CHAPTER IV

DISCUSSION AND INTERPRETATION

Field and petrographic observations have given information about the type and distribution as well as the relationship of igneous rocks and metamorphic rocks in the Khao Phra Ngam area. The intrusion of diorite had thermally metamorphosed the host rocks of the Khao Khad Formation which is composed predominantly thick bedded limestone and dolomitic limestone intercalated with chert nodules or beds. Contact metamorphism and metasomaticsm took place and a series of metamorphic zones have been observed and classified based on the mineral assemblages. A systematic zonal arrangement of rock types observed from the host rock side to the igneous rock side are; marble with associated diopsidic marble, wollastonite skarn, garnet-clinopyroxene skarn, garnet skarn and contaminated diorite. A white zone of predominantly wollastonite and diopside assemblage can be observed rimming around chert nodules and chert beds. The presence of both marble and skarns near diorite suggest a contact metamorphic origin for the high temperature marble and skarn minerals.

Form the above zonal arrangement of marble and skarn rocks, we can decipher the evolution of skarn formation at Khao Phra Ngam area into 3 stages; 1) metamorphic (isochemical) stage, 2) metasomatic stage and 3) retrograde alteration stage.

1) Metamorphic (isochemical) stage was probably took place shortly after the intrusion of diorite. This stage was formed in response to the emplacement of diorite into the carbonate rocks of Khao Khad Formation with little or no introduction of chemical component (only water might be released from the intrusive and CO_2 from the carbonate rocks). The rock formed in this stage was controlled predominantly by temperature and the composition and texture of the host rocks. As such, the massive to thick bedded limestone

protolith was transformed into marble in which most of the carbonaceous matter was converted into graphite. Wherever there were interbedded silty dolomitic limestone, a zone of diopsidic marble was formed according to the reaction (3-1).

An excellent example of local compositional control on calc-silicate mineralogy was observed as a white zone of wollastonite + diopside assemblage (reaction skarn or bimetasomatic skarn) surrounding chert nodules or rimming chert beds. The local exchange of chemical component of dissimilar lithologies (i.e., quartz from the chert and calcite and dolomite from the marble) to form wollastonite and diopside according to the reaction (3-2) is rather obvious. This local exchange phenomena could be formed during the first stage.

2) Metasomatic stage was characterized by the formation of wollastonite skarn, garnet-clinopyroxene skarn, garnet skarn and contaminated diorite. The development of these zonal skarns was likely to response to the mobility of elements as small a scale exchange of CO_2, Ca and Mg rich fluid from the marble and Al, Si, Fe–rich fluid from the diorite. The Al, Si and Fe contents decrease gradually from igneous rock side to the marble side and concentrations of Ca and CO_2 increase progressively away from the intrusive (i.e. the good mobility Si combines with Ca to yield wollastonite, the moderate mobility of Al, Mg and Fe produce diopside and garnet, respectively). These mineralogical zonations were likely to replace marble and/or diopsidic marble, and are characteristically coarse-grained, i.e. large garnet grains are quite abundant in garnet zone. The fact that the mineralogy of those skarn is simple and not reflecting the composition or texture of the host marble, and that the zonations are gradational in which garnet tends to replace other minerals. It is likely that these skarn were formed during the prograde metasomatic stage of diorite intrusion. Traces of copper mineralization, i.e. chalcopyrite and bornite, in wollastonite-diopside skarn at Wat Thung Singto, might have been formed during this stage. It is also likely that formation of magnetite (later altered to hematite) ore lens, veins or dikes and

irregular bodies in the garnet skarn and garnet-clinopyroxene skarn at Khao Thab Kwai was probably taken place during or slightly after this stage.

3). Retrograde alteration stage is characterized by a minor development of hydrous minerals, such as epidote, chlorite, tremolite, as well as quartz and calcite replacing the high temperature mineral assemblages. For example, epidote + chlorite + calcite replace grossular garnet, tremolite replaces diopside and quartz replaces wollastonite. This stage was probably formed during the declining temperature of the diorite intrusion and the composition of fluid was probably changed into a meteoric dominated component.

Owing to the fact that the prograde skarns were developed as a relative narrow shell surrounding the diorite intrusion, and that there was only minor development of retrograde alteration in those skarns (or minor descent of meteoric dominated fluids), and that the bedding in marble is nearly parallel to intrusive contact, it is likely that these skarns were formed at relatively deep level, i.e., deeper than shallow prophyry environments (1-2 km depth). Generally the main sulfide phase of activity usually occurs during the retrograde alteration. The fact that there is only minor development of retrograde alteration, hence the prospect for sulfide mineralization in this area is quite limited.

The skarns at Khao Phra Ngam can be called a calcic skarn due to mineralogy. In terms of ore deposits which are hosted by skarns, they can be classified as skarn deposits. Based on the most commonly used classification of skarn deposits which is on the basis of the dominant metal; i.e., Cu, Au, Pb-Zn, Fe, Mo, W and Sn (Einaudi et al. 1981a; Meinhart 1993; Einaudi 1981 b), the skarn at Khao Phra Ngam to Khao Thab Kwai area can be classified as iron $\pm$ copper skarn deposit. They are associated with diorite plutons and probably related to oceanic subduction and island-arc environment.

Finally because of the fact that the intrusions of granodiorite into the prexisting diorite, skarns and marble are in the forms of irregular veins or dikes, they are postdated the skarn formation and are unlikely to influence further skarn development as evidenced from a thin reaction rim developed along contact zone.