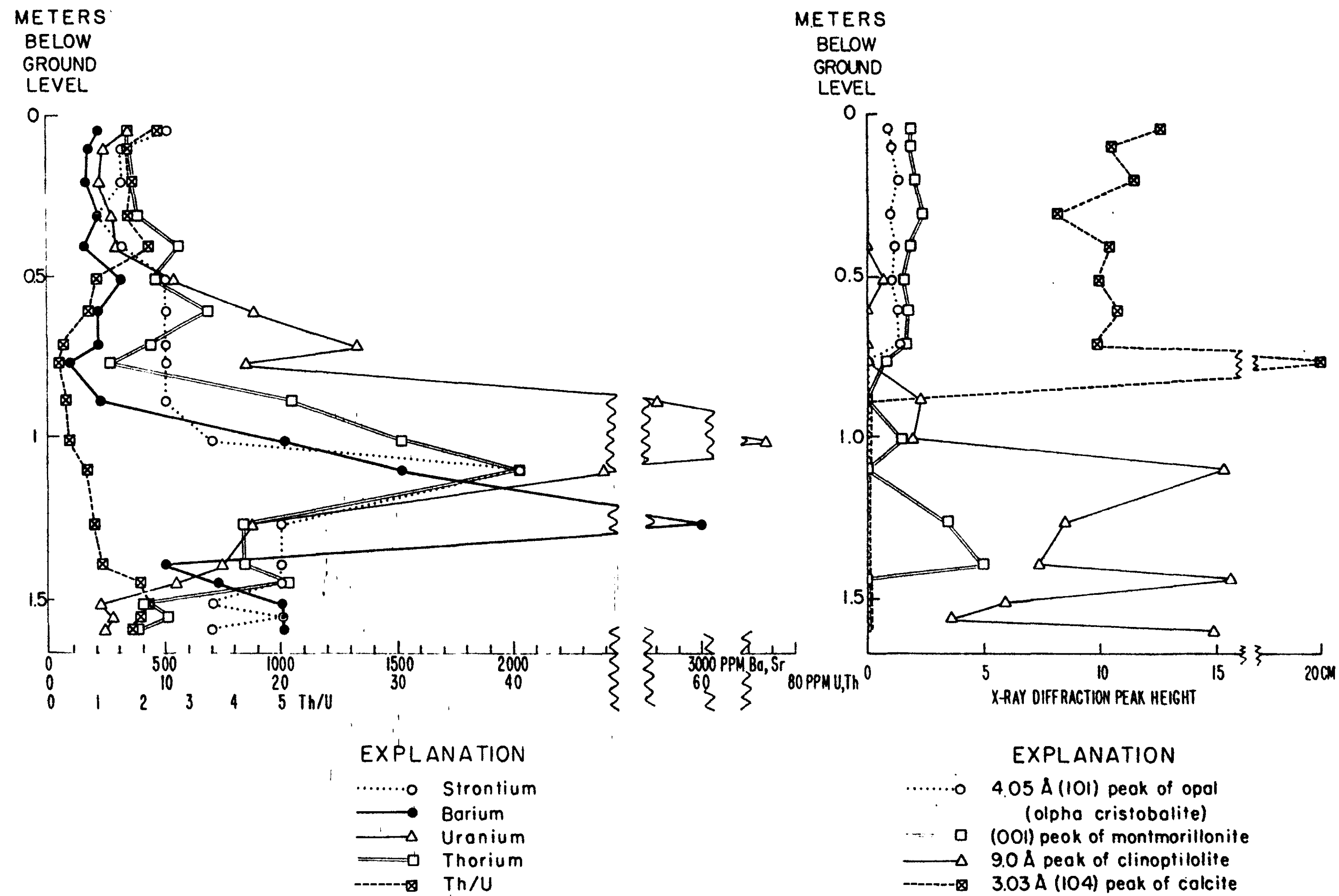


Figure 5.--Profile number 2, located in a roadcut on State Highway 72, 1.5 km east of Tilden, Texas.

Formation. The bedrock at this site is paludal mudstone that consists mostly of detrital montmorillonitic clay. A thin black soil is developed on the surface, but the entire section is calcareous and may not extend below the calichified layer. Uranium, thorium and strontium, slightly increase downward, and barium is enriched in the upper part of the profile.

The fourth profile (fig. 7) was located on the north ramp of the Pawelek mine. This section, also in the Fashing Clay, consists mostly of unaltered volcanic ash that was deposited in a flood-plain environment. The upper meter contains some clinoptilolite, montmorillonite, and cristobalite, but no calcite is found in the section. The uranium averages 14.5 ppm and the thorium, 30 ppm. Uranium, barium and, to a lesser extent, thorium and strontium are enriched in the upper meter of this profile. The unaltered character of the volcanic ash in this section suggests little uranium leaching here prior to the present erosion cycle, and the average values for this unit may be close to the original uranium content of the ash.

Profile five (fig. 8) is from the Catahoula Tuff at the Manka uranium mine in Karnes County. In this profile uranium averaged 2.7 ppm and thorium, 14 ppm. The bedrock at this profile consists of fluvially deposited tuffaceous material. A slight calichification occurred at a depth of about 1 to 1 1/2 m. Only one sample in the profile contains clinoptilolite, in very minor amounts. Of the four minerals measured, montmorillonite and cristobalite compose most of the samples. Barium, and, to lesser extent, strontium and uranium are concentrated in the calichified zone, and thorium is depleted there.

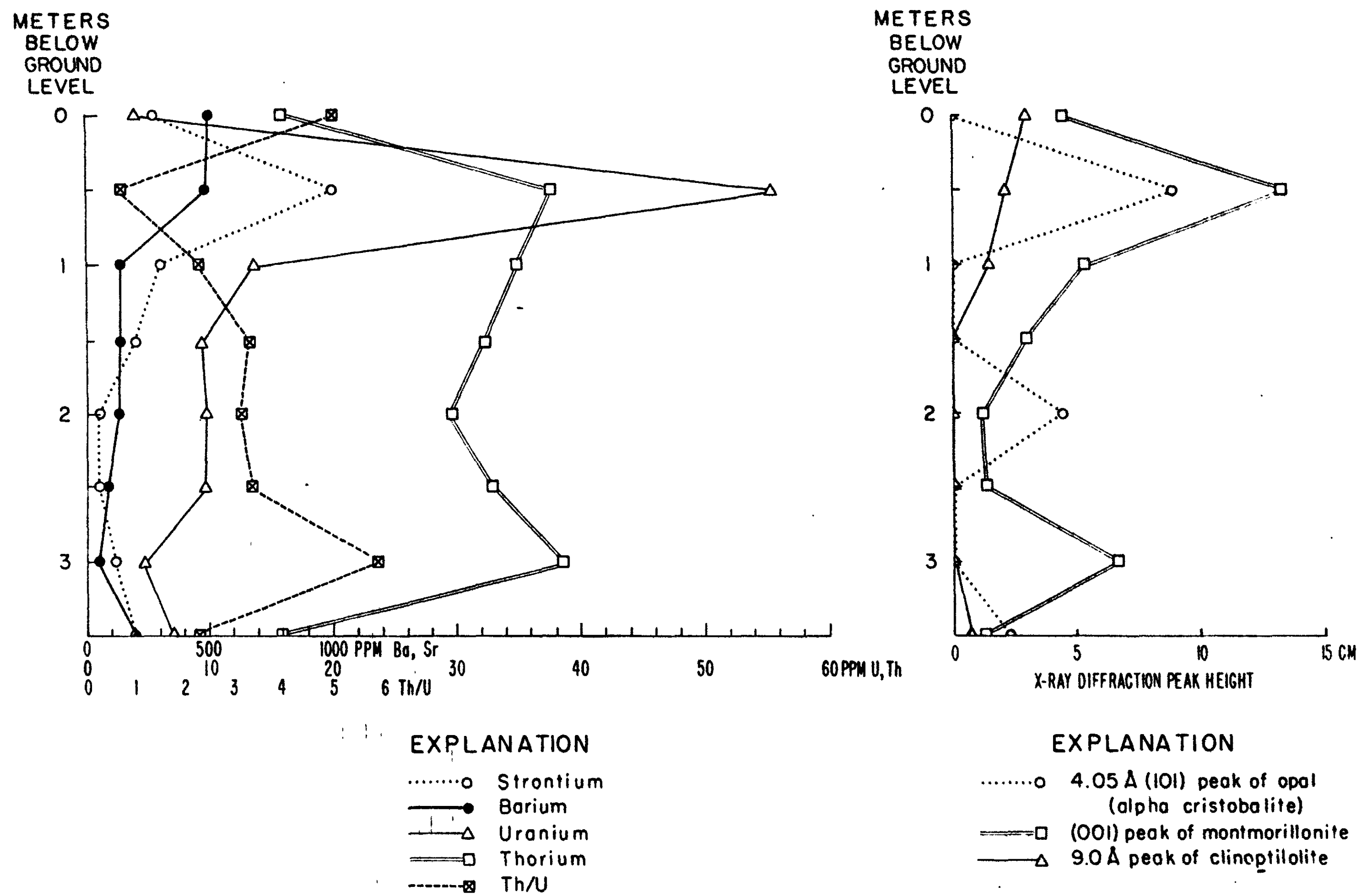


Figure 7.--Profile number 4, located on the north ramp of the Pawelek uranium mine.

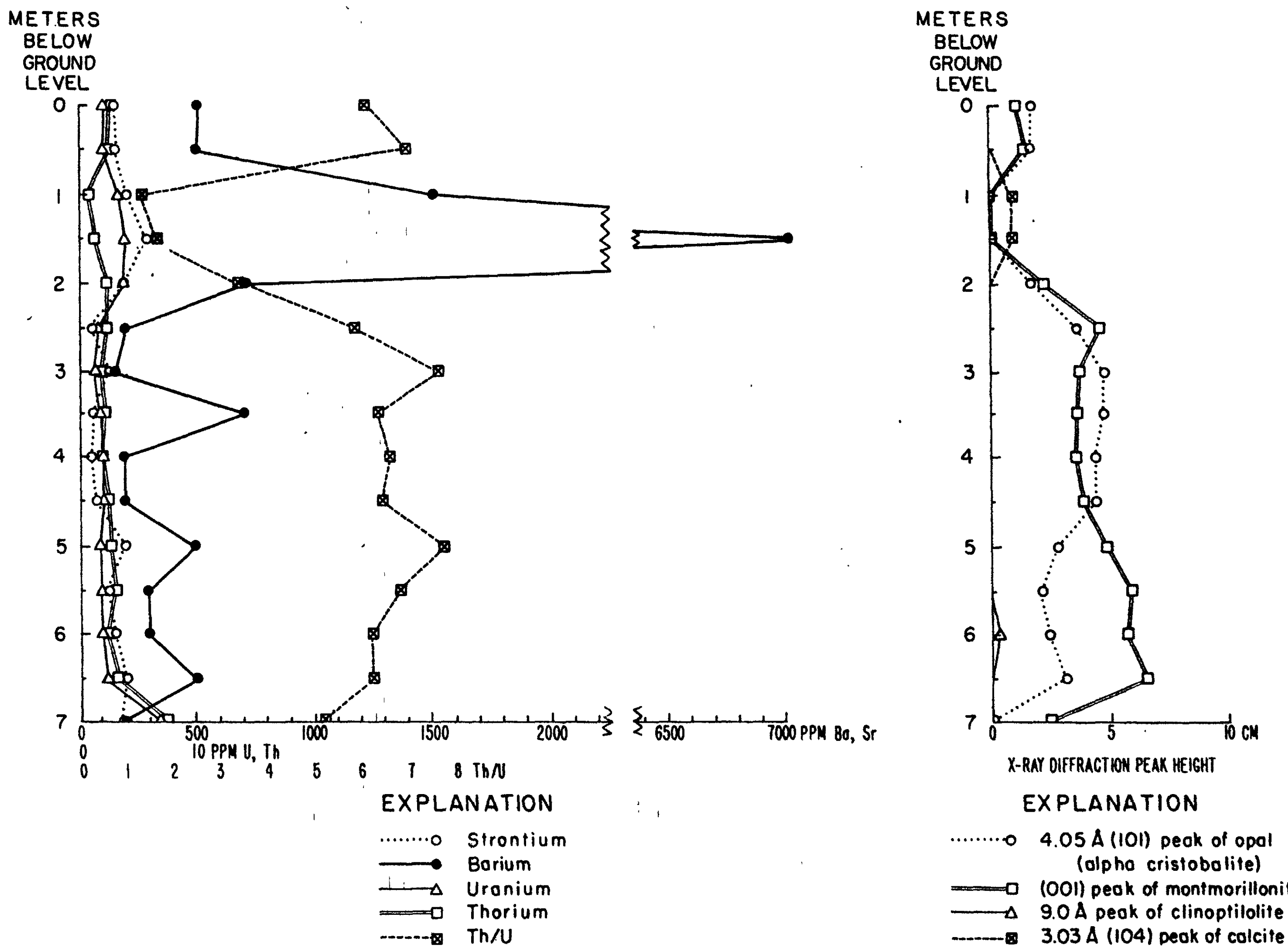


Figure 8.--Profile number 5, located on the west ramp of the Manka uranium mine, 6 km southwest of Falls City, Texas.

McBride, E. F., Lindemann, W. L., and Freeman, P. S., 1968, Lithology and petrology of the Gueydan (Catahoula) Formation in south Texas: Texas Univ. Bur. Econ. Geology Rept. Inv. 63, 122 p.

Millard, H. T., 1976, Determination of uranium and thorium in USGS standard rocks by the delayed neutron technique, _in_ Flanagan, F. J., ed., Descriptions and analyses of eight new USGS rock standards: U.S. Geol. Survey Prof. Paper 840, p. 61-65.

Pliler, R., and Adams, J. A. S., 1962, The distribution of thorium and uranium in a Pennsylvanian weathering profile: Geochimica et Cosmochimica Acta, v. 26, p. 1137-1146.

Weeks, A. M. D., and Eargle, D. H., 1963, Relation of diagenetic alteration and soil-forming processes to the uranium deposits of the southeast Texas coastal plain, _in_ Clays and Clay Minerals, v. 10--10th Natl. Conf. Clays and Clay Minerals, 1961, Proc.: New York, MacMillan Co. (Internat. Ser. Mons. Earth Sci., v. 12), p. 23-41.