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RADON STUDIES IN BRITISH COLUMBIA, CANADA

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ABSTRACT

Three radon studies, involving 150 background gamma measurements and long-term alpha track tests in a total of 400 homes have been conducted in three geologically distinct areas of the province of British Columbia. A positive correlation between the background gamma radiation and the measured radon level can be depicted only at the regional scale.

In the Coastal Area where the terrestrial gamma radiation is low, no homes were found to exceed 4 pCi/l on the main floor. In the Kootenays, where the background gamma is relatively high, considerably higher radon levels were encountered. The highest radon levels were encountered in the West Kootenay where the terrestrial gamma level is comparatively higher than East Kootenay. In West Kootenay about 45% of the homes demonstrate radon levels above 4 pCi/l and 7% above 20 pCi/l on the main floor. In the same area more than 80% of the homes demonstrate radon levels above 4 pCi/l in the basement. In the East Kootenay, where the radon levels were found to be lower than in West Kootenay, the terrestrial gamma levels are generally lower.

In some areas, the age of the house and the combustion air supply system seem to correlate with the radon level. In West Kootenay, where the highest radon levels were encountered, a positive correlation was observed between the radon level in the basement and the age of the house. The correlation was negative for the main floor (possibly due to air circulation between main floor and the basement in the new houses). In both Kootenay areas, the homes with combustion air supply from outside demonstrated reduced radon levels on the main floor (most probably due to increased inside pressure).

INTRODUCTION

Surveys of radon gas in homes have been carried out in Canada since 1977(1). These early studies, although they covered over 14,000 homes, were based upon single grab measurements normally in the basement of the house during summer and therefore gave poor indications of the annual exposure(2) and the correlation between annual exposure and construction parameters. The British Columbia (B.C.) Ministry of Health began making terrestrial gamma ray measurements in 1980 using both Thermoluminescent Dosimeters (T.L.D.s) in 25 locations(3), and a portable high pressure ionization chamber (Reuter Stoke RSS-111) in 150 locations. The areas of higher gamma activity generally corresponded with rock structures where uranium is likely to occur(4). We found the province could be divided into three gamma background areas. The coastal region of the province has very low gamma background, a moderate or normal gamma background regions that is located in the interior of the province: and an elevated gamma radiation area of the province which is scattered about the interior and associated with areas favourable for uranium deposits. Figure 1 shows the province of British Columbia and the three areas where our long-term radon surveys were carried out during 1988 - 89.

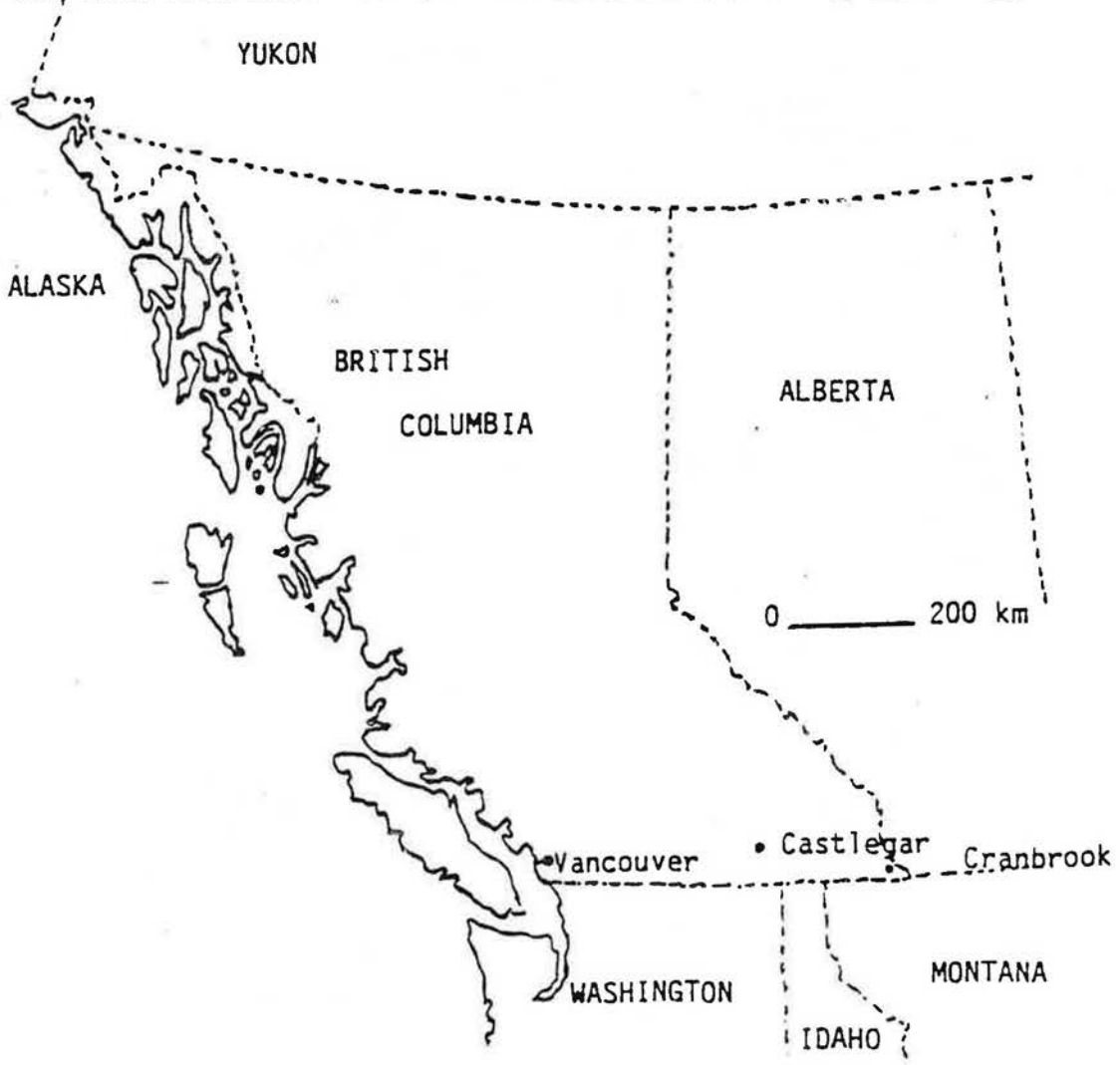

Figure 1 - British Columbia with the locations of 3 radon surveys

The first long-term radon study was carried out in the town of Castlegar, the West Kootenay region of the province. A previous radon grab sample study indicated elevated radon levels in many basements there(5). The region has an elevated gamma background and there has been uranium exploration in the area. The second study was carried out in the East Kootenay (Cranbrook) region of the province. Moderate gamma radiation levels had been detected in the region. However just south of the region, moderately elevated radon levels had been measured in Montana(6). The third study was conducted in the Greater Vancouver Region of the coastal British Columbia low gamma background region. In a previous grab sample study(1) by Health and Welfare Canada in this area, only low radon concentrations were found.

This paper will compare the data obtained in these three long-term radon surveys, the terrestrial gamma surveys, other geological and construction data available. This is the first step in developing a good potential radon risk model for homes in this province.

METHODOLOGY

RADON SURVEYS

The first survey was conducted in Castlegar, in the West Kootenay area of B.C. The homes are located on glacial terraces created by the Columbia River. The soil is dry gravelly and permeable. The monitors were installed in July of 1987 and removed in March of 1988. This period was representative of the observed annual weather pattern. 174 homes were monitored (173 homes returned monitors). All but one home had an upstairs and a downstairs (or basement) monitor. The monitors were mounted 4 - 7 feet above the ground, away from drafts and placed in an area where the family commonly resided. Measurement of the terrestrial gamma were made at each house, usually outside on the front yard.

The second survey was conducted in the East Kootenays where 157 of the 160 monitors were recovered. The monitors were placed one per house. In this study, the owner decided if the monitor should be placed in the basement or upstairs. The monitors were again placed 4 - 7 feet above the ground, away from draft and in a central living area. They were installed in January 1988 and removed in July 1988. It was our observation that this period represented an average annual weather conditions. Most of the monitors were placed in Cranbrook, the principal community in the area but some were placed in the nearby communities of Fernie, Invermere, Kimberley, Creston and Golden. These communities are located in valley bottoms at the foot of the Rocky Mountains.

The third set of 140 monitors was distributed in Greater Vancouver area. 135 monitors were recovered. Although the terrestrial gamma background is consistently low the geology varies from the Fraser River delta (rich farming land) to the North Shore mountains and includes bed rock and glacial outwash. One monitor was placed in the main living area of each home 4 - 7 feet above the floor and away from drafts and corners. No terrestrial gamma measurements were made in Greater Vancouver in this study since previous studies had detected no significant difference from one home to another in this area. The radon monitors were placed in January 1988 and removed in August 1988. This period was observed as representative of the average annual weather pattern. Similar weather patterns have been observed in previous years by Ghomshei et

al(8) during their radon studies.

At the time of monitor placement, a questionnaire was completed by the surveyor. Information was collected on the location of the monitor(s), house construction, age of home, home occupancy, basement or slab construction, possible radon pathways, heating and ventilating systems and the geological environment. Surveyors were instructed on required procedures prior to going out so that survey consistency would be maintained.

ANALYTICAL PROCEDURES

Terradex alpha tract radon detectors were obtained from Landauer Inc. They were type DRN and had a detection limit of about (.4 pCi/l) - month. Terrestrial gamma measurements were made using a Reuter-Stokes RSS-111 Environmental Radiation Monitor. The monitor's gamma ray response extends from .060 MeV to above 8 MeV. Correction for cosmic rays was made by recording the barometric pressure and subtracting the corresponding cosmic ray component, as specified in the operators manual for the Reuter Stokes instrument.

RESULTS AND DISCUSSION

TERRESTRIAL GAMMA MEASUREMENT

Terrestrial gamma radiation levels were determined in 150 areas of the province (2 to 100 measurements/area). The province (Figure 1) can be divided into 3 regions of terrestional radiation intensity. The first or low background area is the coastal strip composed of the two tectonic belts which were most recently ratted into North America to build the province. The second, moderate terrestrial radiation area, composes much of the interior area of the province. Within this interior area are large areas of high terrestrial background. These areas correspond to the areas identified by the British Columbia Ministry of Mines as being favourable environments for uranium deposits(7).

There is a good correlation between average terrestrial gamma background and average radon concentration (see Figure 2). This however does not follow through to the individual homes. There was no correlation between the individual homes terrestrial gamma intensity and the radon levels found in the basement or upstairs. The elevated terrestrial gamma was not the only indicator of potential radon problems in communities. In the Castlegar, West Kootenay area the soil was dry, gravelly, and permeable while in the East Kootenay area a number of communities (Cranbrook and Creston) were underlain with clay which appears to retard radon migration.

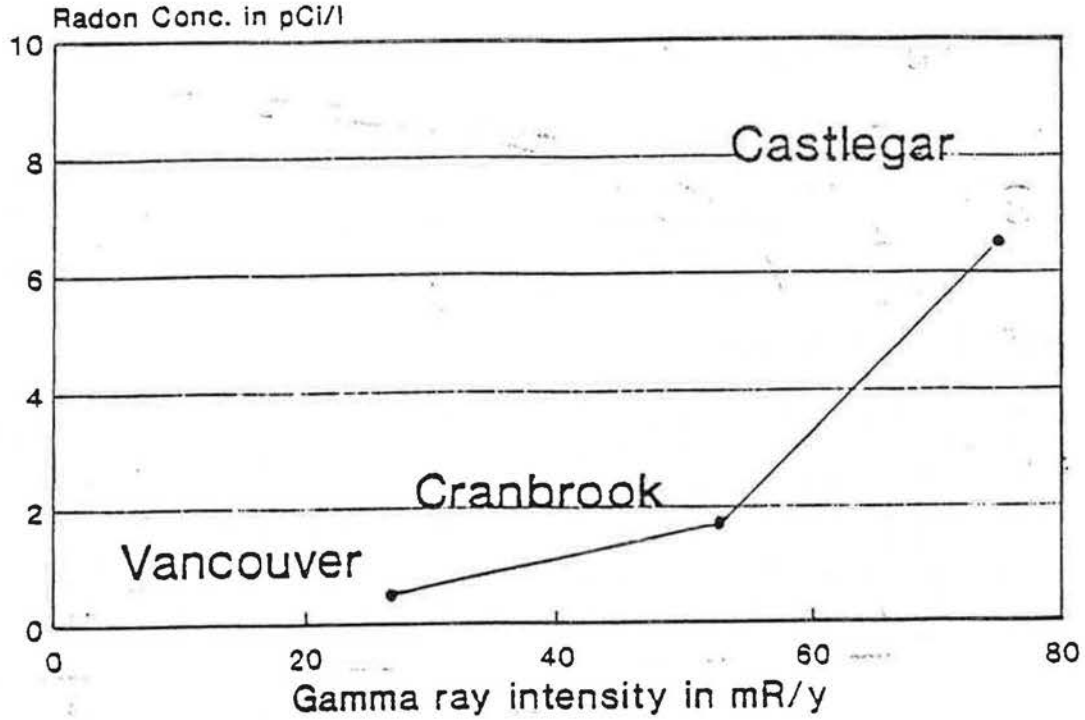

Figure 2 - Main Floor Radon Levels as a Function of Terrestrial Gamma Radiation.

CASTLEGAR, WEST KOOTENAY AREA

All but one of the homes surveyed in Castlegar had two levels. The land was strongly sloped and the lower levels were sunk into the ground on at least 3 sides of the home. Most of the second level was located above ground. The average main radon level was 6.5 pCi/l and the average basement level was 10.6 pCi/l. A low pass filter was applied to smooth out some of the fluctuation in the data (figure 3). As can be seen from figure 3, about 45% of the homes demonstrated radon levels above 4 pCi/l and 7% were above 20 pCi/l on the main floor. More than 60% of the homes had radon levels above 4 pCi/l in the basement. Approximately 15% of the homes had higher radon concentrations upstairs. In these homes fresh air entering at the basement level was probably diluting the radon in the vicinity of the monitor. The age of the home had a marked influence on the radon concentration (figure 4). Older homes can be characterized as having poorly constructed basement foundations with a doorway sealing them off from a leaky upstairs. New homes, although they have better constructed basements, have open stairways, an occupied basement, a central heating system, and a better sealed housing envelop. Although less radon enters the newer building, it gets distributed over both floors and is retained there. There was no direct correlation between upstairs and downstairs radon levels. If a home was supplied with make up combustion air the average radon level was downstairs 10.8 +/- 10.5 and 5.4 +/- 6.0 pCi/l upstairs. If no combustion air was supplied the average radon level downstairs was 10.2 +/- 12.0 pCi/l and upstairs was 8.2 +/- 10.5 pCi/l. Although the evidence is not strong it appears that the combustion air supply may reduce the negative pressure in the home reducing radon infiltration.

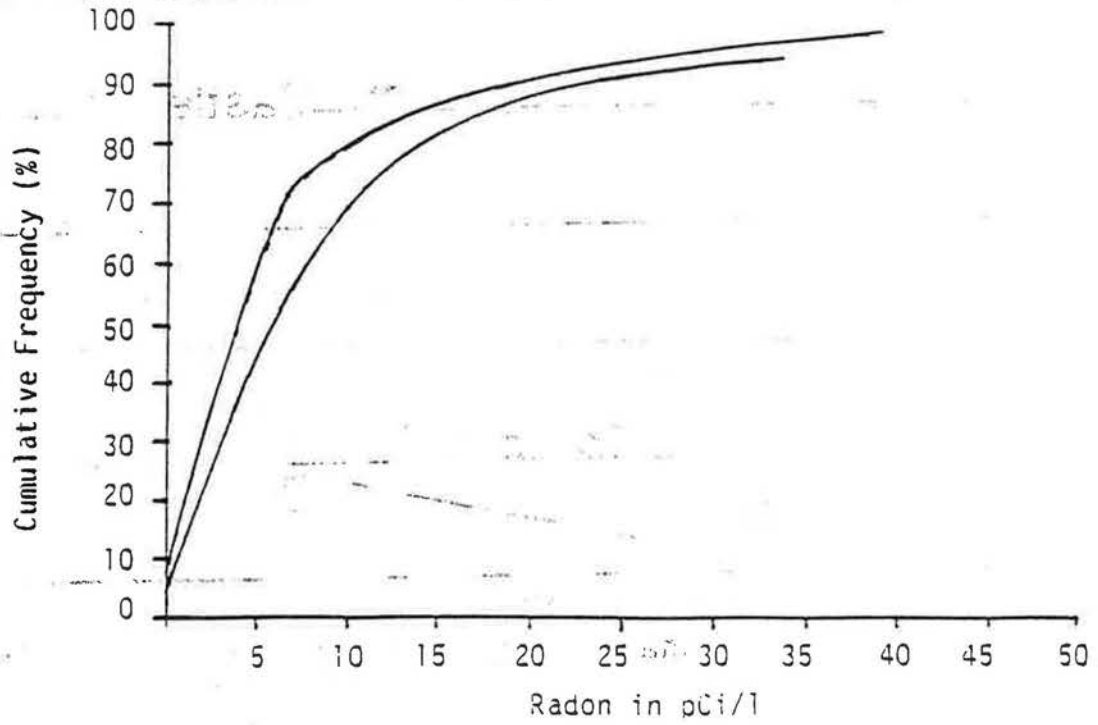

Figure 3 - Distribution of Main Floor and Basement Radon Values (Castlegar, B.C.)

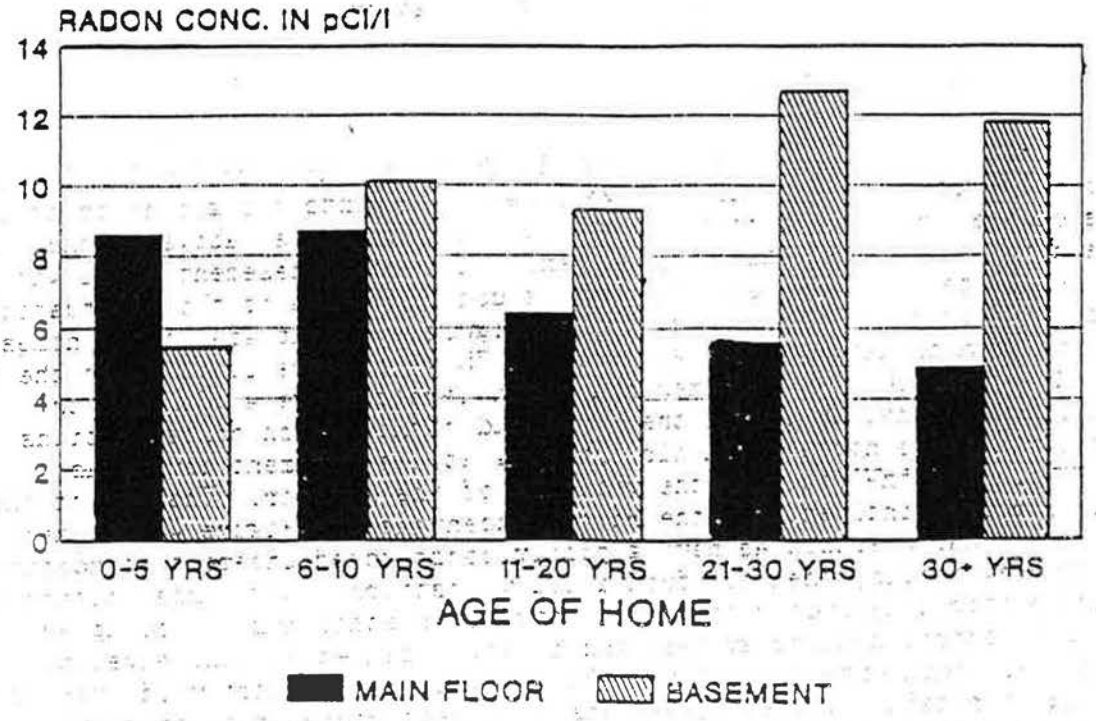

Figure 4 - Radon in Castlegar Homes as Function of Age

EAST KOOTENAY DATA (CRANBROOK AND VICINITY)

The East Kootenay area had, unlike the West Kootenay, a wide variety of housing types. Table 1 gives the average radon values found in the region. Terrestrial gamma levels are relatively constant throughout the region. It is interesting to note that Creston and Cranbrook are underlain with clay. This clay is not permeable and presents problems when septic fields are constructed. The other nearby communities are located on rocky and coarse soil which is much more permeable. These communities have higher radon levels. No clear trend was detected when comparing the age of the houses with radon concentration. This may be because both upstairs and downstairs measurements were not conducted in each home. Combustion air intake however does appear to have some impact on radon levels. If combustion air is supplied the average radon concentration was 1.56 +/- 2.90 pCi/l on the main floor and 1.87 +/- 1.82 pCi/l in the basement. If combustion air was not supplied the average radon concentration was 2.29 +/-2.75 pCi/l on the main floor and 2.29 +/- 3.36 pCi/l in the basement. 10% of the main floor radon levels exceeded 4 pCi/l and 1% exceeded 20 pCi/l.

Table 1 -- Radon Concentrations in the East Kootenay Area (Cranbrook and Vicinity)

Area	Number of Homes	Average Conc. in pCi/l	Standard Deviation
All Survey Sites			
Main Floor	90	1.7	2.8
Basement	67	2.0	1.9
Fernie			
Main Floor	3	3.2	2.9
Basement	7	1.7	.6
Cranbrook			
Main Floor	47	.9	.7
Basement	41	1.7	1.7
Kimberley			
Main Floor	15	2.1	2.3
Basement	10	3.4	2.8
Invermere			
Main Floor	6	7.1	8.5
Basement	4	1.6	.9
Golden			
Main Floor	4	1.7	1.8
Basement	5	3.1	1.7
Creston			
Main Floor	14	1.4	1.0
Basement	1	.9	-

GREATER VANCOUVER AREA

Radon concentrations in the Vancouver region were very low (average of 0.49 +/- 0.23 pCi/l and ranged between .2 and 1.6 pCi/l in the 135 homes measured. There is no significant difference from one area of the city to another despite a large variation in geological environments. The three factors that are common to the city which may explain the low radon levels are the low terrestrial gamma, an abundance of "hard pan" clay that deters radon infiltration and higher than average rainfall.

CONCLUDING REMARKS

Terrestrial gamma measurements can be used in British Columbia to predict a community radon potential. They however cannot be used to predict an individual home's concentration of radon. Soil structure particularly permeability appears to have a marked impact on radon potential (9). The province can be divided into three radon risk areas. There is a wide coastal

strip where the risk of radon exposure is very low compared to other areas of North America. However the majority of the province lies in an interior belt where the radon risk is typical of other areas of North America. There are patches within that belt where both the terrestrial gamma and radon risk are relatively high. Further study is required to delineate these areas and all homeowners in these areas should make it a priority to test their homes. Modern changes to house construction have been reported to increase radon concentration in the living area(10). Although we have also seen this in the Castlegar study, some construction techniques such as supplying combustion area and well built basements are tending to mitigate this trend. There is some concern that annual variations in household radon levels may also have to be investigated(10). At this time, fifteen additional regional radon surveys are being carried out. These additional surveys should allow us to more accurately delineate the geological, meterological, and construction parameters that impact on radon levels in the province of British Columbia.

ACKNOWLEDGEMENTS

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