1993 - 20

GEOLOGIC CONTROL OF RADON IN THE GREATER ATLANTA REGION, GEORGIA

L. Scott Ranger
Radon Detection Systems - Georgia
Marietta, GA

ABSTRACT

1,908 indoor radon screening tests are plotted by geologic formation. Each is presented with average, range and house construction type. For the region, 7.6% of homes measure 4.0 pCi/l or greater with an average of 1.7 pCi/l for all construction types and 2.2 pCi/l for basement houses. The range is 0.0 to 25.4 pCi/l. Radon levels are lowest in the Upper Coastal Plain unconsolidated sands and the Piedmont metamorphic rock of basic (mafic) chemistry. Highest levels are found in acidic rock as granites, schists and mylonites particularly in areas of ductile shearing. This paper presents radon measurements in the most meaningful manner, by geologic formation. Radon does not recognize zip codes and political boundaries yet many decisions use these criteria. Geologic precision allows for a greater understanding of radon potential. This paper illuminates the possibility for more accurate potential maps based upon geology.

INTRODUCTION

Radon, as the decay product of uranium in rock, is at its most basic level a geologic phenomenon. As all rock has some uranium in it, radon is ubiquitous. But as the level of uranium in rock varies markedly, so do radon levels. The variance in radon levels follow the geology of the rock. Those rocks with the highest levels of uranium have the highest levels of radon emitted from them. It follows then that homes and buildings built upon rock with higher levels of uranium will have higher levels of radon, all other things being equal.

On the basis of this assumption, a database of 1,908 houses tested for radon gas during the period from October 1989 through June of 1993 has been collected that includes, among other things, the 1) radon level measured, 2) house construction type; and, 3) geologic formation the house sits upon. This data base is analyzed by geologic formation as to 1) average, 2) range, 3) percentage of houses 4.0 pCi/l and above, and further as to all construction types versus basement construction.

GEOGRAPHY OF THE GREATER ATLANTA REGION

Atlanta sits amid the Piedmont province that is sometimes characterized as the piedmont plateau (Hunt: 1974) which is then a part of the Appalachian province. It is a rolling upland that in the southern United States is usually 500 to 1,000 feet in elevation and in the northern U.S. below 500 feet. The average elevation in the Greater Atlanta region is about 900 feet above sea level. The area covered by this paper follows the area of the 1:100,000 Greater Atlanta Regional Map produced by the United States Geological Survey with a few extensions beyond. This map includes areas that are in the Valley and Ridge province to the northwest as well as a band of Blue Ridge Province rock that traverses it from the northeast to the southwest. The data includes some radon measurements from the Upper Coastal Plain Province to the southeast of Atlanta. The bulk of the over 2,000,000 population live on the Piedmont.

GEOLOGY OF THE GREATER ATLANTA REGION

The geology of the area covered by the database can be characterized in four basic rock types: 1) sedimentary consolidated rock of the Valley and Ridge province, 2) unconsolidated sands of the Upper Coastal Plain province, 3) metamorphic rocks in both the Piedmont and Blue Ridge provinces, and 4) igneous intrusions into the Piedmont.

The rock of Atlanta in the Piedmont can be characterized as highly metamorphosed crystalline rock of many origins. Many are from sands, shales, granites, and various kinds volcanic flows. Some of the rock has been metamorphosed up to five different times (Dallmeyer: 1989) which makes determination of ultimate origin difficult. This also greatly complicates the mapping of the area, and much of the mapping is incomplete. The area has four granite intrusions into the metamorphic rock and a number of diabase dikes cris-crossing the southeast area.

The area is split dramatically by the Brevard Fault Zone, a tectonic remnant of continental collision that has its evidence in a distinct zone of cataclasis. Other major faults separate the Piedmont from the Blue Ridge (Allatoona Fault) and the Blue Ridge from the Valley and Ridge (Cartersville Fault--the Georgia name for the Great Smoky Mountains Fault in Tennessee that continues through Georgia into Alabama). The faulted areas tend to show in the rock as areas of highly fractured or jointed rock. The formations away from faults tend to be massive and little jointed other than surface unloading joints. A number of broad regional folds parallel the Brevard Fault Zone. Biotite gneiss is the dominant rock, followed by various schists. Many local areas of amphibolite and other mafic and ultramafic rock pepper the area.

MATERIALS AND METHODS

Houses tested were in the context of a real estate transaction. Testing was done with (in order of use) E-PERMs, diffusion barrier charcoal canisters, and continuous monitors (primarily Femto-Tech 210). On both placement and retrieval of the primary device, three air grab working level samples were taken as a double check against the primary method. A gamma radiation survey was made of the foundation and masonry for each house and any exposed rock outcrop in the yard with a Scintrex BGS-3 Scintillation Counter. The underlying rock of each house was checked where possible as a check against the mapped rock unit. A thick layer of saprolite topped with luxuriant vegetation makes definitive rock identification uncertain for many houses, and determination for those houses was made using the geologic map. Radon Detection Systems - Georgia is EPA listed as a primary lab for E-PERMs and continuous monitors, and as a secondary lab for charcoal canisters in the Radon Measurement Proficiency Program (RMP).

CONCLUSIONS

Granite produces the highest average levels of radon in houses, followed by granite gneisses and some of the schists, particularly those in the Brevard Fault Zone where mylonites and fracturing no doubt contribute to radon upward mobility. Lowest levels of radon are in the mafic and ultramafic rock of the Piedmont and the Coastal Plain sands. Amphibolites as mafic rock produce little radon, with the notable anomaly of the Wolf Creek Amphibolite in the northeast area where uranium obviously occurs in greater than expected levels for a mafic rock.

The geologic map of Atlanta can be effectively used to determine areas of greater or lesser concern for radon levels. It cannot be used to predict the radon level of any particular home or even specific locality. When geology is compared to the EPA Map of Radon Zones in Georgia that uses county lines, marked differences can be seen where the EPA cuts a geologic formation off in a lower zone county where it probably should be in a higher zone. Any effort to plot radon test results with geology would be a fruitful effort.

REFERENCES

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CHART 1

KEY TO THE GEOLOGIC FORMATIONS OF THE GREATER ATLANTA REGION WITH DESCRIPTIONS

Arranged Alphabetically by Abbreviation to Match Charts

ABR	GEOLOGIC FORMATION
ACG	**Acworth Gneiss:** Medium-grained biotite-quartz-plagioclase orthogneiss with accessory muscovite and epidote. Mafic xenoliths occur locally. [New Georgia Group]
AG	**Austell Gneiss:** Fine- to coarse-grained blastophorphyritic to nonporphyritic orthogneiss composed of muscovite, biotite, oligoclase and microcline.
BA	**Bill Arp Schist:** Interlayered garnet-biotite-muscovite-plagioclase-quartz schist; muscovite schist; quartz-muscovite-biotite schist; muscovite-biotite-quartz-plagioclase schist; and metagraywacke. [Sandy Springs Group]
BCI	**Big Cotton Indian Biotite Gneiss:** Intercalated biotite-plagioclase gneiss (locally porphyritic), hornblende-plagioclase amphibolite, and biotite-muscovite schist. [Atlanta Group]
BZ	**Button Schist Ductiley Sheared Zone:** Primarily undifferentiated ductiley sheared rock in the Brevard Fault Zone, the largest area of button schists, with lesser areas of mylonite.
CA	**Clarkston Sillimanite Schist:** Sillimanite-garnet-quartz-plagioclase-biotite-muscovite schist interlayered with hornblende-plagioclase amphibolite. [Atlanta Group]
CB	**Ben Hill Granite:** Coarse-grained, porphyritic muscovite-biotite quartz-plagioclase microcline granite.
CC	**Camp Creek Granite Gneiss:** Massive granite gneiss interlayered with thin, fine-grained, dark-green hornblende-plagioclase amphibolite. [Atlanta Group]
CCS	**Conasauga Shale:** Cambrian siliceous shale and thin-bedded sandstone to mostly siliceous shale to dark black shale.
CL	**Clairmont Biotite Gneiss:** Interlayered medium-grained biotite-plagioclase gneiss and fine- to medium-grained hornblende-plagioclase amphibolite. [Atlanta Group]
CP	**Palmetto Granite:** Coarse-grained porphyritic granite composed of microcline, quartz and plagioclase with accessory biotite, muscovite, perthite, sphene, apatite, epidote and zircon.
CPQ	**Chattahoochee Palisades Quartzite:** Massive, white, yellowish, or bluish, sugary to vitreous quartzite locally containing accessory mica, feldspar, and elongate garnets. Graded bedding is apparent locally. [Sandy Springs Group]
CS	**Stone Mountain Granite:** Fine- to medium-grained granite composed of biotite, muscovite, microcline, quartz and oligoclase with characteristic rosettes of tourmaline.
DRU	**Dog River Metagraywacke:** Undifferentiated muscovite-biotite-quartz-feldspar gneiss (metagraywacke), garnet-muscovite schist, and amphibolite. [Sandy Springs Group]
FS	**Factory Shoals Metagraywacke:** Intercalated light-gray, lustrous, garnet-biotite-oligoclase or muscovite-biotite-plagioclase metagraywacke, kyanite-quartz schist, and staurolite-muscovite quartz schist. Locally, schist grades into a garnet-graphite-schist. [Sandy Springs Group]
IY	**Inman Yard Gneiss:** Porphyritic-blastic biotite-plagioclase gneiss porphyroblastic granite gneiss and sillimanite-muscovite schist. [Atlanta Group]
KCC	**Kellogg Creek Mafic Complex:** Garnet-hornblende-plagioclase amphibolite, metagabbro and lesser amounts of ultramafic rocks. [New Georgia Group]
LIG	**Lithonia Gneiss:** Evenly banded biotite-quartz-feldspar gneiss, quartz-rich garnetiferous layers and migmatitic muscovite-biotite-plagioclase-microcline-quartz gneiss.
LLU	**Laura Lake Mafic Complex:** Migmatitic garnet amphibolite with smaller amounts of pyroxene (relict)-bearing metagabbro, meta-quartz diorite, meta-ultramafic rock and banded iron formation. Magnetite occurs as common porphyroblasts in amphibolite.

CHART 1

KEY TO THE GEOLOGIC FORMATIONS OF THE GREATER ATLANTA REGION WITH DESCRIPTIONS, CONTINUED

LMA	**Lost Mountain Amphibolite:** Hornblende-plagioclase amphibolite, hornblende gneiss and local lenses and layers of banded iron formation. Univeter Formation [New Georgia Group]
N	**Norris Lake Schist:** Interlayered garnet-biotite-muscovite schist, biotite-muscovite schist, thin amphibolites and minor biotite gneiss. Part of the Snellville Formation. [Atlanta Group]
NG	**Norcross Gneiss:** Light-gray epidote-biotite-muscovite-plagioclase gneiss locally containing amphibolite. [Atlanta Group]
OCK	**Knox Dolomite:** Upper Cambrian and Lower Ordovician light- to medium-gray, fine to coarse-grained, thickly to massively bedded cherty dolomite and brownish-gray, medium to coarse-grained "asphaltic" dolomite. Surface expression nearly exclusively chert.
OCR	**Rome Limestone:** Cambrian limestones generally to the west of Knox Dolomite and of similar origin.
OCRS	**Rome Sandstone:** Cambrian thin-bedded, fine-grained sandstones and sandy shales.
PFU	**Powers Ferry Metagraywacke:** Undifferentiated biotite-quartz-plagioclase gneiss (metagraywacke), mica schist and amphibolite. The largest single mapped unit in the area. [Sandy Springs Group]
PL	**Promised Land Granite Gneiss:** Massive to thinly-layered, medium-grained, gray, banded biotite granite gneiss interlayered with fine-grained, dark-green to greenish black, blocky amphibolite. [Atlanta Group]
PZUC	**Soapstone Ridge Complex Ultramafics:** Undifferentiated coarse-grained ultramafic rock.
RCS	**Rose Creek Schist:** Garnet biotite-muscovite schist locally varying to garnet-hornblende-muscovite-quartz schist. Part of the Univeter Formation. [New Georgia Group]
SE	**Senoia Schist:** Garnet-biotite-muscovite schists interlayered with fine-grained amphibolite, local thin layers of spessartine quartzite, Sillimanite schist and biotite gneiss. [Atlanta Group]
ST	**Stonewall Biotite Gneiss:** Intercalated fine-grained biotite gneiss, hornblende-plagioclase amphibolite and Sillimanite-biotite schist. [Atlanta Group]
UNA	**Unnamed Amphibolite:** Widely scattered amphibolites of unknown affinity.
UNB	**Unnamed Biotite Gneiss:** A large area primarily to the southeast of Atlanta of unknown affinity.
UNM	**Unnamed Metamorphics:** A mixture of metamorphic rocks, primarily amphibolites, hornblende gneiss and felsic gneiss, primarily to the west area of unknown affinity.
UNS	**Unnamed Sands:** Coastal plane sediments south of the fall line.
WAC	**Wahoo Creek Biotite Gneiss:** Slabby, medium-grained muscovite-plagioclase-quartz gneiss, amphibolite, mica schist and epidote-calcite-diopside gneiss (calcsilicate). [Atlanta Group]
WC	**Wolf Creek Amphibolite:** Thinly laminated, fine-grained amphibolite interlayered with lustrous, silvery, gray, biotite muscovite schist. [Atlanta Group]

Descriptions taken largely from Abrams & McConnell with additions and modifications. Names here include the predominant rock in the formation or named rock unit that are not included in Abrams text. When keying to Chart 6, use the group name for locating the general area of this rock. Chart 6 does not inlcude individual formations as the scale precludes printing.

CHART 2

Formations Arranged Alphabetically by Abbreviation

ABR	GEOLOGIC FORMATION	n =	low	high	average: all constr	average: base-ment	% 4.0+	base-ment % 4.0+
ACG	Acworth Gneiss	9	0	2.8	1.0	1.2	0	0
AG	Austell Gneiss	7	0.4	2.5	1.9	2.0	0	0
BA	Bill Arp Schist	21	0.2	15	3.7	4.5	29	36
BCI	Big Cotton Indian Biotite Gneiss	30	0	4.1	1.4	2.4	3	0
BZ	Button Schist Ductiley Sheared Zone	101	0	25.4	2.7	3.1	17	24
CA	Clarkston Sillimanite Schist	80	0	3.7	1.3	1.6	0	0
CB	Ben Hill Granite	3	3.2	5.7	4.2	4.2	33	33
CC	Camp Creek Granite Gneiss	16	0.3	5.7	1.7	2.5	12	17
CCS	Conasauga Shale	17	0.2	4.8	1.9	2.1	12	14
CL	Clairmont Biotite Gneiss	102	0	9	1.9	2.6	6	11
CP	Palmetto Granite	9	0.1	4.9	1.5	3.0	11	50
CPQ	Chattahoochee Palisades Quartzite	41	0.5	8	2.0	2.1	9	10
CS	Stone Mountain Granite	12	1.1	8.9	3.8	4.3	58	70
DRU	Dog River Metagraywacke	4	0	1.2	0.7	n/a	0	0
FS	Factory Shoals Metagraywacke	104	0	8.5	2.1	2.4	11	12
IY	Inman Yard Gneiss	8	0	6.6	1.8	3.3	12	25
KCC	Kellogg Creek Mafic Complex	7	0	1	0.6	0.5	0	0
LIG	Lithonia Gneiss	30	0.6	15.1	3.0	4.1	27	41
LLU	Laura Lake Mafic Complex	129	0	3.9	0.9	1.1	0	0
LMA	Lost Mountain Amphibolite	43	0	3.1	0.7	0.8	0	0
N	Norris Lake Schist	17	0.6	6.8	2.5	3.8	24	17
NG	Norcross Gneiss	44	0	4.2	1.3	1.2	2	0
OCK	Knox Dolomite	52	0	7.4	1.3	2.1	4	13
OCR	Rome Limestone	18	0	3.5	1.3	1.6	0	0
OCRS	Rome Sandstone	6	0.3	2.7	1.3	1.7	0	0
PFU	Powers Ferry Metagraywacke	583	0	10.3	1.6	1.9	5	7
PL	Promised Land Granite Gneiss	46	0.4	6.7	2.5	2.8	17	20
PZUC	Soapstone Ridge Complex Ultramafics	3	1.1	1.8	1.5	1.7	0	0
RCS	Rose Creek Schist	7	0.6	4.1	1.8	2.0	14	17
SE	Senoia Schist	12	0.2	3.4	1.6	2.3	0	0
ST	Stonewall Biotite Gneiss	46	0	2.6	1.0	1.4	0	0
UNA	Unnamed Amphibolite	7	0.2	2.1	1.0	1.1	0	0
UNB	Unnamed Biotite Gneiss	6	0.5	5.2	2.6	3.8	17	33
UNM	Unnamed Metamorphics	115	0	8.3	1.3	1.7	4	8
UNS	Unnamed Sands	4	0.5	1.6	0.9	n/a	0	0
WAC	Wahoo Creek Biotite Gneiss	62	0	7.8	1.9	2.8	8	17
WC	Wolf Creek Amphibolite	56	0	23.4	2.6	4.0	16	31

	n =	low	high	average: all con-struction	average: basement	% 4.0+	base-ment % 4.0+
ATLANTA AREA	1908	0	25.4	1.7	2.2	7.4	11.2

Basement	45.0%	857
Basement + Crawl Space	12.5%	240
Slab-On-Grade	20.0%	378
Crawl Space	21.5%	411
2nd Floor and above	1.0%	21

CHART 3

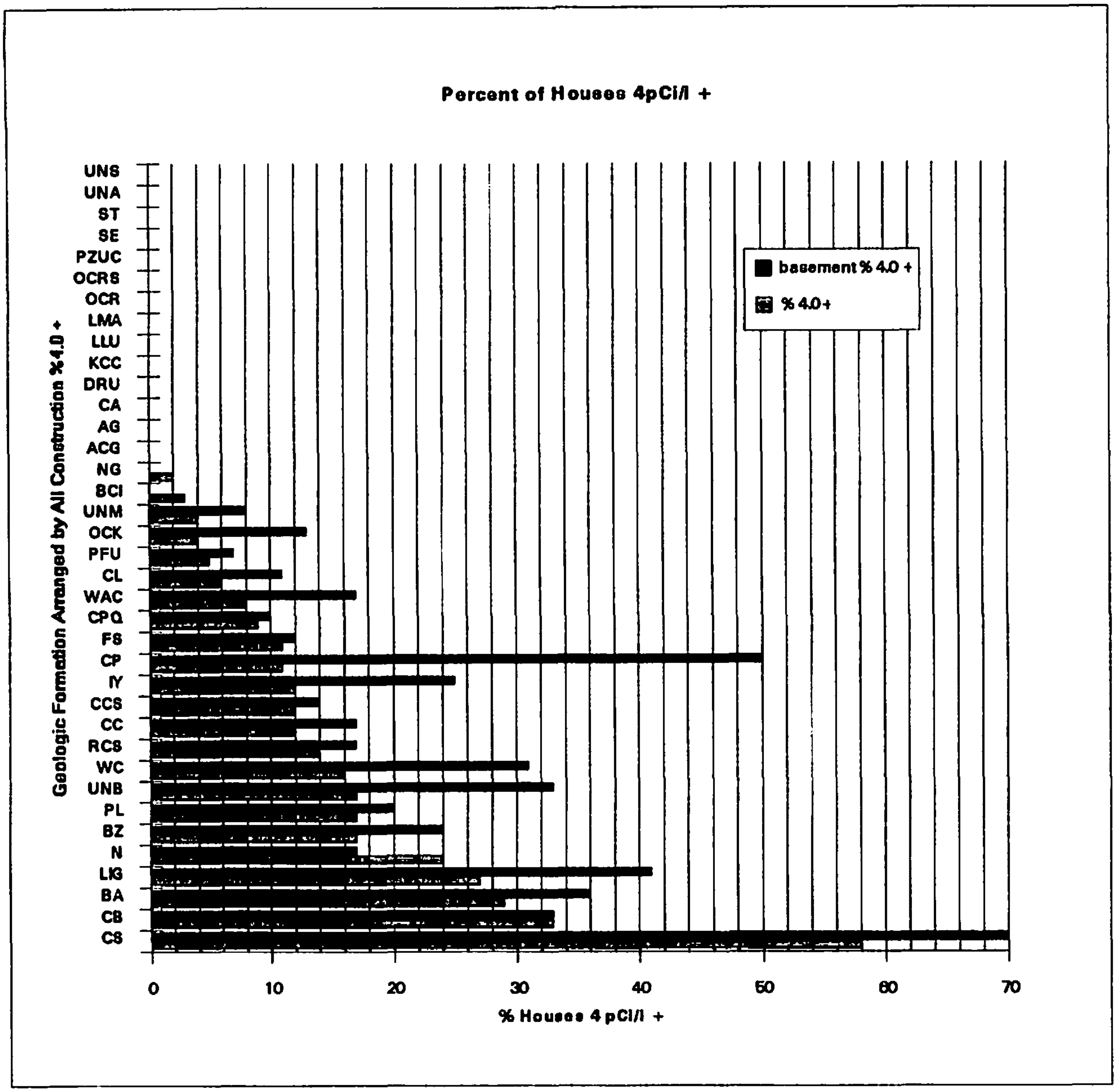

Percent of Houses 4pCi/l +
UNS
UNA
ST
SE
PZUC
OCRS
OCR
LMA
LLU
KCC
DRU
CA
AG
ACG
NG
BCI
UNM
OCK
PFU
CL
WAC
CPQ
FS
CP
IY
CCS
CC
RCS
WC
UNB
PL
BZ
N
LIG
BA
CB
CS
Geologic Formation Arranged by All Construction %4.0 +
basement % 4.0 +
% 4.0+
0
10
20
30
40
50
60
70
% Houses 4 pCi/l +

CHART 4

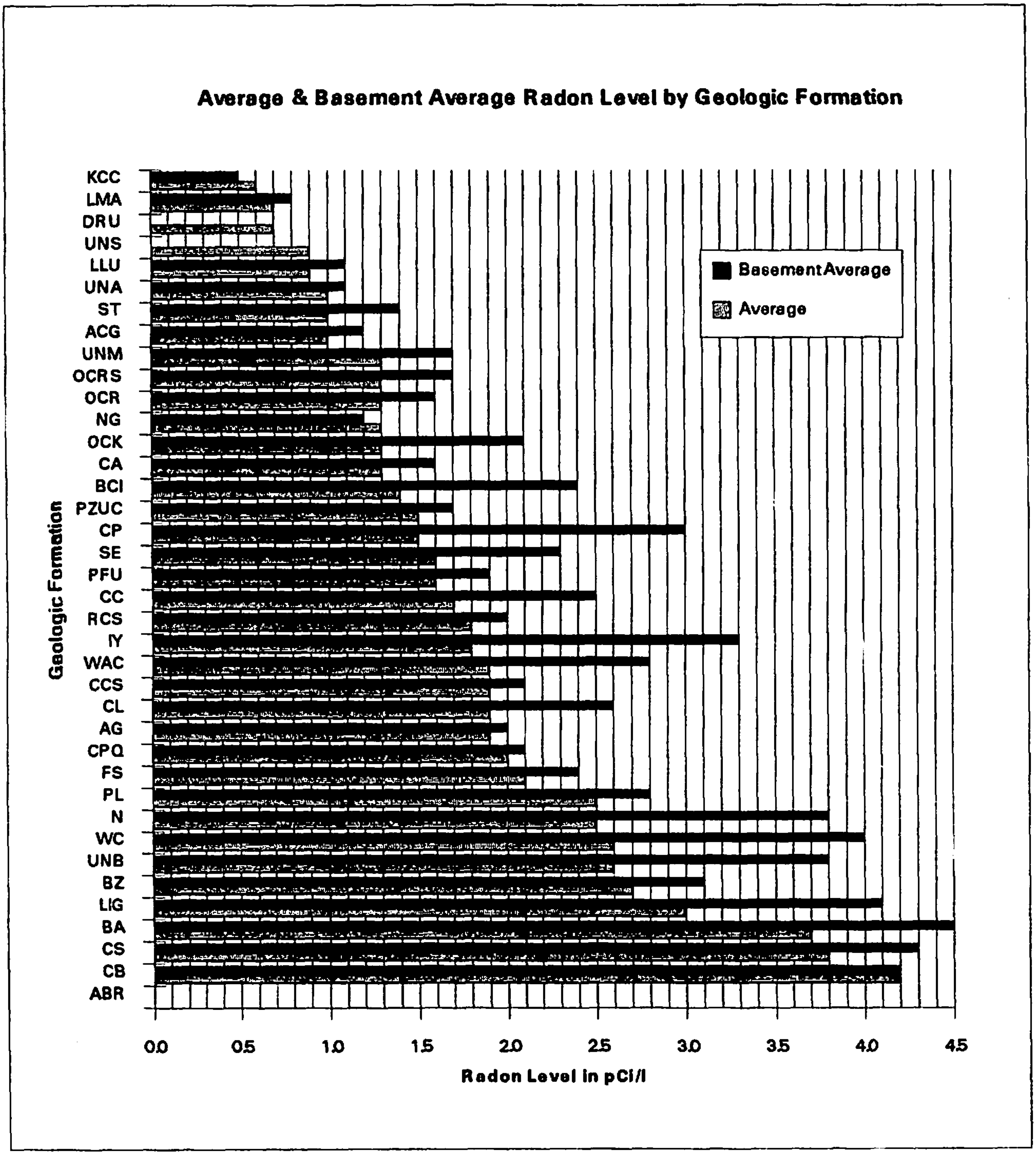
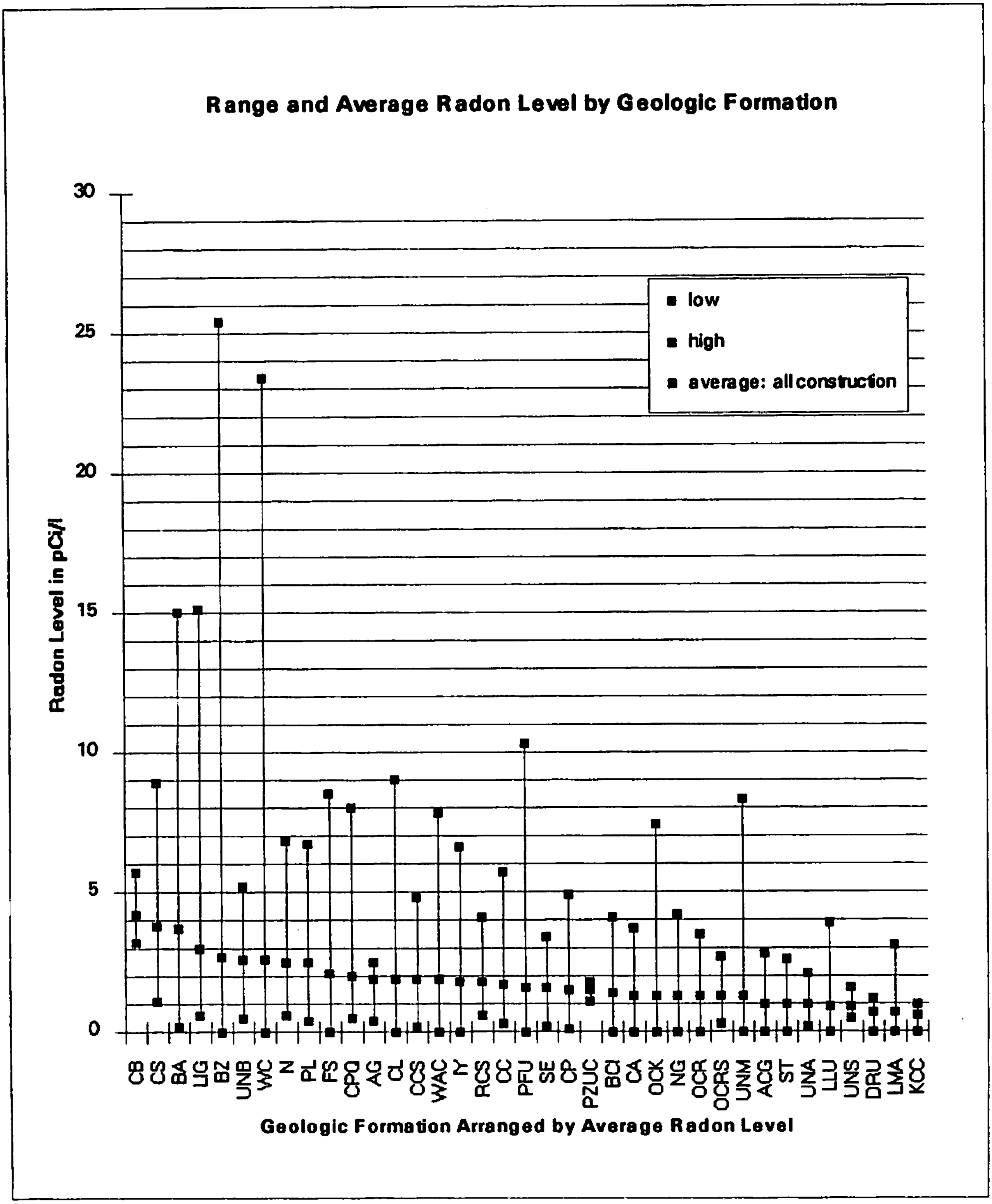
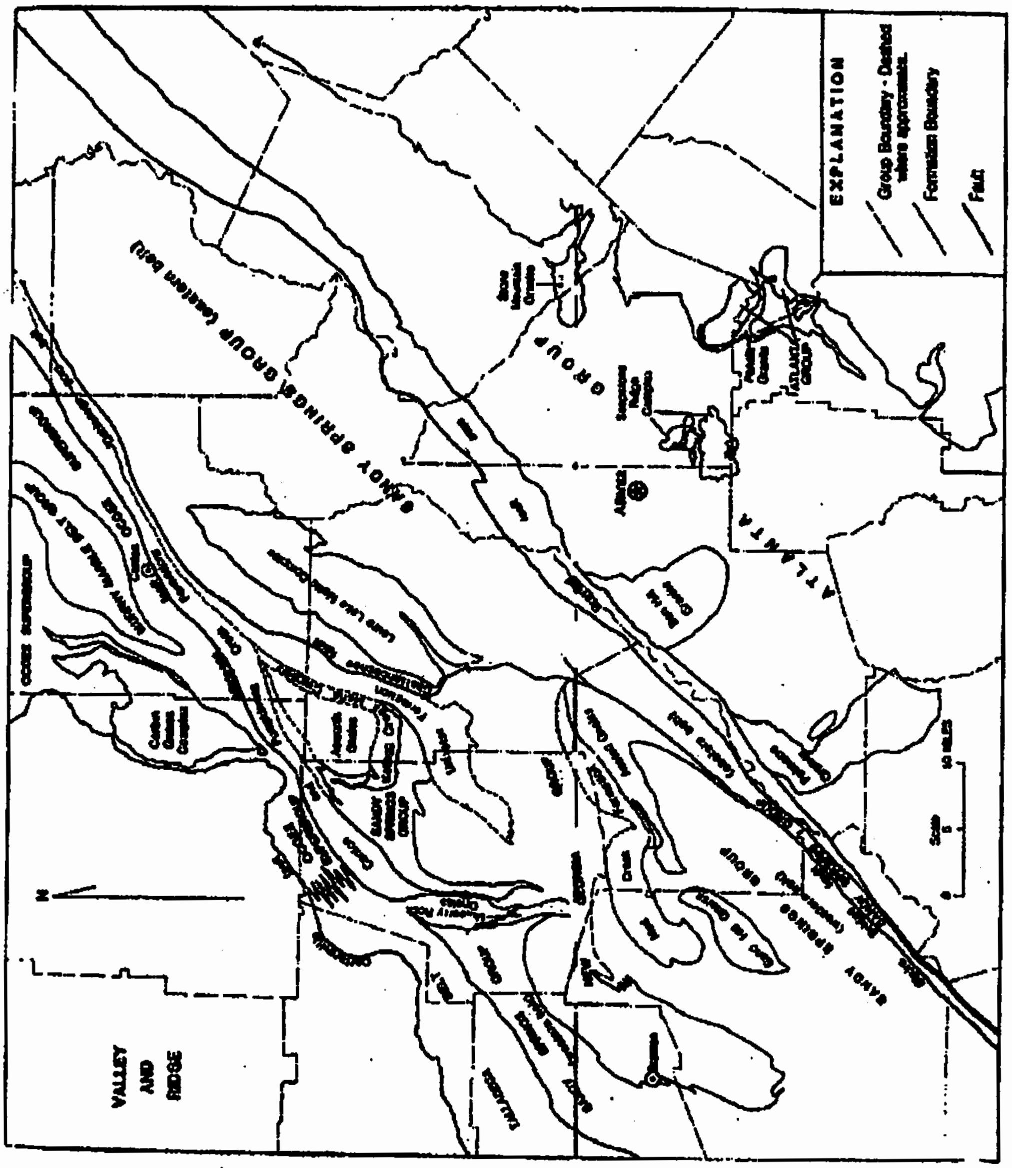

Average & Basement Average Radon Level by Geologic Formation
Basement Average
Average
KCC
LMA
DRU
UNS
LLU
UNA
ST
ACG
UNM
OCRS
OCR
NG
OCK
CA
BCI
PZUC
CP
SE
PFU
CC
RCS
IY
WAC
CCS
CL
AG
CPQ
FS
PL
N
WC
UNB
BZ
LIG
BA
CS
CB
ABR
Geologic Formation
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
Radon Level in pCi/l

CHART 5



Range and Average Radon Level by Geologic Formation
Radon Level in pCi/l
30
25
20
15
10
5
0
low
high
average: all construction
CB
CS
BA
LIG
BZ
UNB
WC
N
PL
FS
CPQ
AG
CL
CCS
WAC
IY
RCS
CC
PFU
SE
CP
PZUC
BCI
CA
OCK
NG
OCR
OCRS
UNM
ACG
ST
UNA
LLU
UNS
DRU
LMA
KCC
Geologic Formation Arranged by Average Radon Level

CHART 6



Group and formation boundaries of the crystalline rocks of the Greater Atlanta Regional Map
(Abrams: 1984, page 23)