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-306

General aeroradioactivity and related geology

The natural gamma aeroradioactivity of the Savannah River Plant (SRP) area ranges from 150 to 2100 cps (counts per second). Field examination and comparison with geologic maps indicate that the natural radiation level is closely related to the type of soil or rock at the surface of the ground. This relationship is locally so good that geologic contacts may be reasonably mapped from changes in radiation level. Aeroradioactivity not related to natural causes was measured only within the SRP reservation, approximately 20 miles southeast of Augusta, and is discussed in another report (Schmidt, 1961).

The SRP area is located in two major physiographic provinces: the Piedmont, underlain by steeply inclined metamorphic and igneous rocks, of probable Precambrian or Paleozoic age; and the Coastal Plain, underlain by gently dipping sedimentary rocks, Late Cretaceous to Quaternary in age. The highest natural radiation measured occurs in the Piedmont province, and the Piedmont is generally more radioactive than the Coastal Plain. The range of aeroradioactivity is great in both provinces -- 250 to 2100 cps in the Piedmont and 150 to 1300 cps in the Coastal Plain. In the southeastern Coastal Plain there are many areas of swampland in which the shielding effect of standing water reduced the measured radiation to 50 or 100 cps.

Four major rock units are present in the Piedmont: (1) a metamorphic complex of slate, schist, gneiss, and granite; (2) argillite, slate, schist, and quartzite of the Carolina slate belt; (3) granite in plutons; and (4) porphyritic granite. Relatively low aeroradioactivity (generally 300 to 600 cps) is associated with the Carolina slate belt, and high aeroradioactivity (generally 700 to 1800 cps) is associated with the granites. The metamorphic complex includes areas of both high and low radiometric intensity.

In Lexington County, S. C., along a line extending about 6 miles southwest of Lake Murray, a slate belt-granite contact is clearly defined by aeroradioactivity. The aeroradioactivity of the slate belt rocks is 400 to 600 cps, and of the granite, 900 to 1800 cps. A linear aeroradiation high, generally 700 to 1500 cps, which trends east from Clark Hill Reservoir in Edgefield County, S. C., is associated with narrow migmatized zones in the Carolina slate belt. Similar contrasts are observed throughout the SRP area where slate belt rocks are bounded by granite or other more radioactive rock.

Within the Carolina slate belt in Saluda County, S. C., aeroradioactivity indicates zoning parallel to the regional strike. The general ranges of aeroradioactivity in the zones, from northwest to southeast, are: 400 to 600 cps, 300 to 500 cps, and 400 to 600 cps. Field examination revealed no difference between these rocks of the slate belt: composition is uniform, and colors, textures, and metamorphic grade appear similar throughout.

Approximately 4 miles southeast of Clark Hill Reservoir, in Edgefield and McCormick Counties, S. C., aeroradiation clearly defines granite (800 to 1400 cps) bounded by rocks of the metamorphic complex (generally 500 to 700 cps). Similarly, 6 miles south of Clark Hill Reservoir, in Columbia County, Ga., the aeroradioactivity of a large mass of porphyritic granite is chiefly 800 to 1100 cps, and that of adjacent rocks of the metamorphic complex is generally 400 to 900 cps.

Near the Fall Line (Piedmont-Coastal Plain contact), Piedmont rocks are exposed downstream along valleys and also in several valley bottoms entirely surrounded by sedimentary rocks of the Coastal Plain. In these marginal exposures, the contact of Piedmont rocks with the surrounding Coastal Plain formations is generally reflected in the radioactivity survey where the Piedmont rock is schist, gneiss, or granite, but little or no radioactivity contrast is found at the contact where the Piedmont rock is that of the Carolina slate belt.

Locally, the most radioactive parts of the Coastal Plain, especially certain gravelly layers near the base of the Tuscaloosa formation (generally 700 to 1300 cps), were found to be as radioactive as most of the granites and the metamorphic complex. Near McTier Creek in northern Aiken County, S. C., approximately 30 miles southwest of Lake Murray, H. S. Johnson, Jr. (Division of Geology, South Carolina State Development Board) showed the writer highly radioactive gravelly sand at the base of the Tuscaloosa formation resting on a radioactive granite. The sand at this locality is considerably more radioactive than the underlying granite. Small quartz pebbles in the sand are angular and are similar to a blue-gray quartz that is very abundant in veinlets in the underlying granite, suggesting that the pebbles were locally derived.

The sedimentary rocks of the Coastal Plain consist mostly of sand, silt, clay, marl, and limestone. In general, the older rocks are exposed along the northwest side of the Coastal Plain and successively younger formations occur toward the ocean. The older rocks, Late Cretaceous and Eocene in age, are generally associated with radioactivity of 400 to 800 cps. Many areas in Lexington and eastern Aiken Counties, S. C., underlain mostly by rocks of Late Cretaceous age, are much higher in radioactivity, ranging from 700 to 1300 cps. The younger rocks, Miocene through Pleistocene in age, are associated with low radioactivity of 300 to 600 cps.

The areas of higher radioactivity (700 to 1300 cps) in Lexington and eastern Aiken Counties, S. C., southeast of Lake Murray, are generally underlain by the Tuscaloosa formation of Late Cretaceous age, which consists of arkosic sand with lenses of clay. Radioactive layers, including several occurrences similar to the McTier Creek locality, seem to occur at different positions throughout the thickness of the formation. Elsewhere in the SRP area, the Tuscaloosa formation is much less radioactive, generally 400 to 700 cps.

The Claiborne group of middle Eocene age is extensively exposed in the east-central part of the SRP area, where it provides a broad radiometric high (350 to 800 cps) in comparison with adjacent less radioactive Eocene, Oligocene, and Miocene rocks. The Claiborne group is variable in lithology, consisting of massive sands, thin layers of marl and glauconitic marl, fuller's earth, limestone, and siltstone.

In the lower part of the Coastal Plain, most areas of similar radioactivity are large and irregular, and many of the changes are gradual and difficult to show as distinct lines. Some swamps form areas of low radioactivity, and many river flood plains are distinctly higher or lower in radioactivity than the adjacent Coastal Plain. Where the Ogeechee River (Georgia), the Savannah River, and the Edisto River (South Carolina) cross the formations of Oligocene, Miocene, and Pleistocene ages, parts of their flood plains are more radioactive than the adjacent formations even though they are swampy in places. These long river systems, heading in the Piedmont and in older Coastal Plain formations, have transported radioactive material from the headwater areas and deposited it in the flat Coastal Plain. In contrast, the Salkehatchie and Little Salkehatchie Rivers in South Carolina drain basins developed mostly in the Hawthorn formation and Pleistocene terraces. The flood plains of these rivers are generally about as radioactive as the adjacent upland. In several places the flood plains are slightly less radioactive; this is particularly noticeable along the Coosawhatchie, a smaller river in Hampton County, S. C.

1/ Schmidt, R. G., 1961, Aeroradioactivity survey and areal geology of the Savannah River Plant area, South Carolina and Georgia: U. S. Atomic Energy Comm., Rept. CEX-58.4.2, available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C.

Geology compiled from many sources by R. G. Schmidt, 1959

GENERALIZED GEOLOGIC MAP OF THE SAVANNAH RIVER PLANT AREA, SOUTH CAROLINA AND GEORGIA

SCALE 1:750 000

10 0 10 20 30 MILES

EXPLANATION

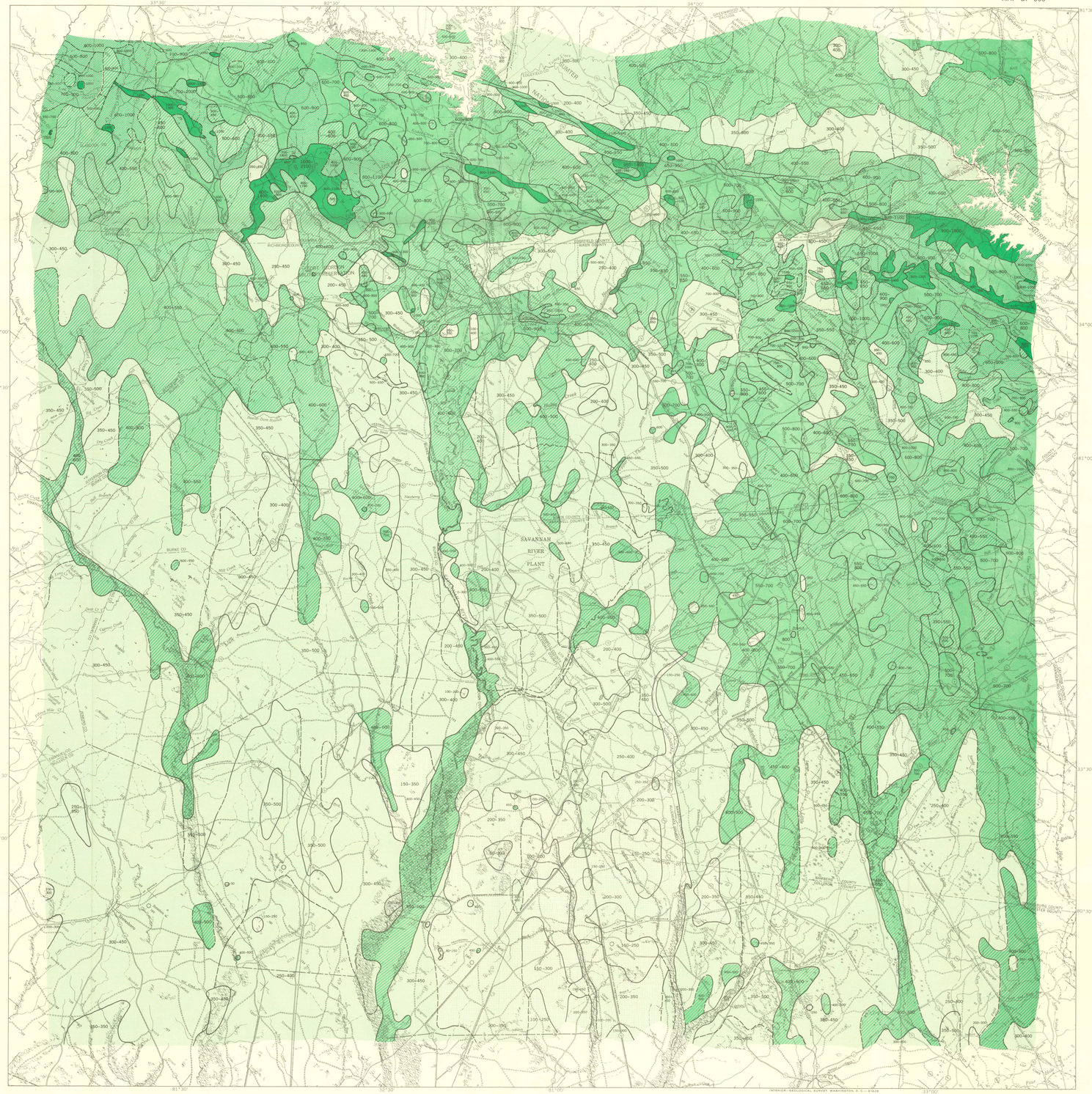
QUATERNARY
- Pleistocene — Qpu — Pamlico, Talbot, Penholoway, and Wicomico formations, undivided
- Miocene — Thw — Hawthorn formation *May include Duplin marl locally*
- Oligocene — Tbu — Cooper marl, Suwanee limestone, and Flint River formation, undivided

TERTIARY
- Eocene, Jackson group — Tjb — Barnwell formation *Includes some younger and some older strata*
- Eocene, Claiborne group — Tcu — Congaree formation, Warley Hill marl, Santee limestone, and McBean formation; entirely McBean formation locally along McBean Creek

CRETACEOUS
- Upper Cretaceous — Kt — Tuscaloosa formation *Includes undivided strata of Tuscaloosa to Providence age*
- Kcs — Rocks of the Carolina slate belt
- pCgp — Porphyritic granite and granite gneiss
- pCgg — Granite and granite gneiss *Includes granitized zone in Carolina slate belt*

PRECAMBRIAN OR PALEOZOIC
- pCm — Metamorphic complex *Slate, schist, gneiss, granite, and pegmatite*

Contact — *Dashed where inferred; dotted where concealed*



Base from Army Map Service, Corps of Engineers, 1:250 000-scale topographic map series, Athens, Augusta, Macon, Savannah, Spartanburg sheets

MAGNETIC NORTH DEVIATES FROM 1°15' E TO 2° W WITHIN MAP AREA

NATURAL GAMMA AERORADIOACTIVITY OF THE SAVANNAH RIVER PLANT AREA, SOUTH CAROLINA AND GEORGIA

By

Robert G. Schmidt

SCALE 1:250 000

4 2 0 4 8 12 16 20 MILES

1961

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—61428

Aeroradioactivity survey made at 500 feet above the ground under the direction of P. W. Philbin, 1958

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

EXPLANATION

400–550 — Radioactivity boundary
Solid where well defined, dashed where transitional, queried where not well defined. Numbers indicate general ranges of radioactivity levels in counts per second.

- 800 - 1800
- 600 - 1100
- 500 - 800
- 400 - 650
- 250 - 500
- 0 - 350

Approximate ranges of radioactivity

The survey was made with scintillation detection equipment (Davis and Reinhardt, 1957[1]) installed in a twin-engine aircraft. Parallel northwest-southeast flight traverses spaced at one-mile intervals were flown at a nominal elevation 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 elevation, and for the cosmic-ray component.

The effective area of response of the scintillation equipment at an elevation of 500 feet is approximately 1,000 feet in diameter, and the radiation recorded is an average of the radiation 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 assure uniformity of equipment response.

A 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 radiation 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 inversion 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 discrimination of the radioactivity levels that reflect changes in the ground component.

The ground component comes from approximately the upper 6 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 radioactive nuclear fission products. Locally, if fallout is present it must be small, as the lowest total radiation measured is 150 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.

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

GEOPHYSICAL INVESTIGATIONS
MAP GP-306