DEPARTMENT OF THE INTERIOR
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PREPARED IN COOPERATION WITH
DIVISION OF BIOLOGY AND MEDICINE
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NATURAL GAMMA AERORADIOACTIVITY OF THE GEORGIA NUCLEAR LABORATORY AREA, GEORGIA

By
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Aeroradioactivity and related geology

Natural gamma radioactivity in the GNL (Georgia Nuclear Laboratory) area ranges from 0 to 2,100 cps (counts per second). In more than two-thirds of the area surveyed the radioactivity is 500 to 1,000 cps. Over and adjacent to lakes radioactivity ranges from 0 to 350 cps. In most other areas of low radioactivity (500 cps or less) the range is 350 to 500 cps, although in a few places the radioactivity is as low as 250 cps. Radioactivity is higher than 1,000 cps only in a few small areas.

About 15 percent of the GNL area lies west of the Cartersville fault and in the Valley and Ridge physiographic province. This province is characterized by long, narrow valleys and ridges formed by differential erosion of sedimentary rocks that have been faulted and folded into anticlines and synclines. In Georgia these features trend north-northeast. About 80 percent of the GNL area surveyed is in the Piedmont province, which contains a wide variety of metamorphic and igneous rocks. Except for a few monadnocks, such as Stone Mountain in Georgia, the Piedmont is a region of moderate relief. Outcrops are scarce and most of the area is covered with saprolite--deeply weathered residual soil. The other 5 percent of the area surveyed, near the southern borders of Tennessee and North Carolina, is in the Blue Ridge province. Most of the Blue Ridge near the GNL site is too rugged for aerial surveying.

In the Valley and Ridge province, areas underlain by carbonate rocks (O€ld) correlate with areas of low radioactivity. For example, between Cartersville, Bartow County, and Rome, Floyd County, which are on opposite flanks of a broad, gentle syncline, an area more than 10 miles wide is underlain by limestones and dolomites of the Knox Group; the radioactivity in this area ranges from about 300 to 600 cps and there is a conspicuous radioactivity low. Other small areas of carbonate rocks correlate similarly with low radioactivity.

The Shady Dolomite and Weisner Formation (€sw) crop out only in Bartow County and are shown as one unit on the geologic map. Radioactivity of the unit ranges from 450 to 700 cps, and the geologic contact between this unit and the sandstones and shales of the Conasauga and Rome Formations (€cr) coincides with a radioactivity boundary.

The Conasauga and Rome Formations are shown as a single unit (€cr) on the geologic map. Radioactivity of the unit ranges from 600 to 900 cps. In many places these two formations are separable on the basis of aeroradioactivity (MacKallor 1/), the Rome being slightly higher in radioactivity than the Conasauga. The geologic contacts of this unit in most places closely coincide with changes in radioactivity levels. In central Bartow, eastern Floyd, and western Gordon Counties, prominent changes in radioactivity levels mark the €cr-O€ld contact, and in western Bartow County a radioactivity unit of 650 to 800 cps between much lower radioactivity units coincides with a tongue of €cr between areas of O€ld.

The Cartersville fault separates the sedimentary rocks of the Valley and Ridge province on the west from the metamorphic and igneous rocks of the Piedmont to the east. This fault is obscured in places, and Kesler 2/ concluded that there is no major fault in the Cartersville district (eastern Bartow County) but that there probably are minor thrust faults. He also concluded that the phyllites and quartzites are weakly metamorphosed equivalents of the sedimentary rocks of Paleozoic age in eastern Bartow County.

Although the Cartersville fault cannot be precisely located on the ground, a major change in the level of radioactivity occurs along the trace of this fault. The radioactivity of the sedimentary rocks immediately west of the Cartersville fault ranges from 450 to 800 cps, and the rocks immediately east of it are 600 to 1,500 cps. Every flight line showed a sharp change in radioactivity over the fault, and in places the difference was several hundred cps. Even in Gordon County, where radioactivity ranges from 600 to 800 cps on both sides of the fault, the flight lines showed a sharp change in radioactivity of about 100 cps.

The radioactivity of an area of augen gneiss in eastern Bartow County east of the Cartersville fault is 1,000 to 1,300 cps, and the same type of rock in western Cherokee County is 1,500 to 2,000 cps. Radioactivity of 2,100 cps, the highest in the GNL area, was recorded in a few places. Such radioactivity is high, but not unusually so, for granitic rocks.

The low-grade metamorphic rocks of the Talladega Slate (Precambrian) that lie immediately east of the Cartersville fault and in northeastern Bartow County show a range in radioactivity of 800 to 1,200 cps. Radioactivity as high as 1,000 cps is unusual for such kinds of rock. Possibly either small amounts of uranium are associated with carbonaceous material in the graphitic schists, or trace amounts of radioactive elements have been introduced into the Talladega rocks. In Fannin County the radioactivity of the Talladega rocks is 650 to 900 cps except along the axis of the Murphy syncline, which is delineated by a high of 800 to 1,000 cps.

The Piedmont portion of the GNL area contains a wide variety of metamorphic and igneous rocks. Many conspicuous radioactivity units trend northeast, but not all can be related to specific rock units because the area has not been mapped in detail. No such radioactivity units were detected in eastern Pickens County or the adjacent part of Dawson County, but in that area the geologic structure locally trends northwest, parallel to the flight direction of the aircraft.

The Brevard Schist includes a wide variety of lithologic types exposed along the Brevard shear zone. This shear zone is marked in most places by a change in radioactivity level; in some places the higher radioactivity unit is to the northwest and at other places it is to the southeast. Such variations in radioactivity are not unexpected because of the heterogeneous lithology of the Brevard.

Radioactivity of areas of hornblende gneiss is within the general range of 250 to 500 cps, although locally it is slightly higher than 500 cps. However, not all areas of the Piedmont within the 250 to 500 cps range are hornblende gneiss.

More than half of the biotite gneiss and schist of the Carolina Gneiss of former usage ranges in radioactivity from 500 to 750 cps. Only a few small areas of these rocks show levels less than 500 cps. Most of the gneiss and schist along the southeastern edge of the project and a large area of these rocks in Dawson and Pickens Counties range in radioactivity from 750 to 1,000 cps. The higher radioactivity along the southeastern edge of the GNL area occurs just northwest of an extensive belt of monazite-bearing rocks delineated by Mertie 3/ and may reflect an increased thorium (in monazite) content of rocks formerly assigned to the Carolina Gneiss.

Southeast of the belt of rocks equivalent to the Ashland Schist, granitic gneiss is abundant and occurs in northeast-trending belts. Northwest of the Ashland Schist equivalent, there are only a few small equidimensional areas of granitic gneiss. On the geologic map, three small granitic intrusions (Stone Mountain, De Kalb County; Ben Hill, southwest of Atlanta; and an area in Hart County) are included with the granitic gneiss, which has a wide variation in radioactivity. More than one-third of the gneiss shows a range of 750 to 1,000 cps, and a few small areas show levels higher than 1,000 cps. More than one-third of the gneiss registers 250 to 500 cps, but less than one-fourth shows an intermediate range of 500 to 750 cps.

The granitic gneiss in Pickens County is delineated by high radioactivity of 700 to 1,100 cps, and in Lumpkin County a small area of gneiss coincides with low radioactivity of 400 to 500 cps. A band of granitic gneiss nearly 20 miles wide lies immediately southeast of the Brevard shear zone and trends northeastward for almost the entire length of the GNL project. Radioactivity levels can be used to separate this gneiss into a northwestern belt (northwest of the "Y"-shaped area of Brevard Schist and the small area of biotite gneiss and schist in Banks County) and a southeastern belt. The radioactivity level of the northwestern belt is 250 to 500 cps except for two small areas that register more than 1,000 cps in Hall and Jackson Counties and an area showing 750 to 1,000 cps in Gwinnett County. The southeastern belt progressively increases in radioactivity from less than 500 cps at the northeastern end of the belt to more than 1,000 cps in Rockdale and Henry Counties at the southwestern end of the belt.

One area of dioritic injection gneiss is shown on the geologic map, and it registers less than 500 cps. Such rocks normally contain less potassium than typical granitic gneiss. Those areas mapped as granitic gneiss that correspond to areas of low radioactivity may contain appreciable amounts of dioritic injection gneiss.

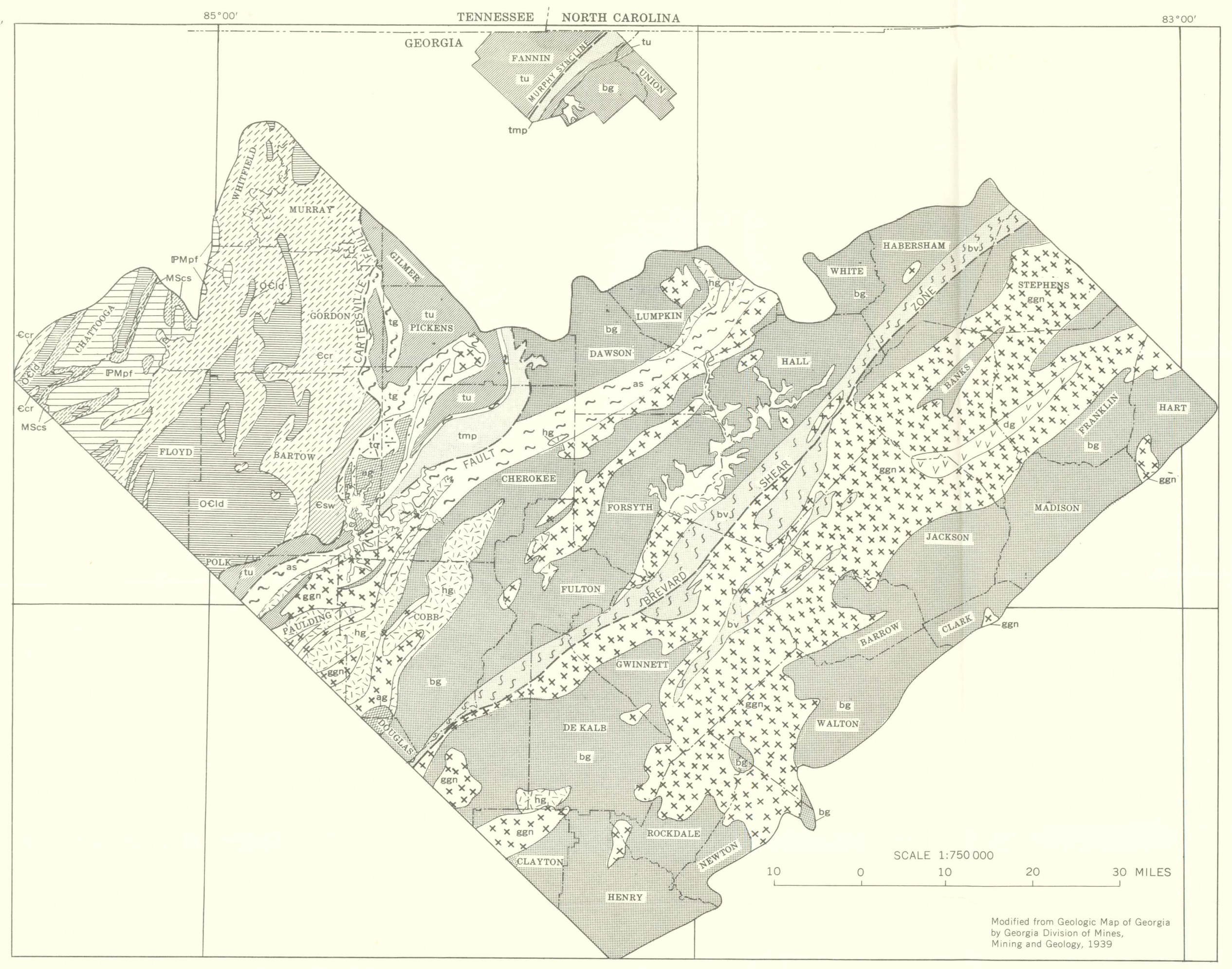
Both the biotite gneiss and schist and the granitic gneiss show a considerable range in radioactivity. Little is known about the distribution of uranium in these rock units, but it is believed that in most cases higher radioactivity corresponds to a higher content of both potassium and uranium.

1/ MacKallor, J. A., in preparation, Aeroradioactivity survey (ARMS-I) and areal geology of the Georgia Nuclear Laboratory area, northern Georgia: U. S. Atomic Energy Comm. Rept. CEX-58.4.6, available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C.

2/ Kesler, T. L., 1950, Geology and mineral deposits of the Cartersville district, Georgia: U. S. Geol. Survey Prof. Paper 224, p. 30-33.

3/ Mertie, John B., Jr., 1953, Monazite deposits of the southeastern Atlantic States: U. S. Geol. Survey Circ. 237, pl. 1

4/ Watson, T. L., 1902, A preliminary report on a part of the granites and gneisses of Georgia: Georgia Geol. Survey Bull. 9-A, 367 pp.



GENERALIZED GEOLOGIC MAP OF GEORGIA NUCLEAR LABORATORY AREA, GEORGIA

EXPLANATION

SEDIMENTARY ROCKS WEST OF CARTERSVILLE FAULT

- PMpf — Pottsville Formation equivalent, Floyd Shale, and Fort Payne Chert. *Pottsville Formation equivalent contains conglomerate, sandstone, and shale* (MISSISSIPPIAN AND PENNSYLVANIAN; CARBONIFEROUS)
- MScs — Chattanooga Shale, Armuchee Chert, and Red Mountain Formation. *Red Mountain Formation consists of ferruginous shale and sandstone* (SILURIAN, DEVONIAN, AND MISSISSIPPIAN)
- O€ld — Limestone and dolomite. *Includes Upper and Middle Ordovician limestones and the Knox Group* (CAMBRIAN AND ORDOVICIAN)
- €cr — Conasauga and Rome Formations, undivided. *Contains limestone of the Conasauga and shale and sandstone of the Rome* (CAMBRIAN)
- €sw — Shady Dolomite and Weisner Formation, undivided. *Includes argillaceous beds in the Shady, and meta-shale, quartzite, and conglomerate in the Weisner* (CAMBRIAN)

METAMORPHIC ROCKS EAST OF THE CARTERSVILLE FAULT

Stratigraphic succession not implied by position

- tmp — Mica schist and phyllite
- tg — Graphite schist
- tq — Quartzite
- tu — Talladega Slate, undivided
- bv — Brevard Schist
- as — Ashland Schist equivalent
- bg — Biotite gneiss and schist. *Includes rocks formerly assigned to the Carolina Gneiss*

PRECAMBRIAN AND PALEOZOIC

IGNEOUS AND META-IGNEOUS ROCKS

Chronologic sequence not implied by position

- ggn — Granite gneiss. *Similar to Lithonia Granite-Gneiss (Watson, 1902)4/. Typically consists of broad light-colored bands containing abundant quartz and feldspar, alternating with narrow dark bands mostly of biotite. Includes some intrusive muscovite-biotite granite of late Paleozoic(?) age, such as at Stone Mountain*
- dg — Dioritic injection gneiss
- ag — Augen gneiss
- hg — Hornblende gneiss. *Contains hornblende, quartz, plagioclase, and epidote. Includes some ultramafic rocks*

PRECAMBRIAN OR PALEOZOIC

——— Contact

EXPLANATORY TEXT

An aeroradioactivity survey of about 7,000 square miles around the GNL (Georgia Nuclear Laboratory) site was flown in 1958. Mountainous terrain prevented flying all the area near the site. The survey was made with continuously recording scintillation-detection equipment (Davis and Reinhardt, 1957)1/ installed in a twin-engine aircraft. Parallel northwest-southeast flight traverses spaced one mile apart were flown at approximately 500 feet above the ground. County road maps 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 altimeter records.

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 is approximately 1,000 feet in diameter.

The gamma-ray flux at 500 feet above the ground has three principal components: (1) cosmic radiation, (2) radionuclides in the air, and (3) radionuclides in the upper few inches of the ground. The cosmic component is measured two or more times daily at 2,000 feet above the ground, and the scintillation equipment is adjusted to remove the cosmic effects from the radioactivity data.

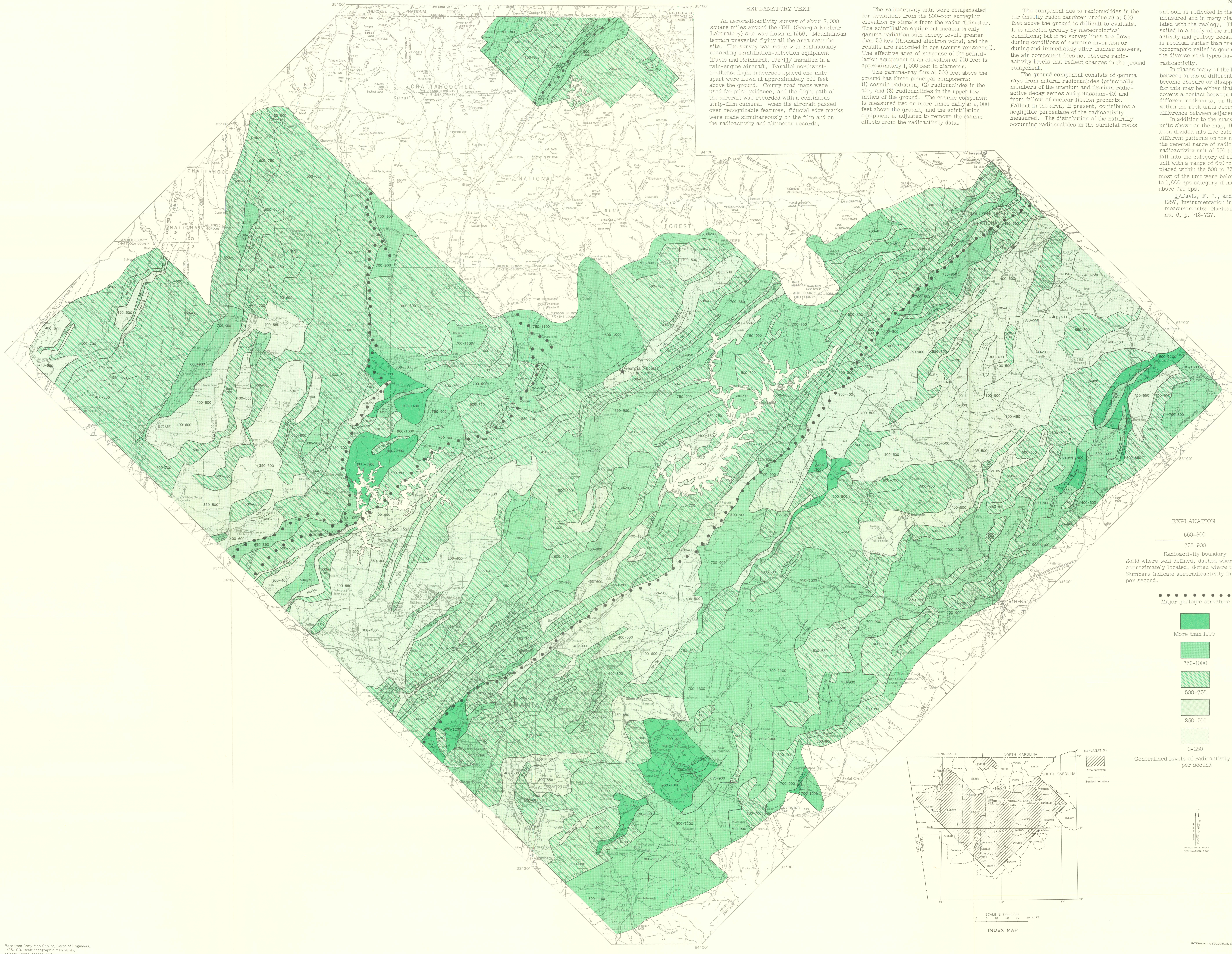
The component due to radionuclides in the air (mostly radon daughter products) at 500 feet above the ground is difficult to evaluate. It is affected greatly by meteorological conditions; but if no survey lines are flown during conditions of extreme inversion or during and immediately after thunder showers, 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 of nuclear fission products. Fallout in the area, if present, contributes a negligible percentage of the radioactivity measured. The distribution of the naturally occurring radionuclides in the surficial rocks and soil is reflected in the radioactivity measured and in many places can be correlated with the geology. The GNL area is well suited to a study of the relation between radioactivity and geology because much of the soil is residual rather than transported, the topographic relief is generally moderate, and the diverse rock types have a wide range of radioactivity.

In places many of the breaks or contacts between areas of different radioactivity become obscure or disappear. The reason for this may be either that transported soil covers a contact between two radiometrically different rock units, or that facies changes within the rock units decrease the radiometric difference between adjacent rock units.

In addition to the many small radioactivity units shown on the map, the entire area has been divided into five categories, shown by different patterns on the map, according to the general range of radioactivity. A small radioactivity unit of 550 to 800 cps would fall into the category of 500 to 750 cps. A unit with a range of 650 to 850 cps would be placed within the 500 to 750 cps category if most of the unit were below 750, or into the 750 to 1,000 cps category if most of the unit were above 750 cps.

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.



EXPLANATION

550-800 / 750-900 — Radioactivity boundary. Solid where well defined, dashed where approximately located, dotted where transitional. Numbers indicate aeroradioactivity in counts per second.

• • • • • • • • • Major geologic structure

- More than 1000
- 750-1000
- 500-750
- 250-500
- 0-250

Generalized levels of radioactivity in counts per second

EXPLANATION
Area surveyed
Project boundary
SCALE 1:2 000 000
10 0 10 20 30 40 MILES

INDEX MAP

Base from Army Map Service, Corps of Engineers, 1:250 000-scale topographic map series, Atlanta, Rome, Athens, and Greenville sheets

SCALE 1:250 000
4 2 0 4 8 12 16 20 MILES

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