DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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

GENERAL AERORADIOACTIVITY AND RELATED GEOLOGY

The natural gamma aeroradioactivity of the Washington, D. C., area ranges from 100 to 1500 cps (counts per second) and all changes in levels are due to the varying radionuclide content of the rocks and soils. The linear pattern of radioactivity units throughout the area shows a remarkable correlation with the north-northeast strike of the geologic units. Most of the changes in radioactivity can be related directly to known geologic contacts. Aeroradioactivity not related to natural causes was measured only within the Fort Belvoir reservation, approximately 12 miles southwest of Washington, D. C., and is discussed in another report (Neuschel, in press).

Parts of four physiographic provinces lie within the area. From east to west these are: (1) the Coastal Plain, underlain by gently southeastward dipping, relatively unconsolidated sedimentary rocks of Early Cretaceous to Pleistocene age; (2) the Piedmont, underlain by complexly deformed sedimentary, metamorphic, and igneous rocks of Precambrian to Triassic age; (3) the Blue Ridge, narrow northeast-trending mountain ridges, composed of resistant quartzites and phyllites of Early Cambrian age; and (4) the Appalachian Valley portion of the Valley and Ridge province, a lowland area developed on steeply dipping clastics and calcareous rocks of early Paleozoic age.

The Coastal Plain has predominantly low radioactivity levels (100 to 400 cps). The Piedmont and Blue Ridge provinces have a wide range of radioactivity (100 to 1500 cps) because of the great variety of rocks. In the Appalachian Valley radioactivity is moderate to high (400 to 800 cps).

The uniformly low radioactivity of the Coastal Plain stands out in strong contrast with the rest of the Washington, D. C. area, which has distinct northeast-trending bands of low and high radioactivity. With the exception of a few areas, it is not possible, at least with mile-spaced flight lines, to delineate geologic formations in the Coastal Plain. In southern Anne Arundel and eastern Prince Georges Counties, Md., a large, almost circular area about 20 miles in diameter has an aeroradioactivity of 300 to 600 cps and stands out from the surrounding area of the Coastal Plain where 200 to 300 cps are recorded. This area of higher radioactivity is underlain by the Monmouth Formation and the Aquia Greensand, both of which are glauconitic. The abundant glauconite, which is high in potassium, probably accounts for the higher radioactivity of this area. From Fredericksburg, Va., northeast to the Potomac River, radioactivity values are 400 to 700 cps. Along the Rappahannock River from Fredericksburg to the southern edge of the surveyed area, a strip 4 to 6 miles in width has values of 400 to 600 cps, which contrasts markedly with the 200 to 300 cps level of the adjacent Coastal Plain. Immediately west of Fredericksburg, in the Piedmont province, the Rappahannock River for about 10 miles crosses the Petersburg Granite and other granites which are among the most radioactive rocks of the Washington, D. C. area with values to 1100 cps. It is probable that the area of higher radioactivity along the Rappahannock River is over stream valley alluvium which contains radioactive detrital material derived from granitic areas upstream. Similarly, the higher values northeast of Fredericksburg reflect the presence of material within the Pleistocene terrace deposits derived from granites to the west.

Much of the Piedmont and Blue Ridge provinces has moderate radioactivity of 400 to 600 cps developed over the metamorphic sequence (schists and phyllites of the Glenarm Series) and over the limestones and shales of the Frederick Valley and Triassic lowlands. Extensive areas of low radioactivity (100 to 300 cps) were developed over sandstones, quartzites, and mafic rocks. Highest levels in the Piedmont are associated with granites and the Baltimore Gneiss.

The principal ridges of the Blue Ridge province, Catoctin Mountain, Short Hill, South Mountain, and Blue Ridge Mountains are sharply defined by the several north-northeast trending narrow belts of low radioactivity (100 to 300 cps) in the northwestern part of the surveyed area. These ridges are formed by the resistant Weverton and Antietam Quartzites of the Chilhowee Group. In southeastern Frederick County, Sugarloaf Mountain rises about 800 feet above the Piedmont Upland and is capped by the resistant Sugarloaf Mountain Quartzite, which is lithologically similar to the Weverton Quartzite of Catoctin Mountain. Sugarloaf Mountain can be readily located on the aeroradioactivity map by the nearly circular area of very low radioactivity (100 to 200 cps) about 4 miles west of Hyattstown, Md.

Outside of the Coastal Plain the Catoctin Metabasalt accounts for the largest areas of low radioactivity in the study area. The broad north-northeast trending belt of low radioactivity (100 to 300 cps) extending diagonally through Point of Rocks, Md., and Warrenton and Culpeper, Va., outlines almost perfectly a zone of Catoctin Metabasalt and clastic deposits of the Chilhowee Group. Low radioactivity along this belt contrasts sharply with the higher radioactivity (300 to 1100 cps) over granite and the injection complex to the west and with the 300 to 600 cps values over the Triassic rocks to the east.

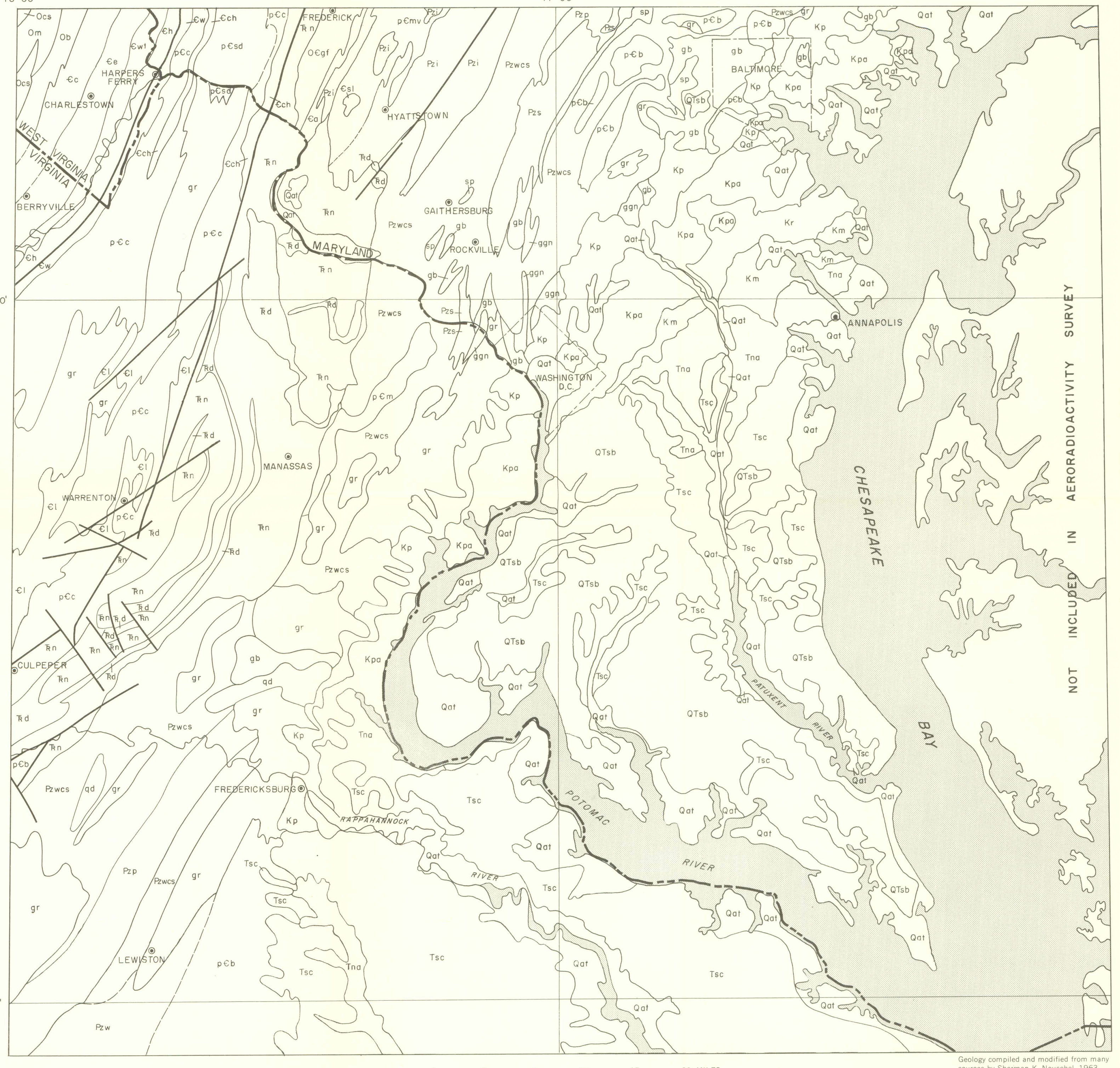
Detailed geologic mapping in the Piedmont of Maryland has delineated numerous mafic bodies of different sizes. In every case their uniformly low radioactivity makes them stand out in strong detail. A large gabbro mass covering all of western Baltimore City and the western suburbs has a northeast-southwest extent of 15 miles. Over the entire area radioactivity is remarkably uniform (200 to 300 cps). One cannot, on the basis of radioactivity, determine the boundary between the gabbro and overlapping sediments in the Baltimore area because they have nearly identical radioactivity. On the west, however, the edge of the gabbro is well marked by the abrupt change to the higher levels of the Wissahickon Formation (400 to 500 cps) and the granite (600 to 800 cps).

A serpentine dike striking north-northeast extends a continuous distance of 18 miles from Carroll County across Howard County into Montgomery County. Over most of its length it is 1/8-1/4 mile wide, yet each flight profile shows a marked low over the serpentine. In southern Montgomery County, south and west of Gaithersburg and Rockville, are several elongate bodies of gabbro and serpentine. Each of these is delineated by the contrasting low radioactivity of 200 to 300 cps.

In the Piedmont there are several areas of high radioactivity developed over a variety of granitic rocks that have been intruded into the metamorphic sequence. These intrusives are small in Maryland, but they are fairly extensive in Virginia. Radioactivity ranges from 200 to 1500 cps and over each of these areas, and within them are some of the highest levels to be found in the surveyed area. Radioactivity is not uniform as the areas contain many small north-northeast trending units with intervals of 100 to 200 cps. Detailed geologic mapping would probably show a variety of granitic and mafic rocks to account for the range of radioactivity. The Baltimore Gneiss has uniformly high radioactivity (600 to 800 cps). Two elliptical bodies of gneiss, one to the northwest of Baltimore traversing the regional strike, and the other to the west of the city paralleling the strike, are excellently delineated on the radioactivity map. The abrupt change to higher values is present nearly everywhere at the contact of the Baltimore Gneiss with the surrounding Wissahickon Formation, Cockeysville Marble, or the gabbro. Variations within the gneiss probably reflect the difference between the granitic and hornblendic varieties.

In the Appalachian Valley there are well defined linear radioactivity units paralleling the regional strike. Some of the best correlations of aeroradioactivity to geology in the area surveyed are found in this province. In general, low radioactivity is found over the relatively pure limestones and dolomites, and higher values over the impure limestone and shale. The Waynesboro Formation and the Elbrook Limestone both contain beds of shale, argillaceous limestone, impure sandstone, and dolomite. Radioactivity over these formations ranges from 200 to 800 cps and reflects this inhomogeneity. The area is broken up by numerous small radioactivity units of 100 cps intervals both across and along the strike. This pattern contrasts strongly with the uniform 400 to 500 cps radioactivity over the Conococheague, Beekmantown, Stones River and Chambersburg Limestones, all of which consist of massive beds of uniformly pure limestone. The contact between the limestones and the Martinsburg Shale is very well defined by the higher radioactivity of 500 to 600 cps over the Martinsburg.

Neuschel, S. K., in press, Aeroradioactivity survey and areal geology of the District of Columbia and parts of Maryland, Virginia, and West Virginia (ARMS-I): U. S. Atomic Energy Comm. Rept. CEX-59.4.17 (Report prepared for the U. S. Atomic Energy Commission, Civil Effects Test Operation series, by U. S. Geological Survey).



Geology compiled and modified from many sources by Sherman K. Neuschel, 1963

5 0 5 10 15 20 MILES

GENERALIZED GEOLOGIC MAP OF WASHINGTON D.C. AND VICINITY

EXPLANATION

QUATERNARY
- Qat — Recent alluvium, Wicomico Formation, and Talbot Formation
- QTsb — Sunderland and Brandywine Formations

TERTIARY
- Tsc — St. Marys, Choptank, and Calvert Formations (Chesapeake Group)
- Tna — Nanjemoy and Aquia Formations (Pamunkey Group)

CRETACEOUS
- Km — Monmouth, Matawan, and Magothy Formations
- Kr — Raritan Formation
- Kpa — Patapsco Formation and Arundel Clay
- Kp — Patuxent Formation

TRIASSIC
- ₸n — Newark Group

ORDOVICIAN
- Om — Martinsburg Shale
- Ocs — Chambersburg and Stones River Limestones

ORDOVICIAN
- Ob — Beekmantown Group
- O€gf — Grove Limestone and Frederick Limestone

CAMBRIAN
- €c — Conococheague Limestone
- €e — Elbrook Limestone
- €wt — Waynesboro Formation and Tomstown Dolomite
- €ch — Chilhowee Group: €a, *Antietam Quartzite*; €h, *Harpers Phyllite*; €w, *Weverton Quartzite*; €l, *Loudoun Formation*

CAMBRIAN(?)
- €sl — Sugarloaf Mountain Quartzite

PALEOZOIC
- Pzs — Sykesville Formation

PALEOZOIC(?) (Glenarm Series)
- Pzp — Peters Creek Quartzite
- Pzi — Ijamsville Phyllite
- Pzwcs, Pzw — Wissahickon Formation, Cockeysville Marble, and Setters Formation. Pzw, Granitized gneiss of Wissahickon Formation in Virginia

PRE-CAMBRIAN
- p€b — Baltimore Gneiss

IGNEOUS ROCKS

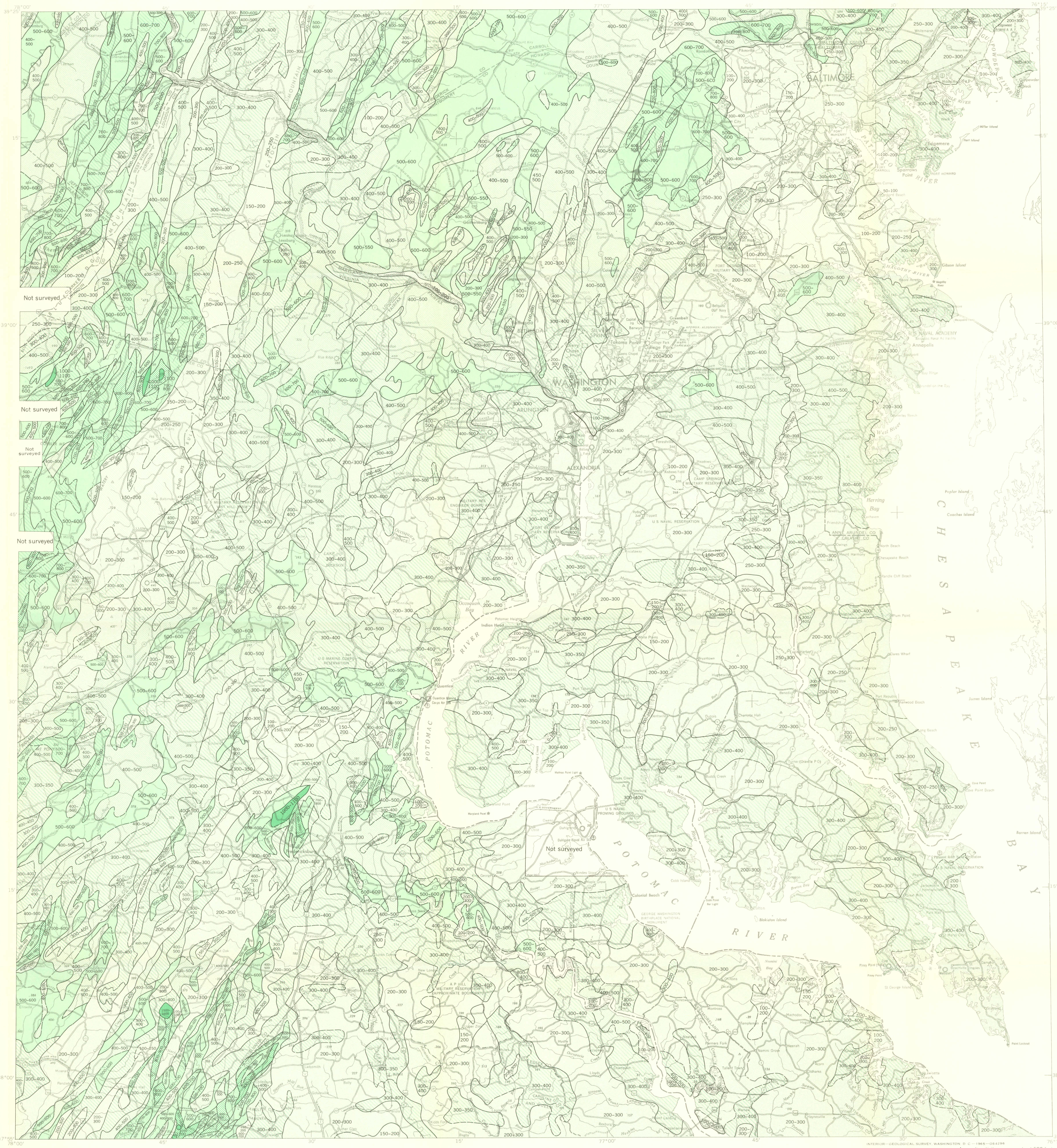
TRIASSIC
- ₸d — Diabase

AGE UNKNOWN
- gr — Granite
- qd — Quartz diorite
- ggn — Granite gneiss. *Includes Kensington Granite-Gneiss of Cloos (1951) and Laurel Gneiss of Chapman (1942) in Maryland*
- sp — Serpentine
- gb — Gabbro

PRECAMBRIAN
- p€mv — Metavolcanic rocks. *Mostly metarhyolites and metaandesites*
- p€c, p€m — Catoctin Metabasalt and other metabasalts. p€m, other metabasalts
- p€sd — Mica schist and hornblende diorite. *Called injection complex*

Geologic contact. *Dashed where inferred*

Fault



Base from Army Map Service 1:250,000 series: Baltimore, 1956; Richmond, 1959; Washington D. C., 1961

MAGNETIC NORTH DEVIATES FROM 5°15'W TO 8°15'W WITHIN MAP AREA

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON D. C.—1965—G64296

Aeroradioactivity survey made at 500 feet above the ground, 1960

NATURAL GAMMA AERORADIOACTIVITY OF THE DISTRICT OF COLUMBIA AND PARTS OF MARYLAND, VIRGINIA, AND WEST VIRGINIA

By

Sherman K. Neuschel

SCALE 1:250 000

5 0 5 10 15 20 25 MILES

5 0 5 10 15 20 25 KILOMETERS

1965

EXPLANATION

300-400

Radioactivity boundary
Solid where well defined, dashed where not well defined. Numbers indicate general range of radioactivity levels in counts per second

- Over 1000
- 900-1000
- 800-900
- 700-800
- 600-700
- 500-600
- 400-500
- 300-400
- 200-300
- 100-200
- 0-100

Radioactivity units having ranges of 100 counts per second. Locally subdivided into units having range of 50 counts per second

EXPLANATORY TEXT

The survey was made with scintillation detection equipment (Davis and Reinhardt, 1957, 1962) installed in a twin-engine aircraft. Parallel east-west flight traverses spaced at one-mile intervals were flown at a nominal altitude of 500 feet above the ground. The flight path of the aircraft was recorded by a gyro-stabilized 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 that encompassed by a circle approximately 1,000 feet in diameter, and the radioactivity recorded is the average radioactivity of that area. The scintillation equipment records only pulses 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.

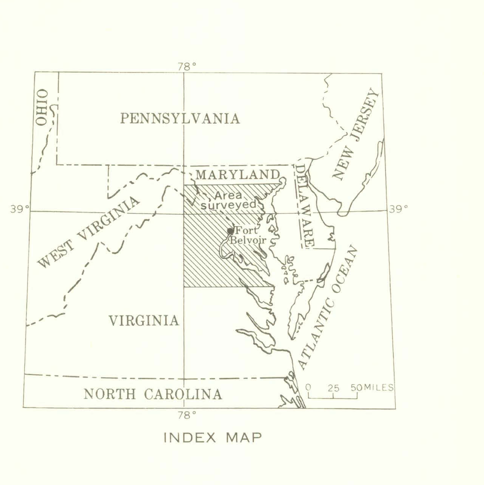
The gamma-ray flux at 500 feet above the ground has three principal sources: cosmic radiation, radionuclides in the air (mostly radon daughter products), and radionuclides in the surficial layer of the ground. The cosmic component is determined twice daily by calibrations at 2,000 feet above the ground,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

The ground component comes from approximately 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 fallout of radioactive nuclear fission products. Locally the amount of fallout, if present, must be small as the lowest total radiation measured is 100 counts per second in areas not affected by absorption of gamma rays by water. The distribution of fallout in the area surveyed is assumed to be uniform.

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

Davis, F.J., and Reinhardt, P.W., 1962, Radiation measurements over simulated plane sources: Health Phys., v. 8, p. 233-243.



INDEX MAP