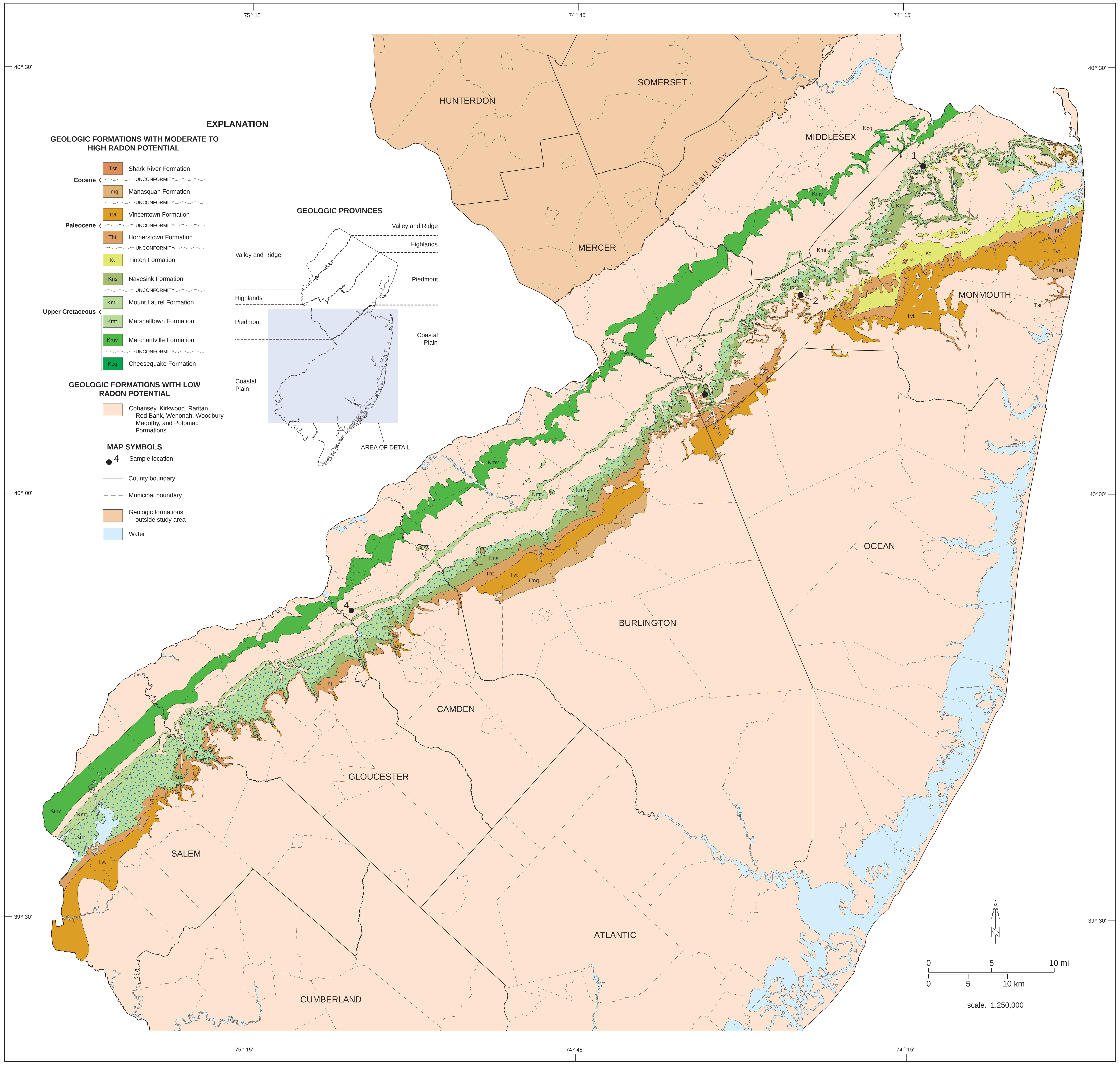

Geology from Geologic Map of New Jersey: Central and Southern Sheets. U.S. Geological Survey Open-File Reports 95-253 and 95-254.
Base map from New Jersey Department of Environmental Protection digital database.
Cartography by Z. Allen-Lafayette and R.S. Pristas.

RADON POTENTIAL OF NEW JERSEY COASTAL PLAIN FORMATIONS

by
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INTRODUCTION

Radon (Rn) is a colorless, odorless, radioactive gas produced by the radioactive decay of uranium. The isotope ^{222}Rn (3.8235 day half-life) is a progeny ("daughter" isotope) of radium-226 in the uranium (^{238}U "parent") radioactive-decay series. It occurs in nearly all soils. Because it is a gas it may enter homes or buildings through cracks in floors and walls, and other avenues such as drains and sump pumps. Areas of the home close to the soil, particularly the basement, commonly have the highest radon levels.

Environmental studies indicate that radon is a carcinogen. Approximately 5,000-20,000 deaths per year in the United States may be due to lung cancer resulting from long term exposure to radon (United States Environmental Protection Agency, 1986). In New Jersey, 500 deaths per year may result from long-term indoor radon exposure (Cahill and Stern, 1989). The U. S. Environmental Protection Agency recommends that homes with radon levels above the 4 picocuries per liter (pCi/L) action level should be remediated.

Generation and transmission of radon are directly controlled by the geologic setting. Rock and soil with naturally high uranium concentrations (>2 ppm) have the potential to create indoor radon problems. The transmission of radon is controlled by its mobility in the soil, which depends on several factors, including the soil's radium content and distribution, porosity, permeability, and moisture content (Gunderson and others, 1992). In low-permeability soil radon travels only a short distance before decaying due to its short half-life. Conversely, radon can easily migrate through permeable soil into vulnerable building foundations. Moisture in soil pores can impede radon movement. Consequently, a radon atom will travel a short distance in a water-filled pore in the unsaturated zone; it may dissolve in ground water below the water table.

PURPOSE AND SCOPE

Geologic data, including the type of sediment and rock and their distribution, can be used to delineate areas of known or potential elevated radon. Because different sediment and rock types (formations) contain varying amounts of uranium, locating these formations on a geologic map can be used as a guide to where moderate to high levels of radon might occur.

The purpose of this map is to show possible areas of elevated radon based primarily on the lithologic and chemical composition of the host rocks and their contact zones. This map should be used only as a general guide. If a home is in an area that may have a high potential for radon, then testing of the dwelling by a certified radon laboratory is recommended.

GEOLOGIC SETTING AND PREVIOUS WORK

The geology shown on this map is from the "Geologic Map of New Jersey: Central Sheet" (Owens and others, 1995a) and "Geologic Map of New Jersey: Southern Sheet" (Owens and others, 1995b); detailed descriptions of the map units can be found there. Overall, the New Jersey Coastal Plain consists of several distinct lithologies that were deposited in two major depositional environments: 1) nonmarine and marginal marine delta; and 2) marine shelf (Owens and Sohl, 1969). The deltaic deposits include the Potomac, Raritan, Magothy, Woodbury, Englishtown, Kirkwood, and Cohansey Formations. The Potomac, Magothy, Englishtown, Kirkwood, and Cohansey Formations are typically quartz sand with interbedded thin to thick clay-silts. The Raritan and Woodbury Formations are predominantly clay-silt deposits and are interpreted as the marginal marine or prodelta deposits of a "muddy" delta system. The Cohansey in its outcrop is almost entirely quartz sand which was deposited in barrier beach and barrier-protected environments (Carter, 1978). The marine shelf deposits, including the Cheesequake, Merchantville, Marshalltown, Wenonah, Mount Laurel, Navesink, Red Bank, Tinton, Hornerstown, Vincentown, Manasquan, and Shark River Formations, consist of varying amounts of glauconite sand, clay-silt, and quartz sand.

Low radon values are generally associated with the nonmarine fluvial and deltaic quartz sands. For instance, in a transect across the New Jersey Coastal Plain, the lowest soil radon values and equivalent uranium were measured in quartz sands of the Magothy, Kirkwood and Cohansey Formation, and the silty quartz sands of the Red Bank Formation (Gunderson and Peake, 1992). Quartz sand typically has a low uranium concentration of 0.45 ppm (Klement, 1982).

Higher soil radon concentrations were measured in glauconite-bearing sands and glauconitic clays such as those of the Navesink and Hornerstown Formations. In a study of radon in the Texas, Alabama, and New Jersey Coastal Plains, the highest soil radon measured was 16,200 pCi/L in the Navesink Formation of New Jersey (Gunderson and Peake, 1992). In the Delaware Coastal Plain, uranium concentrations of 3 to 7 ppm (and as high as 114 ppm) were recorded in glauconite sediments (Woodruff and others, 1992). Gundersen and Schumann (1989) attributed the higher radon values of glauconite to the fact that uranium is concentrated near the surface of the glauconite grains.

Radon may also be more common at the contact zone of geologic formations, especially in marine shelf deposits. Reworked deposits tend to concentrate phosphatic and bone material which contain uranium. Uranium is associated mainly with apatite in the phosphate nodules and in the bone material (Altschuler and others, 1958).

The concentration of uranium (Table 1) was measured in the following formations and their contact zones: 1) the Marshalltown/Englishtown Formations; 2) the Navesink/Mount Laurel Formations; and 3) the Hornerstown/Tinton Formations. The Navesink/Mount Laurel contact is a consistent marker throughout the entire Atlantic Coastal Plain (Owens and Gohn, 1985). The unconformity is recognized in outcrop because it occurs below a massive pebbly quartz sand containing sand- to pebble-sized phosphatic fragments, and because of a pronounced positive spike on natural-gamma logs. These logs record the amount of natural gamma radiation emitted by earth materials, and generally measure decay products of uranium, thorium, and potassium-40. Thus a high positive gamma spike is indicative of an elevated concentration of radioactive elements.

The contact of the Hornerstown and Navesink Formations commonly contains a reworked zone including bone material. This "bone bed" exhibits enriched uranium concentrations. Uranium is known to substitute for calcium in the bone forming mineral apatite. Enrichment of the uranium at these intervals may also be the result of circulating ground-water (Altschuler and others, 1958).

Consistently high levels of uranium were measured at the formational contacts studied (Table 1), and range from 6.1 to 46.5 ppm uranium. The highest uranium concentrations were in zones that contained phosphate nodules, or where consolidated ironstones occur. Some of the geologic material within 5 ft of the contacts also contained levels of uranium high enough to cause elevated indoor radon levels.

Fluvial sediments containing uranium are also potential sources of radon gas (Gunderson and others, 1992). In a study of natural radioactivity in the Kirkwood-Cohansey aquifer system in southern New Jersey, Kozinski and others (1995) identified the highest concentrations of radium in water samples near the outcrop area of the Bridgeton Formation. These highest concentrations were attributed to the leaching of uranium and radium from sediments which are mineralogically immature compared to the Cohansey and Kirkwood Formation (Kozinski and others, 1995). The surficial geologic map of the central New Jersey sheet, which shows the distribution of the Bridgeton Formation, is in preparation. When the central sheet is completed, this map may be revised to include the Bridgeton.

Another source of uranium, thorium, and radium are heavy minerals such as zircon, sphene, and monazite (Gunderson and others, 1992). In work in the South Carolina Coastal Plain, Owens and others (1989) report a good correlation between high radioactivity and monazite concentration. Some of these heavy minerals may be abundant enough locally in the New Jersey Coastal Plain to cause elevated radon levels. Heavy minerals have been mined from the Cohansey and Kirkwood Formations in New Jersey; however, the lack of radon data from these areas precludes any correlation with heavy minerals at present.

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GLOSSARY

Daughter isotope: An isotope resulting from radioactive decay.

Fluvial: Produced by the action of a stream.

Half-life: The time required for half of a sample of a radioactive isotope to decay.

Heavy minerals: A mineral from a sedimentary rock having a specific gravity greater than 2.9.

Ironstones: Any rock containing a substantial portion of an iron compound.

Isotope: Any of two or more forms of an element that have different atomic weights due to different numbers of neutrons found in the nucleus. The chemical properties of isotopes are identical.

Marine shelf: The gently sloping submerged portion of the continental margin extending from the shoreline to the continental slope.

Natural gamma log: A record of the amount of natural-gamma radiation that is omitted by all rocks. The gamma-emitting radioisotopes normally found in rocks are potassiuim-40 and daughter products of the uranium- and thorium-decay series.

Paleoenvironment: An environment in the geologic past.

Parent: A radionuclide regarded in relation to the nuclide or nuclides into which it is transformed by decay.

Picocuries per liter (PCi/L): A unit expressing the concentration of radioactive constituents in solution as the radioactivity (picocuries) of the solute per unit volume (liter) of water. One picocurie is equal to 1 x 10-12 curies, where one curie is the amount of radiation emitted by one gram of radium. One picocurie represents 2.2 radioactive decays per second.

Prodelta: The outermost seaward part of the subaqueous delta which is usually composed of the finest silts and clays.

Radioactive-decay series: The series of radionuclides successively formed by the radioactive decay of a long-lived parent radionuclide before a stable isotope of a product element is formed.

Table 1. Uranium values (U) in parts per million (ppm) from selected Coastal Plain formations and their contact zones.

Section 1 - Navesink and Mount Laurel Formations
Location: Keyport quadrangle; 74^0 13' 12"; 40^0 23' 08"
Laboratory: XRAL Activation Services, Ann Arbor, Michigan
Data received: January 16, 1990

	U (ppm)
Navesink	5.4
Navesink/Mount Laurel contact	6.1
Mount Laurel	4.2

Section 2 - Vincentown, Hornerstown, and Tinton Formations
Location: Roosevelt quadrangle; 74^0 24' 30"; 40^0 14' 05"
Laboratory: XRAL Activation Services, Ann Arbor, Michigan
Data received: January 16, 1990

	U (ppm)
Vincentown	1.4
Hornerstown	3.4
Hornerstown	13.6
Hornerstown/Tinton contact	14.6
Hornerstown/Tinton contact	40.3
Tinton	6.5
Tinton	3.4

Section 3 - Navesink and Mount Laurel Formations
Location: New Egypt quadrangle; 74^0 33' 16"; 40^0 07' 06"
Analysis by: Terraplus Portable Gamma Ray Spectrometer
Model GR 256 with GPS-21 NaI detector
Samples taken and analyzed: December 16, 1992

	U (ppm)
Navesink	1.6
Navesink	0.9
Navesink	1.4
Navesink	3.1
Navesink-Shell Bed	16.9
Navesink/Mount Laurel contact with phosphate nodules	46.5
Mount Laurel	6.5
Mount Laurel	6.9

Section 4 - Marshalltown and Englishtown Formations
Location: Runnemede quadrangle; 75^0 05' 35"; 39^0 51' 48"
Laboratory: Chemex Labs, Sparks, Nevada
Data received: July 11, 1990

	U (ppm)
Marshalltown	4.0
Marshalltown/Englishtown contact	13.2
Englishtown	0.4