

*Geologically based correlation of rock
type and indoor radon levels in
southeastern PA from 531,799 ²²²Rn
measurements between 1990-2022*

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Background

What is radon?

- Radioactive, inert, odorless, colorless, tasteless gas that is naturally occurring in soil and ground water; formed from the decay of uranium
- ^{222}Rn is a decay product of ^{226}Ra which itself is a decay product of ^{238}U
- EPA recommends mitigation at 4 pCi/L

Where is radon found?

- In homes/other buildings, especially lower levels

Why is radon dangerous?

- When inhaled, radon can deposit in the lungs and cause cancer
- Approx 21,000 lung cancer deaths/year in the USA, 2nd leading cause of lung cancer death after smoking

Background

What do these radon levels mean?

- 4 pCi/L* = 200 chest x rays per year or 8 cigarettes/day
- 8 pCi/L = 400 chest x rays per year or 16 cigarettes/day
- 20 pCi/L = 1000 chest x rays per year or 40 cigarettes/day

How does radon exposure correlate to lung cancer risk?

- Cigarette smoking and radon exposure work together to increase lung cancer risk

Why is radon being studied in Pennsylvania?

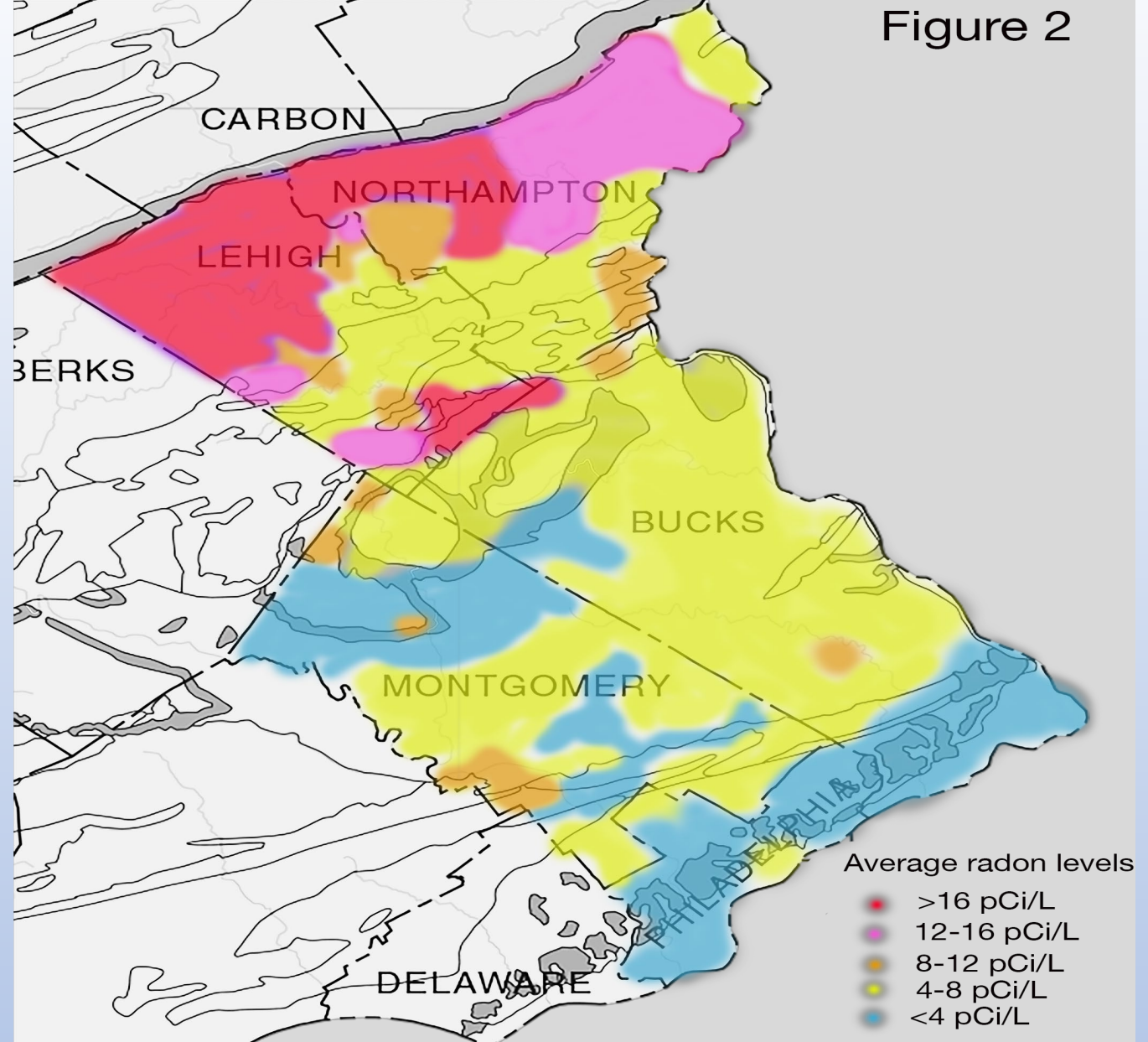
- **49/67 counties in PA have indoor radon levels > national average**
- Highest level of radon, **6,176 pCi/L**, ever recorded was found in the area being studied
Center Valley, PA (independently measured)
- <https://www.mcall.com/2016/11/17/record-high-level-of-radon-found-in-lehigh-county-home/>

Study Design

- Between 1990-2022, millions of indoor radon tests were performed in the state of PA by homeowners and the private radon industry. This data was collected and made available to the public on the PA state Department of Environmental Protection (DEP) website
- Five counties: Lehigh, Northampton, Montgomery, Bucks and Philadelphia; 224 zip codes and 531,799 radon tests
- Radon zip code data was matched to a publicly available digital geologic map, PAGEODE, to determine the major geologic rock type for these counties
- The data was then analyzed as part of one of the five counties
- The data was also grouped based on its rock type.
- Data was then overlaid using photoshop on a map of the five counties
- Zip codes that contained less than 30 tests were not evaluated

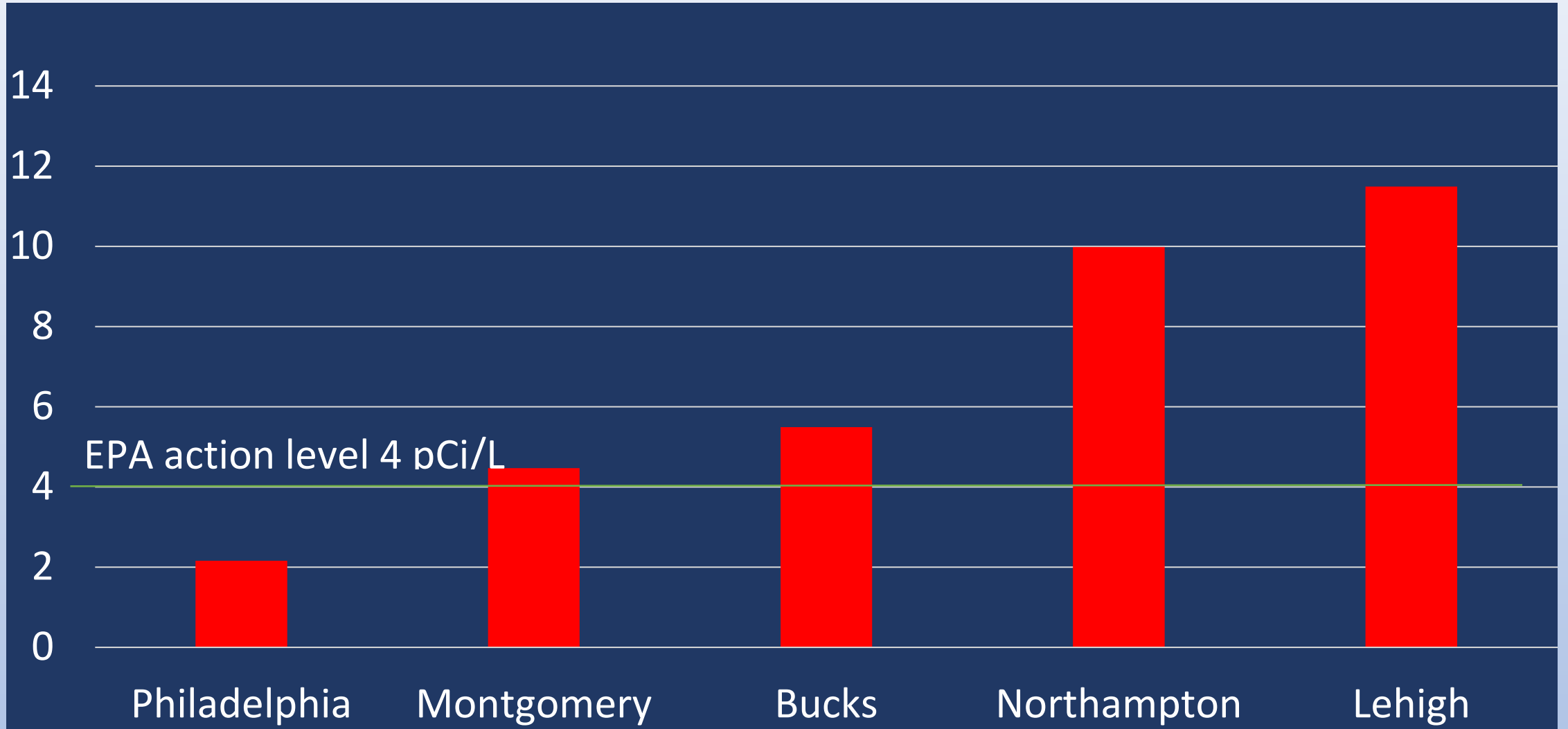
Radon Levels

County	# Tests	Avg Radon Level (pCi/L)
Lehigh	77,948	11.5
Northampton	52,582	10.0
Bucks	136,384	5.5
Montgomery	203,195	4.5
Philadelphia	61,470	2.2
Total	531,799	



Highest recorded radon level in this study: 5,336.0 pCi/L in zip code, 18036

Average radon levels for each county (pCi/L)



A Closer Look: Northampton County

Zip codes	# of tests	Max result pCi/L*	Average result pCi/L*	Geology (visual assessment)
18088	1206	382.9	19.5	Ordovician, shale
18038	413	281.8	18.4	Ordovician, shale, sandstone, siltstone
18014	1837	338.1	17.3	Ordovician, limestone
18091	791	421.6	14.6	Ordovician, shale
18072	969	528	13.6	Ordovician, shale

A Closer Look: Lehigh County

Zip codes	# of tests	Max result pCi/L*	Average result pCi/L*	Geology (visual assessment)
18053	331	301.7	26.6	Ordovician, sandstone, shale, siltstone
18036	3819	5336.0	21.4	Jurassic Triassic, mudstone and quartz, heterogeneous
18051	1225	235.4	19.5	Ordovician, shale
18066	1087	848.1	19.2	Ordovician, sandstone, shale, siltstone
18080	1565	718.7	19.1	Ordovician, shale

Comparison: Lehigh and Northampton Counties

Lehigh

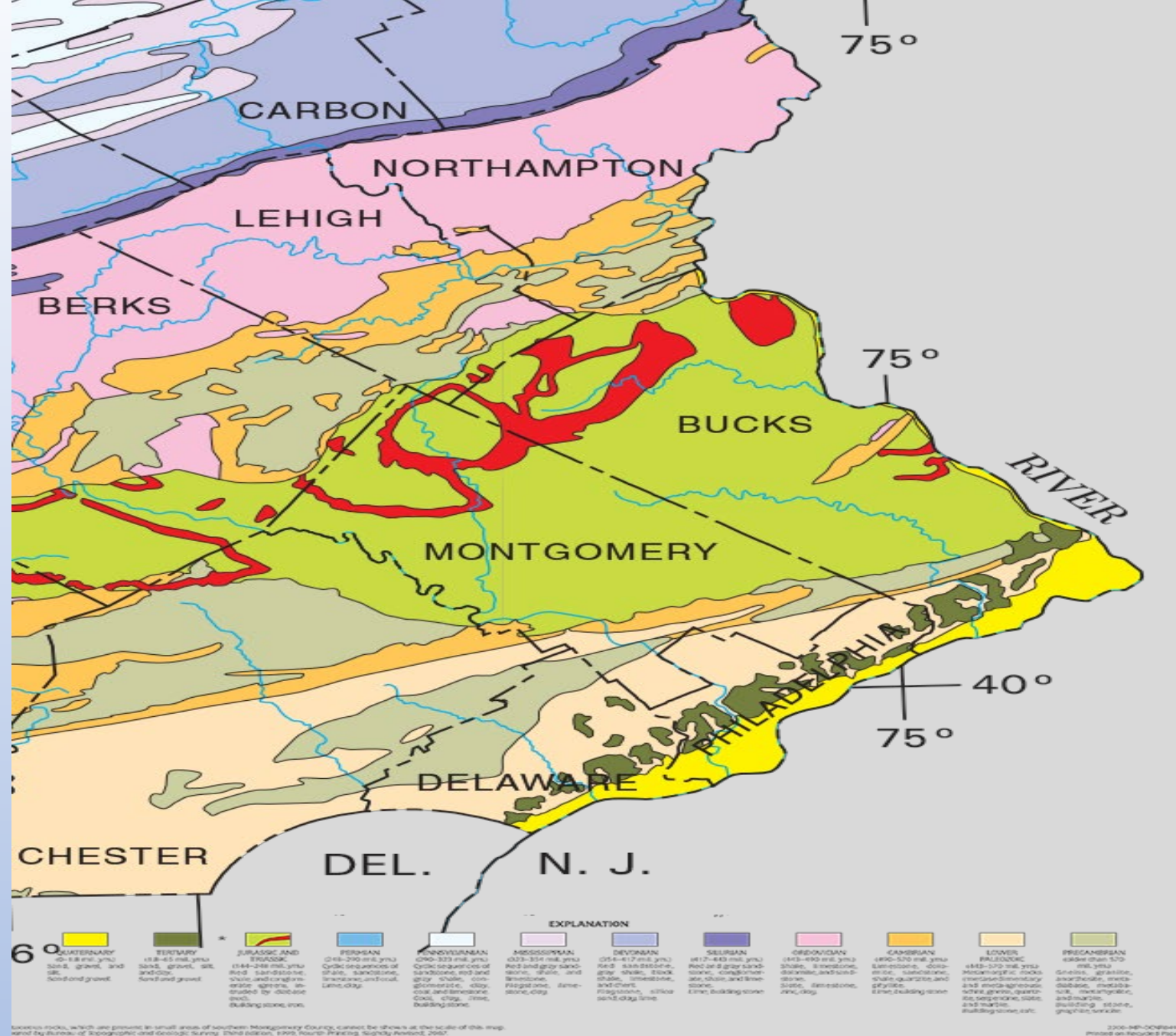
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Rock Type

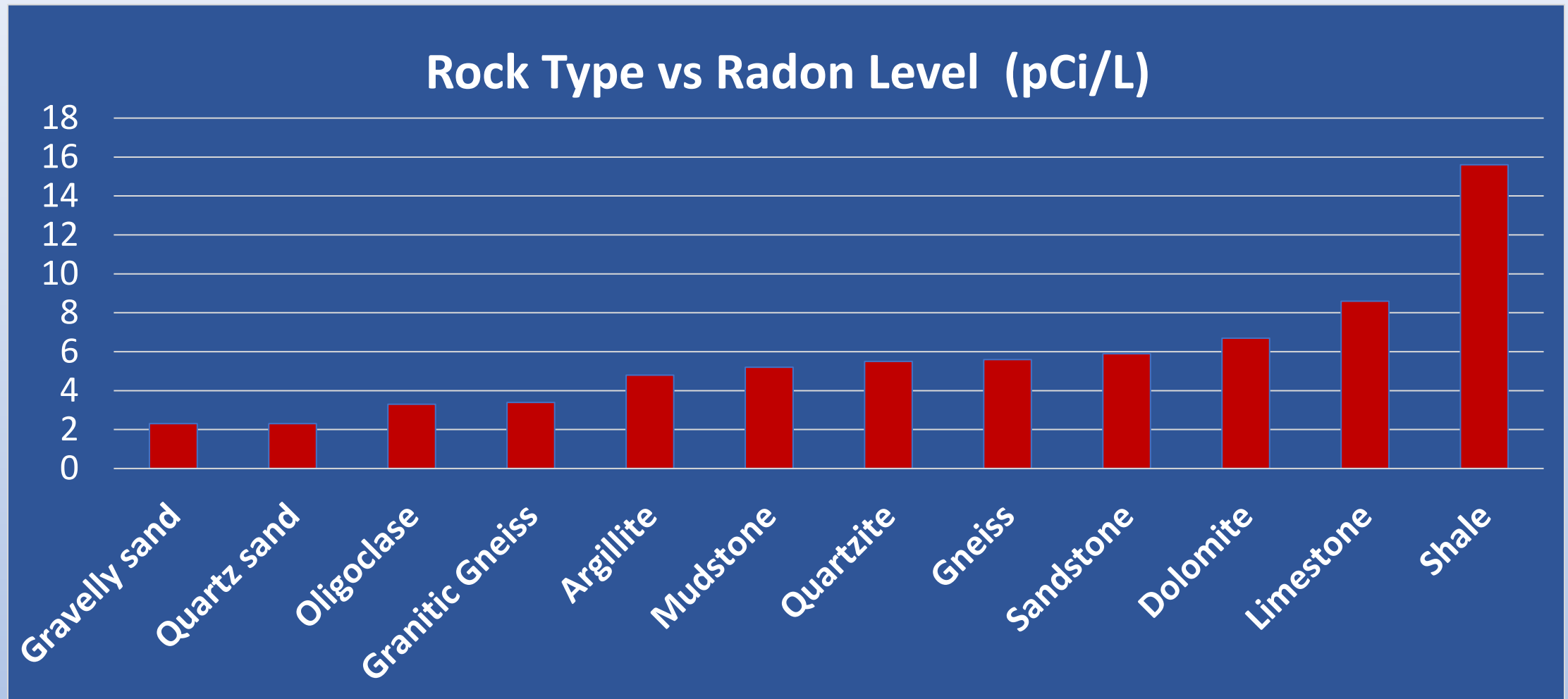
- 12 predominant rock types/minerals were identified: argillite, dolomite, gneiss, granitic gneiss, gravelly sand, limestone, mudstone, oligoclase, quartzite, quartz sand, sandstone, and shale
- Shale was found to be associated with the highest average basement radon level, 15.6 pCi/L, out of all rock types



Rock Type Data correlated with elevated radon levels

Rock type	# of tests	Max	Min	Average pCi/L
Shale	28894	848.1	61.5	15.6
Limestone	29695	949	33	8.6
Dolomite	82586	1440.4	27.8	6.7
Sandstone	66853	803.2	24	5.9
Gneiss	16757	1285.2	29.1	5.6
Mudstone	78697	5336	8.8	5.5
Quartzite	19588	529.2	44	5.5
Argillite	80682	1000	27.1	4.8
Granitic Gneiss	10701	87.5	39	3.4
Oligoclase	59858	351.5	7.9	3.3
Gravelly sand	26038	847.6	3.8	2.3
Quartz sand	25469	341.4	9.5	2.3

Rock Type and Radon Levels



Potential errors

- Limited by radon zip code data
- Assumptions about geology
- Variation in quality of radon data, mostly short term tests

Conclusions

- Highest average level of radon was found in Lehigh County
- From 531,799 individual radon tests found in 224 zip codes, this study found that the highest average radon level was predominantly associated with the presence of shale rock
- Sedimentary rock was associated with higher levels of radon which also has been observed in other studies
- Creating a geologically based indoor-radon potential map allows better future risk assessment
- PA's high levels of radon require further assessment/ monitoring of radon levels to reduce cancer risk to the population

Future Implications/Applications

- Possible study of all the zip codes in the state of PA for a complete comprehensive study of the state and geology and the observation of other geologic features
- Raise awareness with local state representatives; amended bill is up for review in the PA state house, SB339, would require radon assessment/mitigation in daycares
- Data could guide new construction to build structures that promote radon gas dispersion in high radon areas
- Investigation of fault lines/sink holes could clarify other geologic hazards in this area

Acknowledgements

- Jacqueline Nixon, Citizens for Radioactive Radon Reduction (CR3) Director of Marketing and Communications
- Robert K. Lewis, PA DEP/Bureau of Radiation Protection Radon Division, Chief
- Dr. Robert Smith, PA Dept. Conservation and Natural Resources, Geological Survey, Retired.