DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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

CORRELATION OF GEOLOGY WITH AERORADIOACTIVITY

The radioactivity of the GNOME area measures from 50 to 600 cps (counts per second). The Llano Estacado portion of the area ranges from 100 to 400 cps, the Pecos lowlands from 50 to 600 cps, and the foothills and mountains from 200 to 600 cps.

The oldest rocks exposed in the area are of Permian age, and these rocks have been divided into a number of formations. Permian rocks of Guadalupe age crop out extensively in the Guadalupe Mountains. These marine formations from oldest to youngest are the Grayburg, the Queen, the Seven Rivers, the Yates, and the Tansill. The Grayburg Formation consists chiefly of dolomite, but contains some limestone, siltstone, and sandstone. The formation has a radioactivity of 200 to 500 cps. The lower part of the Queen Formation consists of interbedded dolomite and sandstone as does the underlying Grayburg, but sandstone is relatively more abundant in the Queen (Hayes and Koogle, 1958). The upper 100 feet of Queen is predominantly siltstone. With the exception of one small area with a maximum of 600 cps, the radioactivity of the Queen Formation is 300 to 450 cps. The Seven Rivers Formation consists of limestone, dolomite, and anhydrite, which near the surface weathers to gypsum; the radioactivity is 200 to 400 cps. The siltstone in the upper part of the Queen Formation is noticeably higher in radioactivity than the Seven Rivers Formation, and a radioactivity contact coincides with the geologic contact. The Yates Formation consists of alternating beds of dolomite, siltstone, and sandstone; the radioactivity is 200 to 400 cps. The Tansill Formation is composed chiefly of dolomite and limestone but contains some siltstone, sandstone, and anhydrite. The radioactivity is generally 200 to 300 cps, but locally is 400 cps.

In the Delaware Mountains the rocks of Guadalupe age were deposited in a different environment from the rocks of equivalent age in the Guadalupe Mountains. The Delaware Mountain Group consists of sandstone and a minor amount of limestone. The radioactivity of the Delaware Mountain Group ranges from 250 to 500 cps, but more than half is 400 to 500 cps.

The Castile and the Rustler Formations belong to the Ochoa Series of Permian age and crop out in the Pecos lowlands. Both formations consist principally of anhydrite. Salt, which occurs in both formations in the subsurface, is too soluble to occur in outcrop. Clay- and silt-sized particles tend to be concentrated at the surface as the more soluble constituents are leached. The Rustler Formation contains two dolomite and several siltstone and sandstone members (Jones, 1954). The radioactivity of the Castile ranges from 50 to 450 cps, but most is 100 to 300 cps. The Rustler is 200 to 500 cps, but most is 200 to 300 cps. Although the Rustler is slightly more radioactive than the Castile, the geologic contact between these two formations is not marked by a change in radioactivity.

The GNOME area contains a few outcrops of redbeds of Permian and Triassic ages and of a sandstone of Cretaceous age. These rocks have a radioactivity of 300 cps or less, and are briefly discussed in another report (MacKallor, in press).

The Ogallala Formation of Tertiary age is dominantly sand, silt, and gravel but contains a minor amount of bentonitic clay, marl, and volcanic ash. The sediments were deposited by coalescing streams, and the lithology changes within short distances. The formation forms the bedrock for the Llano Estacado portion of the GNOME area, and there are several outliers of Ogallala in the Pecos lowlands. The radioactivity ranges from 100 to 400 cps. Along Mescalero Ridge, the western boundary of the Llano Estacado, a distinct radioactivity break coincides with the contact between the surficial deposits of Quaternary age and the Ogallala, which is about 100 cps higher than the Quaternary.

Along the west bank of the Pecos River a wide strip of alluvial and terrace deposits has a radioactivity of 300 to 600 cps and forms a conspicuous radioactivity high. West of the Pecos River valley most of the Quaternary material consists of alluvium along eastward-flowing small streams and outwash from the mountains. The radioactivity is 200 to 500 cps. East of the Pecos River the Quaternary consists of alluvial material and sand dunes, and the radioactivity is 100 to 300 cps.

The radioactivity of Crow Flats, a large playa east of the Pecos River in northern Eddy County, New Mexico, is about 150 cps higher than its drainage area. Books (1962) observed that playas in the Mojave Desert of California were more radioactive than their drainage areas.

SELECTED REFERENCES

Books, K.G., 1962, Natural gamma aeroradioactivity of parts of the Los Angeles region, California: U.S. Geol. Survey Geophys. Inv. Map GP-309.

Dane, C.H., and Bachman, G.O., 1958, Preliminary geologic map of the southeastern part of New Mexico (Scale, 1:380,160): U.S. Geol. Survey Misc. Geol. Inv. Map I-256.

Darton, N.H., Stephenson, L.W., and Gardner, J.A., 1937, Geologic map of Texas (Scale, 1:500,000): U.S. Geol. Survey.

Hayes, P.T., 1957, Geology of the Carlsbad Caverns East Quadrangle, New Mexico: U.S. Geol. Survey Geol. Quad. Map GQ-98.

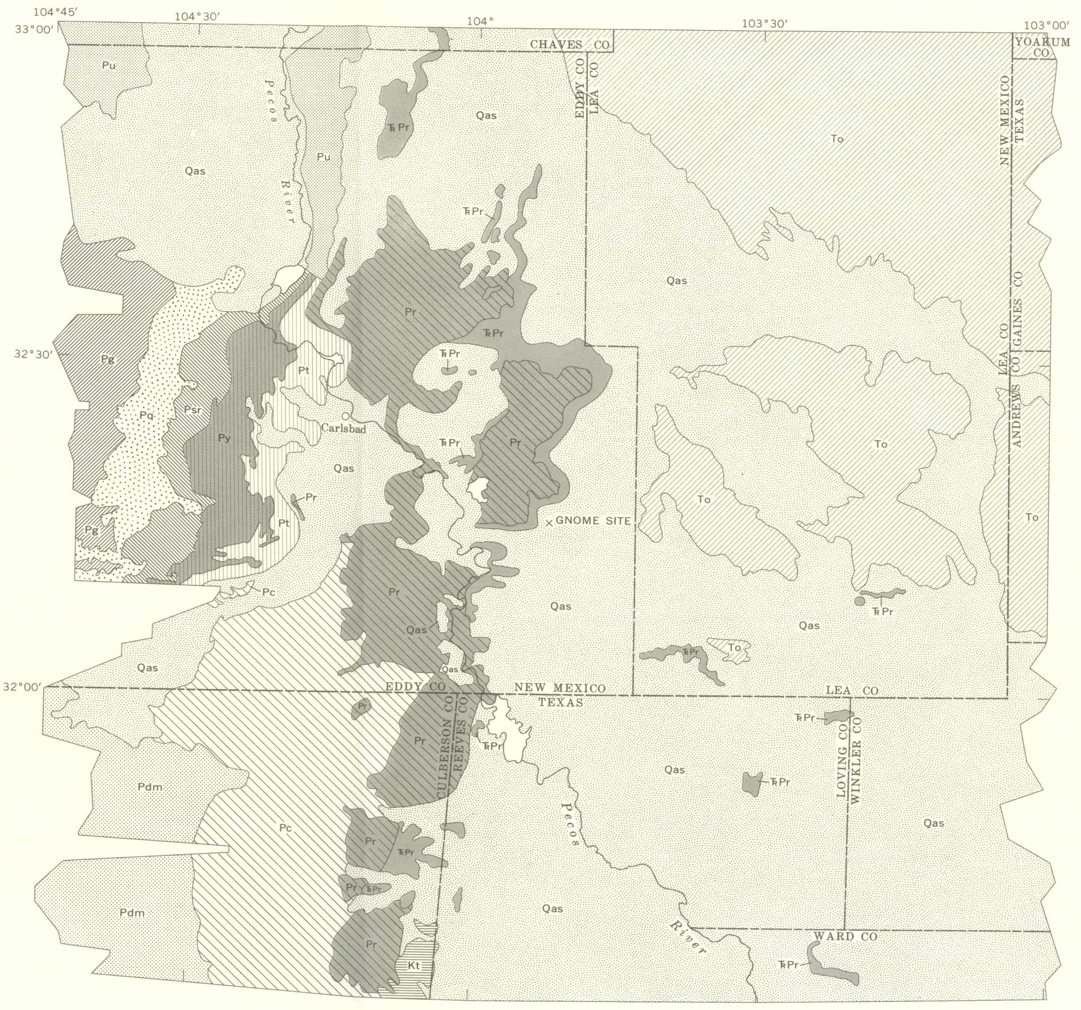
Hayes, P.T., and Koogle, R.L., 1958, Geology of the Carlsbad Caverns West Quadrangle, New Mexico-Texas: U.S. Geol. Survey Geol. Quad. Map GQ-112.

Jones, C.L., 1954, The occurrence and distribution of potassium minerals in southeastern New Mexico, in Guidebook of Southeastern New Mexico, Fifth Field Conference: New Mexico Geol. Soc.

King, P.B., 1948, Geology of the southern Guadalupe Mountains, Texas: U.S. Geol. Survey Prof. Paper 215, 179 p.

MacKallor, J.A., Aeroradioactivity survey and geology of the GNOME (Carlsbad) area, New Mexico and Texas (ARMS-I): U.S. Atomic Energy Comm. Rept. CEX-59.4.24. (Report prepared for the U.S. Atomic Energy Commission, Civil Effects Test Operation Series, by U.S. Geological Survey.) (In press.)

Motts, W.S., 1962, Geology of the West Carlsbad Quadrangle, New Mexico: U.S. Geol. Survey Geol. Quad Map GQ-167.



Geology of New Mexico portion from Dane and Bachman (1958).
Geology of Texas portion from Darton, Stephenson, and Gardner (1937)

5 0 5 10 15 20 MILES

GENERALIZED GEOLOGIC MAP OF GNOME AREA, NEW MEXICO AND TEXAS

EXPLANATION

QUATERNARY — Pleistocene to Recent

Qas — **Alluvium and sand**
Alluvium west of the Pecos River valley; mostly sand east of the Pecos River valley in New Mexico, some sand in Winkler and Andrews Counties, Texas

TERTIARY — Pliocene

To — **Ogallala Formation**
A continental deposit of sand and gravel, locally with calcareous cement. Contains beds and lenses of clay, silt, volcanic ash, and limestone

CRETACEOUS — Lower Cretaceous

Kt — **Trinity Group**
Sandstone

PERMIAN AND TRIASSIC

ŦPr — **Redbeds**
Sandstone and siltstone, some shale and conglomerate, mostly red, some gray. Includes Dewey Lake Redbeds of Late Permian age and Dockum Group of Late Triassic age

PERMIAN — Ochoa Series

Pr — **Rustler Formation**
Thin-bedded dolomite and anhydrite, some siltstone

Pc — **Castile Formation**
Anhydrite and limestone

PERMIAN — Guadalupe Series

Pt — **Tansill Formation**
Carbonate rocks, some siltstone, sandstone, and anhydrite

Py — **Yates Formation**
Dolomite, sandstone, and siltstone

Psr — **Seven Rivers Formation**
Limestone, dolomite, and anhydrite

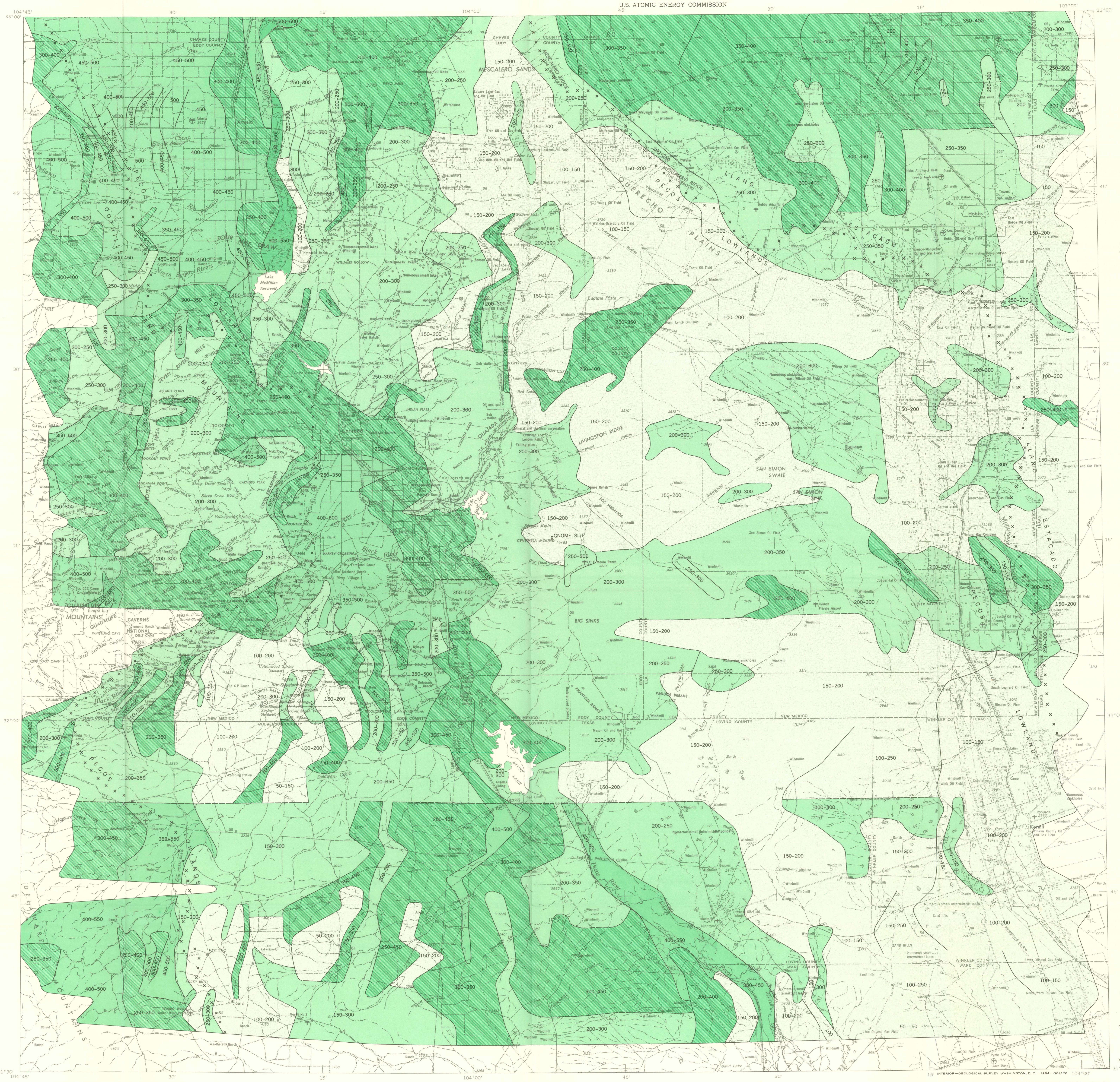
Pq — **Queen Formation**
Sandstone, siltstone, and dolomite

Pg — **Grayburg Formation**
Carbonate rocks, sandstone, and siltstone

SHELF FACIES
Pu — Anhydrite, carbonate rocks, and siltstone

DELAWARE BASIN FACIES
Pdm — **Delaware Mountain Group**
Sandstone and limestone

——— Contact



Base from U.S. Geological Survey 1:250,000 series quadrangles Carlsbad, Hobbs, Pecos, and Van Horn, 1954

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1964—G64176

Aeroradioactivity survey made at 500 feet above the ground under the direction of J. L. Meuschke, 1960

TRUE NORTH / MAGNETIC NORTH 12°
APPROXIMATE MEAN DECLINATION, 1964

SCALE 1:250 000
5 0 5 10 15 20 25 MILES
5 0 5 10 15 20 25 KILOMETERS

EXPLANATION

Radioactivity boundary
Dashed where approximately located

× × × × × × Physiographic boundary

500–600
400–500
300–400
200–300
100–200
0–100 (over lakes)

Generalized levels of aeroradioactivity in counts per second

EXPLANATORY TEXT

An aeroradioactivity survey of about 7000 square miles around the GNOME test site was flown in 1960. The survey was made with continuously recording scintillation-detection equipment (Davis and Reinhardt, 1957[1]) installed in a twin-engine aircraft. The survey was flown along east-west flight lines approximately 500 feet above the ground. The central one-third of the area was flown at a flight-line spacing of one mile, and the northern and southern parts at a spacing of two miles. Aerial photographs were used for pilot guidance, and the flight path of the aircraft was recorded with a continuous-strip-film camera. When the aircraft passed over recognizable features, fiducial edge marks were made simultaneously on the film and on the radioactivity and the altimeter charts.

The radioactivity data were compensated for deviations from the 500-foot surveying elevation by signals from the radar altimeter. The scintillation equipment measures only gamma radiation with energy levels greater than 50 kev (thousand electron volts), and the results are recorded in cps (counts per second). The effective area of response of the scintillation equipment at an elevation of 500 feet above the ground is approximately 1000 feet in diameter.

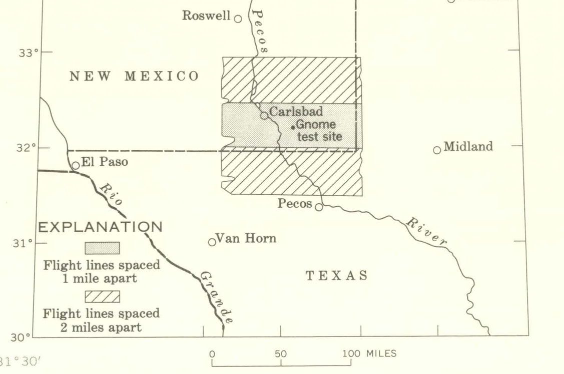
The gamma-ray flux at 500 feet above the ground has three principal components: cosmic radiation, radionuclides in the air, and radionuclides in the upper few inches of surficial material. The cosmic component is measured two or more times daily at 2000 feet above the ground, and the scintillation equipment is adjusted to remove the cosmic effects from the radioactivity record.

The component due to radionuclides in the air (mostly radon daughter products) at 500 feet above the ground is difficult to evaluate. It is affected greatly by meteorological conditions; but if no survey lines are flown during conditions of extreme inversion or during and immediately after thunder showers, the air component does not obscure radioactivity levels that reflect changes in the ground component.

The ground component consists of gamma rays from natural radionuclides (principally members of the uranium and thorium radioactive decay series and potassium-40) and from fallout from atomic testing. The total radioactivity measured in the GNOME area is quite low, and the component due to fallout, if any, is negligible. The distribution of the naturally occurring radionuclides in the surficial rocks and soil is reflected in the measured radioactivity, and in some areas can be correlated directly with geology.

Some of the small radioactivity breaks or contacts between areas of different radioactivity become obscure or disappear, and the contacts, as shown on the map, terminate without enclosing an area of distinct radioactivity. The usual explanation is that in places there is a sharp boundary between two types of surficial material and in other places the surficial material is mixed within a transitional zone between the two types of surficial material. In addition to the small radioactivity units shown on the map, the entire area has been divided by 100 cps increments into six generalized levels of radioactivity shown by green patterns on the map.

[1] Davis, F.J., and Reinhardt, P.W., 1957, Instrumentation in aircraft for radiation measurements: Nuclear Sci. and Eng., v. 2, no. 6, p. 713-727.



INDEX MAP SHOWING AREA OF THIS REPORT

NATURAL GAMMA AERORADIOACTIVITY OF THE GNOME (CARLSBAD) AREA, NEW MEXICO AND TEXAS

By
Jules A. MacKallor
1964

For sale by U.S. Geological Survey, price 75 cents