CHAPTER V

CONCLUSION

Generally, almost all of the study on heavy minerals primarily aims at utilizing the result for pure scientific purposes, namely, indices of provenance, correlation criteria, etc. However, the study and evaluation of heavy minerals from the view point of economic geology are possible in some particular area. Kathu Valley and adjacent areas have been chosen as the target areas under the present investigation for both scientific purpose and economic implication.

Basically, the objectives of the present study cover the heavy mineral associations, physical properties, degree of abundance, and their interrelationships. The synthesis of mineralogical data and information will be used as guide lines to primary sources and the economic potential of some heavy minerals.

Considering from the theoretical point of view, the heavy mineral suites in a sediment are controlled by 4 main factors, notably, lithology of the source area, differential stability of heavy minerals with respect to weathering, durability of heavy minerals due to abrasion, and the hydraulic factor (shape and specific gravity of heavy mineral).

Certain species and characteristics of some heavy minerals including their association can be used to define the nature of original source rocks. The present stage of knowledge on this matter is summarized in Table 5.1.

Using the established guide-line previuosly stated, the heavy mineral samples under the present investigation which include 8 samples from the Kathu Valley area and 7 samples from adjacent area outside the Valley have been analyzed for heavy mineral associations in

Table 5.1 Heavy mineral associations and provence.

Association	Source
Apatite, biotite, brookite, hornblende, monazite, muscovite, rutile, titanite, tourmaline (pink variety), zircon	Acid igneous rocks
Cassiterite, dumortierite, fluorite, garnet, monazite, muscovite, topaz, tourmaline (blue variety), wolframite, xenotime	Granite pegmatites
Augite, chromite, diopside, hypersthene, ilmenite, magnetite, olivine, picotite, pleonaste	Basic igneous rocks
Andalusite, chondrodite, corundum, garnet, phlogopite, staurolite, topaz, vesuvianite, wollastonite, zoisite	Contact metamorphic rocks
Andalusite, chloritoid, epidote, garnet, glaucophane, kyanite, sillimanite, staurolite, titanite, zoisite-clinozoisite	Dynamothermal metamorphic rocks
Barite, iron ores, leucoxene, rutile, tourmaline (broken grains), zircon (rounded grains)	Reworked sediments

(modified from Feo-Codecido, 1956, p.997)

order to define the potential source materials. General conclusion drawn from this method is presented in Table 5.2.

The major source materials have been focused upon only 3 different types, namely, pegmatite,pneumatolitic/hydrothermal, and surficial deposit. No attempt has been made to further subdivide these 3 potential sources into different categories in more detail. This is basically due to the lack of in-depth study on the nature characteristics of the original source materials including detailed geology of the area concerned.

The findings clearly indicate that samples obtained from Kathu and Lun Seng mines are of reworked sediment (fluvial, fluvial-marine). This is characterized by the presence of leucoxene, rutile, broken tourmaline, and rounded zircon. It is also noted that samples obtained from Sapayakorn, Sap Bangku, and Chao Fah mines show evidences

Table 5.2 Detrital mineral suites characteristics of source rock type.

Origin \ Location	Within Kathu Valley								Outside Kathu Valley						
	Tor Soong Mine	Tantikowit Mine	Pad Roi Mine	Ban Nguan Mine	Pin Yoh Mine	Kathu Mine	Tung Tong Mine	Pol Thavee Mine	Sapayakorn Mine	Sinpatana Mine	Sap Bangku Mine	Lun Seng Mine	V.I.P. Mine	Sahakit Mine	Chao Fah Mine
<u>Reworked sediment</u>															
Leucoxene	-	-	X	-	-	-	-	-	-	-	-	X	-	-	-
Rutile	-	X	X	-	X	X	X	X	X	-	X	X	x	X	X
Tourmaline (broken)	-	-	-	-	-	X	-	-	-	-	-	X	-	-	-
Zircon (rounded)	-	-	-	-	-	X	-	-	X	-	X	X	-	-	X
<u>Acid igneous</u>															
Apatite	-	X	-	X	-	-	-	X	-	-	X	-	-	-	-
Biotite	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-
Hornblende	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Monazite	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Muscovite	X	X	X	X	X	X	X	X	-	X	-	-	X	X	-
Sphene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zircon(euhedra)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Microcline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnetite	-	-	-	-	X	X	-	-	-	-	-	-	-	X	-
Tourmaline(pink)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>Pegmatite</u>															
Fluorite	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-
Tourmaline	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Garnet	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Monazite	X	X	-	X	X	X	X	X	X	X	X	X	X	X	X
Muscovite	X	X	X	X	X	X	X	X	-	X	-	-	X	X	-
Topaz	X	-	X	X	-	X	X	X	-	X	X	X	-	-	-
Albite	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Microcline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cassiterite	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Wolframite	X	X	-	-	X	-	-	-	-	-	X	-	X	X	-

Remarks

X = Present

\- = None

of colluvial origin as indicated by the presence of rutile and rounded zircon in the considerable amount.

The heavy mineral associations of samples from Tantikowit, Pol Thavee, and Sahakit mines incline to indicate that there is a strong influence of acid igneous source materials. This is evaluated from the presence of the following minerals, apatite, biotite, hornblende, monazite, muscovite, zircon (euhedra), and magnetite in the same assemblage. Besides, considering the role of pegmatite on the mineral assemblages from all sampling localities, it is apparent that all heavy mineral deposits are partially or mainly derived from pegmatitic source materials.

Slight variation in the heavy mineral suites of the same category of original source material can be explained in terms of a variety of ore-bearing fluids and the interaction between the ore-bearing fluid and different types of country rocks.

The stability of some detrital heavy minerals as they are subjected to weathering is considered to be one of the influential factor that control the nature, characteristics, and degree of abundance of the secondary deposit. The knowledge of the stability of various heavy mineral species can be summarized in Table 5.3.

Table 5.3 Stability of some detrital heavy minerals

Ultrastable	Rutile, zircon, tourmaline, anatase
Stable	Apatite, garnet (iron-poor), staurolite, monazite, biotite, ilmenite, magnetite
Moderately stable	Epidote, kyanite, garnet(iron-rich), sillimanite, sphene, zoisite
Unstable	Hornblende, actinolite, augite, diopside, hypersthene, andalusite
Very unstable	Olivine

(after Pettijohn, Potter, Siever, 1972)

The survival of those relatively stable minerals certainly indicate complete weathering of the original source materials. In addition, the durability of heavy minerals which can be simply defined in terms of hardness and other cohesive properties of the mineral is also another influential factor on the degree of abundance of heavy minerals in the secondary deposit. The higher hardness of mineral indicates the higher durability after a long-continued abrasion during transportation.

The importance of hydraulic factor on heavy mineral contents in a sediment is most pronounced only when the heavy minerals have undergone transportation in fluid media, notably, fluvial process, marine process. The grain shape characteristics and the specific gravity of heavy minerals are directly related to the hydraulic factor.

Considering the area within Kathu Valley, the finding of the present investigation shows that the common heavy minerals are cassiterite, cassiterite interlocking with quartz,cassiterite with manganese coat, wolframite, garnet, topaz, manganese oxide, Fe-oxide, zircon, ilmenite, limonite, tourmaline, monazite-xenotime. The most abundant heavy minerals are cassiterite including cassiterite with manganese coat, cassiterite interlocking with quartz. Other accessorial minerals are columbite-tantalite, struverite, multiple oxide containing Nb-Ta,mica,mangan-tantalite, rutile, spinel, allanite, apatite, leucoxene, and magnetite.

For the area outside the Valley,the common heavy minerals are cassiterite, cassiterite interlocking with quartz,wolframite, wolframite interlocking with quartz,tourmaline, zircon, struverite, spinel, limonite, leucoxene, mica, monazite-xenotime, ilmenite. The most abundant heavy minerals are cassiterite and cassiterite interlocking with quartz. Other accessorial heavy minerals are columbite-tantalite,multiple oxide-containing

Nb-Ta, mangan-tantalite, apatite, rutile,pyrite, altered pyrite, Fe-oxide,siderite, thorite, fluorite, scheelite, arsenopyrite, hematite, and magnetite.

The nature and characteristics of heavy mineral assemblages from 7 tin-mines outside the Valley are generally fairly similar to those within the Valley. The main differences are some minerals which were found only in some localities outside the Valley, namely, hematite, pyrite, siderite, thorite, fluorite, scheelite, arsenopyrite, and altered pyrite. The only variety of cassiterite with manganese coat is present only in Kathu Valley.

The interrelationship between grain size parameters of heavy minerals within the Kathu Valley reveal that if the average grain size falls within the range of coarse to very coarse sand, the deposit will be in situ weathering of pegmatite. In contrast, if the average grain size is fine sand, the deposit will be of alluvial origin. In addition, almost all heavy mineral suites in the Valley show poorly sorting in nature indicating the in situ weathering of pre-existing pegmatitic rocks.

The general pattern of average grain size of heavy mineral suites of an area adjacent to the Valley show a relatively wider range from coarse to fine sand indicating the diversity of origin of the deposits. Similarly, the sorting characteristics fall within the range of moderately well sorted to poorly sorted indicating the complexity and diversity in the origin.

Among different heavy minerals found in the area under the present investigation, the economic ones are cassiterite, columbite-tantalite, niobium/tantalum-bearing minerals (columbite-tantalite, mangan-tantalite, etc.), zircon, monazite, xenotime, and ilmenite . Cassiterite is most abundantly present in the size range of 10-40 mesh while niobium/tantalum-bearing minerals are more abundant inside the Valley as compared with that of outside the Valley, and most abundantly present in the size range of 20-60 mesh. For zircon, it is most abundant in the size range of 80 mesh to more than 100 mesh with a tendency to be more concentrated in the area outside the Valley as compared with that of within the Valley. The contents of monazite and xenotime in heavy mineral suites are relatively higher for samples obtained from area outside the Valley as compared with those in the Valley and they are mainly distributed within the size range of 60 mesh to more than 100 mesh. Ilmenite is mianly present in the size range of 40 mesh to more than 100 mesh, and is more abundant in an area outside the Valley. It is interesting to note that the higher degree of abundance of zircon, monazite, xenotime, ilmenite always indicate the alluvium and/ or beach placer including marine placer.

It is realized that the finding of the present investigation will be of benefits not only to the mineralogical aspects of heavy minerals in a pure scientific sense, but also to the development potential of heavy mineral deposit. The information on the availability of economic heavy minerals including their characteristics will be served as a basis for further evaluation programme including the decision on proper mining techniques and mineral dressing techniques. Considering from the mineralogical point of view, information regarding the heavy mineral characteristics, their associations, interrelationships between various parameters, ets. are obtained from this study. However, there are quite a number of areas of study that should be carried out in order to obtain a better understanding of heavy mineral problem which are not covered by the present study. These include detailed geology of the economically important area, detailed description and classification of mineralization, exploration criteria, trace elemental composition of heavy minerals. The present investigation is merely an attempt to assess the preliminary aspects of heavy minerals in this area. The scope of the study is also limited by the time availability and financial support including technical assistance in many aspects. Therefore, conclusion on any technical aspects cannot be completely and perfectly drawn from the limited data and information obtained.