CHAPTER 1

INTRODUCTION

1.1 Statement and significance of the problem

In the past, soil gas radon concentrations have been recorded near active faults in search of possible precursors to earthquakes. However, changes in radon concentration with time at a particular site do not depend only on stress buildup associated with a particular earthquake, but these changes can also be caused by a variation of weather conditions. Therefore, before soil gas radon variations can be used as a reliable tool for earthquake prediction, an understanding of the interaction between meteorological variables and soil gas radon is essential. To find such interaction effectively, a signal processing technique is needed.

1.2 Literature review

Radon was reportedly discovered by F.E. Dorn in 1900. Over the years the bulk of radon research has been done on the following: generation and release of radon from its site of formation; radon's movement through media remote from the site of formation, e.g., soil or air; effects of atmospheric variables on radon concentration; and the application of radon techniques to uranium exploration. In addition, radon characteristics of lunar material and the potential of a radon method for earthquake prediction have also been investigated.

The first observation of changes in the radon concentration of ground water was reported prior to the 1966 Tashkent earthquake (Ulomov and Mavashev, 1967). These changes have been considered to be a plausible precursory earthquake phenomenon. Since there was a systematic increase in well water radon prior to the 1966 Tashkent earthquake, radon isotopes have been extensively monitored in many seismic areas of the world for the purpose of earthquake prediction. Many precursory changes of radon have been observed at favorably located stations as far away as several hundred kilometers from their respective epicenter.

King (1978) studied soil gas radon emanation on the San Andreas fault. He found that subsurface radon emanation monitored in shallow dry holes along an active segment of the San Andreas fault in central California showed spatially coherent large temporal variations that seemed to correlate with local seismicity.

Asada (1982) reported that changes in radon concentration have occurred prior to earthquakes in China. For example, radon concentrations increased prior to the Songan-Pingwu earthquake in China. The increase in radon concentration began two to three years before the earthquake and continued until just before the earthquake. In addition, the amplitude of change in radon concentration ranged from 20-100 percent. There was also a correlation between the epicenter distance, the magnitude of change, and the time the radon concentration change was observed. The closer the radon to the epicenter, the greater the amplitude of the concentration changed, and the earlier the concentration change appeared.

Vulkan and Steinitz (1993) observed soil gas radon anomalies along the western shore of the Dead Sea. The results of the statistical analysis suggested that radon events are preferentially associated with earthquakes in the Dead Sea Rift, close to Enot Zuqim.

King and others (1993) observed radon content of soil gas from 1975 to 1985 at a network of 60 stations along several active faults in central California. The recorded radon concentrations showed large spatial differences not attributable to differences in uranium content of local soil. The radon data also showed large temporal variations, part of which were seasonal in appearance. The nonseasonal components of the radon variations may correlate with occurrences of large local earthquakes.

Virk and Singh (1994) observed radon concentration in both soil and ground water. The results showed that about a week before the Uttarkaski earthquake occurred on October 20, 1991, in the Garhwal Himalayas, about 450 km from recording stations in the Kangra valley and about 450 km from Amritsar, radon anomalies were recorded at all sites. This clearly demonstrated that radon changes are related to earthquakes.

Igarashi and others (1995) found that radon concentration in ground water increased for several month before the 1995 southern Hyogo Prefecture (Kobe) earthquake on January 17, 1995.

Although the amount of radon concentration in soil may be controlled by earthquake mechanisms, there are a number of climatic and meteorological controls as well. These climatic and meteorological controls may have hindered the use of soil gas radon variations as an earthquake forecasting tool in some other areas in the past, especially for lower magnitude earthquakes. The climatic and meteorological variables influencing soil gas radon concentration are soil moisture, precipitation, barometric pressure, soil and air temperature, and capping effect. A summary of the historical finding on the effects of each of these factors follows.

Soil Moisture and Precipitation: Previous investigators observed that soil moisture has a major impact on observed soil gas radon concentrations. Baranov and Novitskaya (1960) observed an increase in emanation of radon from uranium minerals when the humidity of the air increased. Tanner (1980) suggested that water is the most important agent in enabling radon to escape from solid material because the water surrounding soil particles absorbs the kinetic energy of the recoiled radon atom and prevents the radon atom from burying itself in an adjacent soil grain. Damkjaer and Korsbech (1985) found that radon emanation rates increase with an increase in soil moisture of up to 15 to 17 percent by weight. At greater amounts of moisture, the emanation rate decreases.

Barometric Pressure: Low barometric pressure causes an increase in soil gas radon concentration in the upper few meters of soil. Low pressure causes soil gas to rise toward the surface from greater depths, where the soil gas radon concentrations are generally higher because of less dilution by atmospheric air. High pressure has the opposite effect and pushes atmospheric air into the ground, diluting the soil gas. Kovach (1945) observed variations caused by barometric pressure to a depth of 2 m. Kraner and others (1964) noted that barometric pressure influences soil gas radon concentrations to a depth of 240 m.

Soil Temperature and Air Temperature: There are conflicts over observations concerning the effects of soil temperatures on radon concentrations. Kovach (1945) suggested that soil temperature has little or no effect on soil gas radon content. However, Kovach (1946) also observed higher radon emanation when the temperature was low. Ball and others (1983) suggested that radon concentration may be correlated with soil temperature and, to a lesser extent, with air temperature. Jaacks (1984) observed a negative correlation between both soil and air temperatures and radon concentrations and noted that temperature gradients within the soil, or between the soil and air, may induce convective soil gas transport.

Capping Effect: High soil moisture can cause expandable lattice clays (smectites) to swell and this swellling lowers the permeability of the soil. As pores are filled with water, the gas permeability is progressively reduced. As the top layer of the soil becomes saturated, soil gas flow is restricted. This produces a cap which prevents mixing of soil gas with the atmosphere. This capping may reduce, or block, the effects of barometric pressure, or wind, on soil gas radon concentration. Kovach (1946) found that water frozen within the soil produced an effective cap that retarded radon flux to the atmosphere; resulted in an increase in soil gas radon concentrations. Kraner and others (1964) found that heavy precipitation could produce a cap that caused radon concentrations to reach levels in the near-surface equaled to those found at greater depths.

Asher-Bolinder and others (1993) found that radon concentrations correlate with relative humidity, air and soil temperatures, and the difference between these temperatures. These factors are interrelated but it is difficult to determine the magnitudes of their individual influences.

It can, therefore, be concluded from the above information that radon gas measured in soils or in the weathered layer of the substratum can be strongly altered by environmental conditions, such as atmospheric pressure, soil and air temperature, and precipitation or moisture. An accurate description of the effect of environmental variables is necessary in order to decipher information from deeper phenomena.

Pinault and Baubron (1996) modeled variations in radon concentration, used as a gas flow tracer, using a new approach based on signal processing techniques in order to express impulse responses from multivariable time series. A general formulation and the solution of the inverse problem that consists of calculating some parameters as functions of a few different variables were proposed. This method may be useful in separating radon anomalies caused by meteorological factors from field radon data. This work employed such a technique during this study. It was expected that the residual radon data obtained after separation could be used more effectively for earthquake prediction.

1.3 Objectives

The objectives of this work are:

(a) To determine the effects of meteorological variances (soil temperature, precipitation and barometric pressure) on soil gas radon concentrations using a signal processing technique.

(b) To determine the correlation between residual radon anomalies (the meteorological variation corrected anomalies) with earthquakes occurrence in northern Thailand and surrounding areas.

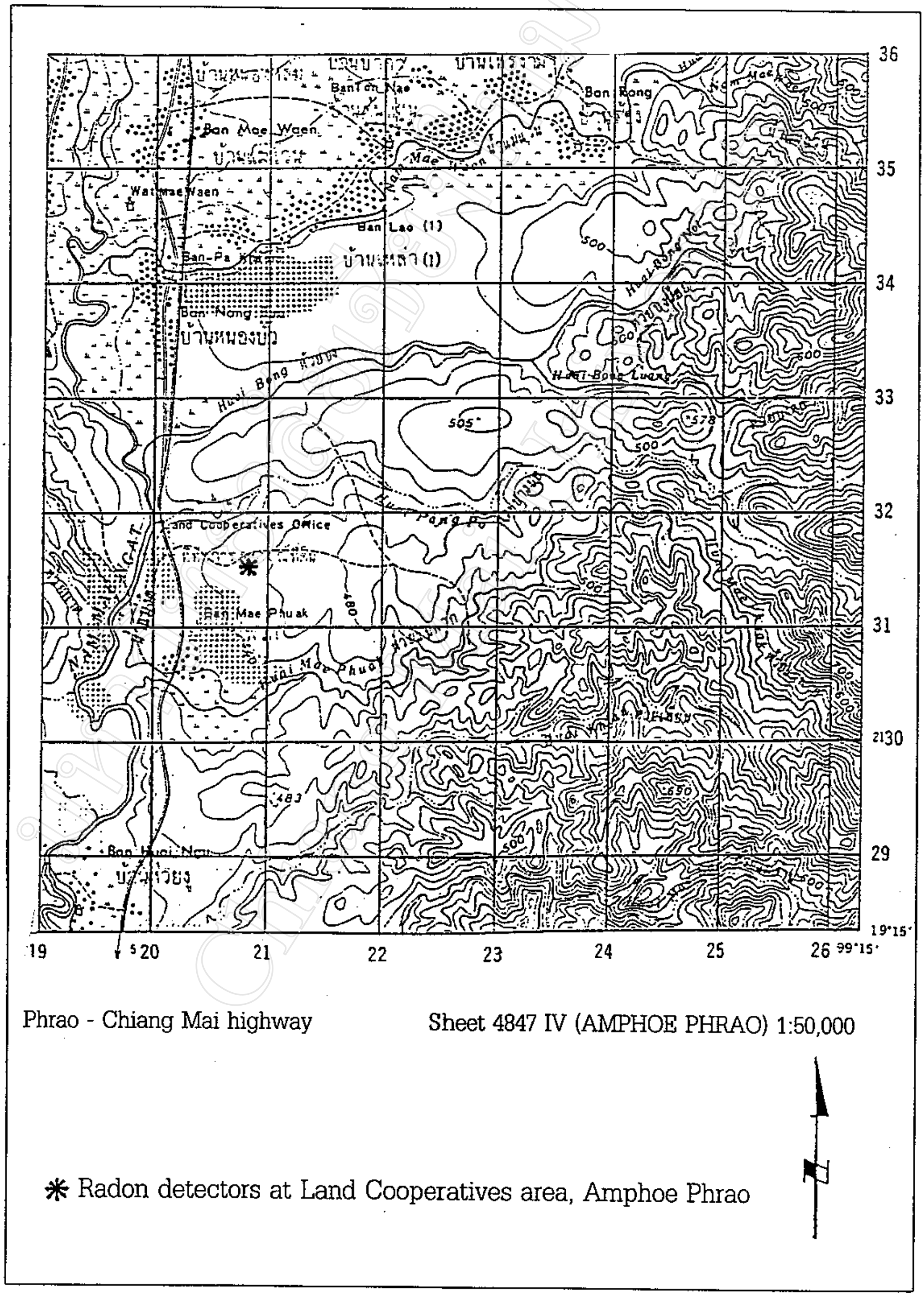
1.4 Area and Method of study

1.4.1 Geology of the study area

An area suitable for installation of radon detectors needed to be selected. This area should locate near fault zone and a meteorological station, and had to be easily accessible so that a comparison between radon data and meteorological data and earthquake activity could be made. Using these criteria, the Land Cooperatives area at Amphoe Phrao was selected for this study (Figure 1.4.1a). The site is located at longtitude 99° 11.8' E, latitude 19° 16.8' N (from GPS measurement) on flatlying, undisturbed, and unirrgated land, and is about 450 m above sea level.

Figures 1.4.1b and 1.4.1c show the geology of study area and its surrounding area. The radon detectors were located at a site within a major north-south trending syncline. The faults occur in the axial area of the syncline and also trend generally north-south, though minor faults have an east-west component. The syncline involves mainly Lower and Upper Carboniferous, Devonian, and Silurian coarse clastic rocks that dip westward off the flank of a large granitic intrusion to the east. The west flank of the syncline becomes complexly folded away from the synclinal axis. Neogene sandstone, conglomerate, and shale unconformably overlie the Carboniferous strata in the syncline axial area and, in turn, are unconformably overlain by Quaternary alluvial deposits in stream and river courses. The radon detectors site is an area of Neogene deposits and is east of a possible active fault that controls the course of the Ngat River, which flows in the axial area of the syncline.

The relation of the study area to major faults in northern Thailand is shown in Figure 1.4.1d.



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✱ Radon detectors at Land Cooperatives area, Amphoe Phrao

Figure 1.4.1a Location map of the study area.

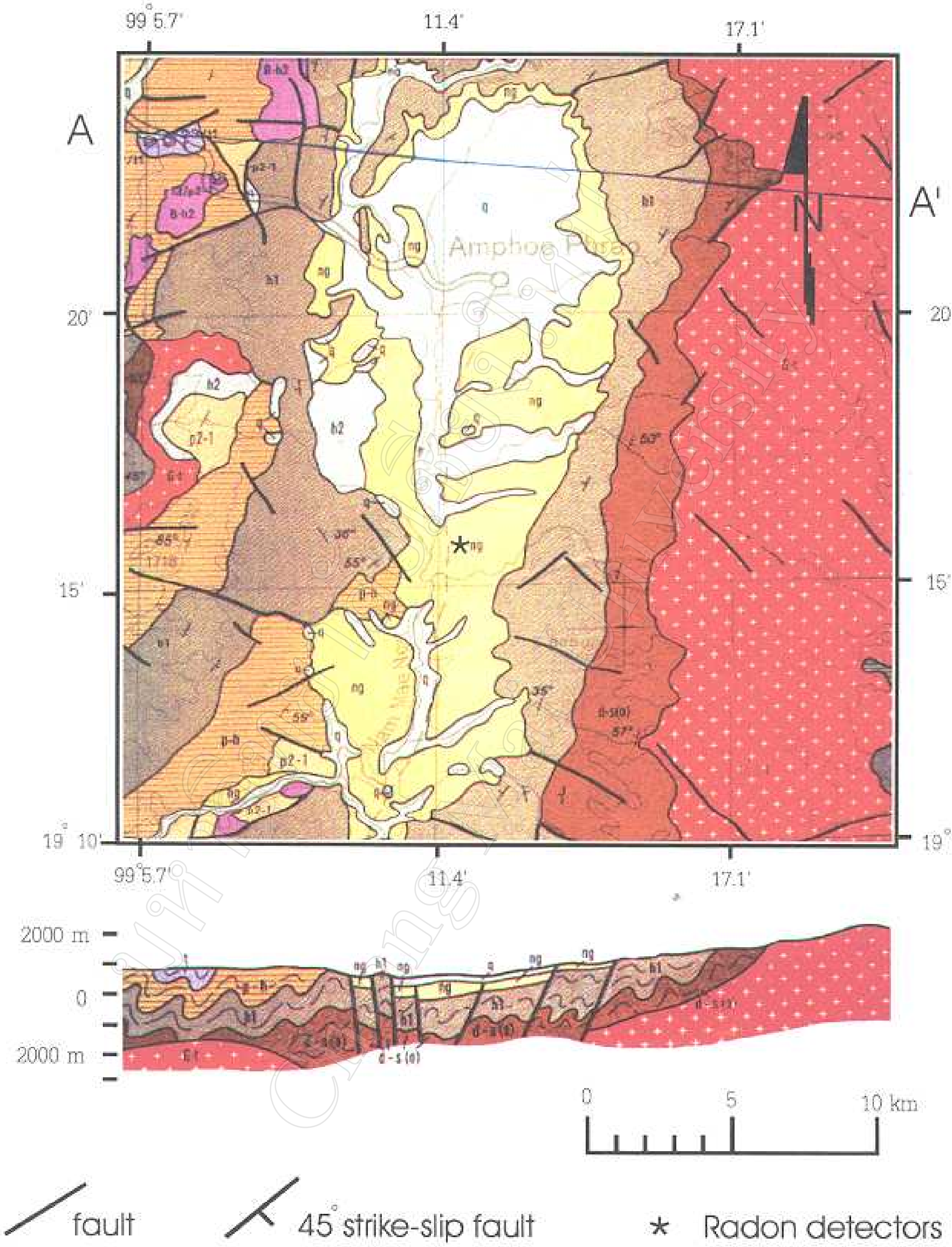
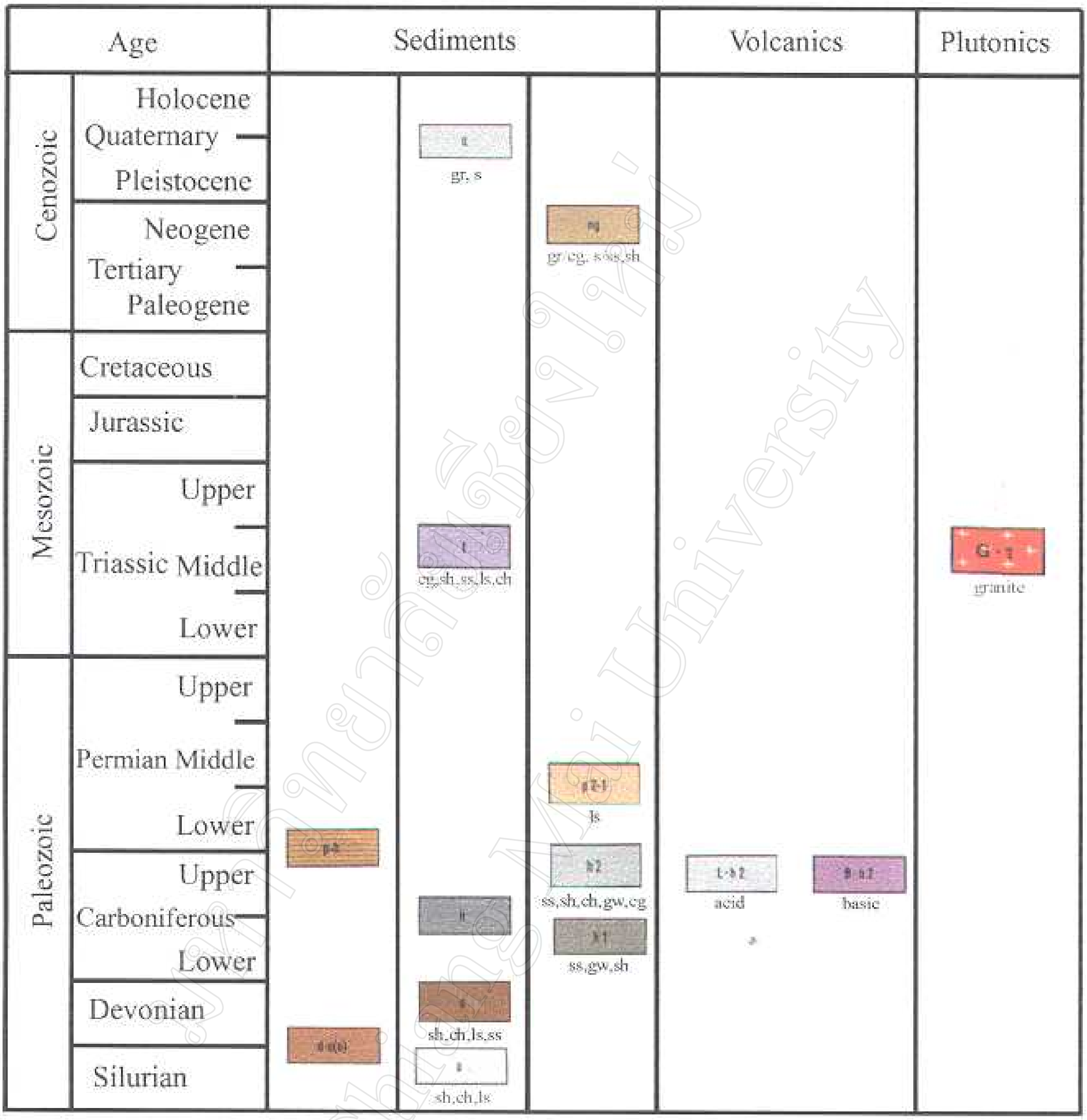


Figure 1.4.1b Geological map of the study area.
(from Baum and Hahn, 1977)



Facies: ch- chert s-sand ls-limestone cg-conglomerate
gr-gravel sh-shale ss-sandstone gw-greywacke

Figure 1.4.1c Legend.

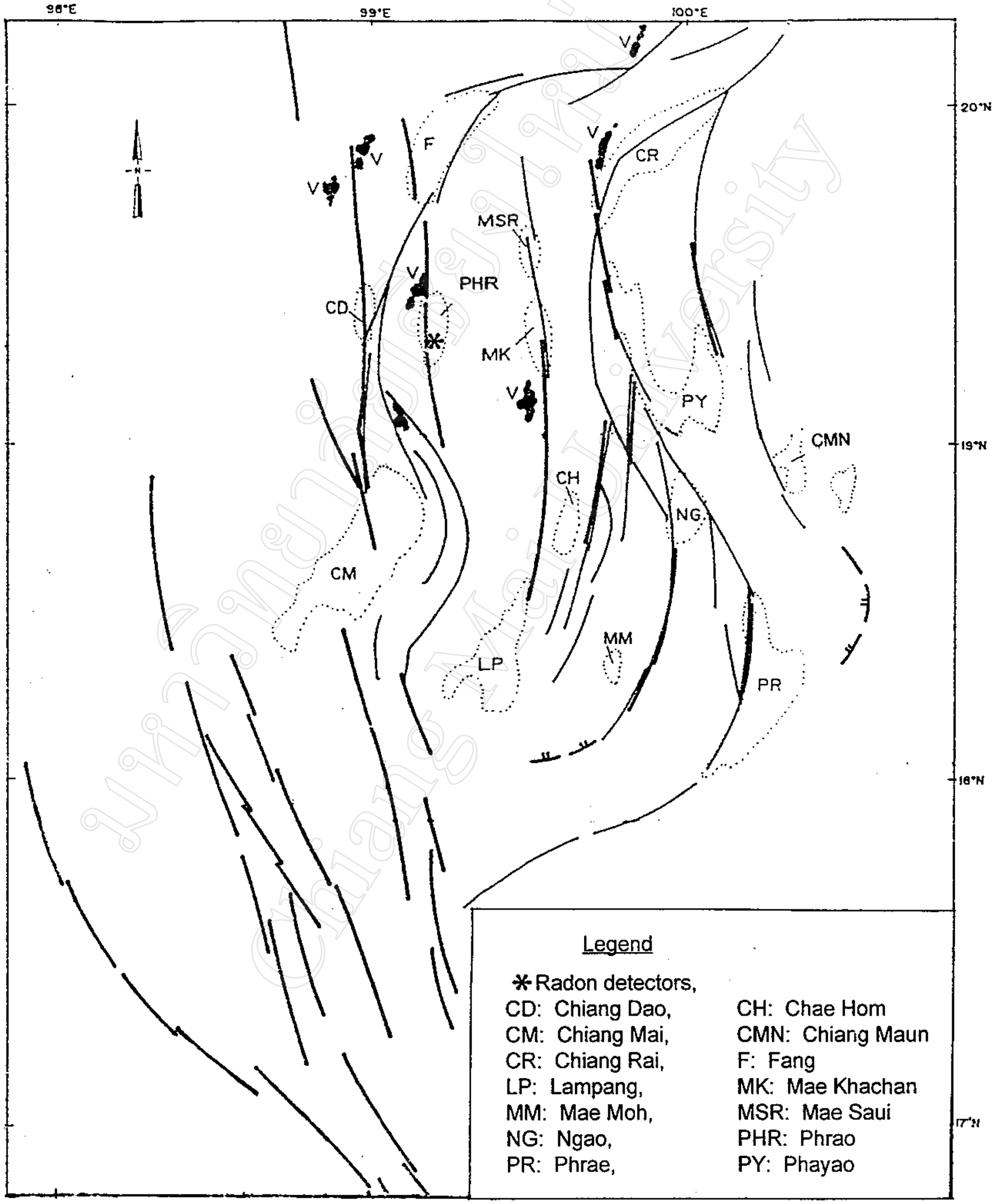


Figure 1.4.1d Lineament pattern of the Northern Thailand region and Tertiary sediment Basins. (from Chantaramee and others, 1994)

1.4.2 Measuring station

Soil gas radon concentrations at the Land Cooperatives area were determined by measuring the α-decay rate of radon with cellulose nitrate film detectors (Kodak LR-115 type 2). These detectors were placed at ten stations inside small holes of 1 m and 0.5 m depths.

The configuration of these measuring stations is shown in Figure 1.4.2. The exposure time of each detector was seven days before measurements were repeated.

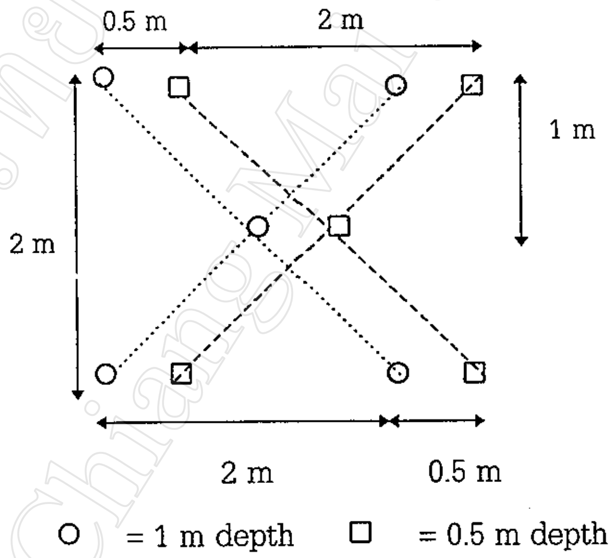


Figure 1.4.2 Station locations.

Soil samples at the Land Cooperatives area were also collected at every measuring station. After that, radon concentrations of the samples were measured in a laboratory for later analysis.

1.4.3 Method of study

Using the mathematical model of Pinault and Baubron (1996), the variation of radon concentration due to meteorological factors was subtracted from the measured radon data to yield residual anomalies. These residual radon anomalies were compared with earthquake data, and then analyzed and conclusions were made.