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INDOOR RADON CONCENTRATION DATA: ITS GEOGRAPHIC AND GEOLOGIC DISTRIBUTION, AN EXAMPLE FROM THE CAPITAL DISTRICT, NY

John J. Thomas
Geology Department., Skidmore College
Saratoga Springs, NY

Barbara R. Thomas
Saratoga Springs, NY

Helen M. Overeynder
Schenectady, NY

ABSTRACT

U.S. Environmental Protection Agency (EPA) and the New York State Department of Health (NYSDOH) means of indoor radon concentrations for the Capital District of New York (Albany and surrounding counties) indicate low potential for Schenectady (3.0), Saratoga (3.2), and Albany (3.7) counties; and moderate potential for Rensselaer (6.4) and Columbia (7.0) counties. The authors' database of over 3,000 analyses contains over 800 records of indoor radon counts above 4 pCi/L (14-47% of each county's analyses), many high enough to be rated as a serious health hazard.

Using MapInfo® Geographic Information System (G.I.S.) software, The data was plotted by street address and the distribution of the data was compared to both the Bedrock Geology and Surficial Geology Maps of New York State. The results show a striking relationship of radon concentrations to bedrock, faults and permeability of surficial material.

INTRODUCTION

Most studies of the geographic distribution of indoor radon levels are plotted by county or ZIP code. This method is used for the radon potential maps produced by the U.S. Environmental Protection Agency (EPA) and the New York State Department of Health (NYSDOH). The basis for the mapping in New York is the mean or median indoor radon count for all the data provided by NYSDOH within each geographic area.

While analyzing the indoor radon data provided to the authors by CMT Independent Laboratories, Inc., Clifton Park, NY, the authors discovered data that varied markedly from the EPA and NYSDOH means for the Capital District of New York (Laymon et al. 1990 and Schumann 1993). Their screening indoor radon average concentrations in pCi/L, indicate low potential for Schenectady (3.0), Saratoga (3.2), and Albany (3.7) counties; and moderate potential for Rensselaer (6.4) and Columbia (7.0) counties. The database of over 3,000 analyses contains over 800 records of indoor radon counts above 4 pCi/L (14-47% of each county's analyses), many high enough to be rated as a serious health hazard.

Since uranium is ubiquitous in the earth's crust, the threat of high levels of indoor radon is real. But concentrations vary greatly due to site specific geologic conditions. "Hot spots" occur in the Midwest, Northern Plains, Maine, New Mexico, Pennsylvania and other states (Castleman 1993). One such "hot spot" in Pennsylvania occurred at the home of Stanley Watras in the Colebrookdale Township in Eastern Pennsylvania on the Reading Prong. The Reading Prong is rich in uranium bearing bedrock. Investigations showed that his home had radon levels of 2,700 pCi/L. These levels are nearly 2,000 times greater than the National Average of 1.35

pCi/L. Further study showed that other homes in the area had extremely high radon levels including some above the 200 pCi/L mark, but none as high as the Watras' home (Atwood 1992).

Although this is an extreme case, it shows how important the bedrock becomes in trying to determine the radon potential of a certain area. However, the major factor for the amount of radon in a given house is the rate of seepage. The main reason that it comes into the house is because "there is a slight air pressure difference between the interior and the exterior of the house" (Atwood 1992). This factor is very important when evaluating ways to reduce radon in the home. "It is the equilibrium established in a home between the radon generated in the soil, the pressure differential between the house and the ground, and the ventilation rate between the house and the outdoors that ultimately determines the average radon concentrations in a building" (Atwood 1992). Most radon enters the house through the basement since soil radon concentrations are generally very high "with average soil gas (in the United States) at about 100 pCi/L" (Brookins 1990).

RADON LEVELS

Large numbers of high radon concentrations substantiate a nation-wide fear of radon contamination. As a by-product of uranium, radon occurs everywhere in the earth's crust, and thus a small amount of radon in the air is inevitable. "Normal" background radon levels in the outdoor air approach 0.1 to 0.2 pCi/L while the average indoor level is 1.5 to 2.0 pCi/L (Consumer Reports 1989). The Environmental Protection Agency estimates that 6% (8 million) of all United States homes have radon levels above suggested maximum of 4 pCi/L. "In at least 17 states, the number rises to 20% or more" (Castleman 1993).

The best way to understand where radon comes from is to focus on the rocks and soils in the region. Radon exists as one of the intermediate decay products of uranium and thorium. Uranium is present in granite, shale, phosphate, and pitchblende minerals. Thorium is found in certain phosphates, granite, and gneiss (Atwood 1992). Core rocks in the Appalachian Mountains, granites and granitic metamorphic rocks, are high in radon, as well as sediment derived from granitic terrains such as those in the Appalachians, California, the Rocky Mountains, and the Canadian Shield (Brookins 1990).

Granites and granitic igneous rocks usually contain uranium-bearing minerals. The uranium concentration in metamorphic rocks varies greatly and is too widely distributed to make any reasonable predictions as to the extent of radon amounts (Brookins 1990).

Uranium is sporadically distributed among sedimentary rocks with the highest concentrations in black shales, bauxites and marine phosphorites. The Mancos Shale in New Mexico and the Chattanooga Shale in Tennessee are potential low-grade uranium sources. Shales similar to these pose threats, for when they underlie housing development areas, they create high potential for radon emissions (Brookins 1990). Shales contain organic matter which is efficient for uranium fixation, thus explaining the higher concentrations. In "the Alum Shale in Sweden, and the Chattanooga Shale in the eastern United States, the uranium contents may be in the hundreds to perhaps even thousands of ppm" (Brookins 1990). Marine phosphorites, such as apatite-rich shales, also contain significant amounts of uranium due to the high concentrations of organic materials. Homes built on them are similarly prone to high radon (Brookins 1990).

"Scientists say that 75% of the radon that escapes from the earth comes from the top three to seven feet of soil" (Castleman 1993). Attempts at predicting radon in various types of surficial material in a specific area, however, may not prove to be a substantial means of estimating radon levels. "Even if surface material is low in uranium, but is underlain by more uraniferous media, then a high radon flux at the surface is still possible" (Brookins 1990). Also, if the area has been faulted or cracked, the radon can migrate up the break and show up as a high local radon flux. The abundance of radon cannot be solely determined by bedrock, the surficial material must also be permeable.

PROCEDURE

The data in this paper was supplied by CMT Independent Laboratories, Inc., a New York State ELAP and RMP listed laboratory. The company provides a radon testing service to the public; therefore the samples are random. The main source of testing is home inspections for sales and mortgage renewals. In most cases, in order to get a mortgage in New York, the radon must be below 4 pCi/L. The testing is concentrated where buildings and building sales are concentrated. The areas of little or no data are due to the data source. Tests were performed using charcoal canisters. Most were placed by home inspectors, many of whom are RMP listed. The radon canister concentrations were analyzed by Barbara R. Thomas, an RMP listed radon analyst.

Because many canisters were placed by many different individuals and precautions against tampering varied, reliability of an individual measurement is not certain. In many instances, repeat measurements were performed or canisters were used with continuous monitors, and results in these instances were consistent. Most interference that might have occurred, such as moving or covering the canister, or ventilating the area, would have lowered results. The authors believe, therefore, that the data indicating results greater than 4 pCi/L are reliable, and that the patterns indicated by these results are real.

The level of radon in a building is dependent on many factors. A building with a low radon reading does not necessarily indicate an area of low radon susceptibility. It only means that the house does not leak or is well ventilated. Therefore, low readings do not necessarily indicate an area of low radon. The only data used for readings of less than 4 pCi/L in this study are from the lowest level of the building, usually the basement. Data above the basement is not an accurate indicator of the radon influx into the building.

The data of site specific radon concentrations were entered into MapInfo® (MapInfo Corporation, One Global View, Troy NY 12180-8399), a Geographic Information System (GIS) software program. The database includes columns for street address, town, county, zip code, radon concentration, location in the building and year of the reading. Once the database was created, data points were located by using the Geocode function, based on StreetInfo® (MapInfo Corporation, One Global View, Troy NY 12180-8399), a compilation of U. S. Bureau of Census TIGER files, to match the data entry to its appropriate location on a base map. Problems arose because, in New York, several towns have the same names (up to seven). However, geocoding on a county basis cured the problem. We first looked for the county, then compared the town in the database with the town in the StreetInfo® file, and finally matched the street and address. The final match rate was about 75%. The missing 25% could not be plotted because of incomplete or incorrect reporting of the test address. The data was then plotted on a map of the county downloaded from the StreetInfo®, as one can see in figure 1. The radon concentrations were then overlain on the bedrock and surficial geology maps of the Capital District, (Fischer et al. 1972 and Caldwell 1989). The maps associated with this study cover five counties around Albany: Albany, Columbia, Rensselaer, Saratoga, and Schenectady. Because the work has generated many maps, the figures included with this paper cover two counties: Albany and Saratoga.

RESULTS

When the radon and its locations were matched up with the surficial and bedrock geology, a relationship between the geology and high radon immediately became apparent. These results are discussed below.

Albany County

In figure 2, the high radon data is plotted on the bedrock geology map of Albany County. The concentration of high radon readings in the eastern part of the northern half of the map (Loudonville and Menands) is associated with the Austin Glen Formation, the Normanskill Shale, and a thrust fault. The Austin Glen Formation consists of graywacke, gray and black shales. All of these could be sources of radon. The black shale is an especially good source. The Normanskill Formation consists of gray and black shales. The thrust fault, an earlier crack in the earth's surface, could serve as an excellent conduit for the transmission of radon and many of the sites appear to be associated with this fault. The concentration in the middle of the northern half of the county (Altamont and Guilderland) is located on the Schenectady Formation which consists of thin sandstones, graywacke and gray and black shales. Figure 3 shows the radon and surficial geology of the county. The concentration of high radon readings in the eastern part of the northern half of the map is associated with kame deposits. These deposits are well sorted, unconsolidated sands and gravels with a very high porosity and permeability. If there is a source of radon beneath them, the gas will easily reach the surface. The concentration in the middle of the upper half is associated with outwash gravels, lacustrine deltas, and kames. Again sands and gravels of high porosities and permeabilities. The other scattered high readings are usually associated with sands and gravels of different types. Occasionally, they are located on tills, a material of varying composition with everything from impermeable clays to 10 foot diameter boulders. The authors suspect that these particular locations would occur in areas having high permeability.

Saratoga County

Figure 4 is the bedrock geology and radon map of Saratoga County. The highest level of radon in the county is in Saratoga Springs, marked by the star. Notice that these are associated with the Canajoharie Shale and a normal fault. The Canajoharie Shale is hundreds of feet of black carbonaceous shale, an excellent source of radon. The shale is impermeable, but is cut by a normal fault, the McGregor Fault, which is highly permeable and supplies the mineral waters of Saratoga Springs and adjacent areas. The waters themselves are radon free. Notice that the fault extends into Ballston Spa where there are additional high readings. In Halfmoon, in the southeast part of the county, one can again see high radon readings associated with the edge of a thrust fault containing Austin Glen Formation, this time on the Canajoharie Shale. Starting in Clifton Park in the south central part of the county and extending north-northeast through Ballston and Saratoga Springs, is a linear array of high readings. The bedrock is the Canajoharie Shale. The authors speculate that these may mark the trace of a buried normal fault which does not show up at the surface. The radon and surficial geology are shown in figure 5. The surficial materials in the Saratoga Springs area are bedrock, kames, and lacustrine sands and clays. The bedrock is faulted and highly jointed (cracked) and covered with a very thin layer of highly permeable sands and gravels. The Halfmoon area and the area of the linear array extending from Clifton Park north-northeast are both associated with sands and gravels of a variety of origins, again highly permeable. Throughout the map there is no association with till.

CONCLUSIONS

The authors have found a very close association between the bedrock, surficial geology and radon concentrations. In the Capital District of New York, high radon concentrations are associated with known source rocks, faults, and permeable soils. The results for all five counties indicate that high levels are likely to be found along the thrust faults of the Taconic Front in the Capital District; the normal fault systems in Saratoga County; and the Cobbleskill, Normanskill, Austin Glen, and Schenectady Formations.

This study shows that average radon concentrations plotted by Zip Code or county boundaries may not indicate the level of radon danger at a specific location. The authors advise all persons in the Capital District to have their radon tested.

The overall result of this research is an environmental map of radon concentrations in the Capital District that relates geographic location to radon concentrations. The precise location of radon data may prove extremely useful in determining and predicting where problem areas occur for radon high concentrations.

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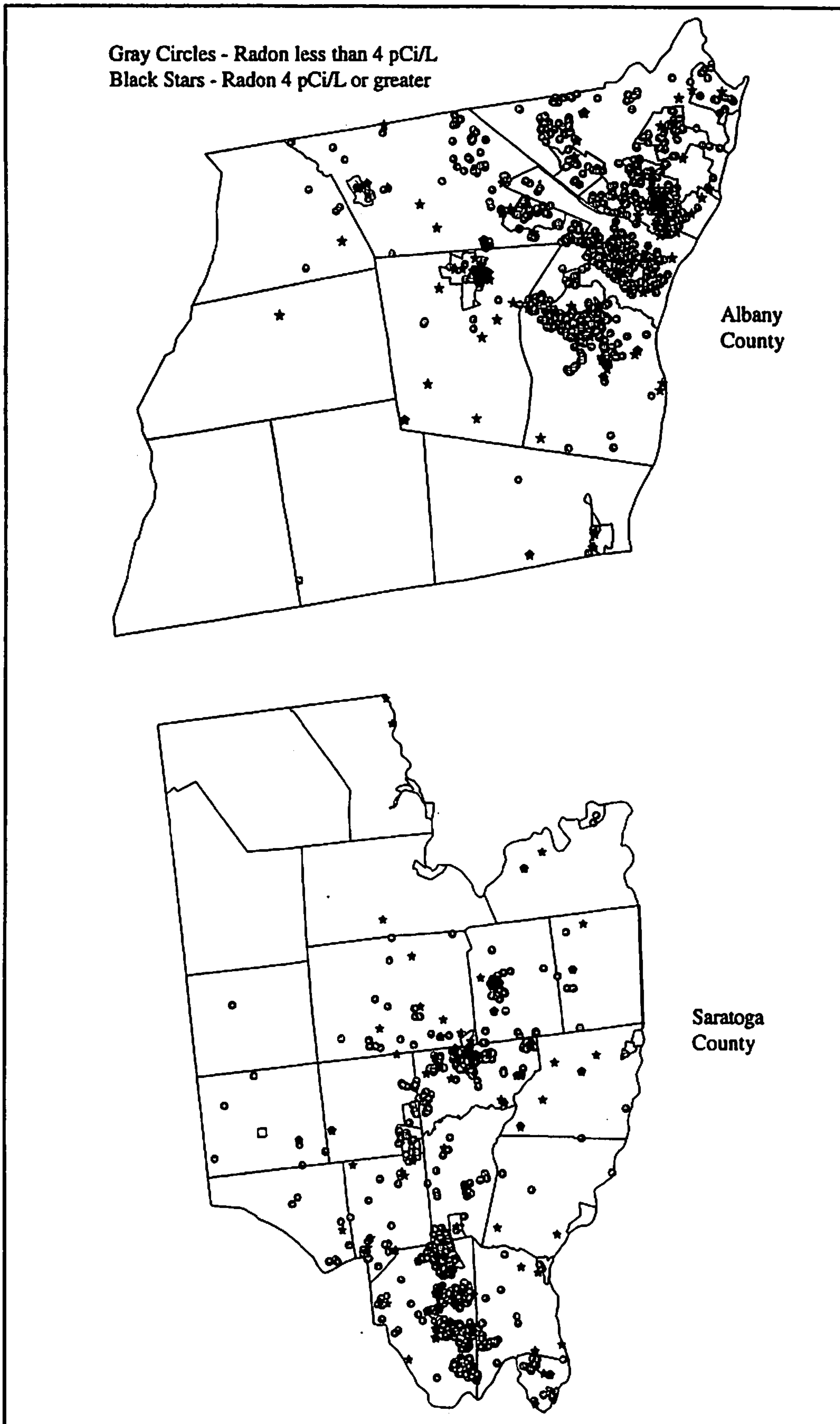

Fig. 1 All radon data for Albany and Saratoga Counties

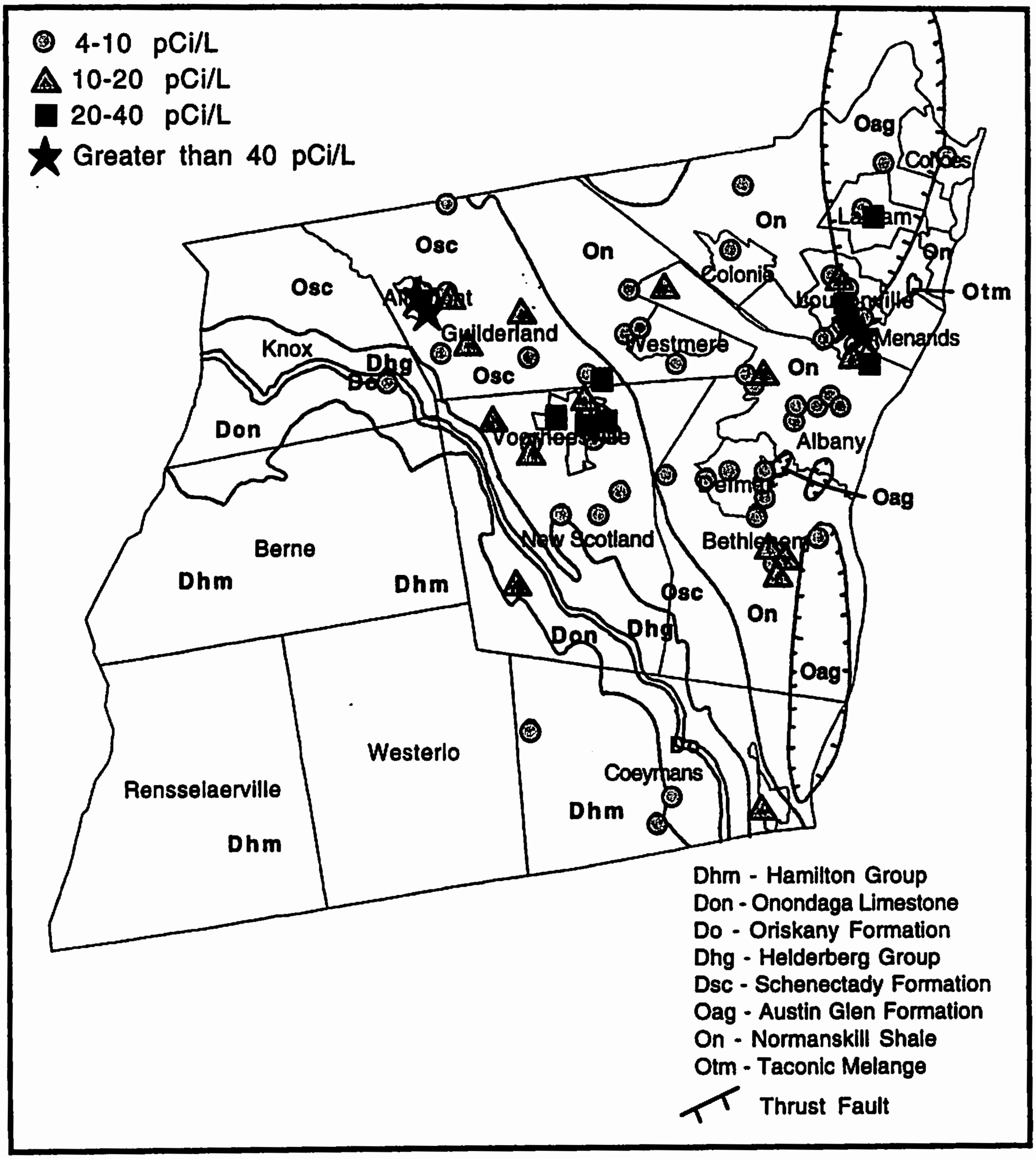

Fig. 2 Bedrock geology of Albany County NY and radon concentrations of 4 pCi/L and greater

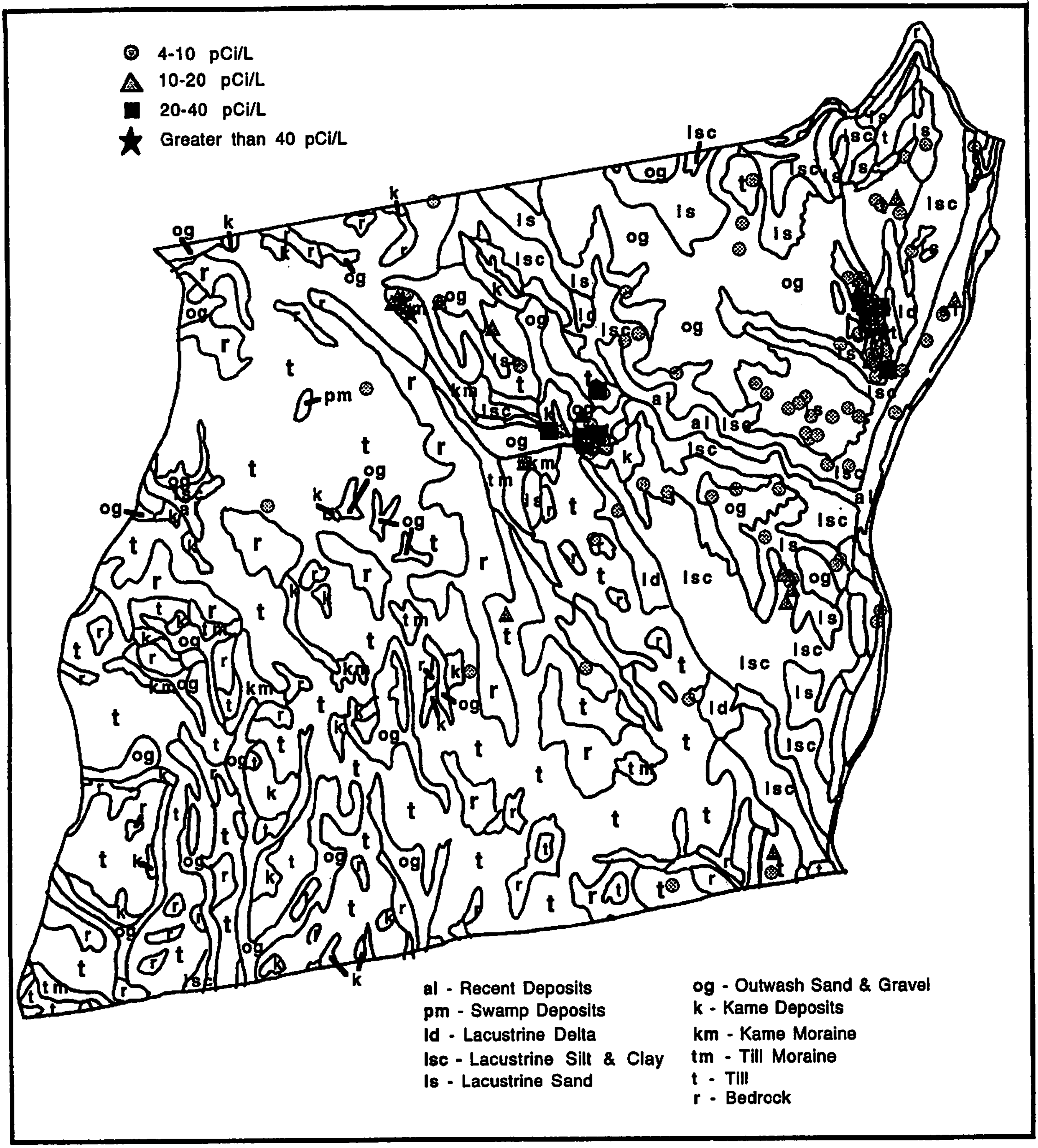

Fig. 3 Surficial Geology of Albany County NY and radon concentrations of 4 pCi/l and greater

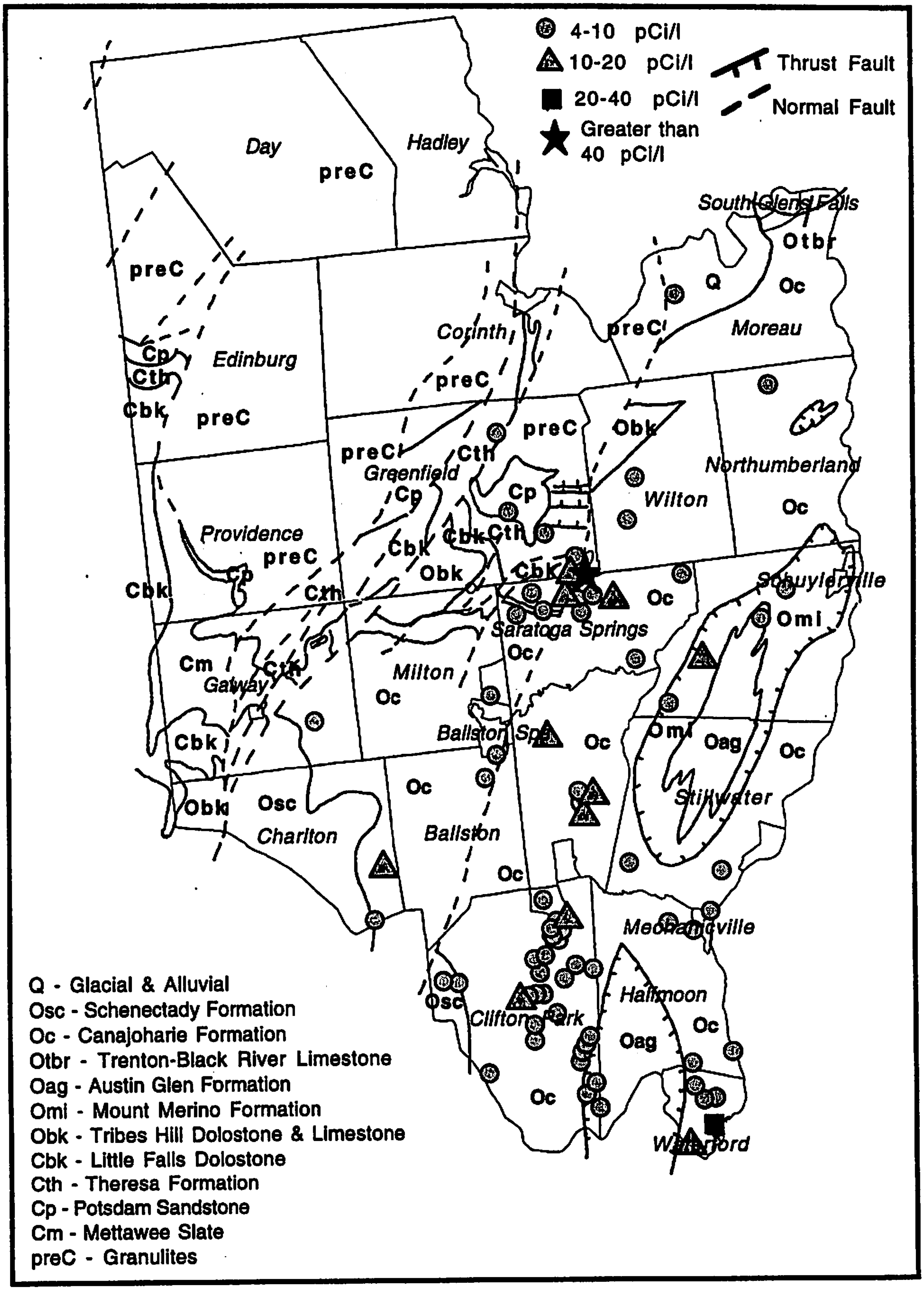

Fig. 4 Surficial geology of Saratoga County NY and radon concentrations of 4 pCi/L and greater

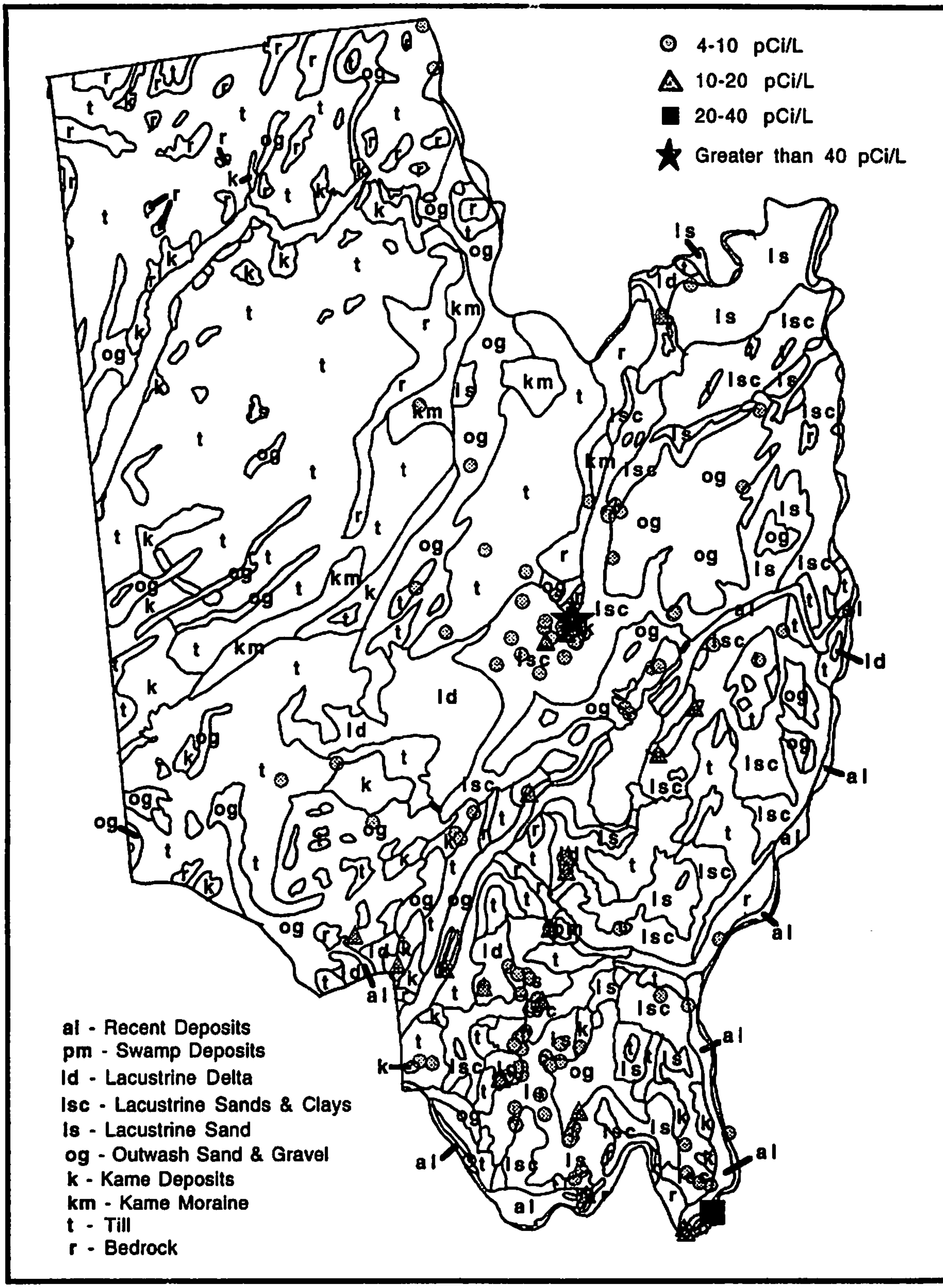

Fig. 5 Surficial geology of Saratoga County and radon concentrations of 4 pCi/L and greater