

การศึกษารัฐวิद्या แร่วิทยา และ พลูอิค อินคูลชันของแหล่งแร่วลวง - ทองค้ำที่
ค้ำบลแจ้ช้อน กิ่งอำเภอเมืองปาน จังหวัดล่ำปาง



นาย อภิลิทธิ ชำล่ำ

วิद्याนิพนธนี้ เป็นส่วนหนึ่ของการศึกษาคำหลักสุทรบริณญำวิद्याศำสตรมหำบัณฑิต
ภำควิชำธรรณีวิद्या

บัณฑิตวิद्याลัย จุฬำล่งกรณั่มหำวิद्याลัย

พ.ศ. ๒๕๒๕

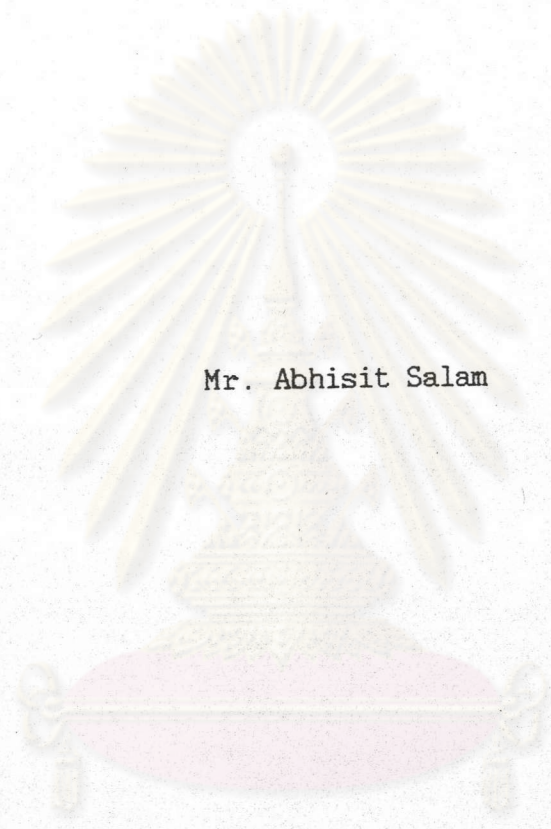
ISBN ๙๗๔-๕๗๑-๖๐๑-๕

ลิขสิทธิ์ของบัณฑิตวิद्याลัย จุฬำล่งกรณั่มหำวิद्याลัย

019154

๑๑๒๑๕๙๒๒๔

GEOLOGICAL, MINERALOGICAL AND FLUID INCLUSION STUDIES
OF ANTIMONY-GOLD MINERALIZATION AT TAMBON CHAE SORN,
KING AMPHOE MUANG PAN, CHANGWAT LAMPANG



Mr. Abhisit Salam

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science

Department of Geology

Graduate School

Chulalongkorn University

1992

ISBN 974-581-601-9

Copyright of the Graduate School, Chulalongkorn University



Thesis Title Geological, Mineralogical and Fluid Inclusion Studies
of Antimony - Gold Mineralization at Tambon Chae
Sorn, King Amphoe Muang Pan, Changwat Lampang

By Mr. Abhisit Salam

Department Geology

Thesis Advisor Assistant Professor Visut Pisutha-Arnond, Ph.D.

Accepted by the Graduate School, Chulalongkorn University in
Partial Fulfillment of the Requirements for the Master's Degree.

Sam Vornakase..... Dean of Graduate School
(Professor Thavorn Vajrabhaya, Ph.D.)

Thesis Committee

Sompop Vedchakanchana..... Chairman
(Sompop Vedchakanchana, M.Sc.)

Visut Pisutha-Arnond..... Member
(Visut Pisutha-Arnond, Ph.D.)

Wasant Pongsapich..... Member
(Wasant Pongsapich, Ph.D.)

Somchai Nakapadungrat..... Member
(Somchai Nakapadungrat, Ph.D.)



พิมพ์ต้นฉบับบทคัดย่อวิทยานิพนธ์ภายในกรอบสี่เหลี่ยมนี้เพียงแผ่นเดียว

อภิสิทธิ์ ชาลำ : การศึกษาธรณีวิทยา แร่วิทยา และฟลูอิด อินคลูชันของแหล่งแร่พลวง-ทองคำ
ที่ตำบลแจ้ซ้อน กิ่งอำเภอเมืองปาน จังหวัดลำปาง (GEOLOGICAL, MINERALOGICAL AND
FLUID INCLUSION STUDIES OF ANTIMONY-GOLD MINERALIZATION AT TAMBON
CHAE SORN, KING AMPHOE MUANG PAN, CHANGWAT LAMPANG) อ.ที่ปรึกษา: ผศ.ดร.
วิสุทธิ์ พิสุทธอนันท์, 89 หน้า, ISBN 974-581-601-9

แหล่งแร่พลวง-ทองคำ ที่ตำบลแจ้ซ้อน เกิดอยู่ในรอยเลื่อนซึ่งวางตัวอยู่ระหว่างหินชุดตะกอน ซึ่งถูก
แปรสภาพและหินตะกอนแปรทึบ ซึ่งแหล่งแร่ดังกล่าวเกิดหลังจากการเกิดรอยเลื่อน

การเกิดแหล่งแร่เหล่านี้สามารถแยกออกเป็น 4 ระยะเวลาเป็นอย่างน้อย สองระยะเวลาแรกเป็น
ช่วงก่อนเกิดสินแร่ ได้แก่ ระยะเวลาการเกิดแร่กาสินา-สฟาเลอไรต์-เฟอโรน โคลโลไมต์ ในปริมาณเล็กน้อย (ระยะ
ที่ 1) และอาร์เซนไพไรต์-ไพไรต์-ควอร์ตซ์ ในปริมาณเล็กน้อย (ระยะที่ 2) ที่เหลืออีก 2 ระยะเวลาคือช่วง
การเกิดของสินแร่แอนทิโมนี ได้แก่ สติบไนต์-ควอร์ตซ์ ตอนต้น (ระยะที่ 3) และสติบไนต์-ควอร์ตซ์ ตอนปลาย
(ระยะที่ 4) การเกิดแร่ทั้ง 4 ระยะนี้มีลักษณะเป็นการเข้าไปบรรจุอยู่ในช่องว่างที่เป็นสายแร่ขนาดกลางถึงขนาด
เล็ก การเข้าไปบรรจุในช่องว่างทั่วไป และช่องว่างระหว่างหินกรวดเหลี่ยม ทองคำที่แจ้ซ้อนเกิดในลักษณะเป็น
อนุภาคขนาดเล็กมากอยู่ร่วมกับแร่ซัลไฟด์ ซึ่งอาจจะเป็นอาร์เซนไพไรต์ของการเกิดแร่ระยะที่ 2

ซิลิซิไฟเคชัน เป็นขบวนการเปลี่ยนแปรหินข้างเคียงที่พบและกระจายอยู่ทั่วไปในพื้นที่แหล่ง
แจ้ซ้อน ขบวนการเปลี่ยนแปรหินข้างเคียงแบบฟิลลิกพบบ้างเล็กน้อย ขบวนการซิลิซิไฟเคชันครั้งใหญ่พบที่
หลังจากการเกิดรอยแตกและการแตกหักของหินครั้งใหญ่ในแนวการเกิดแหล่งแร่ ซึ่งเกิดขึ้นก่อนการเกิดสินแร่
ระยะที่ 3

การศึกษาฟลูอิด อินคลูชันจากแร่สฟาเลอไรต์ระยะที่ 1 และควอร์ตซ์ระยะที่ 4 พบว่าฟลูอิดอินคลูชัน
ชนิดไพโรมารี และซูเซคอนคาร์ เป็นชนิดที่มีของเหลวบรรจุอยู่ค่อนข้างมาก โดยมีอัตราส่วนของของเหลวต่อไอ
ค่อนข้างคงที่ อุณหภูมิการขยายตัวเต็มของของเหลวในฟลูอิดอินคลูชันในสฟาเลอไรต์ระยะที่ 1 มีค่าอยู่ระหว่าง
150-250 °C และในควอร์ตซ์ระยะที่ 4 มีค่าระหว่าง 130-150 °C ในการเกิดแร่ระยะที่ 1 คู่มือน่าจะมี
อุณหภูมิสูงกว่าการเกิดแร่ระยะที่ 4 อยู่บ้างเล็กน้อย ช่วงอุณหภูมิการเกิดแหล่งแร่มีพบในระบบน้ำแร่ร้อนชนิด
อุณหภูมิต่ำที่ถือกำเนิดมาจากน้ำฝน

ภาควิชา
สาขาวิชา
ปีการศึกษา 2534

ลายมือชื่อนิสิต อภิสิทธิ์ ชาลำ
ลายมือชื่ออาจารย์ที่ปรึกษา
ลายมือชื่ออาจารย์ที่ปรึกษาร่วม

C025756 : MAJOR GEOLOGY

KEYWORD : ANTIMONY-GOLD MINERALIZATION/FLUID INCLUSION/CHAE SORN/LAMPANG

ABHISIT SALAM : GEOLOGICAL, MINERALOGICAL AND FLUID INCLUSION STUDIES OF ANTIMONY-GOLD MINERALIZATION AT TAMBON CHAE SORN, KING AMPHOE MUANG PAN, CHANGWAT LAMPANG. THESIS ADVISOR : ASST. PROF. VISUT PISUTHA-ARNOND, Ph.D. 89 pp. ISBN 974-581-601-9

The Chae Sorn Antimony-Gold mineralization occurs in an old shear zone lying between metasediment unit and clastic unit. The mineralization post-dated shearing.

At least four stages of mineralization has been recognized in which the first two stages are preore stage, namely ; minor galena-sphalerite-ferroan dolomite (stage I), and minor arsenopyrite-pyrite-quartz (stage II). The later two stages are stibnite mineralizing episodes, namely ; the early-stibnite-quartz (stage III) and the late stibnite-quartz (stage IV) mineralization. All these four stages are characterized mainly by open space filling texture in the forms of veins and/or veinlets, vug-filling and breccia-filling. Gold in Chae Sorn most probably occurs as fine particle associated with sulfide minerals possibly arsenopyrite of stage II mineralization.

Silicification is widely distributed wall rock alteration in Chae Sorn area with minor phyllic alteration. The major silicification was found to accompany the major fracturing and brecciation in the mineralized zone which occurred prior to stage III mineralization.

Fluid inclusion study from stage I sphalerite and stage IV quartz show that all the primary and pseudosecondary inclusions are simple liquid-rich type with approximately constant liquid/vapor ratio. The filling temperatures of stage I sphalerite vary from 190-250°C and stage IV quartz from 130-190°C. The stage I seems to show somewhat higher temperature than those of the stage IV. These temperature ranges are expected in low temperature epithermal system of meteoric water origin.

ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

ภาควิชา ธรณีวิทยา
สาขาวิชา ธรณีวิทยา
ปีการศึกษา 2534

ลายมือชื่อนิสิต อภิสิทธิ์ งาม
ลายมือชื่ออาจารย์ที่ปรึกษา วิสูตร งาม
ลายมือชื่ออาจารย์ที่ปรึกษาร่วม _____



ACKNOWLEDGEMENTS

The author would like to express his profoundly sincere gratitude and appreciation to his thesis supervisor, Assistant Professor Dr. Visut Pisutha-Arnond for his guidance, encouragement as well as reading and constructive criticism of the manuscript.

The author is grateful to the Siam Antimony Co.Ltd. for the permission to study at Chae Sorn prospect, providing a useful material and facilities.

Financial supports of this research programme are provided by Chulalongkorn-Amoco Geological Fund and the Research Fund of the Graduate School of Chulalongkorn University.

The Department of Geology of Chulalongkorn University has continuously provided numerous facilities to support this work.

Special acknowledgements are due to Mr. Somchai Trianwichanon, Mr. Surachai Sompadung, Mr. Sasin Chalermklarp and Mr. Poolswat Prachakbanchong for their help in preparing the manuscript.

Finally, the author would like to thank to several persons whose names are not mentioned here. No thesis can be completed without the help and encouragement of the parents, friends and others who put up so much efforts to the author as well.



CONTENTS


	page
ABSTRACT IN THAI	iv
ABSTRACT IN ENGLISH.....	v
ACKNOWLEDGEMENT	vi
LIST OF FIGURES	vii
CHAPTER	
I INTRODUCTION	1
1.1 Location and Accessibility	3
1.2 Physiographic Description	3
1.3 Climate and Vegetation	6
1.4 Previous Investigation	6
1.5 Purpose of Study	7
1.6 Methodology	7
II REGIONAL GEOLOGY	9
III GEOLOGY OF CHAE SORN ANTIMONY-GOLD PROSPECT	12
3.1 Metasediment Unit	17
3.2 Clastic Unit	21
3.3 Granitoid Unit.....	23
3.3.1 Fine-, to medium - grained biotite- muscovite granite.....	23
3.3.2 Fine-, to medium - grained tourmaline- (+muscovite-biotite) granite.....	26
3.4 Rocks in the Shear Zone	29
3.4.1 Phyllonite	29
3.4.2 Schist	30

CHAPTER	page
3.4.3 Sandstone and Stretched Sandstone of Mae Tha Group.....	35
3.4.4 Carbonate Rock	37
3.4.5 Dioritic Rock	37
3.4.6 Mylonite	42
IV MINERALIZATION	46
4.1 General Characteristic Features	46
4.1.1 Breccia	48
4.2 Stages of Mineralization	51
4.2.1 Stage I (Minor Galena-Sphalerite-Ferroan Dolomite Mineralization)	51
4.2.2 Stage II (Minor Arsenopyrite-Pyrite- Quartz Mineralization)	53
4.2.3 Stage III (Early Stibnite-Quartz Mineralization)	59
4.2.4 Stage IV (Late-Stibnite-Quartz Mineralization)	61
4.3 Gold Mineralization	68
4.4 Wall Rock Alteration	68
4.4.1 Alteration Related to Stage II Mineralization	69
4.4.2 Alteration Accompanying Major Fracturing and Brecciation	71
4.4.3 Alteration Related to Stage III Mineralization.....	71

CHAPTER

page

	4.4.4 Alteration Related to Stage IV	
	Mineralization.....	73
V	FLUID INCLUSION STUDY	76
	5.1 Nature of Fluid Inclusion	76
	5.2 Result	76
VI	GEOLOGIC HISTORY AND MINERALIZATION AT CHAE SORN AREA...	80
VII	CONCLUSION	82
	REFERENCES	85
	APPENDIC.....	87
	BIOGRAPHY	89



ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

LIST OF FIGURES

Figure	page
1.1	2
Distribution of stibnite occurrences in Northern Thailand (1, 2, 3 and 4 indicate stibnite-quartz, stibnite - fluorite, ferberite - stibnite - fluorite - quartz, sheelite - stibnite associations, respectively), after Asanachinda (1981).....	
1.2	4
Topographic map showing the accessibility to the area. Note the N-S trending mountain range in the middle of the map is a part of Wiang Pa Pao-Khuntan batholith.....	
1.3	5
Location map of the study area.....	
2.1	10
Regional geological map covering the study area, after Piyasin (1972) and Charusiri (1989).....	
3.1	13
Geologic map of the study area.....	
3.2	14
Drilling location map	
3.3	15
Cross-section along AA' or line 15 after SAC (1987).....	
3.4	16
Cross-section along BB' or line 16 after SAC (1987).....	
3.5	19
Exposure of phyllite along stream bank showing phyllitic structure.....	
3.6	19
Hand specimen of phyllite showing well developed phyllitic structure.....	
3.7	19
Photomicrograph of phyllite showing phyllitic structure Note it is slightly folded at the top of photograph. (Bar-scale = 0.45 mm; transmitted light, crossed nicols).....	

3.8	Hand specimen of phyllite showing phyllitic structure (S_1) forms a low angle to the bedding plane(S_0).....	19
3.9	Photomicrograph of phyllite showing phyllitic structure (S_1) forming a low angle to the bedding plane (S_0). (Bar-scale = 0.45 mm; transmitted light, crossed nicols).....	20
3.10	Photomicrograph of phyllite showing S_1 (foliation), S_2 (strain-slip cleavage). (Bar-scale = 0.23 mm; transmitted light, crossed nicols).....	20
3.11	Photomicrograph of phyllite showing strain-slip cleavage (vertical) coincident with the limbs of asymmetrical folds in phyllitic structure. (Bar-scale = 0.23 mm; transmitted light, crossed nicols).....	20
3.12	Hand specimen of sandy micaceous band in phyllite....	20
3.13	Photomicrograph of sandy micaceous rock showing stretched quartz (Q) and muscovite (Mu). The dark material filled along grains is iron oxides. (Bar-scale = 0.45 mm; transmitted light, crossed nicols).....	22
3.14	An outcrop of shale showing well developed fissility moderately dipping toward the east.(Looking toward the north).....	22
3.15	Hand specimen of shale showing moderately developed fissility.....	22
3.16	Photomicrograph of shale showing preferred orientation of sericite and quartz. (Bar-scale = 0.45 mm; transmitted light, crossed nicols).....	22

3.17	Hand specimen of calcareous arkosic sandstone.....	25
3.18	Photomicrograph of calcareous arkosic sandstone showing framework grains of quartz (Qz), plagioclase (Pl), K-feldspar (Kf), calcite (Ca) and the matrix partially cemented by calcite. (Bar-scale = 0.45 mm; transmitted light, crossed nicols).....	25
3.19	An exposure of fine-, to medium-grained biotite-muscovite granite exposed along the bank of Nam Mae Soi (stream).....	25
3.20	Hand specimen of fine-, to medium-grained biotite-muscovite granite, showing few K-feldspar megacrysts. Note that the dark mineral is biotite.....	25
3.21	Photomicrograph of fine-, to medium-grained biotite-muscovite granite showing quartz (Qz), K-feldspar (Kf), plagioclase (Pl), muscovite (Mu) and biotite (Bi). (Bar-scale = 0.45 mm; transmitted light, crossed nicols).....	27
3.22	Photomicrograph of fine-, to medium-grained biotite-muscovite granite showing myrmekitic quartz in plagioclase bounded by microcline on top, microperthite at the bottom and large altered plagioclase on the right of photograph. (Bar-scale = 0.23 mm; transmitted light, crossed nicols).....	27
3.23	Photomicrograph of fine-, to medium-grained biotite-muscovite granite showing inclusions of biotite(Bi), quartz(Qz) and plagioclase(Pl) in large microcline megacrysts. (Bar-scale = 0.45 mm; transmitted light, crossed nicols).....	27

- 3.24 Hand specimen of fine-, to medium-grained tourmaline - (\pm muscovite -biotite) granite. Dark color is tourmaline riched spots..... 27
- 3.25 Photomicrograph of fine-, to medium grained tourmaline - (\pm muscovite-biotite) granite showing plagioclase (Pl), micro - perthite (Mp), tourmaline (T) and quartz (Qz). (Bar-scale = 0.45 mm; transmitted light, crossed nicols)..... 31
- 3.26 Photomicrograph of tourmaline - (\pm muscovite - biotite) granite showing K-feldspar(Kf), plagioclase (Pl), tourmaline (T) and quartz(Qz). (Bar-scale = 0.45 mm; transmitted light, crossed nicols)..... 31
- 3.27 Hand specimen of phyllonite showing well developed foliation and also containing quartz lenses (Qz), pyrite (Py)..... 31
- 3.28 Photomicrograph of phyllite showing lenticular structure particularly at the center of photo. (Bar-scale = 0.23 mm; transmitted light, crossed nicols).....31
- 3.29 Photomicrograph of phyllonite showing similar structure of that Figure 3.34 and microfault (Mf). (Bar-scale = 0.23 mm; transmitted light, crossed nicols)..... 33
- 3.30 Photomicrograph of phyllonite showing stretched quartz at the center of photo. (Bar-scale = 0.23 mm, transmitted light, crossed nicols)..... 33

- 3.31 Hand specimen of schist showing well developed schistosity. Note the folding (Lower specimen)..... 33
- 3.32 Photomicrograph of schist showing compositional layering of quartz - riched and mica-riched layers, muscovite (Mu), biotite (Bi). (Bar-scale = 0.45 mm; transmitted light, crossed nicols)..... 33
- 3.33 Photomicrograph of schist showing folded S_1 (foliation). Note that abnormal blue is chlorite. (Bar-scale = 0.45 mm; transmitted light, crossed nicols)..... 34
- 3.34 Photomicrograph of schist showing S_1 (foliation), S_2 (strain - slip cleavage). (Bar-scale = 0.23 mm; transmitted light, crossed nicols)..... 34
- 3.35 Photomicrograph of schist showing tourmaline (T) and quartz (top center) exhibiting ductile deformation. (Bar-scale = 0.45 mm; transmitted light, crossed nicols)..... 34
- 3.36 Photomicrograph of schist showing crushed muscovite marked by set of micro - fractures parallel to long axis of photograph and also shows wavy extinction (left). (Bar - scale = 0.45 mm; transmitted light, crossed nicols)..... 34
- 3.37 Core specimen showing small stretched sandstone lenses surrounded by phyllonitic rock material..... 36
- 3.38 Core specimen of stretched sandstone which occurs as thick lens. (Bar-scale = 3.5 mm) 36

3.39 Photomicrograph of stretched sandstone showing moderate foliation that is marked by preferred orientation of quartz, feldspar grain and partly sericite matrix. (Bar - scale = 0.45 mm; transmitted light, crossed nicols)..... 36

3.40 Photomicrograph of stretched sandstone showing stretched quartz and partly crushed material (top center). (Bar - scale = 0.23 mm; transmitted light, crossed nicols).....36

3.41 Photomicrograph of stretched sandstone showing crushed quartz with some relicts of detrital quartz (Qz), plagioclase (Pl) grains. (Bar-scale = 0.23 mm; transmitted light, crossed nicols).....38

3.42 Core specimen of sheared limestone showing some deformation.....38

3.43 Photomicrograph of sheared limestone showing kinked cleavage and partially crushed calcite crystals. (Bar-scale = 0.23 mm; transmitted light, crossed nicols)..... 38

3.44 Photomicrograph of sheared limestone showing stretched calcite. (Bar-scale = 0.45 mm; transmitted light, crossed nicols)..... 38

3.45 Photomicrograph of sheared limestone showing mortar texture. (Bar - scale = 0.45 mm; transmitted light, crossed nicols)..... 41

3.46 Hand specimen of diorite, the left is coarser grained than that of the right..... 41

- 3.47 Photomicrograph of unfoliated diorite showing more or less inequigranular aggregate of plagioclase (Pl), hornblende (Hb). (Bar-scale = 0.45 mm; transmitted light, crossed nicols)..... 41
- 3.48 Photomicrograph of unfoliated diorite showing poikilitic inclusions of plagioclase crystals (Pl), biotite (Bi) and opaque mineral (O) in a large hornblende crystal (Hb). (Bar-scale = 0.23 mm; transmitted light, crossed nicols)..... 41
- 3.49 Hand specimen of foliated diorite showing compositional layering marked by dark and light bands, (each layer is shown in Figure 3.50)..... 43
- 3.50 Photomicrograph of foliated diorite showing compositional layering of mafic-rich and felsic - rich layer. (Bar-scale = 0.45 mm; transmitted light, crossed nicols)..... 43
- 3.51 Photomicrograph of protomylonite (sheared diorite) showing crushed quartz (left) and chlorite (ch), chlorite probably derived from hornblende. It should be noted that the amount of quartz is abnormally high particularly in this photo., probably due to the later introduction. (Bar-scale = 0.45 mm; transmitted light, crossed nicols)..... 43
- 3.52 Photomicrograph of protomylonite (sheared diorite) showing undulatory extinction in quartz and also shows hornblende (yellow color). The high amount of quartz is due to similar reason as given by Figure

3.51.	(Bar - scale = 0.45 mm; transmitted light, crossed nicols).....	43
3.53	Hand specimen of mylonitic granite showing poorly defined foliation marked by preferred orientation of chlorite? and feldspar porphyroclasts.....	45
3.54	Photomicrograph of mylonitic granite showing crushed quartz (top) and augen of feldspar (F). (Bar - scale = 0.45 mm; transmitted light, crossed nicols).....	45
3.55	Photomicrograph of sheared granite showing that most porphyroclasts are feldspar (F). (Bar-scale = 0.45 mm; transmitted light, crossed nicols).....	45
4.1	Adit cross-section showing the morphology of mineralized zone, modified after SAC (1987).....	47
4.2	An exposure of a part of the main mineralized zone at the open pit showing the mineralized body (Min. Body), unsilicified phyllonite (Phy) and silicified sandstone (SS) wall rock.....	49
4.3	A close-up of the mineralized body showing multiple stage of open space filling III (dark) and IV (light) refer to stage of mineralization described in section 4.2.....	49
4.4	Core specimen of a typical mineralizing feature found at 141.50 m. from surface showing silicified sandstone (dark) cross-cut by veinlet networks of serveral stages of mineralization. III and IV	

	refer to stages of mineralization described in section 4.2.....	49
4.5	Photograph of unmineralized breccia showing large fragments (WF) cemented by the matrix of mainly barren quartz (that responsible for major silicification see in section 4.4.2).....	49
4.6	Core specimen of mineralized breccia showing silicified fragments (SF) in the mineralizing matrix. III refers to stage of mineralization described in section 4.2.....	50
4.7	Core specimen showing an intensely fractured wall rock (dark) infilling by barren quartz (white). The wall rock has also been silicified.....	50
4.8	Chae Sorn mineralized history.....	52
4.9	Core specimen of phyllonite contains base metal (arrow) bearing ferroan dolomite veins of stage I mineralization. The arrow is patch of mostly sphalerite and galena.....	54
4.10	Photomicrograph of sphalerite-galena mineralization (stage I) showing intimate intergrowth of sphalerite (Sp), galena (Ga), tetrahedrite (Tt), dolomite (Do) and quartz (Qz). Note small pyrite (Py) grains in galena. Sphalerite contains tiny inclusions of chalcopyrite. (Bar-scale = 0.23 mm; reflected light)....	54
4.11	Photomicrograph of sphalerite-galena mineralization (stage I) showing galena(Ga) with curve grain outline in contact with sphalerite (Sp) and well developed	

- crystal face toward ferroan dolomite (dark color).
 A portion marked by circle is enlarged in Figure
 4.13. (Bar-scale = 0.23 mm; reflected light)..... 54
- 4.12 Photomicrograph of stage I mineralization showing
 intimate intergrowth of dolomite (Do), Sphalerite
 (Sp), galena (Ga), tetrahedrite (Tt), pyrite (Py)
 and quartz (Qz). Note very fine-grained sulfides
 trapped in dolomite (arrow). (Bar-scale = 0.23 mm;
 reflected light)..... 54
- 4.13 Sphalerite - galena mineralization (stage I), galena
 (Ga) contains inclusions of chalcopyrite (Cpy) and
 tetrahedrite (Tt). (Bar-scale = 0.06 mm; reflected
 light)..... 56
- 4.14 Hand specimen showing two episodes of brecciation
 and cementation. Fragments of stage II mineralization
 (II), which also contains small silicified rock
 fragments (SF), is cemented by stage III
 mineralization (III)..... 56
- 4.15 Hand specimen of stage II mineralization (dark)
 cross-cut by stage IV mineralization (light)..... 56
- 4.16 Photomicrograph of arsenopyrite - pyrite
 mineralization (stage II) showing an association of
 arsenopyrite (Arp), pyrite (Py) and quartz (Qz).
 (Bar-scale = 0.23 mm; reflected light, note that
 pyrite is slightly tarnished)..... 56
- 4.17 Photomicrograph of arsenopyrite - pyrite
 mineralization (stage II) showing euhedral pyrite

- (Py) partly enveloped by arsenopyrite (Arp).
 (Bar-scale = 0.23 mm; (A) reflected light, (B) is
 the sketched of (A)..... 57
- 4.18 Photomicrograph of arsenopyrite - pyrite
 mineralization (stage II) showing lath - shaped
 arsenopyrite (Arp) partially incorporated into
 euhedral pyrite crystal (Py). (Bar-scale = 0.23 mm;
 (A) reflected light, (B) is the sketched of (A)..... 57
- 4.19 Photomicrograph of stage II mineralization
 showing euhedral pyrite (Py) contains inclusions
 of euhedral quartz (Qz) and muscovite (Mu)?. Note
 arsenopyrite (Arp) partly trapped in pyrite.
 (Bar-scale = 0.23 mm; reflected light, uncrossed
 nicols)..... 58
- 4.20 Photomicrograph of arsenopyrite - pyrite - quartz
 mineralization (stage II) showing quartz (Q),
 muscovite (Mu) and associated arsenopyrite and
 pyrite (opaque). (Bar-scale = 0.23 mm; transmitted
 light, crossed nicols)..... 58
- 4.21 Photomicrograph of stage II mineralization showing
 pyrite (Py) surrounded by marcasite (Ma). Note
 that some arsenopyrite (Arp) are trapped in
 pyrite. Bar-scale = 0.23 mm, (A) reflected light,
 (B) is the sketched of A..... 58
- 4.22 Photomicrograph of stage II mineralization showing
 molybdenite (Mo) associated with quartz (Q) and
 pyrite (Py). (Bar-scale = 0.23 mm; reflected light)..... 60

- 4.23 Core specimen of silicified phyllite showing intense fractures infilled by barren quartz marking the major silicification..... 60
- 4.24 Breccia showing mainly unsilicified fragments (grey) of phyllonite cemented by barren quartz (white) marking the major pre-stage III silicification..... 60
- 4.25 Hand specimen of open space filling stage III mineralization (dark, III) containing silicified wall rock (SW). Note the infiltration of stage IV mineralization (IV, white)..... 60
- 4.26 Photomicrograph showing cross-cutting relationships of stage III by stage IV mineralizations. The stage III mineralization is intimately intergrowth of quartz and stibnite (dark, left). (Bar - scale = mm; transmitted light, crossed nicols)..... 62
- 4.27 Photomicrograph showing the intergrowth of stibnite (St), calcite (Ca) and quartz (Qz) of stage III mineralization. (Bar-scale = 0.23 mm; reflected light)..... 62
- 4.28 Photomicrograph of stage III mineralization showing inclusion of stibnite (St) in euhedral pyrite which partially encloses arsenopyrite (Arp). The gangue mineral (dark) is quartz. (Bar-scale = 0.23 mm; reflected light)..... 62

- 4.29 Photomicrograph of stage III mineralization showing stibnite (St) partly trapped in euhedral pyrite. Note stibnite displays corroded grain-boundary. The gangue mineral (dark) is quartz (Qz). (Bar-scale = 0.06 mm; reflected light)..... 62
- 4.30 Photomicrograph of stage III mineralization showing bundles of stibnite needle (dark) partly trapped (center) in calcite (Ca) and quartz (Qz). Note that the coarser stibnite (St) grains are also present. (Bar-scale = 0.45 mm; transmitted light, cross nicols)..... 63
- 4.31 Photomicrograph showing thin - film stibnite (St) along quartz (Qz) grain boundary. Pyrite (Py) is also noted. (Bar-scale = 0.23 mm; reflected light)..... 63
- 4.32 Photomicrograph of stage III mineralization showing stibnite (St) associated with quartz (Qz) of stage III mineralization. (Bar-scale = 0.45 mm; reflected light)..... 63
- 4.33 Photomicrograph showing an association of quartz (Qz), stibnite (St) and calcite (Ca). (Bar-scale = 0.23 mm; crossed nicols)..... 63
- 4.34 Photomicrograph of above veins showing an intergrowth of pyrrhotite (Pyr), stibnite (St), calcite (Ca) and quartz (Qz). (Bar-scale = 0.45 mm; reflected light)..... 64
- 4.35 Slab specimen showing stibnite - quartz of stage III mineralization (dark, III) infilled by

- milky quartz of stage IV (light, IV) along fractures.... 64
- 4.36 Core specimen showing the relationship between stage III and stage IV mineralization. Larger composite fragments of stage III mineralization (III) are cemented by stage IV mineralization (IV). Note that the stage III fragments also contains wall rock fragments (WR). (Bar-scale = cm.)..... 64
- 4.37 Photomicrograph showing cross-cutting relationships between stage III and stage IV mineralization. The stage III quartz-calcite veinlet containing stibnite (III) is cross-cut by stage IV (quartz - stibnite) veinlet at bottom (IV). Note that stage IV shown here is the outer portion of a veinlet. (Bar-scale = 0.45 mm; transmitted light)..... 64
- 4.38 Photograph showing dissolution of earlier phyllic - altered rock fragments indicated by vugs which some of them are partially infilled by stage IV mineralization (arrow)..... 66
- 4.39 Core specimen of stage IV mineralization showing coarsely crystalline quartz (Qz) lining the wall of open fracture and coarsely acicular stibnite (St) plus minor calcite (Ca) in the interior of open - fracture..... 66
- 4.40 Hand specimen showing relationship between stage III and IV mineralization. The stage III (dark) contains relict of phyllic-altered-rock-fragments

- that have been dissolved completely prior to the infilling of milky quartz (IV) and stibnite (St) of stage IV..... 66
- 4.41 Hand specimen of phyllonite cross-cut by quartz -stibnite mineralized veins (stage IV) showing wall rock fragments (WF) cemented earlier by milky quartz (white) and later by massive stibnite (Sb) of the stage IV mineralization..... 66
- 4.42 Slab of composite-mineralized breccia showing wall rock fragment (WF), stage II mineralized fragment (II) cemented by stage III mineralization (III). The milky quartz (probably belongs to stage IV ?..... 67
- 4.43 Core specimen of stage III mineralization post-dated by stage IV veinlets as indicated by milky quartz (arrow)..... 67
- 4.44 Core specimen of silicified sandstone (dark grey) showing zonation of stage IV mineralization overprinting. The comb quartz (Qz) lines the vein wall following by stibnite (St) and calcite(Ca) toward the center of the vein. Note also the silicified rock fragment (WR) in the vein. (Bar- scale = 0.45 mm; transmitted light, crossed nicols)..... 67
- 4.45 Photomicrograph of the above sample (Figure 4.44) showing detailed zonation texture of fracture infilling of comb quartz on the right and stibnite (St) plus calcite (Ca) toward the center of the

- vein on the left. (Bar-scale = 1.0 mm; transmitted light, crossed nicols)..... 67
- 4.46 Photomicrograph of late - stibnite - quartz mineralization (stage IV) showing an intergrowth of stibnite (St) and calcite (Ca) on quartz (Qz). Note that calcite also contains small stibnite inclusions. (Bar-scale = 0.23 mm; (A) reflected and (B) combination of reflected and transmitted light)..... 70
- 4.47 Photomicrograph of late-stibnite-quartz (stage IV) mineralization showing an intergrowth of stibnite (St), pyrrhotite (Pyr) and chalcopyrite (Cpy) and quartz (Qz). The dark color at the lower right and upper left corners is calcite. (Bar-scale = 0.06 mm; reflected light)..... 70
- 4.48 Photomicrograph showing a highly silicified rock fragment (fine-grained) surrounded by matrix of stage II mineralization. The fragment mainly contains very fine-grained quartz plus arsenopyrite and pyrite. The matrix comprises similar mineral assemblages but is much coarser - grained (left). (Bar - scale = 0.45 mm; transmitted light, crossed nicols)..... 70
- 4.49 Photomicrograph of highly silicified phyllonite fragment related to stage II mineralization showing relict texture defined by dark opaque minerals. The non-opaque mineral consists mainly

- of fine-grained quartz. (Bar-scale = 0.23 mm; transmitted light; crossed nicols)..... 72
- 4.50 Photomicrograph of sericitized phyllonite fragment showing coarser muscovite replaced by sericite (very fine-grained). (Bar-scale = 0.23 mm; transmitted light, crossed nicols)..... 72
- 4.51 Hand specimen of silicified sandstone related to the major silicification. Detailed of this silicified wall rock is given in Figures 4.52 and 4.53. Note that it is cross cut by stage IV quartz..... 72
- 4.52 Photomicrograph of moderately silicified sandstone wall rock related to major barren quartz showing original quartz grain (rounded and coarser grain in the middle). Note that some original sericites are also present (Se). (Bar-scale = 0.23 mm; transmitted light, crossed nicols)..... 72
- 4.53 Photomicrograph of highly silicified sandstone related to major barren quartz showing very fine-grained quartz probably replace some original minerals and note the coarser grains are original framework grains (SG). (Bar-scale = 0.23 mm; transmitted light, crossed nicols)..... 74
- 4.54 Photomicrograph of silicified phyllitic rock showing fine-grained quartz and minor sericite (top left corner). (Bar-scale = 0.45 mm; transmitted light, crossed nicols)..... 74

- 4.55 Hand specimen of mineralized wall rock in which the stage II mineralization occurs as infilling fractures and disseminated in wall rock which in turn superimposed by stage IV mineralization (arrow), (see Figure 4.63)..... 74
- 4.56 Photomicrograph of silicified sandstone ? related to stage III mineralization showing quartz and stibnite infilling vugs (top and center) and partly disseminated in wall rock (arrow). (Bar-scale = 0.45 mm; transmitted light, crossed nicols)..... 74
- 4.57 Photomicrograph of silicified sandstone ? showing silicification related to stage III mineralization which contains disseminated fine-grained quartz and stibnite (bottom, arrow). The sandstone is cross cut by stage IV mineralized veinlet (top) containing coarse-grained quartz and stibnite in the interior of veinlet (St). (Bar-scale = 0.45 mm; transmitted light, crossed nicols)..... 75
- 4.58 Hand specimen showing wall rock fragment (white) that undergone phyllic alteration related to stage III mineralization. Note, dark color is matrix of stage III mineralization..... 75
- 4.59 Photomicrograph of phyllic alteration related to stage III mineralization showing sericite-riched zone (at the bottom of photo) cross cutting into

	stretched sandstone?. (Bar-scale = 0.23 mm; transmitted light, crossed nicols).....	75
5.1	Photomicrograph of primary fluid inclusions in the stage I sphalerite of the galena - sphalerite - ferroan dolomite mineralization showing simple liquid-riched type with approximately constant liquid/vapor ratios. (Bar-scale = 0.06 mm). ...	77
5.2	Photomicrograph of primary fluid inclusion in the quartz stage IV of the late-stibnite-quartz mineralization showing simple liquid-riched type with approximately constant liquid/vapor ratios. (Bar-scale = 0.06 mm).	77
5.3	Histogram showing homogenization temperature of simple liquid-rich inclusions in the stage I sphalerite and stage IV quartz (see data in Appendix).....	78

ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย