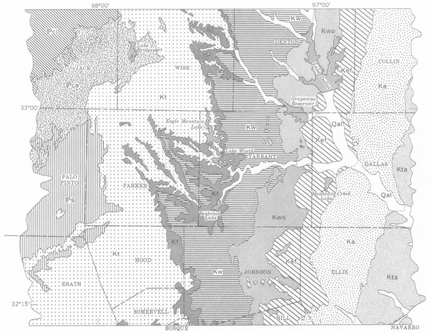
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
DIVISION OF BIOLOGY AND MEDICINE
U.S. ATOMIC ENERGY COMMISSION

GEOPHYSICAL INVESTIGATIONS
MAP GP-696



Base from U.S. Geological Survey 1:250,000, Abilene, Dallas, Sherman and Wichita Falls, 1954

Geology modified from Darton, Stephenson, and Gardner (1937)

SCALE 1:1 000 000

GENERALIZED GEOLOGIC MAP

EXPLANATION

Pleistocene and Holocene	Qal	Alluvial deposits	QUATERNARY
Gulf	Kta	Taylor Marl	CRETACEOUS
	Ka	Austin Chalk	
	Ke	Eagle Ford Shale	
	Kwo	Woodbine Formation	
Comanche	Kw	Washita Group	
Comanche	Kc	Fredericksburg Group	CRETACEOUS
	Kt	Trinity Group	
Upper Pennsylvanian	Pcy	Cisco Group	PENNSYLVANIAN
	Pcn	Canyon Group	
Middle Pennsylvanian	Pst	Strawn Group	CARBONIFEROUS

Contact
Dashed where concealed

MAP SHOWING AREA OF THIS REPORT

INTRODUCTION

Between January 22 and February 27, 1959, the U.S. Geological Survey made an aeroradioactivity survey in north-central Texas that included the greater Fort Worth-Dallas metropolitan area. The area surveyed comprises 8,200 square miles and is centered at the Fort Worth nuclear facility of the Convair Division, General Dynamics Corp.

The survey was made on behalf of the Division of Biology and Medicine, U.S. Atomic Energy Commission, as part of the Aerial Radiological Measurement Surveys (ARMS–I) program (Pitkin, 1968). The purpose of the ARMS–I program was to document the gamma radioactivity for areas in and adjacent to nuclear facilities. These data provided information which would be used to detect future variations in radioactivity that could result from nuclear testing, reactor or other Atomic Energy Commission operations, or radioactivity accidents.

Information on radioactivity levels in the environs and outside the plant boundaries of Atomic Energy Commission and contractor installations are reported in special periodic reports from each installation. These reports are published in the U.S. Public Health Service series titled "RADIOLOGICAL HEALTH DATA," issued monthly and available from the Government Printing Office, Washington, D.C. 20402.

The Fort Worth-Dallas survey was made with scintillation detection equipment (Davis and Reinhardt, 1957) installed in a twin-engine aircraft. Parallel east-west flight traverses spaced at 1- and 2-mile intervals were flown at an altitude of 500 feet above the ground. The flight path of the aircraft was recorded by a gyrostabilized continuous-strip-film camera. The radioactivity data were compensated for deviations from the 500-foot surveying altitude and for the cosmic-ray component.

The effective area of response of the scintillation equipment at an altitude of 500 feet is approximately 1,000 feet in diameter, and the radioactivity recorded is an average of the radioactivity received from within the area. The scintillation equipment accepts only pulses originating from gamma radiation with energies greater than 50 Kev (thousand electron volts). A cesium-137 source is used during periodic calibrations to ensure uniformity of equipment response.

The gamma-ray flux at 500 feet above the ground has three principal sources: cosmic radiation, radionuclides in the air (mostly radon daughter products), and radionuclides in the surficial layer of the ground. The cosmic component is determined twice daily by calibrations at 2,000 feet above the ground and is removed from the aeroradioactivity data.

The component due to radionuclides in the air at 500 feet above the ground is difficult to evaluate. It is affected by meteorological conditions, and a tenfold change in radon concentration is not unusual under conditions of extreme temperature inversion. However, if such conditions are avoided, the air component may be considered to be fairly uniform on a given day in a particular area and will not affect the discrimination of the radioactivity levels that reflect changes in the ground component.

The ground component comes from the upper few inches of the ground. It consists of gamma rays from natural radionuclides, principally members of the uranium and thorium radioactive decay series and potassium-40, and from fallout of nuclear fission products. Locally, the amount of fallout must be small as the lowest total aeroradioactivity measured is 250 cps (counts per second) in areas not affected by absorption of gamma energy by water. The distribution of fallout in the area surveyed is assumed to be uniform.

A recently published report (Pitkin, 1968) discusses the use of aeroradioactivity measurements in geologic mapping and includes a brief discussion of the Fort Worth-Dallas area (p. F20–F21). "Aeroradioactivity" is defined as the "* * * terrestrial gamma-ray intensity measured from an aircraft at 500 feet above ground surface" (Pitkin, 1968, p. F1).

GENERAL AERORADIOACTIVITY

The total range of aeroradioactivity levels in the Fort Worth-Dallas area is 250–750 cps. These low to moderate levels are generally correlatable with bedrock geology. Numerous specific correlations are seen where aeroradioactivity boundaries coincide with geologic boundaries. Significant changes in level of aeroradioactivity at boundaries range from 50 to 200 cps.

Measured values of less than 250 cps are due to the presence of water within the area of response of the scintillation detector. Such values are not shown on the aeroradioactivity map, but can be inferred from the boundaries of lakes and reservoirs shown on the map. The Fort Worth-Dallas survey was made during the winter of 1959, and water levels were usually lower than those shown on the aeroradioactivity map. This is most apparent in the northern part of Lake Dallas, Denton County, where aeroradioactivity of 350–600 cps was measured over the then dry lake bed. With this one exception, aeroradioactivity boundaries are not drawn through bodies of water.

GENERAL GEOLOGY

Bedrock in the Fort Worth-Dallas area consists of sedimentary rocks of Pennsylvanian and Cretaceous age, partially mantled by post-Cretaceous, probably mostly Quaternary alluvial deposits. Cretaceous rocks constitute the dominant outcrop, as Pennsylvanian rocks are confined to the west-central and northwestern parts of the area. All strata are virtually horizontal: Pennsylvanian rocks strike northeast and dip northwest at less than 150 feet per mile, and are overlain with angular unconformity by Cretaceous rocks which strike generally north-northeast and dip east-southeast at less than 50 feet per mile. The geologic map has been generalized from the Geologic Map of Texas (Darton and others, 1937) to show the areal extent of the major geologic units in the area. Lithologic descriptions are mostly from Sellards, Adkins, and Plummer (1932).

The Bureau of Economic Geology of the University of Texas is issuing the Geologic Atlas of Texas, a series of 1° by 2° sheets at 1:250,000. The Sherman sheet (1967) includes part of the Fort Worth-Dallas area and revises a considerable part of the geologic nomenclature, but because this discussion is concerned only with major geologic units, the older nomenclature of Darton and Sellards is used.

STRATIGRAPHY AND RELATED AERORADIOACTIVITY

PENNSYLVANIAN SYSTEM

Rocks of Pennsylvanian age that crop out in the Fort Worth-Dallas area can be considered as an integral aeroradioactivity unit, since specific correlations of aeroradioactivity to mapped geologic units are few. Hendricks (1957, p. 26) described the Pennsylvanian rocks in Parker County as consisting of 83 percent shale (including unmappable sandstone), 13 percent sandstone (including conglomerate), and 4 percent limestone. These lithologies typify rocks of the Strawn Group, but can be considered characteristic of all Pennsylvanian rocks in the area. Aeroradioactivity levels associated with the Pennsylvanian rocks range from 300 to 750 cps. Levels of 700 and 750 cps registered in Jack County are among the highest in the survey area and probably reflect a greater abundance of shale.

CRETACEOUS SYSTEM

Comanche Series.—The Trinity, Fredericksburg, and Washita Groups constitute the Comanche Series. Correlation of aeroradioactivity data can be made with a few more geologic units or contacts for the Comanche rocks than for the Pennsylvanian rocks. Comanche strata are nearly flat-lying and are mostly thin, which accounts for their contorted pattern on the geologic map. Outliers of younger units cap interstream divides, windows of older units are exposed in valley bottoms, and geologic contacts delineate the drainage pattern. This pattern is especially well developed in Wise, Parker, and Tarrant Counties.

The Trinity Group is composed mostly of quartz sand, with abundant limestone occurring in the southern part of the Trinity outcrop. The Trinity strata, which overlap shaly Pennsylvanian rocks, include a discontinuous basal quartz and chert pebble conglomerate. The lithologic contrast of shale to quartz sand and conglomerate is well expressed by the aeroradioactivity data, the shale registering the higher radioactivity. A distinct change in level ranging from 50 to 150 cps was measured on most flight lines across the Pennsylvanian-Cretaceous contact. The basal Cretaceous strata near the Pennsylvanian contact generally register 250–500 cps, and the adjacent Pennsylvanian rocks register 300–600 cps.

Significant correlations of aeroradioactivity boundaries and levels with geologic units within the Comanche Series are found in Wise, Tarrant, and Parker Counties. These correlations are due to the lithologic contrast between sand of the Trinity Group and limestone, marl, and clay of the Fredericksburg Group, the Fredericksburg Group being generally higher in aeroradioactivity. Aeroradioactivity correlations and changes in level at geologic boundaries are seen in eastern Wise and northwestern Tarrant Counties, where the Trinity Group generally registers 300–500 cps and the Fredericksburg Group registers 400–500 cps. Similarly in central Parker County, Trinity strata register 250–450 cps and Fredericksburg rocks 350–550 cps. In these areas distinct changes of at least 50 cps occur at geologic contacts.

Both the Fredericksburg and the Washita Groups are composed of thin-bedded limestone, marl, and clay. This lithologic homogeneity and the involved outcrop pattern preclude aeroradioactivity correlation both within and among the groups.

Gulf Series.—The Gulf Series in the area consists of the Woodbine Formation, the Eagle Ford Shale, the Austin Chalk, and the Taylor Marl. These formations are lithologically distinct and much thicker than most formations of the Comanche Series. Their thickness and a nearly horizontal dip result in a wide outcrop for each formation of Gulf age. These criteria combine to allow good aeroradioactivity boundary and level correlation. The aeroradioactivity boundaries are often distinctive, the change in level at the boundary ranging from 50 to 200 cps.

The Comanche-Gulf contact is unconformable and is well delineated by an aeroradioactivity boundary, the change in level at the boundary ranging from 50 to 100 cps. This boundary extends from Denton, Denton County, in the north approximately southward through Argyle, Richland Hills, Kennedale, Burleson, and Cleburne to the south boundary of the area. In Denton and northern Tarrant Counties, the Comanche strata adjacent to the contact register 400–600 cps and Gulf strata register 300–550 cps. Alluvial deposits in the valley of the Trinity River interrupt the boundary in central Tarrant County. The boundary again occurs in southern Tarrant and Johnson Counties where Comanche strata register 350–550 cps and Gulf rocks register 300–450 cps. The Comanche strata which are adjacent to the Gulf contact are generally limestone, clay, and marl. These strata in gross aspect are more radioactive than the basal Gulf unit, the Woodbine Formation, which is dominantly a sandstone.

The Woodbine Formation is composed of ferruginous sandstone and sandy clay and clay. It is characterized by aeroradioactivity of 300–500 cps throughout the area, its boundaries being defined by the contrast of higher aeroradioactivity of both the Comanche strata to the west and the Eagle Ford Shale to the east.

The Eagle Ford Shale consists of black shale or clay-shale and minor limestone and sandstone and is well defined by aeroradioactivity levels. The Eagle Ford has the highest aeroradioactivity, 450–700 cps, of any major geologic unit in the area, with the exception of two comparative lows of 300–550 cps. These occur (1) in central Johnson and west-central Ellis Counties, and (2) in Tarrant and Dallas Counties north and south of Mountain Creek Lake. The Eagle Ford at its contact with either the Woodbine or the Austin Chalk registers as much as 200 cps more than the adjacent unit.

The potassic mineral alunite, which rarely occurs in sedimentary rocks, and nodular phosphate are described as occurring at the Woodbine-Eagle Ford contact; alunite is also reported within the uppermost Woodbine (Stephenson, 1946). No aeroradioactivity anomalies were seen which correlate with known occurrences of these radioactive minerals; the distinct change in aeroradioactivity level at the Woodbine-Eagle Ford contact is most likely due to the Eagle Ford's being more radioactive in gross aspect than the Woodbine.

The Austin Chalk is composed of chalk or chalky limestone, marl, and calcareous shale. Throughout its outcrop the Austin is defined by aeroradioactivity boundaries and registers general levels of 300–500 cps.

Beginning at Arcadia Park in west-central Dallas County, a distinct low of 350–450 cps extends approximately southward into Ellis County and directly correlates with basal strata of the Austin Chalk. The basal chalk does form a distinct topographic ridge or cuesta in the area; however, relief of the cuesta is not so great as to exceed the limits of the U.S. Geological Survey altitude compensator. Neither the stratigraphy of the chalk nor that of the adjacent Eagle Ford Shale explains the anomaly. Phosphatic (uraniferous) and glauconitic (potassic) material is present at the Austin-Eagle Ford contact, but their presence should cause a radioactive high, not a low. A similar low of 300–400 cps approximately coincides with the Austin-Eagle Ford contact in southeast Denton and west-central Collin Counties.

The Taylor Marl consists of marl or calcareous shale that north of the Trinity River registers 300–600 cps. South of the Trinity River the same strata register 350–650 cps. The Wolfe City Sand Member (not shown on geologic map) of the Taylor crops out in the southeast corner of the area. The Wolfe City is composed of alternating sandy marl and calcareous sandstone, and aeroradioactivity of 350–550 cps is correlative with its outcrop.

QUATERNARY SYSTEM

Alluvial deposits of Quaternary age are abundant throughout the area, blanketing stream flood plains and valleys, and remnants of ancient terraces are common on upland surfaces. Composition is variable, dependent upon upstream source, and grain size varies from clay through silt and sand to pebble-and-cobble gravel. A probable correlation of aeroradioactivity with alluvium exists in Wise County, where a comparative high of 400–600 cps is found along the course of Sandy Creek and southeast of the creek to and including the west fork of the Trinity River. An effect of alluvial cover is seen in Dallas and Tarrant Counties, where the otherwise distinctive aeroradioactivity boundaries correlative with formation contacts in the Gulf Series are interrupted by alluvium of the Trinity River.

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EXPLANATION

400–600

350–550

500–700

Aeroradioactivity boundary
Solid where well defined; dashed where not well defined. Boundaries not drawn through areas of poorly defined levels. Numbers indicate general range of aeroradioactivity levels in counts per second

450–600

Narrow band of high or low aeroradioactivity
Numbers indicate general range of aeroradioactivity level in counts per second

Base from U.S. Geological Survey
Abilene, Dallas, Sherman and Wichita Falls, 1954

SCALE 1:250 000

5 0 5 10 15 20 25 MILES

5 0 5 10 15 20 25 KILOMETERS

DATUM IS MEAN SEA LEVEL
1970 MAGNETIC DECLINATION FOR THIS MAP VARIES FROM 9°00' EASTERLY FOR THE CENTER OF THE WEST EDGE TO 9°00' EASTERLY FOR THE CENTER OF THE EAST EDGE. MEAN ANNUAL CHANGE IS 0°04' WESTERLY

Aeroradioactivity survey made at 500 feet above the ground, 1959

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NATURAL GAMMA AERORADIOACTIVITY MAP OF THE FORT WORTH-DALLAS AREA, TEXAS

By
James A. Pitkin

1970

For sale by U.S. Geological Survey, price 50 cents