CHAPTER 6

Geochronology

6.1 Introduction

U-Pb geochronology in zircon is a widely used technique in Earth Science to determine the age of igneous rocks. The technique involves measuring the parent to daughter ration of three distinct radioactive decay series (Harley and Kelly, 2007). The parent isotopes ^{238}U, ^{235}U and ^{232}Th produce, respectively, ^{206}Pb, ^{207}Pb and ^{208}Pb as their final daughter isotopes. Each of these decay series involves several intermediate steps and short-lived intermediate isotopes only need to be considered for age determinations of very young rocks. The whole decay process can be mathematically described by a single decay number of final radiogenic daughter atom (e.g. $^{206}Pb^*$) relative to time:

$$^{206}Pb^*/^{238}U = e^{\lambda 238t}-1$$

where: e is the exponential function,

t is time

λ is the decay constant specific to this decay scheme, i.e. λ^{238} = 1.55125 $^{e-10}$. $^{206}Pb^*$ refers to the radiogenic ^{206}Pb accumulated in the crystal as a result of the decay of ^{238}U. Similar expressions can be formulated for $^{207}Pb^*$ produced from the decay of ^{235}U and $^{208}Pb^*$ produced from ^{232}Th, with λ^{235} = 9.8485^{e-10} and λ^{232} = 4.9475^{e-11}.

Most of the dates presented in this study are based on the $^{206}Pb/^{238}U$ system with a correction for common-Pb (Pb not derived from in situ radioactive decay of U) based on the $^{207}Pb/^{206}Pb$ ratio. In addition to common-Pb, some zircon grains can experience appreciable Pb-loss, recognizable by the skewing of analyses towards younger age in the U-Pb concordia diagrams (Harley and Kelly, 2007). Subsequently, the analysis of zircons that have been affected by Pb-loss will return values that represent the minimum age of their growth.

Mezger and Krogstad (1997) argued that under conditions typical in the continental crust, Pb-loss is only possible in zircons that have experienced significant radiation damage through α-decay and spontaneous fission (metamic zircon). Pb-diffusion in the pristine zircon lattice is insignificant up to temperatures of at least 1000 ^{o}C. Complete resetting of the U-Pb system in zircon under crustal conditions is only possible through dissolution and reprecipitation of zircon.

Another problem that can be encountered in U-Pb zircon geochronology is the inheritance of older zircon grains in an igneous or metamorphic rock that is not crystallized from that rock's parental magma. Such inherited zircon grains may have been incorporated into a magma though the partial melting of a pre-existing zircon-bearing rock or though assimilation of zircon-bearing country rock during magma ascent (Harley and Kelly, 2007).

6.2 Ages of rocks

The age of igneous rock in the study area was done using U-Th-Pb zircon geochronology. The U-Pb zircon dating was performed on Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) that installed at the University of Tasmania, Australia. The method of analysis is given in Chapter 3. The zircons were carefully selected from a representative felsic volcanic rock sample and a representative hypabyssal rock (shallow intrusive rock) sample that contain zircon for U-Pb dating. Sample locations for the dated rocks are shown in Figure 6.1. LA-ICP-MS U-Pb isotopic and trace element data for zircons from these two igneous rocks are given in Table 6.1.

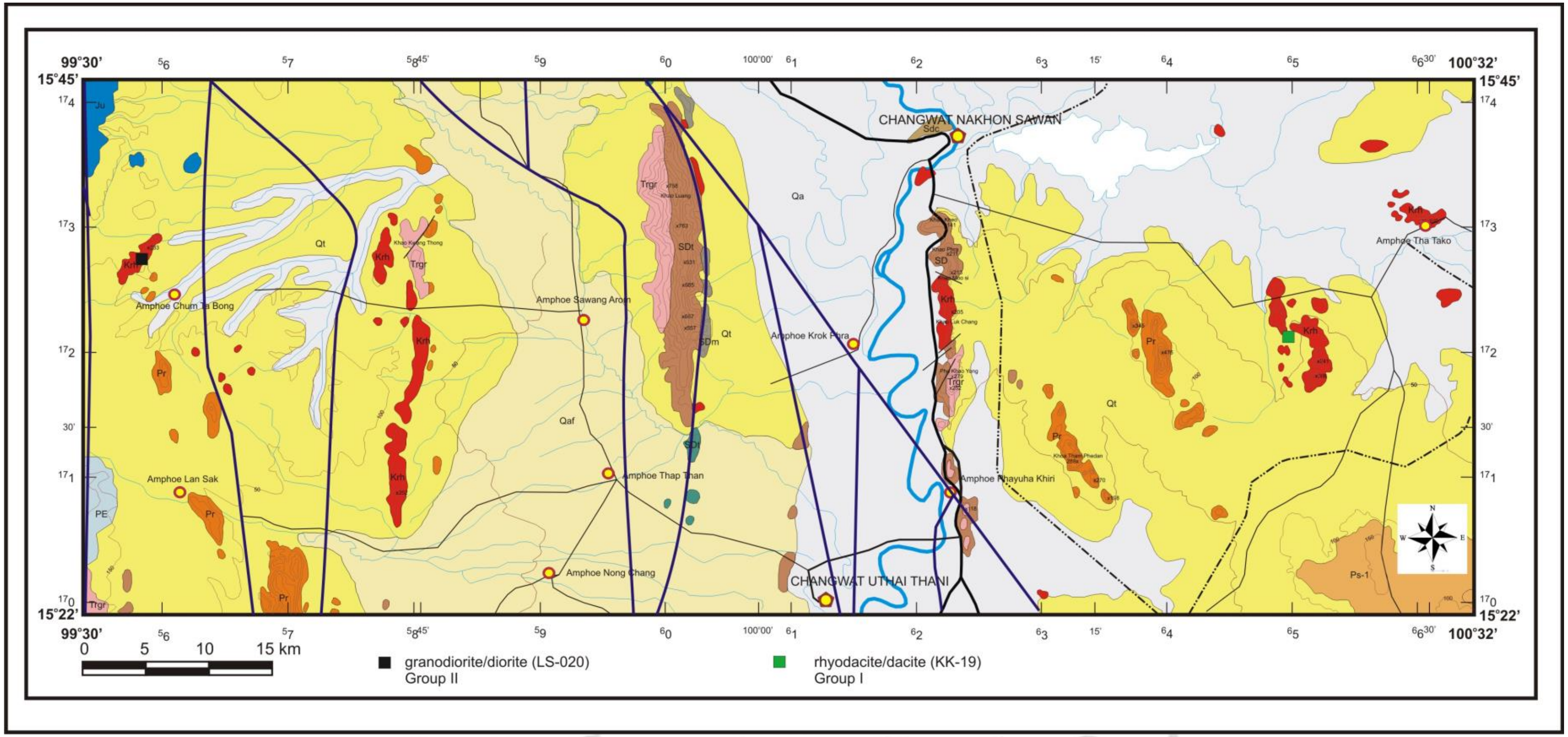

Figure 6.1 Sample locations for the representative volcanic and hypabyssal rocks selected for the U-Pb zircon age dating from the study area. See Figure 2.1, Chapter 2 for symbols and legend.

Table 6.1 Laser ablation ICP-MS U-Pb isotopic and trace element data for zircons from the two representative study rocks.

Sample	$^{206}Pb/^{238}U$ age (Ma) (^{207}Pb corrected.)	+/-1 s	Isotopic ratios $^{206}Pb/^{238}U$	% rsd	$^{208}Pb/^{232}Th$	% rsd	$^{207}Pb/^{206}Pb$	% rsd	Trace element data (in ppm) Ti	Hf	Pb	Th	U
KK-19	335	4	0.0535	1.4%	0.0161	1.6%	0.0546	2.7%	7	9269	33	527	540
KK-19	339	5	0.0540	1.5%	0.0155	1.9%	0.0523	3.7%	10	9425	18	319	286
KK-19	340	6	0.0542	1.8%	0.0159	2.1%	0.0549	3.6%	8	9462	15	225	239
KK-19	342	5	0.0544	1.4%	0.0163	1.8%	0.0517	3.1%	6	9885	22	377	349
KK-19	342	6	0.0549	1.7%	0.0168	2.6%	0.0592	3.7%	7	9856	12	150	209
KK-19	344	4	0.0551	1.3%	0.0151	1.8%	0.0572	2.0%	14	9648	51	997	757
KK-19	346	6	0.0551	1.7%	0.0167	2.4%	0.0544	4.6%	9	9653	12	186	193
KK-19	346	6	0.0551	1.8%	0.0164	2.7%	0.0533	4.6%	9	9699	9	115	158
KK-19	347	4	0.0554	1.3%	0.0164	1.6%	0.0549	2.8%	25	8741	24	407	372
KK-19	347	4	0.0554	1.3%	0.0165	1.7%	0.0555	2.7%	11	9080	25	397	389
KK-19	347	8	0.0552	2.4%	0.0166	3.0%	0.0522	5.8%	11	9792	21	325	337
KK-19	348	6	0.0554	1.7%	0.0162	2.1%	0.0535	3.7%	4	9155	13	203	203
KK-19	351	7	0.0558	2.0%	0.0156	3.0%	0.0510	5.0%	8	9651	7	84	120
KK-19	357	7	0.0575	2.0%	0.0165	2.3%	0.0625	4.4%	20	10578	25	417	367
KK-19	358	5	0.0572	1.5%	0.0172	1.9%	0.0553	3.6%	7	9869	14	226	210
KK-19	359	8	0.0574	2.1%	0.0171	2.8%	0.0545	5.2%	9	9749	10	137	148
LS-020	219	5	0.0346	2.4%	0.0113	2.8%	0.0511	6.3%	33	8870	8	193	216
LS-020	220	4	0.0348	1.8%	0.0111	2.6%	0.0526	4.7%	26	9107	10	229	234
LS-020	220	4	0.0350	1.9%	0.0112	2.2%	0.0583	4.1%	26	9542	10	247	243
LS-020	222	3	0.0350	1.3%	0.0108	1.7%	0.0500	2.6%	1042	8452	29	715	719
LS-020	222	4	0.0351	1.6%	0.0110	2.3%	0.0520	3.8%	24	10313	11	256	274
LS-020	225	4	0.0356	1.8%	0.0109	2.8%	0.0508	4.3%	12	8518	8	128	220
LS-020	226	5	0.0388	2.0%	0.0227	3.0%	0.1158	4.0%	18	8782	8	89	169
LS-020	226	3	0.0355	1.2%	0.0108	1.9%	0.0475	2.6%	14	12104	22	403	573
LS-020	226	4	0.0361	1.8%	0.0119	2.5%	0.0577	4.3%	25	9813	9	178	217
LS-020	227	5	0.0384	2.3%	0.0159	2.7%	0.1040	4.0%	151	10538	13	251	259
LS-020	227	4	0.0359	1.7%	0.0108	1.9%	0.0507	4.8%	31	9197	19	497	440
LS-020	228	4	0.0358	1.6%	0.0106	2.0%	0.0464	4.3%	24	10001	12	275	277
LS-020	228	4	0.0363	1.7%	0.0119	2.0%	0.0556	4.2%	38	9702	11	254	266
LS-020	229	5	0.0363	2.3%	0.0120	2.7%	0.0559	5.5%	25	9378	7	135	162
LS-020	235	4	0.0370	1.5%	0.0113	2.1%	0.0484	4.1%	24	10353	14	285	338

The morphology of zircon grains was studied using optical microscopy. Zircons are small and rare in volcanic rocks, and are subhedral to anhedral, whereas zircons in hypabyssal rock are mostly subhedral to euhedral.

6.2.1 A representative of Group I felsic volcanic rock sample

Sixteen zircon grains were selected for analysis from a rhyodacite/ dacite sample (KK-19) from the Tha Tako area, Nakhon Sawan Province. The results are shown in Table 6.1 and Figure 6.2. Most of zircon grains are consistent with a mean age of 345.5± 3.4 Ma (Early Carboniferous).

6.2.2 A representative of Group II hypabyssal rock sample

Fifteen zircon grains were selected for analysis from a granodiorite/diorite sample (LS-020) from the Chum Ta Bong area, Uthai Thani Province. The results are shown in Table 6.1 and Figure 6.3. Most of zircon grains are consistent with a mean age of 225.4± 1.9 Ma (Late Triassic).

6.3 Summary

The igneous rocks from the study area can be separated into two age groups. An older zircon age group is derived from Group I rhyodacite/ dacite rock sample at the Tha Tako area, Nakhon Sawan Province and the younger zircon age group is from Group II granodiorite/diorite at the Chum Ta Bong area, Uthai Thani Province. The age of volcanic rock in the study area is 345.5± 3.4 Ma (Early Carboniferous) and the age of hypabyssal rock (shallow intrusive rock) is 225.4± 1.9 Ma (Late Triassic). The graph plot of zircon age of rock samples is shown in Figure 6.4.

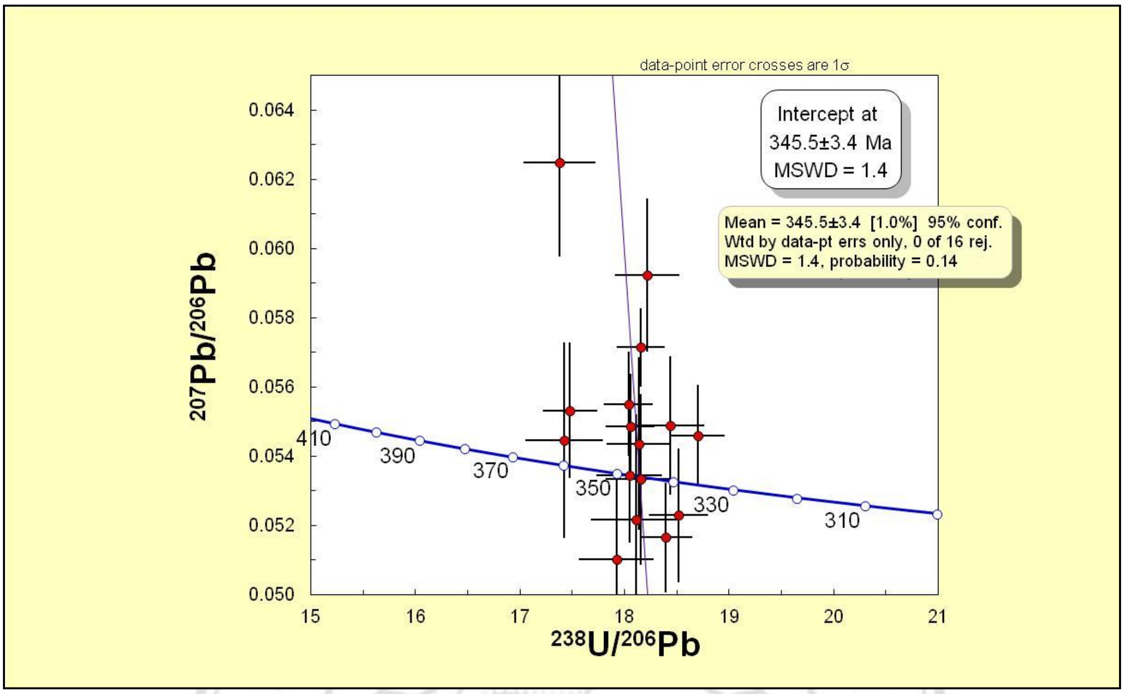

Figure 6.2 Reverse Concordia plot of laser ablation ICP-MS zircon U-Pb measurement for Group I rhyodacite/ dacite rock sample KK-19 from the Tha Tako area, Nakhon Sawan Province.

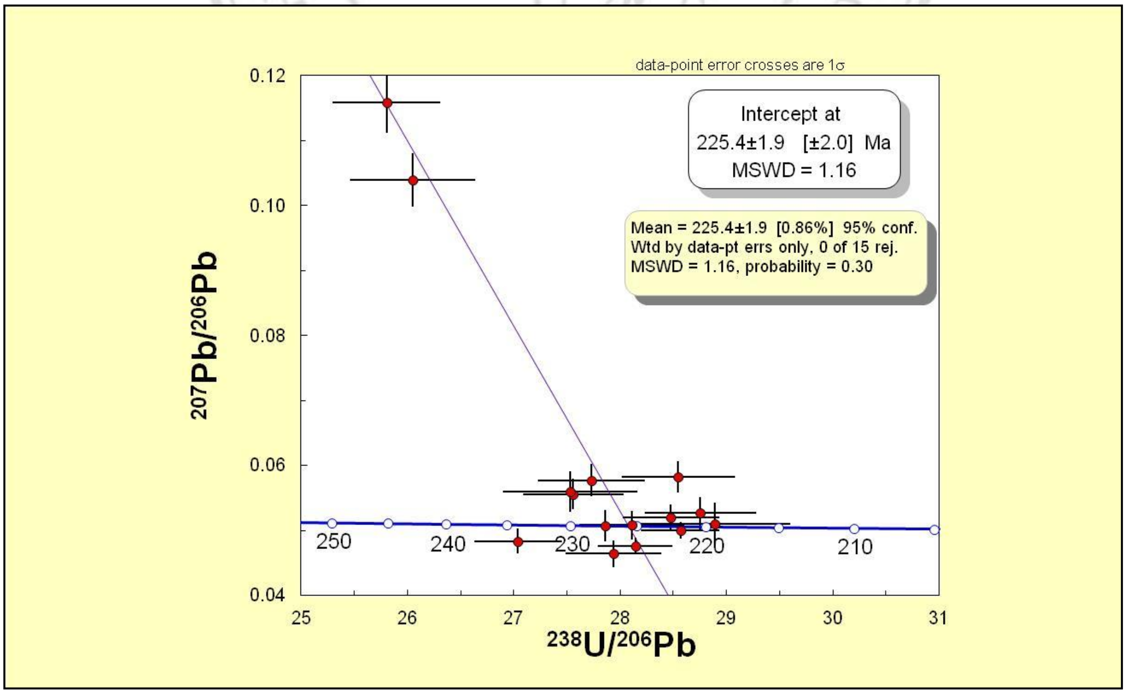

Figure 6.3 Reverse Concordia plot of laser ablation ICP-MS zircon U-Pb measurement for Group II granodiorite/diorite rock sample LS-020 from the Chum Ta Bong area, Uthai Thani Province.

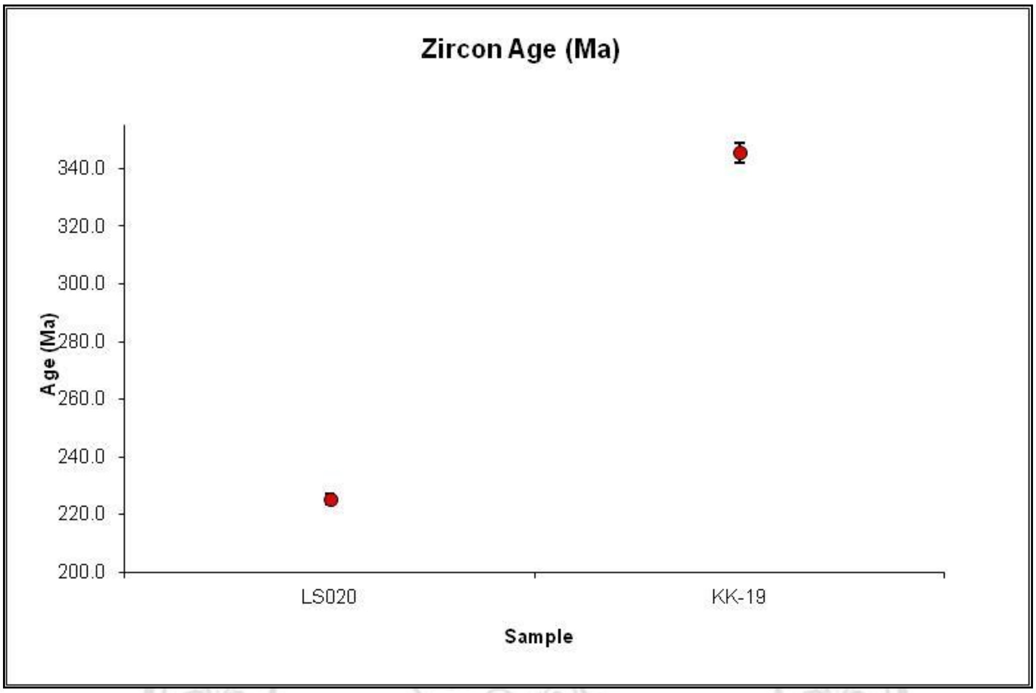

Figure 6.4 The graph plot of zircon age of rock samples.