1995_03

RADON, LUNG CANCER, AND GEOLOGY IN LIVINGSTON, OVERTON COUNTY, TENNESSEE

Curtis Officer, Susie Shimek, Francis Fitzgerald
TN

INTRODUCTION AND HISTORY

During the fall of 1994 tests defined radon levels of 76 piC/l in the basement level of a home in Overton Heights development in Livingston, Tennessee. Subsequent tests confirmed this elevation and also defined a value of 52 piC/l in the second home tested in the same area. Subsequent discussions with local residents indicated 10 to 15 probable lung cancer cases in the previous +/-5 years in a population of about 100 households.

When this situation was brought to the attention of the Tennessee Radon Program the response was to immediately offer support for additional testing. This consisted of the placement of approximately 40 Airchek charcoal packets on a somewhat random basis in February and March of 1995. Each house was tested in the location with potential for greatest radon elevation. The results showed that elevated radon levels were widespread with values as high as 105 piC/l. More significantly, most of the homes tested showed elevations.

The next phase of the program involved some retesting of previously defined elevations but the majority of this stage concentrated on repeating those tests which were inconclusive and on the extension of the test area to establish the limits of the elevated values. Retesting verified elevations as previously defined but the values were generally lower due to testing main living levels and warmer weather which encouraged more ventilation.

LOCATION, PHYSIOGRAPHY, AND PROFILE

Livingston, the county seat of Overton County, is situated in northeast central Tennessee about half way between Nashville and Knoxville. The town has a population of 4,800 with a county total of 18,300 inhabitants.

Physiographically, it is on the eastern edge of the eastern Highland Rim province near the western edge of the higher Cumberland Plateau. Elevations in the vicinity of the town range from just under 1000 to about 1350 feet. The lower and higher elevations are relatively flat areas with the intermediate elevations being somewhat steeper.

In this report the majority of the attention has been directed to Schoolhouse Mountain, a ridge ranging in elevation from 1080 to 1260 feet situated in the northeast quadrant of town. This elevated area is about 4000 feet northeast- southwest and about 2000 feet northwest-southeast containing about 250 acres.

Schoolhouse Mountain was developed for housing in two stages with the east side being called Henson Hills and started about 35 years ago. The west side is Overton Heights and was started about 10 years later. There are approximately 100 households in the area defined by the topographic outline of the mountain.

The tested community is well kept with a probable moderate income level somewhat above the average for the area. An estimated two thirds of the residents are middle aged to past retirement age with the remainder being younger, usually with children. Smokers and reformed smokers abound but are probably in no different proportion than in the overall community.

The house construction is most commonly brick although various siding is also used. Slab, crawl space, and basement construction are all common but it is likely that some form ofbasement with different degrees of burial and outside access is dominant.

TEST RESULTS

In the initial phase of this study about 40 Airchek charcoal packets were distributed over the course of about 5 weeks in February and March. About 46 more detectors were distributed through late April. Meaningful results have been obtained from about 65 of the tests. Although the number of data points is somewhat limited at this writing the preliminary results suggest three distinct populations:

Population 1. Associated with the intermediate to higher topographic elevations such as Schoolhouse Mountain most of these sites tested over 4.0 piC/l. Readings were as high as 105 piC/l with a high proportion of values in the 4 to 50 piC/l range.

Population 2. This second major population was in the topographically lower areas. Here the readings were generally lower than 10 piC/l, often less than 4 piC/l, with an occasional reading to 20 or 30 piC/l. Testing to define this population is incomplete at this writing but the data to date closely resembles the tabulated results for 141 tests for the entire county.

Population 3. A third population suggested by the data is present on the higher tableland in the 1300 to 1350 feet elevations range. Although there are only three data points it appears this level generally has values of less than 4.0 piC/l.

STATISTICAL RESULTS OF TESTING

Range 1 (0.0 to 3.9) 2 (4.0 to 19.9) 3 (20.0 to 49.9) 4 (50.0 to 99.9) 5 (+ 100)

Total Co.	60 tests	61 tests	17 tests	2 tests	1 test
141 Tests	42.6%	43.3%	12.1%	1.4%	0.7%
Pop. 1	3 tests	17 tests	13 tests	3 tests	1 test
37 tests	08%	46%	35%	08%	02%
Pop. 2	7 tests	10 tests	2 tests	0	0
19 tests	36%	52%	10%	0	0
Pop. 3	3 tests	0	0	0	0
3 tests	100%	0	0	0	0

HEALTH

The residents of this community feel they are living in an area with an abnormally high incidence of all forms of cancer. It is not known if this is true statistically but in plotting those cases of lung cancer as defined by local interviews there does appear to be a bias of higher lung cancer in those areas with or directly adjacent to elevated radon values.

In this investigation the cancer cases have been determined by asking established residents of the various sections investigated to define any cases of lung cancer they can recall in the last +/- 5 years. The inquiry specifically solicited only those cases that were first defined as lung cancer and tried to exclude those cases that spread to the lungs from some other type of cancer.

Smokers were noted but no attempt was made to separate smokers and nonsmokers as it is assumed the ratio of smokers should be a constant between the high and low radon areas.

It became very obvious in the initial stages of the study that there is a striking concentration of lung cancer in the Henson Hills area especially along Woodland Avenue. Here 10 lung cancer cases were defined in a 2500 feet section of Woodland containing 25 households. Based just on lung cancer cases the trend is about North 30-35o East.

Four additional lung cancer cases were defined along the western part of Schoolhouse Mountain. These have an apparent trend similar to that defined on Woodland but this is less well defined.

Ten of the cancer cases are in the Population 1 area and do show significant radon elevations. Four appear to be in the Population 2 area but the radon levels are not known as these have not been tested as of this writing.

Most if not all of the lung cancer cases were active or reformed smokers or lived in households with smokers. The cases involved 9 men and 5 women. The specific length of time at the present location was not determined but appears to range from + 2 to +30 years. Again, the east side of Schoolhouse Mountain was developed about 10 years prior to the west side and might be a factor in the higher incidence on the east.

GEOLOGICAL ANALYSIS

The high percentage of elevated levels associated with Schoolhouse Mountain suggested that an analysis of geologic conditions at the site might yield some insight on the presence of the radon here. Several geologic factors which could be influential in the distribution of radon have been considered. These deal with radon source, porous host, and connections between the two.

Stratigraphy

There are six formations considered at the site. Four of these outcrop in the immediate areaand the other two are present at 250 to 450 feet depths and outcrop 5 to 10 miles from the site.

Hartselle Sandstone: This is a sandstone layer which caps the higher elevations which are flat topped hills in the immediate vicinity of Livingston. The geologic map shows this unit to be 40 to 90 feet thick on the Livingston quadrangle. Three tests for radon on this unit were all low and it is probably safe to conclude radon levels associated with this unit are not likely to be excessive.

Monteagle Limestone: This unit is a relatively pure limestone with minor thin green shale layers, fossil fragments and oolitic(limestone sand) zones. It is generally present on the steeper slopes in the area. The thickness on the geologic map is listed as 210 to 300 feet with the lower 180 feet being present in Schoolhouse Mountain.

In outcrop the Monteagle is usually fractured and broken. In the face of a local quarry a number of vertical fracture zones with dissolution and brown stained weathering are visible. Most of the large caves in the region are in this unit.

Oil well logs in this zone do indicate slightly elevated gamma readings in thin sporadic zones thought to be silty or shaley but values are only a fraction of those seen in the underlying Chattanooga Shale. The areas of consistently high radon readings on the surface are most commonly on this unit.

St Louis Limestone: The St Louis Limestone is more dolomitic and cherty than the overlying Monteagle. It is listed as being 100 to 140 feet thick in this area.

This layer often shows strong karst development with water filled surface depressions. Although the karst would indicate dissolution this unit is not thought to be as open or with the interconnected space seen in the Monteagle. Outcrop near the top of this zone shows a layer around 10 feet thick which appears more susceptible to dissolution.

The oil well logs show it to have a very low gamma ray background. Measured radon levels on this unit are generally low but 8 to 10 piC/l values occur and radon highs of 20.7 and 33.8 were found. It was not determined if the elevated levels are related to the karst development or to fracturing.

Warsaw Formation: The Warsaw Formation is defined in this area as consisting of sandy limestone, limestone, or various combinations of limestone, siltstone and shale. Most apparent in outcrop are the interbedded dark limes and greenish limey shales which are solid and show little open space, fracturing, or dissolution. The thickness is shown to be 80 to 100 feet.

Natural Gamma on the oil well electric logs shows that the unit does have slightly elevated gamma levels. This study contains few radon readings from the Warsaw but other than the occasional fracture association it is expected this unit would not have high readings although an occasional 10 or so piC/l is suggested by the data.

Fort Payne Formation: This unit shows considerable regional variation but in the Livingston area it is described as a calcareous siltstone and argillaceous limestone with minor thin limestones and shales. Chert and silicastone are characteristic. In places there is the potential that it could form a fairly porous residuum although the weathered material still in place appears tight in some areas. It is about 250 feet thick.

The unit was not tested in the area but the oil well log indicates that it is not a strong radon generator. The close proximity to the Chattanooga does create potential for elevated radon where high chert content and other geologic factors favor porous weathering products.

Chattanooga Shale: The Chattanooga Shale is present in this area at about 450 feet below the bottom of the Monteagle Limestone. The unit is about 30 feet thick and is present over most of the region except where removed by erosion.

In the late 1940's this unit was tested extensively and based on this data it is estimated to contain as much as 2000 tons of uranium per square mile. The Natural Gamma readings on the oil well logs is " off scale " in the Chattanooga compared to the above described units.

Although Schoolhouse Mountain is 5 to 10 miles from the nearest Chattanooga outcrop this unit is the prime candidate as the source of the elevated radon values in the area since the contained radioactive material far overshadows anything else in the section. Vertically it is only 450 feet away.

Structure

The units in the area are considered to be relatively flat lying with a dip of around 50 feet per mile to the east. However, oil drilling in the area has provided sufficient data to define a significant amount of folding and displacement in the section.

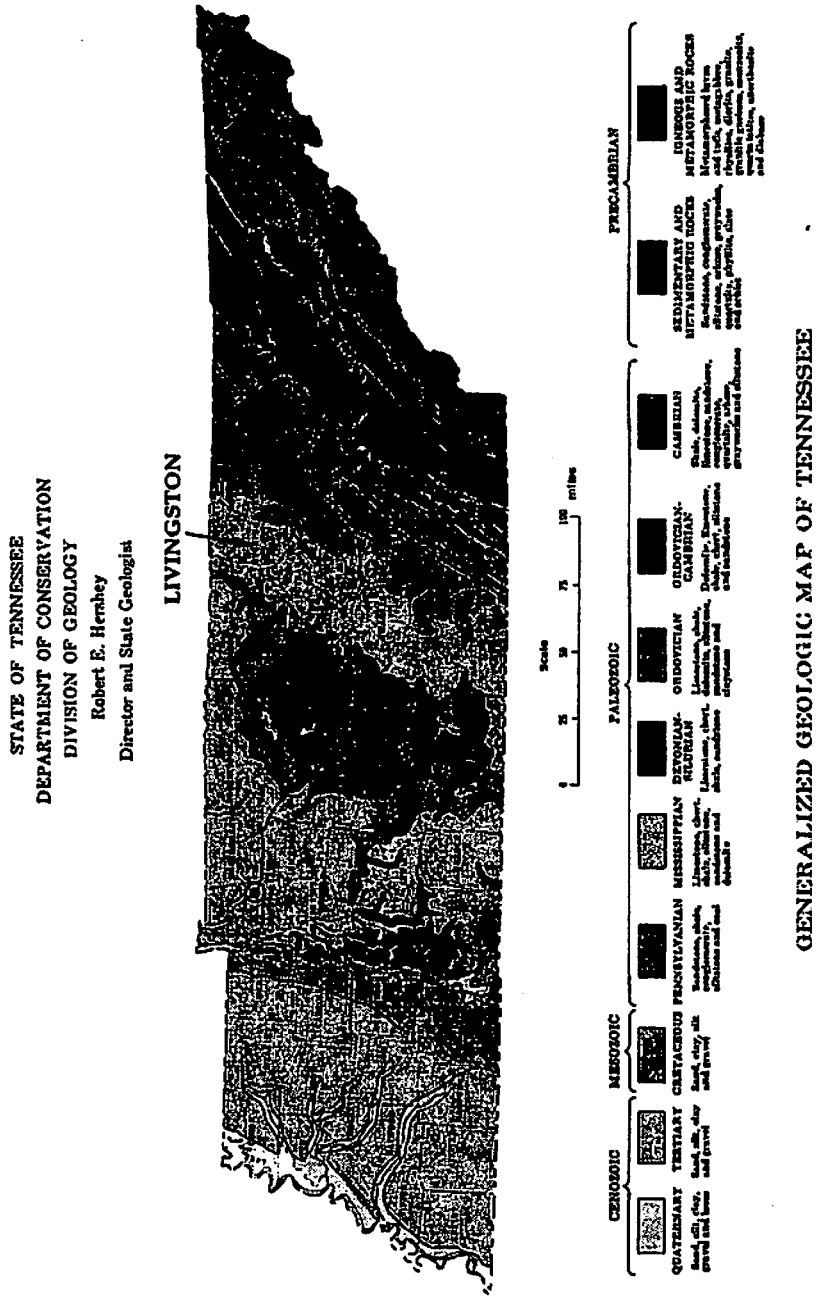
An analysis of aerial photos and topography shows several linear features indicative of fracture zones in the vicinity of Schoolhouse Mountain. Most are associated with basin development and may have been sealed by subsequent events. However, open fractures trending about North 35o East and dipping to the northwest are very apparent in the roadcut just to the north of the high radon area. This direction is thought to be late in the geologic sequence but is not presently assigned to a particular tectonic event.

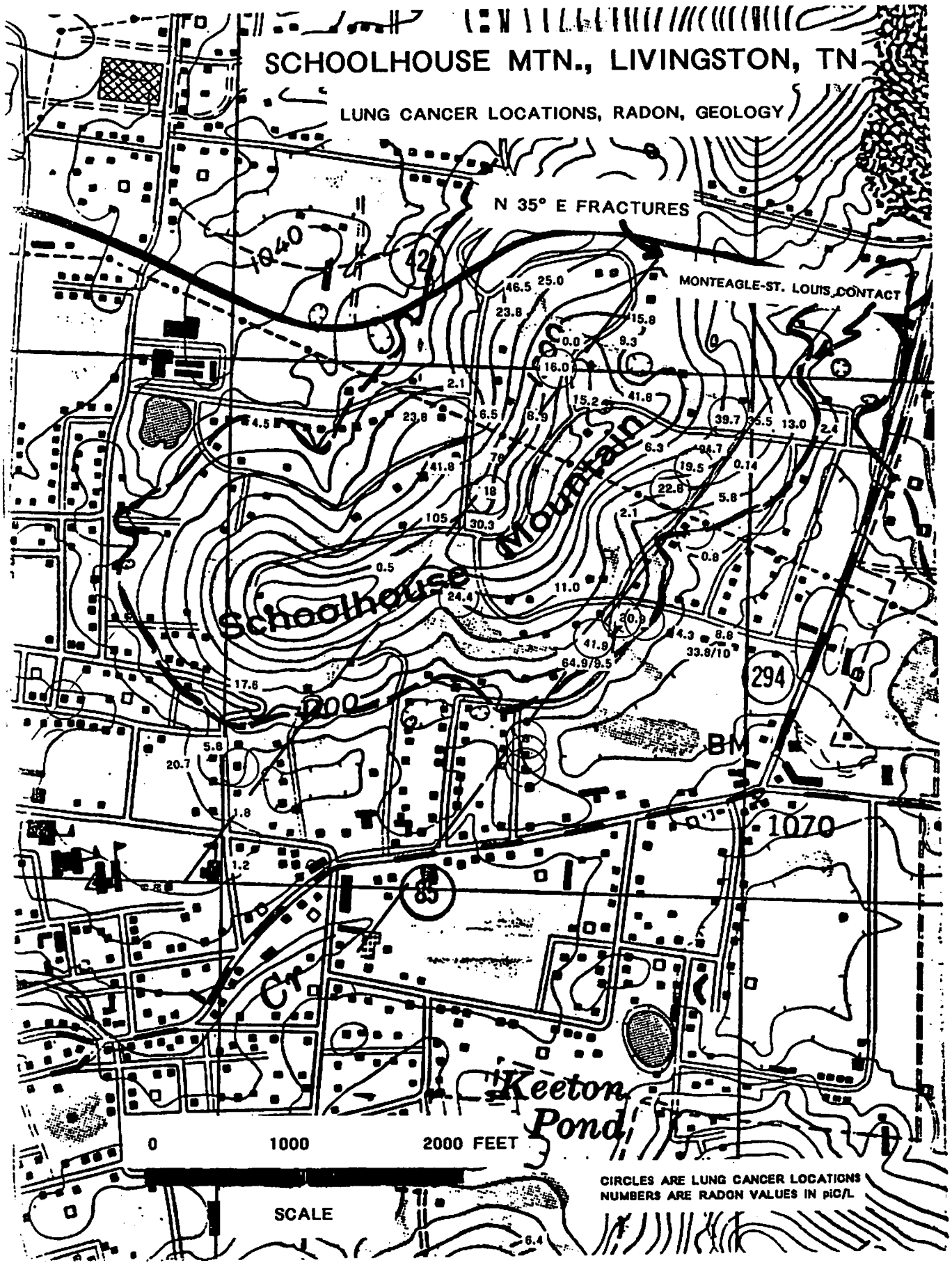
Fracturing, as defined from lineament analyses, is common and widespread in this region. It obviously does play a critical role in the distribution of radon in the Livingston area but the degree or directions of fracturing necessary to generate elevated levels of radon on other Monteagle sites is as yet undefined.

The significant points on the nature of the rock formations in the area are;

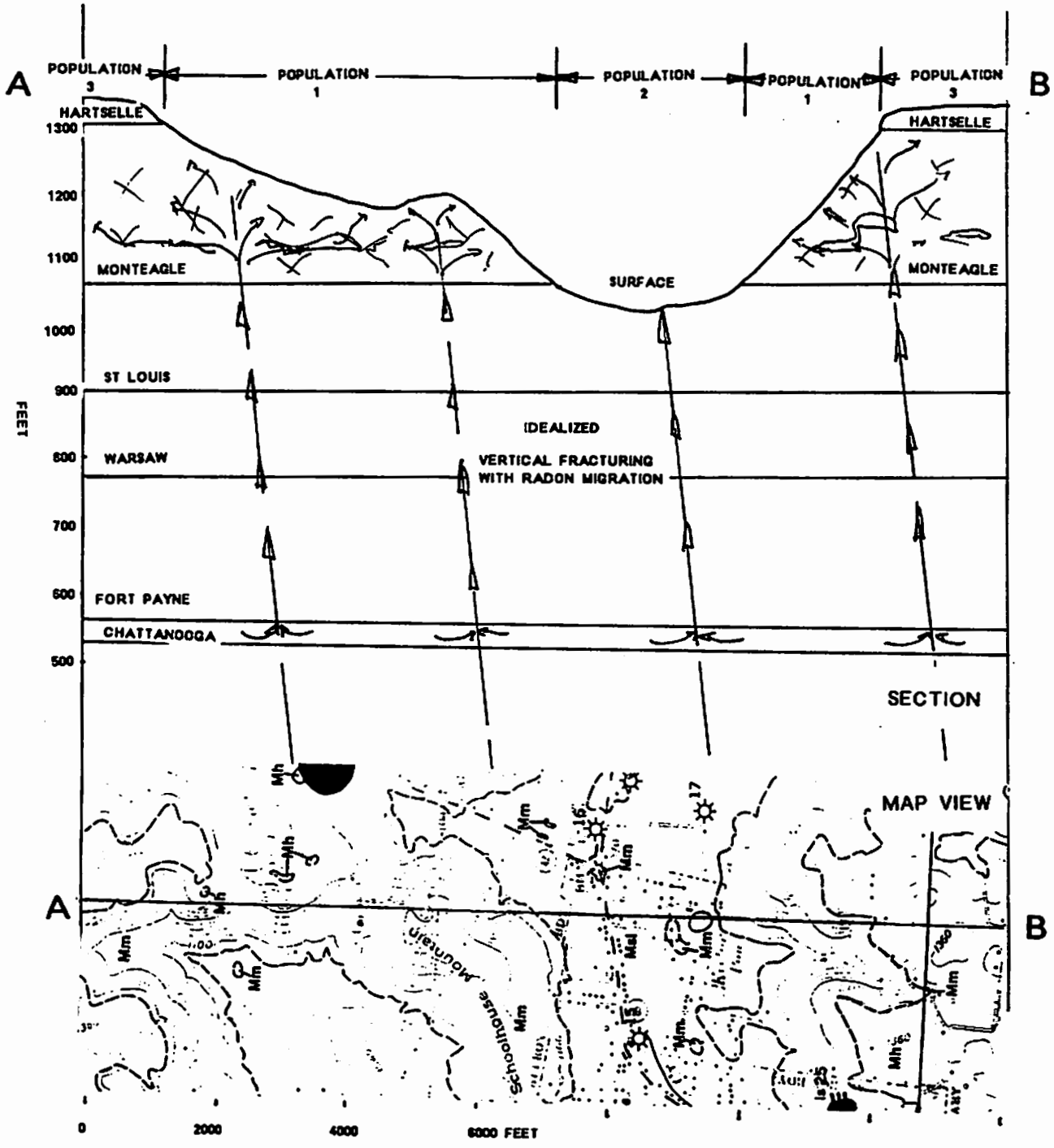
1. The Chattanooga Shale contains sufficient radioactive material to provide a source for the observed radon.
2. The Monteagle Limestone contains widespread well developed fracturing and caverns with interconnected porosity.

3. The St Louis Limestone often shows karst development but the general nature of this unit and its influence on the distribution of radon is poorly defined at this writing.
4. Northeast trending, steep dipping, open fracturing has been measured in the immediate vicinity of the elevated radon values and has the same trend defined by the lung cancer cases. This fracturing necessarily has deep seated origins and likely serves as a conduit between the various units in the section.

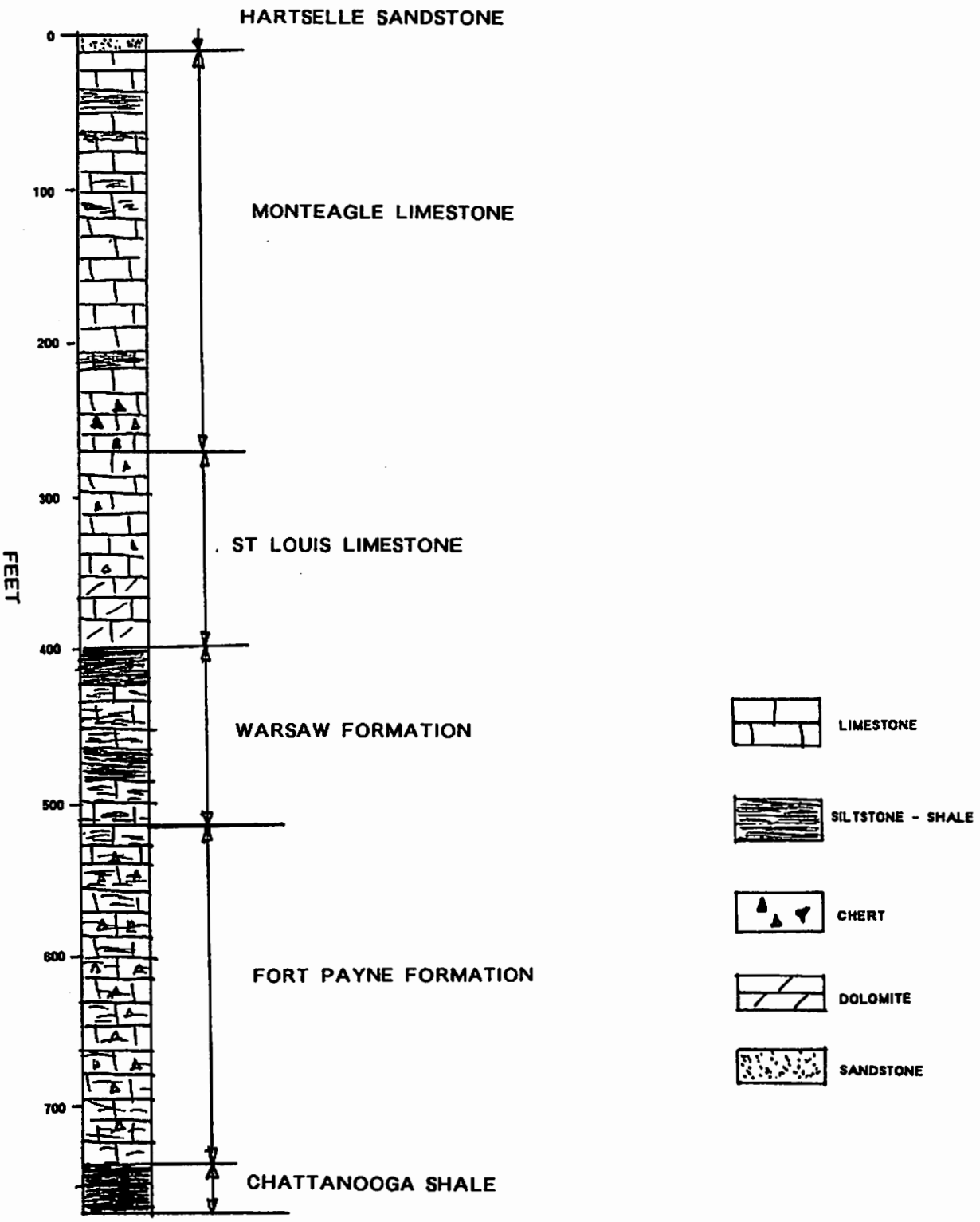


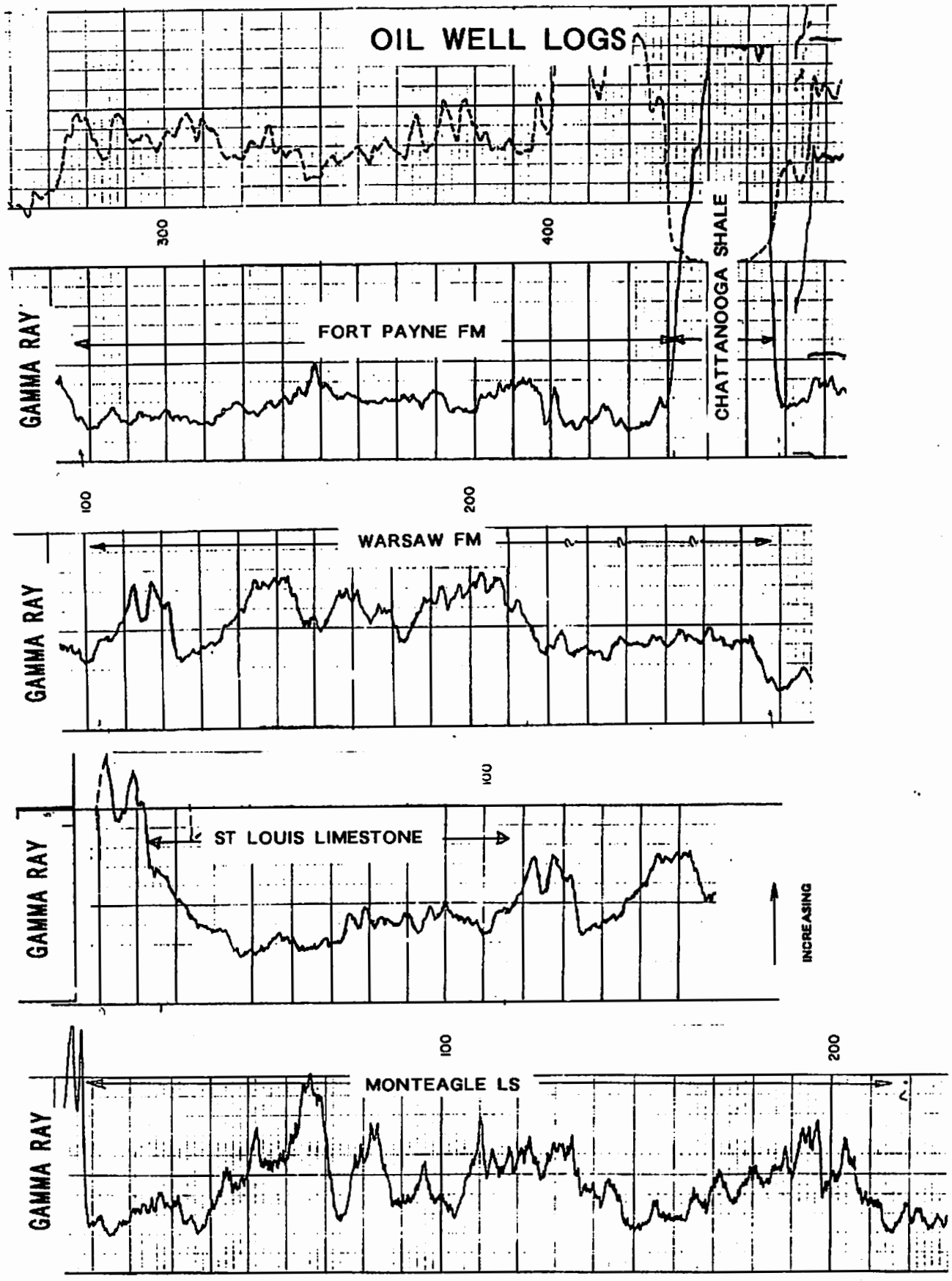

SCHOOLHOUSE MTN., LIVINGSTON, TN
LUNG CANCER LOCATIONS, RADON, GEOLOGY
N 35° E FRACTURES
MONTEAGLE-ST. LOUIS CONTACT
Schoolhouse Mountain
Keeton Pond
1040
1070
294
200
BM
0 1000 2000 FEET
SCALE
CIRCLES ARE LUNG CANCER LOCATIONS
NUMBERS ARE RADON VALUES IN piC/L

CROSS SECTION A-B



IDEALIZED STRATIGRAPHIC SECTION




OIL WELL LOGS
300
400
CHATTANOOGA SHALE
GAMMA RAY
FORT PAYNE FM
100
200
WARSAW FM
GAMMA RAY
100
GAMMA RAY
ST LOUIS LIMESTONE
INCREASING
100
200
MONTEAGLE LS
GAMMA RAY