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 Minneapolis-Saint Paul area ranges from 50 to 550 cps (counts per second) and all changes in levels are due to the varying radionuclide content of the glacial materials and of the bedrock in the few places where it is exposed. In general there is a good correlation between the aeroradioactivity and geology. The radioactivity and related geology are discussed more comprehensively in another report (Neuschel, 1969).

The Minneapolis-Saint Paul area is in the Upper Mississippi Basin subprovince in the northern part of the Central Lowland province. It lies between the Appalachian Plateau province to the southeast and the Great Plains provincie to the west, and is completely glaciated. Its gently undulating to hummocky glacial surface slopes upward from about 800 feet at Red Wing, Minn. in the southeast to a high of about 1,350 feet on the terminal moraine in the northwest. The bedrock surface is buried to a depth of nearly 500 feet. The buried rock floor of the Mississippi Valley in the southeast in the vicinity of Minneapolis-Saint Paul is about 500 feet above sea level. There are a few localities in the study area where underlying bedrock protrudes through the glacial cover; bedrock is exposed in the gorges of the major streams: the Mississippi, Minnesota, and Saint Croix Rivers.

During the Pleistocene Epoch there were recurring advances of ice sheets from Canada and the area was glaciated several times during the Pleistocene. Except for the few outcrops mentioned above, the entire area is covered by glacial deposits, and the present topography is essentially the result of glaciation. The three principal rivers, the Mississippi, Minnesota, and Saint Croix have cut deep gorges since the retreat of the last ice in late Wisconsin time. Glacial material consists mostly of clay-gravel ground moraine characterized by a gently undulating surface. It is interrupted by belts of terminal and recessional moraines which stand above the ground moraine and have irregular and hummocky surfaces. There are also many more-or-less flat areas of glacial outwash deposits that represent interglacial stream areas and the bottoms of glacial lakes. The whole area is dotted with small lakes, ponds, and swamps. The most extensive area of lakes lies in the hummocky Saint Croix moraine, a broad belt extending from Shakopee, Minn., northeast along the western side of the Saint Croix River and from Shakopee in an arcuate belt to the northwest passing to the west of Saint Cloud and Little Falls, Minn.

According to Frank Leverett (1932, p. 14–28) who first mapped in detail the surficial deposits of Minnesota, only the extreme southeastern part of the study area has pre-Wisconsin glacial deposits at the surface. The remainder of the area is mantled by deposits of the Wisconsin Glaciation. Leverett described a Patrician ice sheet which he considered of middle Wisconsin age as having originated in western Ontario and having brought red sandy and silty drift south and southwest across the area. The southern terminus of this drift is marked, according to Leverett, by the well-developed Saint Croix moraine. The sandy red drift carries an abundance of pebbles, cobbles, and boulders of crystalline rocks from the north. In late Wisconsin time the red Patrician drift was overridden by the Keewatin ice sheet which originated to the northwest and advanced southwestward from Winnipeg Lowland moving down the Red River Valley as a major lobe, the Des Moines, to a position near the city of Des Moines, Iowa. A northeastward projection of the Des Moines lobe, the Grantsburg sublobe, moved across the area to the vicinity of Grantsburg, Wis., crossing the Mississippi River between Minneapolis and a point ten miles southeast of Saint Cloud. The Keewatin drift is predominantly gray in color, weathering to buff, is calcareous and clayey, and carries many pebbles and boulders derived from the Paleozoic carbonate terrane of Manitoba.

More recent work of the Minnesota Geological Survey particularly by Wright (1953), has demonstrated that the middle Wisconsin Glaciation or Cary Stade was more complex than the single incursion of the Patrician ice sheet proposed by Leverett. He assigns the Cary drift to four more or less synchronous ice lobes. The Superior and Rainey lobes from the northeast and north brought in red drift, and the Wadena and Des Moines lobes from the northwest brought in gray, clayey, calcareous drift from the Manitoba area. He proposes that all four of these major Cary ice lobes entered Minnesota and Wisconsin from Canada about the same time. During the Mankato Stade of late Wisconsin age, a further advance of the Des Moines lobe moved northeastward forming the Grantsburg sublobe overriding the earlier red drift of the Superior and Rainey lobes. Several recently discovered exposures in the metropolitan area of Minneapolis, described by Wright (1953) within the area of the Grantsburg sublobe, indicate that overlap of gray drift on red drift is not true everywhere. Wright (1953) cites several examples of red drift lying on gray drift and others where the two drifts are interbedded, and explains these associations as the result of a confluence of two or more ice lobes each carrying a different kind of drift.

An interesting physiographic feature in the center of the area is the Anoka Sand Plain, a roughly triangular area of 850 square miles. Cooper (1935, p. 58–65) believes this extensive area of sand is a large outwash plain formed by the glacially diverted Mississippi River after drainage of Lake Grantsburg which had developed at the margin of the retreating Grantsburg sublobe. As the result of postglacial wind action the plain has small scattered areas of sand dunes.

The courses of the major streams in the area can be seen in the narrow ribbons of low radioactivity which are associated with the sandy alluvium in the valleys. Very low radioactivity, 50 to 200 cps, is present along the Upper Mississippi River and in the Mississippi Valley below Minneapolis-Saint Paul; along the lower Saint Croix River, south of Summit, Minn.; and along the Minnesota River upstream to Shakopee. Upstream from Shakopee, Minn., the broad valley of the Minnesota River has a radioactivity background of 250 to 300 cps but stands out markedly from the radioactivity value of 300 to 350 cps of the glacial drift to either side of the river. Along the Saint Croix River above Summit, Minn., the valley train has radioactivity of 250 to 300 cps. This higher radioactivity and the abrupt change at Summit from 50 to 100 cps to 250 to 300 cps is probably due to the fact that north of Summit, Paleozoic sedimentary rocks are exposed in the gorge of the Saint Croix River. Northward broad areas of alluvium in the vicinity of Sunrise, Minn., also have a background of 250 to 300 cps. This higher value for alluvium is probably reflecting the presence of detritus from igneous sources to the north.

Radioactivity of the gray calcareous glacial material of Keewatin age south of the Anoka Sand Plain is generally 300 to 400 cps in contrast to the general background of the Patrician drift to the north and along the Saint Croix River which is mostly 350 to 450 cps. The higher values over the Patrician drift are probably due to a higher percentage of pebbles and cobbles of crystalline rocks present, whereas the Keewatin drift south of the Anoka Sand Plain is mostly derived of calcareous and clayey material.

The glacial outwash plain as mapped by Leverett (1932, pl. 2) along the Mississippi River from a point 20 miles southeast of Saint Cloud to Anoka is delineated by the northwest-southeast-trending band of radioactivity of 250 to 300 cps. Three other areas of glacial outwash correlate with radioactivity with values slightly lower than that of the adjacent glacial drift: the metropolitan area of Minneapolis-Saint Paul, the region north of Saint Cloud just to the east of the Mississippi River, and the area around Richmond, Minn., to the southwest of Saint Cloud.

The east-west-trending triangular radioactivity low with values of 50 to 250 cps correlates with the area of sandy glacial outwash of the Anoka Sand Plain. In the central part, north of Elk River, Minn. values of 250 to 350 cps are over an area of Keewatin drift within the Sand Plain.

Throughout the area are many small elongate areas of low radioactivity (50 to 150 cps) with a northeast trend paralleling the direction of ice movement. Most of these are north of the Anoka Sand Plain in the zone of sandy, red, Patrician drift. The northern part of the area apparently formerly contained three to four times as many lakes as it does today. Since retreat of the last ice sheet, most of these lakes have drained or been silted up.

There are very few places where there is a correlation with bedrock geology. Exposures on the gorge walls of major rivers are not delineated by the airborne survey. The radioactivity high of 450 to 550 cps ten miles southwest of Saint Cloud is over exposures of granite described by Bowles (1918, p. 51). Also the three highs (400 to 500 cps) in Kanabec County in the northern part of the area are over granite which protrudes through the glacial drift.

REFERENCES

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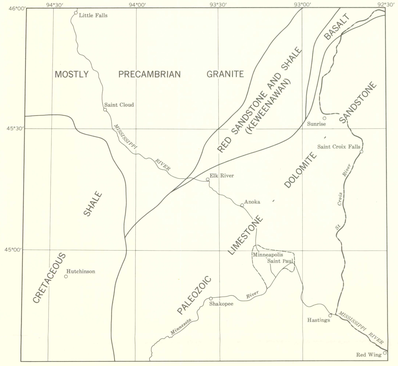


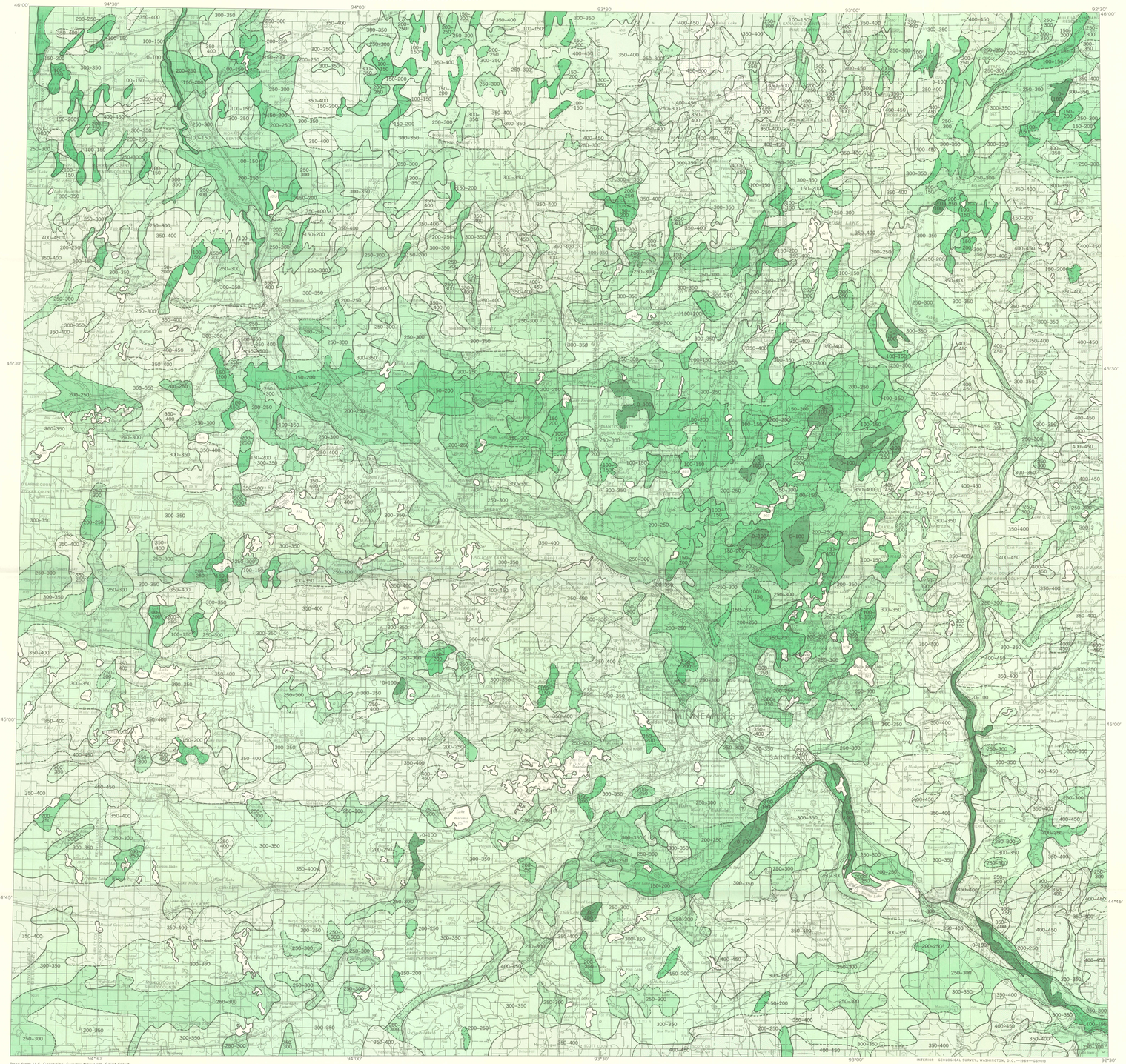
GENERALIZED BEDROCK MAP OF THE MINNEAPOLIS–SAINT PAUL AREA, MINNESOTA AND WISCONSIN

EXPLANATION

- Q — Alluvium
- Qd — Dune sand. *Includes extensive areas of sand and gravel outwash*
- Qw3 — Keewatin gray glacial drift
- Qw2 — Outwash sand and gravel. *Associated with formation of Patrician and Keewatin drifts*
- Qw1 — Patrician red glacial drift
- Terminal moraine of Patrician ice sheet. *Saint Croix moraine*
- Drift of Illinoian and Kansan Glaciations
- Contact
- Direction of Keewatin ice sheet movement
- Direction of Patrician ice sheet movement

Holocene / Pleistocene, Late Wisconsin / Pleistocene, Middle Wisconsin / QUATERNARY

SURFICIAL GEOLOGY OF THE MINNEAPOLIS-SAINT PAUL AREA, MINNESOTA



Base from U.S. Geological Survey: New Ulm, Saint Cloud and Stillwater, 1958; and Saint Paul, 1953

GEOPHYSICAL INVESTIGATIONS MAP GP-658

EXPLANATION

300–350 — Radioactivity boundary

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

450–550	250–300
400–450	200–250
350–400	100–200
300–350	0–100

Approximate ranges of radioactivity

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-stripfilm 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 surface 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.

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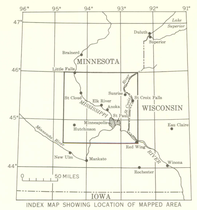
Davis, F. J., and Reinhardt, P. W., 1957, Instrumentation in aircraft for radiation measurements: Nuclear Sci. and Eng., v. 2, no. 6, p. 713–727.

1962, Radiation measurements over simulated plane sources: Health Phys., v. 8, p. 233–243.



INDEX MAP SHOWING LOCATION OF MAPPED AREA

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1969—GP-658

Aeroradioactivity survey made at 500 feet above the ground under the direction of A. J. Petty, 1961

NATURAL GAMMA AERORADIOACTIVITY MAP OF THE MINNEAPOLIS-SAINT PAUL AREA, MINNESOTA-WISCONSIN

By
Sherman K. Neuschel

MAGNETIC NORTH DEVIATES FROM TRUE NORTH 0° 0' TO 2° 0' WITHIN MAP AREA

SCALE 1:250 000

5 0 5 10 15 20 25 MILES

5 0 5 10 15 20 25 KILOMETERS

1969

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