CHAPTER V

CONCLUSION

The main objective of the study is primarily aimed at conducting the geological and geochemical assessment of some Permo-Carboniferous carbonate sediments for industrial utilization in the southern part of the Pha Houa Xang range, Mouang Thakhek, Khammouane Province, the Lao PDR.

Numerous geological works have been earlier carried out in the Khammouane area, including regional investigation. The carbonate rocks of this region, based on study fusulinids, have been identified to be Sakmarian (Lower Permian) in age (Deprat, 1915). Some microfossil and corals are discovered in limestone at Ban Phit section and proposed to be of Upper Visean-Serpukhovian age (Saurin, 1956). Some Coral fossils from limestones at the area near Ban Nakhieu, Ban Nahi and Ban Luang indicated Lower Carboniferous age (Saurin, 1961). By the identification of a fosciclar rugosa from quarry limestones at 13 kilometres easthwards from Thakhek indicates Carboniferous age (Fontaine, 1961). Pham Cu Tian (1991) compiled the 1:1,000.000 scale geological map of Indochina on the basis of existing data, satellite image, photogeological work and field survey and finally proposed the rock unit composing of limestone, chert, siltstone, shale to be of Permo-Carboniferous age. Kondratiev, et al. (1984) interpreted satellite images and aerial photograph for the compiling of 1:1,000,000 scale photogeological map of the Lao PDR and rocks of the study area and its vicinity have been assigned Permo-Carboniferous in age. In current geological and mineral occurences map of the Lao PDR, the carbonate rocks of the study area and its vicinity are referred to as Permo-Carboniferous age. Siam Cement Public Company.(1995) reported rock unit in the study area and its vicinity to be composed of interbedded limestone and bedded chert, light to grey colour; very thick-bedded limestone light to brownish grey; light to grey dolomite and dolomitic limestone. Tran Van Ban et al (2000) carried out mineral investigation and geological mapping of the 1:200,000 scale of the mid central region of the Lao PDR, the carbonate rocks are named Khammouane Formation, which is further divided into two

parts: the lower part comprises of black grey thin-bedded limestone with pockets of siliceous rocks, and the upper part consists of light grey fine -grained , in some places dolomitized limestone with very thick-bedded limestone.

As defined by under this study, carbonate rocks in the study area are lithologically divided into 3 units, namely, A, B and C. They are summarised as follows:

The unit A consists of dark grey, fine-to medium-grained, very thick-bedded dolomitic limestones. This rock unit is considered as the bottommost of stratigraphic succession in the study area. The upper boundary of this unit is overlain conformably by the rock unit B. The thickness of the rock unit A is approximately 20 metres. Generally, these rocks are distributed as isolated hills in the limited area in the northern part of the study area, covering approximately 1 square kilometre.

Microscopically, two representative samples from the unit A reveal that they are essentially euhedral to subhedral rhombs of dolomite with size around 0.1 millimetre, with subordinate micrite calcite.

The X-ray diffractogram (XRD) of representative sample from this rock unit shows that dolomite and calcite are prominent

Geochemically, the rock unit A is characterised by the presence of relatively high magnesium oxide (MgO) content in the range of 4.53 to 14.36 wt.% with the average value of 9.44 wt.%. Calcium oxide (CaO) content ranges from 38.50 to 49.40 wt.% with the average value of 43.95 wt.%, while silica content (SiO_2) is relatively low.

According to the all standards, the rock unit A is considered to be possible uses only for road materials, concrete aggregates, and agricultural purposes. The reserve of this unit is not calcuted in the present study due to its limited areal extent.

The rock unit B which comprises mainly dark-grey, bedded limestone intercalated with thin-bedded, brownish-grey to dark-grey chert. This rock unit is stratigraphically present between the units A and C, covering about 2 square kilometres in the study area. It thickness is more than 80 metres.

Microscopically, the carbonate of this rock unit is composed mainly of laminated micrite rich in organic matter cutting throughout the rock texture by calcite veins.

The X-ray diffractogram (XRD) of the representative sample reveals that it is predominantly calcite with subordinate quartz.

Results of chemical analyses of rock unit B reveal that the calcium oxide content (CaO) is relatively low in range of 10.50 – 46.52 wt.% with the average value of 34.80% ; the magnesium oxide content (MgO) varies from 1.70 to 6.50 wt.%, with the average value of 2.32 wt.%, while the silica content (SiO_2) is relatively high (10.51% – 78.10%) with the average value of 30.74 wt.%.

According to a simple classification of limestone resources based on calcium carbonate content (Cox and others, 1977) the rock unit B is impure. It is not suitable for industrial purposes. However, it can be used for the purpose of road materials and concrete aggregates.

The rock unit C consists of light-grey to brownish-grey, fine-grained thick-to very thick-bedded limestones with calcite veinlets, abundant joints trending northwest-southeast and north-south directions. In the lower part of very thick-bedded limestones, stylolitites are markedly present. The rock unit C is well distributed in most parts of the study area covering about 8 square kilometres. Its thickness is approximately 140 metres.

Microscopically, the carbonates of rock unit C are generally composed predominantly of oosperite with well-developed concentric structure ooids, but some are

broken probably due to post-depositional pressure. Calcite veinlets commonly crosscut ooids, indicating post-depositional changes.

The X-ray diffractogram (XRD) of the representative samples from this rock unit reveal predominantly calcite in composition.

Chemical characteristics of the representative samples of the rock unit C display relatively better quality than those of unit A and unit B. Calcium oxide (CaO) content is relatively very high ranging from 51.01 to 55.60 wt.% with the average value of 54.79 wt.%,while the magnesium oxide (MgO) content varies from 0.08 to 8.90 wt.% with the average value of 1.11 wt.%. Silica (SiO_2) content is fair, varying from 0.02 to 1.36 wt.% with the average value of 0.27 wt.%.

Based on the specification of calcium carbonate content (Cox et al.1977), the rock unit C is classified mainly as high to very high purity. However, this rock unit is not suitable for many industrial uses due to the lowerbrightness of this rock of lesser than 55%. Generally, the brightness is required greater than 80% for paper, 80-82% for plastics and 85-93% for paper coating.

According to standards of Lorenz (1991) and Harrison (1992), the rock unit C is potentially suitable for portland cement, agriculture, ceramic (grade II), quicklime and sugar refining industries.

The possible geological resource is calculated by the software program Surfer V.6.04. These resource of each end-use limestone are as follows: porland cement – 1,381.93 mill. metric tons; agriculture – 1,381.93 mill. metric tons; ceramic (grade II) – 1,364.27 mill. metric tons ; quick lime – 1,314.04 mill. metric tons ; sugar refining – 1,087.26 mill. metric tons.

This study reveals that basic raw materials for constructions and various industrial uses can be obtained from the domestic geological materials especially the

carbonate sediments. Therefore, domestic industrialisation of many products is indeed possible and thus assisting in the import substitution.

From the field investigation, raw material resources, obtained from the rock unit C can be used for earlier mentioned industries because of their distribution, high quality and adequate quantity. The rocks are exposed with trending in the NW-SE direction as mountain ranges with more than 100 kilometres long and more than 40 kilometres wide. Accordingly, the amount of the potential raw materials is considerably adequate for any uses in this region.

In addition, these carbonate mountain ranges are located close to the main roads, and therefore, the transportation of this rock is convenient for industrial and construction purposes in the central part of the country: In addition, the transportation is also convenient in all year round by highway No13 to the all parts of the Lao PDR.

According to the information of the Industrial Promotion Division, Ministry of Industry and Handicraft, the production capacity of cement in the Lao PDR is 250,000 metric tons per annum. It is less than 50% of domestic consumption of the country. Although it is impossible so far to obtain the statistics of construction materials imported to the country including the growth rate of construction materials consumption, the future demand of these raw materials, especially cement in the Lao PDR, will be apparently increasing, for infrastructure, housing, industrial and agriculture developments.

Under the development planning of the Greater Mekong Subregion (GMS) in the near future, many projects will be constructed, particularly a second friendship bridge Savannakhet-Mukdahan, a highway No 9 (Savannakhet - Danang), highway No12 (Khammouane – Vinh). The preliminary output from this study will be most useful for this purpose. Besides, these potential raw materials may also be exported to neighbouring countries, such as, Thailand and Vietnam.

Finally, the present study is aimed at establishing the appropriate assessment as a pilot study covering the field and laboratory works to determine various properties with knowledge of the requirements of the potential consuming industries in future. This pilot study will be used as guidelines for other future development studies in the country.