CHAPTER 1
INTRODUCTION

1.1 Introduction

The Earth's crust contains small amounts of naturally radioactive materials, such as uranium and thorium, that vary greatly with geographic and geological location and with soil type. Uranium and thorium decay to other radioactive atoms, including radium, which then decay to radon gas. Since radon is a colorless, odorless, and tasteless inert gas, its long half-life of 3.825 days permits it to escape into the atmosphere and dwellings. Radon emits alpha radiation and also continuously decays to its progenies. These progenies attach to dust particles in the air shortly after they are formed and are, thus, natural components of the air we breathe. Breathing air that contains radon will increase the risk of getting lung cancer (Bodansky, 1987). Therefore, finding the relationship between indoor radon concentration and soil-gas radon concentration as well as other soil parameters are important. This is in order that these relationships, if can be established, will be useful tools for indoor radon prediction prior to housing construction.

1.2 Literature Review

Wattananikorn and others (1988) determined soil-gas radon concentrations in the vicinity of Linking and Toho Mines, Ban Shimplee, Tambon Doi Tao, Amphoe Doi Tao, Changwat Chiang Mai by using cellulose nitrate films (LR-115 type II). The purepose of this study was to make an exploration for uranium minerals. It has been found that there were many anomalous zones of alpha track density from radon over the area. The anomalous zones having values six times greater than that of the background were found in 17 stations, cover area approximately 30,000 m^2. The maximum track density occurs at a site about 200 m east of the summit of Doi Pae Po Mak, having the value about 35 times that of the background. A small minerals vein has been subsequently discovered close to this site. The vein is about 10 cm thick, consists of quartz, fluorite and torbernite. The maximum uranium concentration in a sample from this vein is as much as 1.4 percents.

Wattananikorn and Sri-unyu (1990) investigated indoor radon concentration in dwellings at Ban Shimplee, Tambon Doi Tao, Amphoe Doi Tao, Changwat Chiang Mai. This area is closed to uraniferous fluorite vien mentioned in previous paragraph. Indoor radon concentrations were found to vary from season to season, having the highest value of 154 ± 51 $Bq.m^{-3}$ in winter and lowest value of 50 ± 12 $Bq.m^{-3}$ in summer. In the rainy season the concentration was 65 ± 23 $Bq.m^{-3}$. There is a large discrepancy in radon concentrations from house to house in winter. These phenomena believed to be influenced primarily by the degree of ground moisture content and less air movement during the winter comparing to the summer and rainy season. The annual average radon concentrations in these dwelling vary from 56 to 163 $Bq.m^{-3}$, having an arithmetic mean of 89 ± 22 $Bq.m^{-3}$, compared to the arithmetic mean of 37 ± 7 $Bq.m^{-3}$ found from dwellings in the Chiang Mai municipality. This must have caused by more radium content in the ground at ban Shimplee.

Damjaer and Korsbech (1992) showed that the permeability of soil-gas is one of the factors that determine the radon source potential of a local site. They designed and tested a permeability probe for in situ measurements. The head of this probe is 16 millimeters in diameter and 150 millimeters long. Measurements were made in a 20-millimeter diameter borehole that was cased with a plastic tube. The permeability probe was operated by injecting air into the formation under constant pressure. Their study summarized the theoretical framework for the permeability measurement and gave the shape factor for the probe. The instrumentation was described and a laboratory calibration facility was designed and tested. The measured shape factor for the probe in the calibration facility was found to agree well with the calculated value. A map was made of the permeability to a depth of 2 meters. The results were summarized and compared with a geological description of the strata. It was possible to correlate between the measured permeability and the applied pressure difference.

Surbeck (1993) studied soil-gas radon concentrations simultaneously with soil gas permeability, an important factor determining underground radon transport. The simultaneous measurement seemed to simplify the interpretation of soil-radon concentration data in relation to indoor radon values.

Hubbard and Hagberg (1996) studied the time variation of indoor radon and radon in the soil gas in the earth under, and near, an occupied house. Since the spring of 1993, the soil-gas radon concentration was measured as a time series, at a depth of 1 meter in three locations under, and near, a research house near Stockholm, Sweden. Indoor radon and environmental parameters were also measured. The result discussed the degree to which the house versus the weather interacts with, and influences, the soil-gas radon concentration, and how much the influence of these two factors on the soil-gas radon content varies with season and location. Strong correlation with barometric pressure and outdoor temperature was found. The maximum soil-gas concentrations occurred during the summer months and the minimum occurred during the winter, with the summer and winter levels differing by a factor of 2 to 3, depending on location. Changes in the 24-hour indoor radon concentration correlated well with the changes in the soil radon. The degree to which soil-gas radon content may be used as an indicator of indoor radon contamination was also discussed.

Kunz and others (1996) studied the relationship between indoor radon concentration, soil-gas concentration, and soil-gas permeability in 18 schools in New York, U.S.A. Two of these schools were located within 200 meters of each other and were situated on similar soil. However, one school had higher indoor radon concentration levels than the other. Because these two schools were sitting on the same rock formation, they could be expected to have only a limited range of soil-gas radon concentration and soil-gas permeability and have only a small variation in soil radon production rate. This was not the case and is an indication of the difficulty of determining the relationship between indoor radon concentration, soil-gas radon concentration, and soil-gas permeability.

Mosley (1996) showed that permeability of soil is an important parameter in determining the rate of transport and entry of radon from soil to indoor environments. This parameter is usually measured in the field by inserting a cylindrical tube with a short porous section into soil and measuring the flow rates over a range of applied pressure. Mathematical relationships are used to analyze the resulting data. All the data can be analyzed with a single curve when appropriate shape factors are used. Mosley concluded that the effective permeability in soil differs by two orders of magnitude in a 1-meter thick soil column when the measurement locations differ by only 35 centimeters. The effective permeability is obtained by inverting the arithmetic average of the reciprocal values of the position-dependent permeability.

Varley and Flowers (1998) studied radon levels and investigated the correlation between indoor radon concentration and soil-gas radon concentration and soil-gas permeability from three difference geological conditions. The results of this study suggested that soil-gas measurements could produce, at best, only a very approximate estimate of the proportion of houses at risk within a geographical region.

Talbot and others (1998) collected soil-gas samples from sites in Derbyshire and Northamtonshire in England and found contradictory results indicating that soil-gas radon concentration was a good indicator of indoor radon risk in the both areas. However, in Northamtonshire, soil-gas radon concentration discriminated more effectively between sites with different radon potential if soil-gas permeability was also taken into account.

Virk (1998) investigated soil-gas radon and indoor radon of dwellings near radioactive sites that were known uranium occurrences in Himachal Pradesh in India. Both active and passive techniques were used. The results of the active technique in soil-gas radon surveys were highly variable, changing as much as 38 times over a distance of 500 meters. Indoor radon levels for two villages measured by the active technique showed a large variation from house to house and from summer to winter. Integrated track-etch radon values, using a passive technique (LR-115 type II), were measured from August 1997 to December 1997. The arithmetic mean for two villages that were close to radioactive sites varied from 145 ± 12 to 165 ± 9 $Bq.m^{-3}$. These results showed that values varied from house to house, depending upon the season, nature of the soil, building materials, ventilation, and type of flooring used.

Kapinska and others (2002) reported a comparison of indoor concentrations in dwellings and soil-gas radon concentration in the area of two geological formations in Poland. The medium radon potential, as defined from the values of soil-gas radon concentration, was reflected in higher-than-average values of indoor radon concentration in the area.

1.3 Objectives of this study

The objectives of this study are:

1.3.1 To investigate soil-gas radon concentration, soil permeability, and indoor radon concentration in an area near a radioactive site at Ban Shimplee, Tambon Doi Tao, Amphoe Doi Tao, Changwat Chiang Mai.

1.3.2 To study the relationship between indoor radon concentration and soil-gas radon concentration, soil-gas permeability, the product of soil-gas radon concentration and soil-gas permeability and the relationship between indoor radon concentration and thoron/radon ratio during different seasons and different depths.

1.3.3 To assess the potential of the relationship between soil-gas radon concentration and soil-gas permeability for the prediction of indoor radon concentration.

1.4 Area and method of study

The village to be studied is Ban Shimplee (Figures 1.1 and 1.2). It is about 2 kilometers west of an abandoned uraniferous fluorite mine and about 134 kilometers south of Chiang Mai city in northern Thailand. Ban Shimplee is situated on Quaternary alluvium that consists of gravel, sand, silt, and clay derived from Triassic muscovite-biotite granite and quartz veins (Figure 1.3).

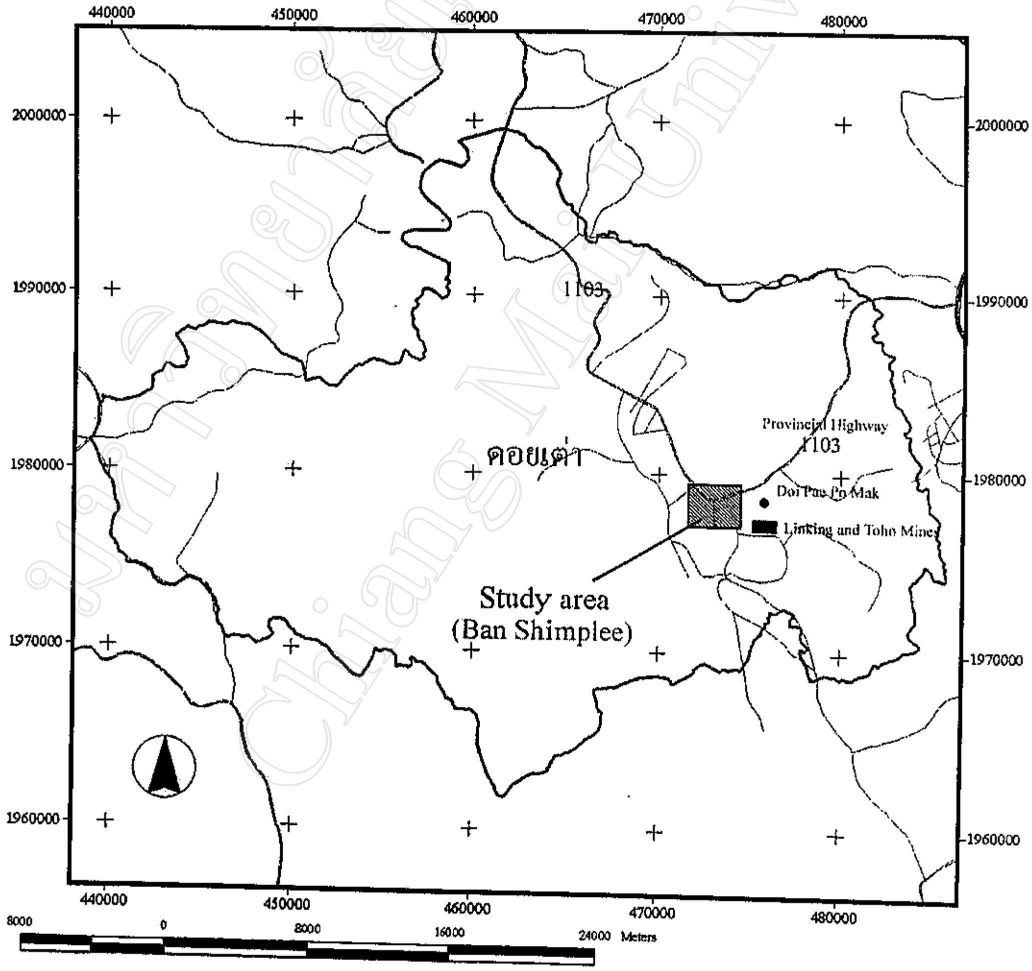

Figure 1.1 Map of Amphoe Doi Tao, showing the study area

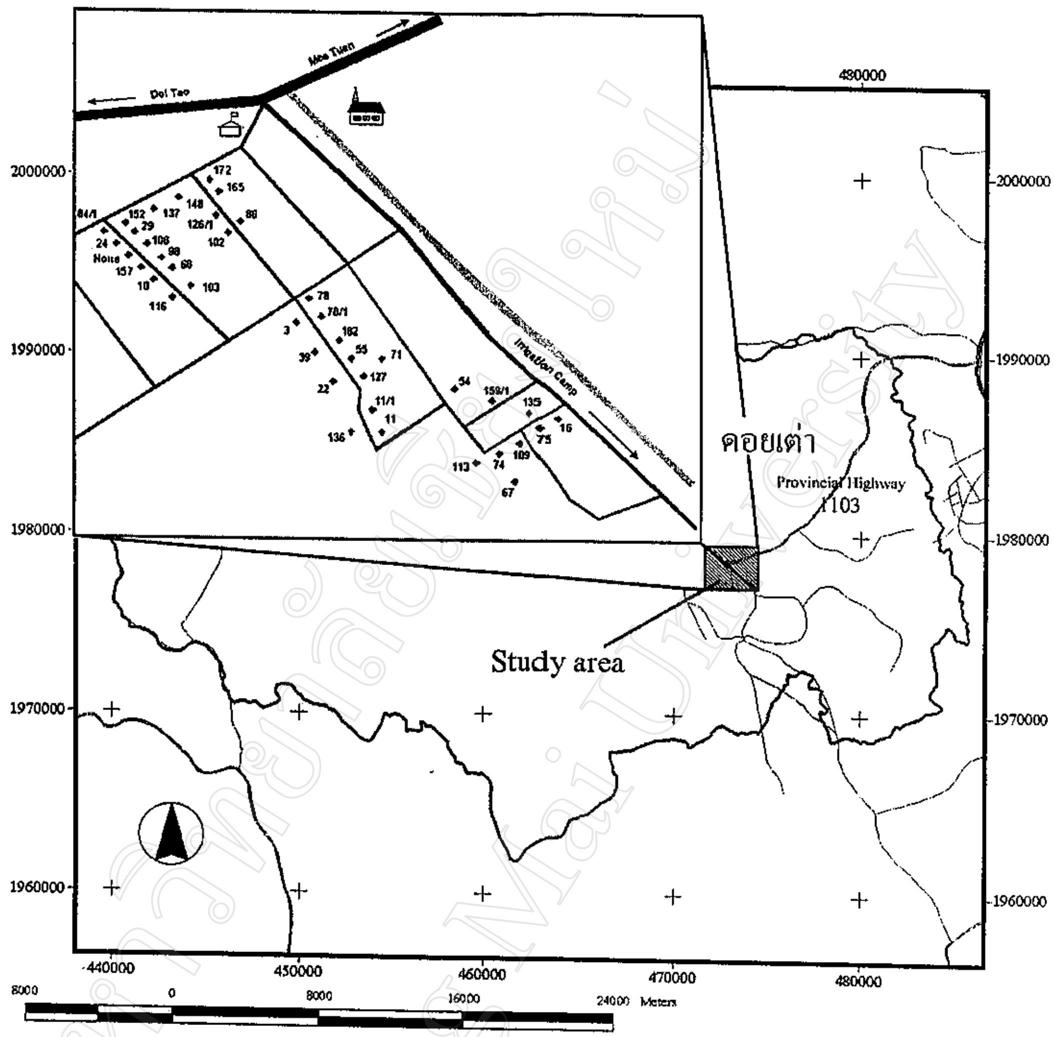

Figure 1.2 Study area and locations of surveyed houses (The number shown in the map are house's ID number)

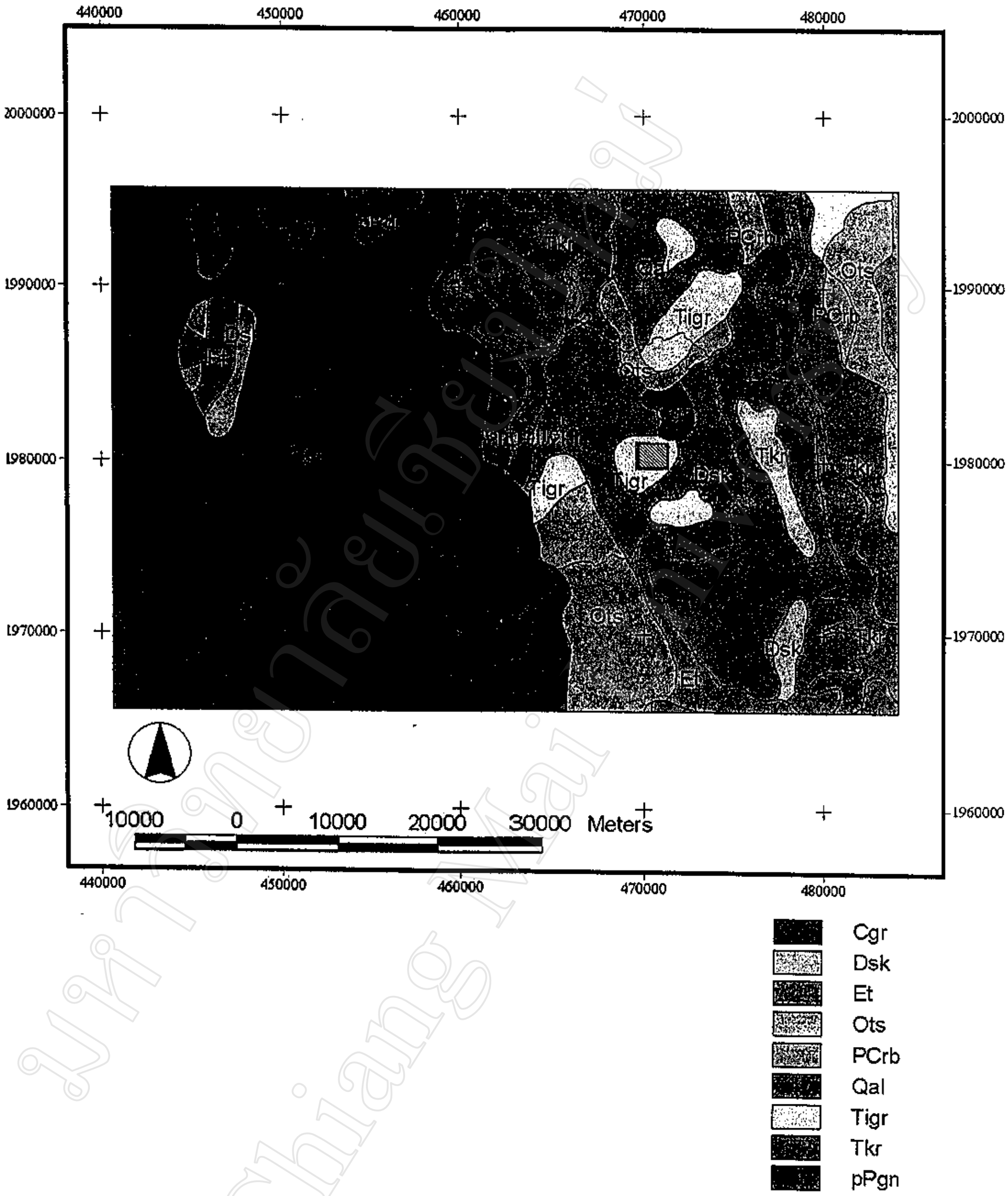

Figure 1.3 Geological map of Amphoe Doi Tao

Rock descriptions	
	A group of shale, sandstone, sandy shale, in many places metamotphosed to phyllite, argillite, quartzite and slate also bedded limestone locally present.
Qal	Alluvium, eluvium, valleyfill and river gravel
Ots	Dark gray massive limestone interbedded with dark greenish gray calcareous shale and sandy shale
pRgn	Gniess and Schist
Cgr	Granite
Trgr	Granite, Granodiorite
PCrb	Massive light gray limestone interbedded with shale sandstone, mudstone, conglomerate and volcanic tuff
Et	Red to bround arenaceous and quartzitic sandstone at Tarutao Island, red shale and sandy shale at Khao Luang, Nakhon Si Thammarat
Tkr	Semiconsolidated fluvialtile, marine and nonmarine deposits of clay, sand, marl, bituminous shale and lignite, inclufing terrace deposits of the north

Table 1.1 Legend of rock

1.5 Methodology and scope of this study

The scope and method of this study are designed and arranged into two main phases, as described below.

1.5.1 Field measurements phase

Indoor radon, soil-gas radon, and thoron concentration and soil-gas permeability will be measured. This phase will concentrate on field work. Soil-gas radon and thoron, as well as soil-gas permeability, will be obtained at two depths, 0.5-meter and 1.0-meter, for each house. These investigations will cover 40 houses.

Indoor radon concentration will be measured employing a time-integrated technique, while soil-gas radon concentration will be obtained using a grab sampling technique. The grab sampling technique is done by inserting a needle probe into the soil and pumping soil-gas into the radon counting system, counting it, and making some corrections. Both of these measurements will be taken in winter and summer. Soil-gas permeability will be measured by inserting a cylinder into the soil and then measuring flow rates of air that result from a range of applied pressure.

1.5.2 Processing and analysis phase

This phase will involve finding the relationships between indoor radon concentrations and soil-gas radon concentrations, soil-gas permeability, product of soil-gas radon concentration and soil-gas permeability, and thoron/radon ratio from the two measurement depths. This should result in understanding the source of indoor radon and will be used to interpret the radon potential as related to the geological environment of the investigated area. Also, the results should indicate the indoor radon risk of the area referenced to U. S. Environmental Protection Agency action level of 148 Bq.m^{-3} of indoor radon concentration. Figure 1.4 is an example radon risk diagram which may be used in this study.

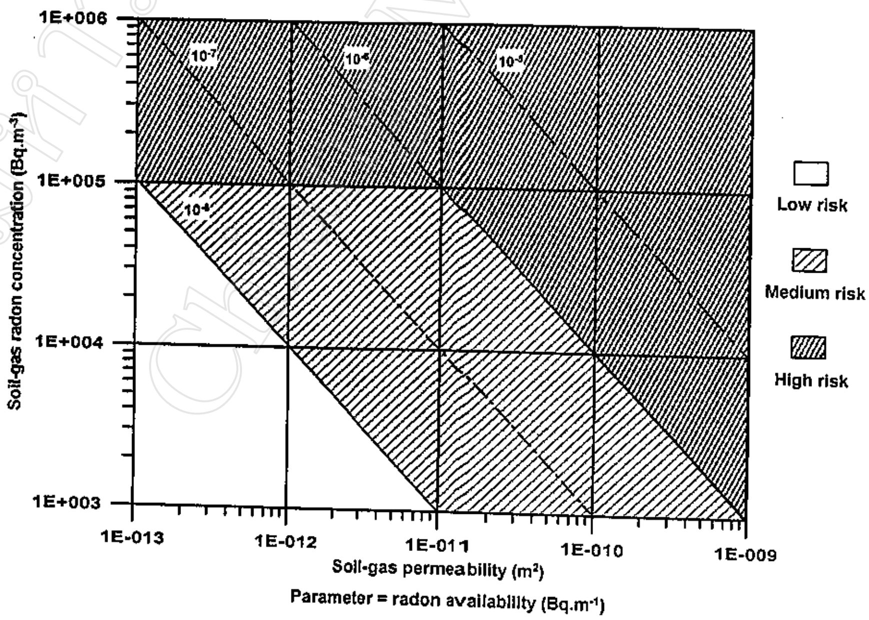

Figure 1.4 A sample of radon risk diagram (Surbeck, 1993)

1.6 Usefulness of the research

1.6.1 To obtain an understanding of relationships between indoor radon concentrations and soil-gas radon concentration, soil-gas permeability and thoron/radon ratio. Also to understand the calculation product of soil-gas radon concentration and permeability as an indication of radon availability and to correlate this factor with indoor radon concentration.

1.6.2 The results of this thesis investigation may be used to develop a site investigation method for potentially high indoor radon concentration areas and can be applied to the investigation of areas prior to establishing residential communities.