CHAPTER IV

MINERALIZATION

4.1 General Characteristic Features

The Chae Sorn mineralization is mainly confined to the shear zone. The mineralization was, however, post-dated shearing because no cataclastic deformation texture could be observed megascopically and microscopically on those mineralizing materials. The mineralization appears as a single major zone in the south but at least three discrete thinner zones are found in the north of the area (see Figure 3.2). The southern mineralized zone is thicker at the southern portion. Its thickest part is approximately 10 meters at the upper level and is thinner as increasing in depth (Figure 4.1). The thickness of each discrete thinner mineralized zone is approximately 3-5 meters at the upper level and probably thinner at lower level. The strike of the main mineralized zone and the discrete thinner zones conforms to the major shear zone. They are approximately northeast-southwest direction (see Figure 3.2) and moderately dip angle toward the east (see Figures 3.3 and 3.4).

The mineralized zone at the upper level is composed of several mineralized body lying within unsilicified phyllonite and silicified sandstone (Figure 4.2). The mineralized body itself is a product of multiple mineralizations in the forms of cross-cutting veins and veinlets and breccia filling (Figure 4.3). The main mineralized zone extends roughly 60 meters down dip (Figure 4.1). At

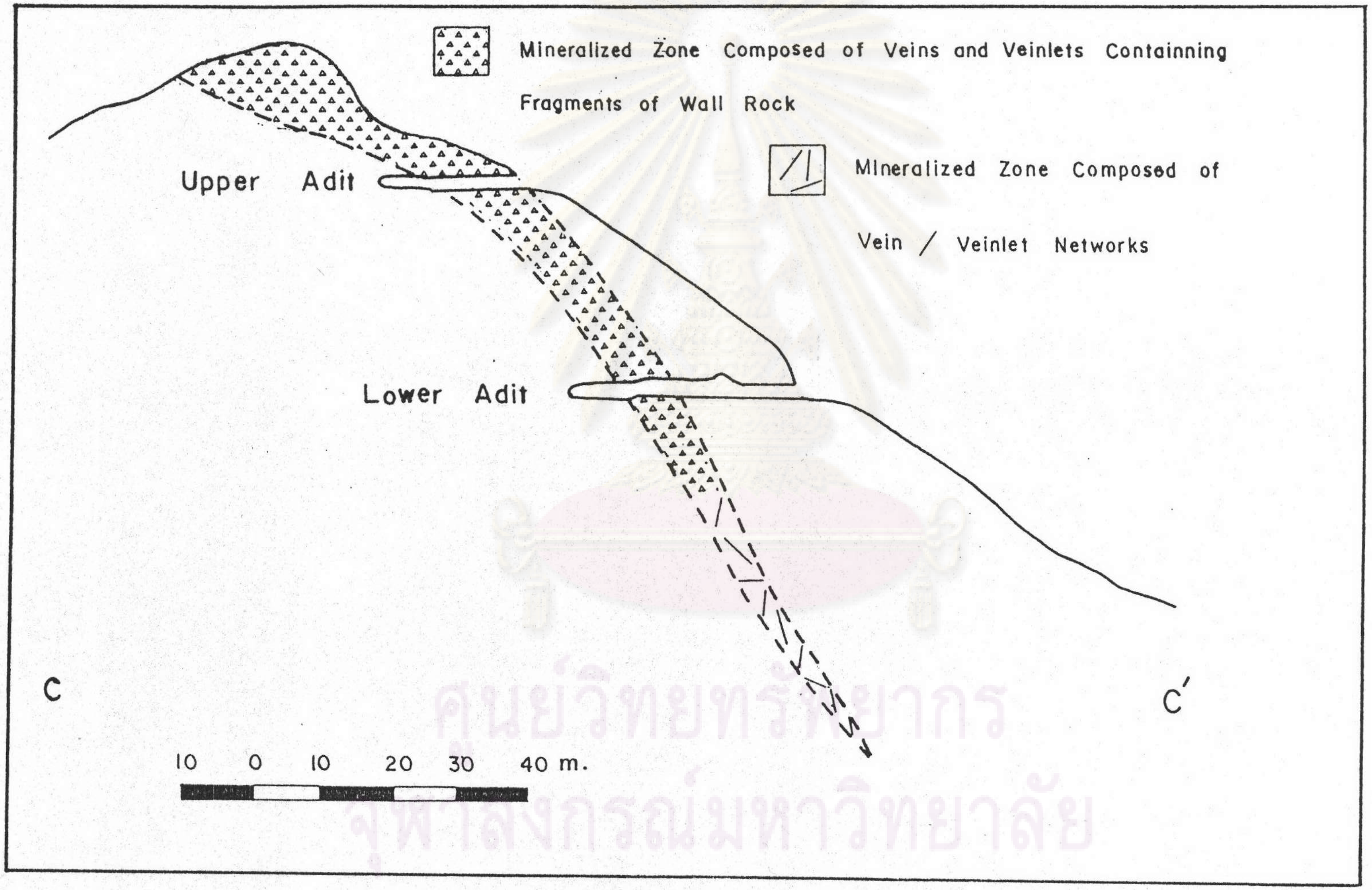


Figure 4.1 Adit cross-section showing morphology of mineralized zone, modified after SAC (1987).

deeper level, the mineralization zone appears as small vein and veinlet networks (Figure 4.4). The three discrete thinner mineralized zones also exhibit similar features. They however contain minor breccia.

Sparse mineralization in the forms of small veins and veinlets are also developed within the host rocks outside the main mineralized zone both in foot wall and hanging wall rocks. The mineralization tends to developed in more competent rock such as silicified stretched sandstone.

4.1.1 Breccia

Breccia in Chae Sorn is quite abundant but it is considered to be minor important as host of mineralization. This is because majority of them are unmineralized or cemented by pre-mineralized barren quartz. The majority of unmineralized and mineralized breccias are confined to the southern portion of the main mineralized zone which can be observed in outcrop including at the open pit (Figure 4.5) and also encountered in subsurface (Figure 4.6) by several drilling holes, such as 1A, 24, 8, 9, 19, 22, 20, 25, 21, 2 and 3. In some DDH such as 10, 11, 13 and etc., the rocks are occasionally intensely fractured and appear as breccia which infilled or cemented mainly by barren quartz (Figure 4.7). In general, the fragments are mainly phyllonite and stretched sandstone, minor phyllite and granite?. The rock flour is virtually absent. The fragments are partly to highly silicified and some of them are undergone phyllic or sericitic alteration (see section 4.4.3).

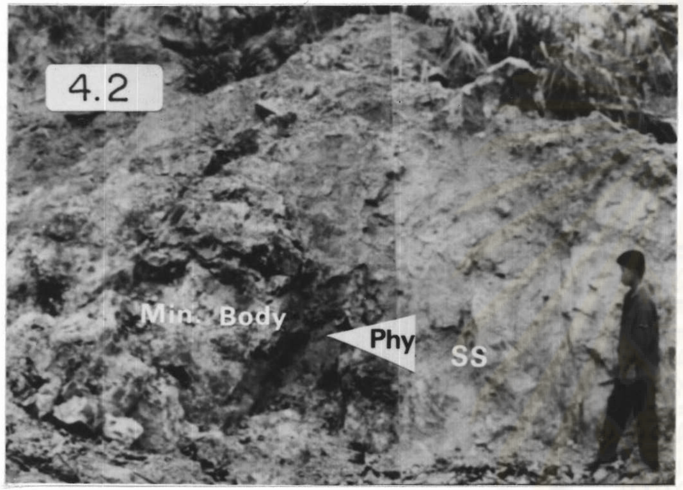
The overall geometry and nature of breccia in Chae Sorn is

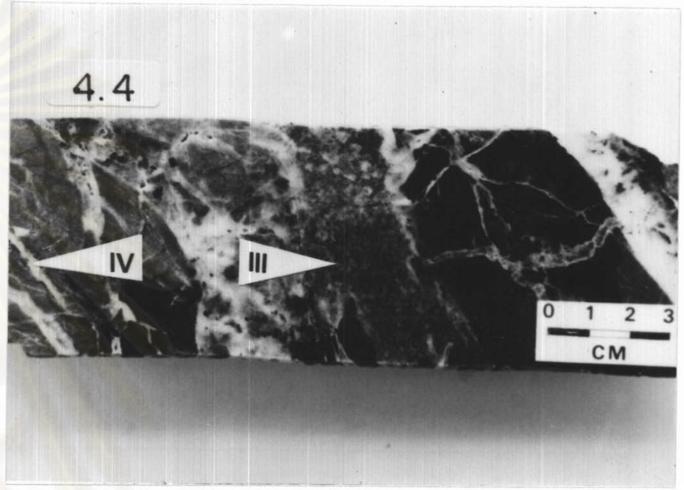
Figure 4.2 An exposure of a part of the main mineralized zone at the open pit showing the mineralized body (Min. Body) ,unsilicified phyllonite (Phy) and silicified sandstone (SS) wall rock.

Figure 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.

Figure 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.

Figure 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).


4.2
Min. Body
Phy
SS


4.4
IV
III
0 1 2 3
CM


4.3

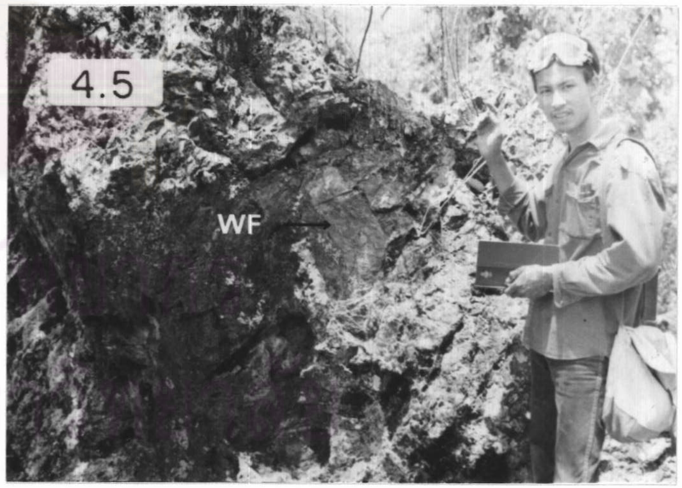
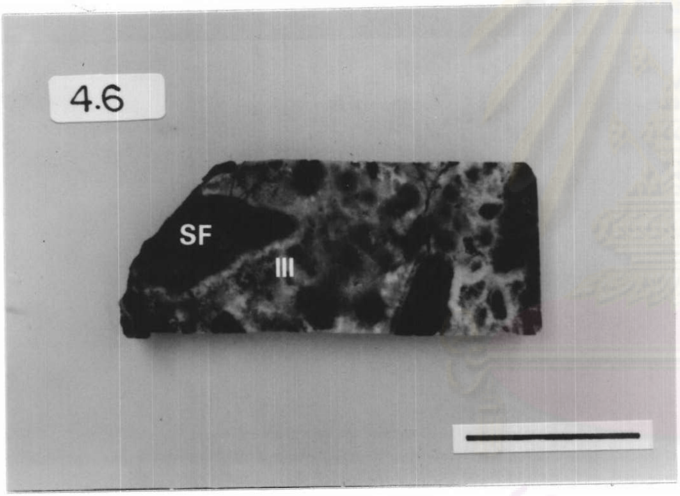
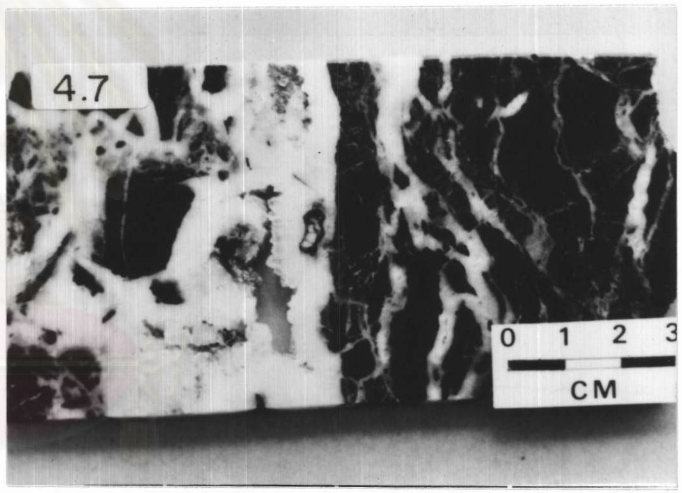

4.5
WF

Figure 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.

Figure 4.7 Core specimen showing an intensely fractured wall rock (dark) infilling by barren quartz (white). The wall rock has also been silicified.


4.6
SF
III


4.7
0 1 2 3
CM

remain uncertain. Neither field observation nor microscopic investigation reveals any evidence that those fragments are fault breccia. Eventhough, small scale faults (including microfault) have been recognized both in the field as well as in core samples, these small scale faults are related to pre-thrusting (see also chapter III). Another post-mineralization fault that displaced the main mineralized zone (see Figure 3.2) has been recognized . This fault is however, unrelated to brecciation in the Chae Sorn area. It is therefore probable that the breccia found in the Chae Sorn area is a phreatic breccia similar to that described by Sillitoe (1980).

4.2 Stages of Mineralization

At least four stages of mineralization in the Chae Sorn area can be broadly deciphered (Figure 4.8) based upon mineral assemblages, cross-cutting relationship, brecciation history and detailed texture. The first two stages are minor mineralization of galena-sphalerite-ferroan dolomite (stage I) and arsenopyrite-pyrite-quartz (stage II). The last two stages are the main stibnite mineralizing episodes; the early-stibnite-quartz (stage III) and the late-stibnite-quartz (stage IV) mineralizations.

4.2.1 Stage I (Minor Galena-Sphalerite-Ferroan Dolomite Mineralization)

Stage I mineralization is volumetrically not important (probably less than 1% of the total metal mineralization in the Chae Sorn area) and has been found as veins of a few centimeters thick outside the main mineralized zone in the DDH no.3.

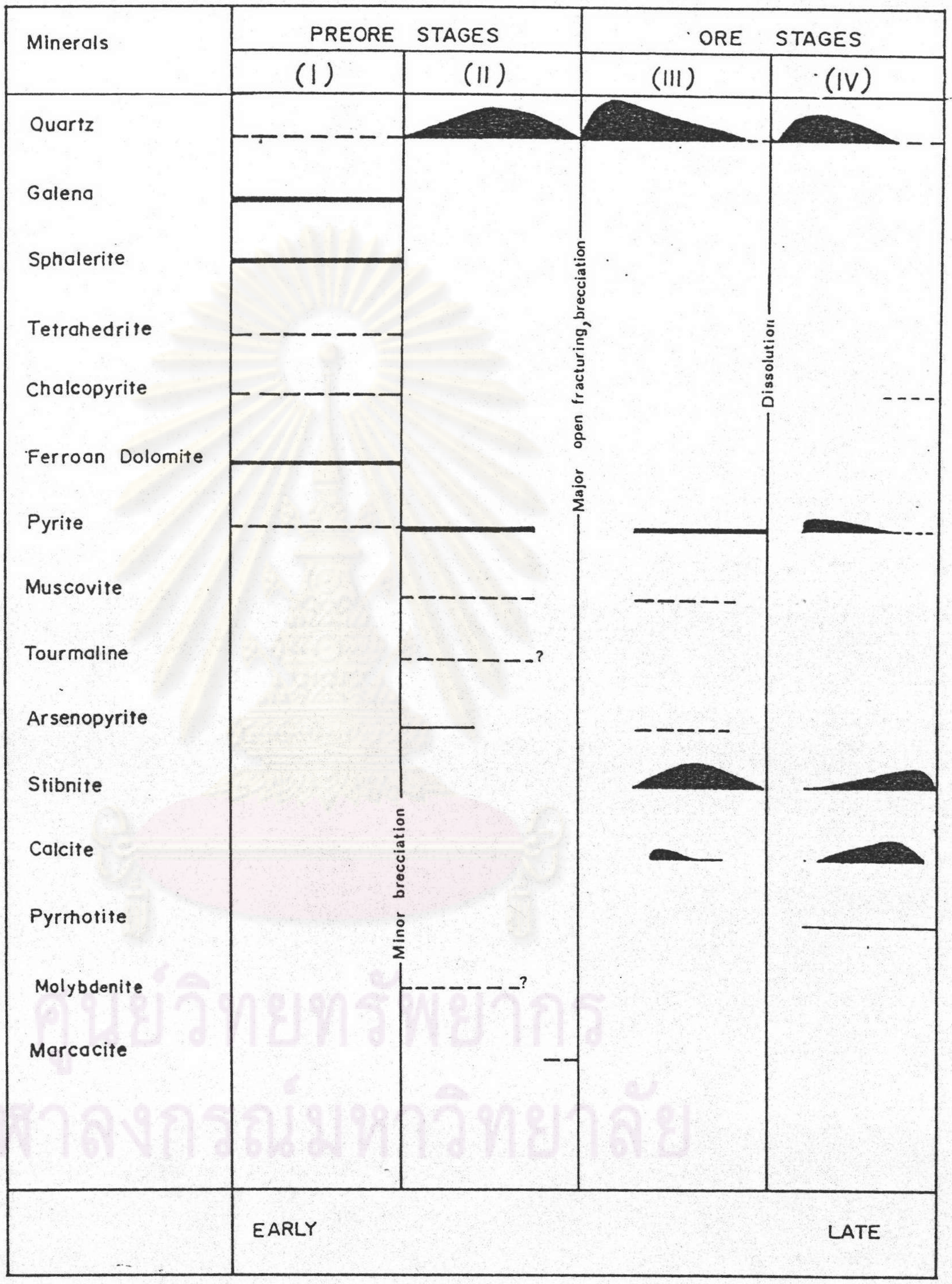


Figure 4.8 Chae Sorn Mineralized History.

Apparently those veins were essentially filled with ferroan dolomite containing patches of mainly sphalerite and galena (Figure 4.9). No obvious mineralogical zonation can be depicted from those veins. Texturally, sphalerite, galena are intimately intergrown with mutual grain boundary relationship suggesting their contemporaneity (Figures 4.10 and 4.11). Minor amounts of tetrahedrite and pyrite are also found as other closely associated sulfides (Figure 4.12). Galena also contains small inclusions of chalcopyrite, pyrite and tetrahedrite (Figure 4.13). Those sulfides commonly form irregular to rhombic crystal-face boundary with ferroan dolomite host (see Figure 4.11). Occasionally dolomite crystals contain inclusions of sulfides (i.e.,sphalerite and galena). Trace amount of quartz also occurs as euhedral to subhedral crystals closely associated with sulfides (see Figure 4.10). In other area quartz and sulfides form irregular grain contact. All these textural relationships suggest that during the infilling of dolomite in the veins, galena, sphalerite minor tetrahedrite, chalcopyrite, pyrite and quartz sporadically coprecipitated with ferroan dolomite (see Figure 4.8).

Eventhough there is no textural relationship between stage I and other mineralizing stages,the galena, sphalerite and ferroan dolomite are still preferentially assigned as stage I mineralization. This is because fluid inclusion study reveals that this stage was precipitated at somewhat higher temperature than those of the other mineralizing stages (see chapter V).

4.2.2 Stage II (Minor Arsenopyrite - Pyrite - Quartz Mineralization)

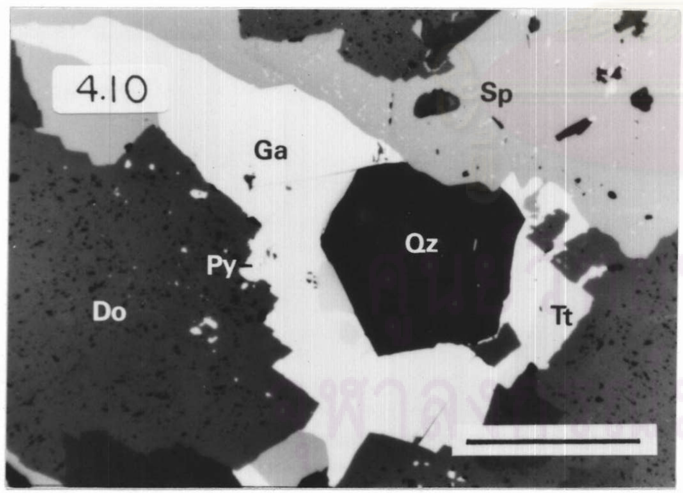
Figure 4.9 Core specimen of phyllonite contains base metal (arrow) bearing ferroan dolomite veins of stage I mineralization. The arrow is patch of mostly sphalerite and galena.

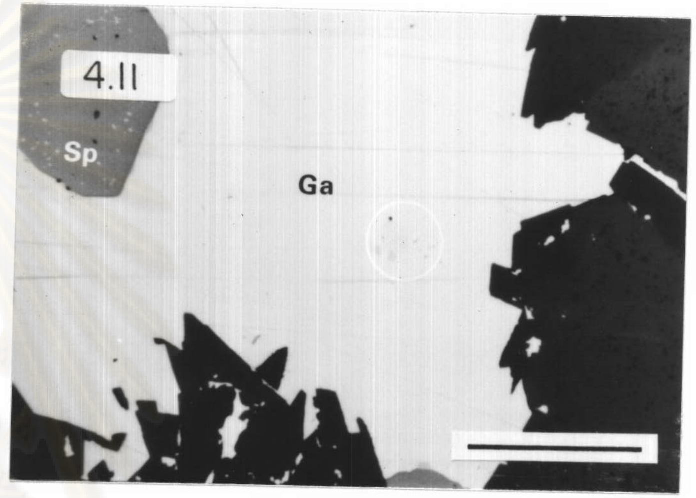
Figure 4.10 Photomicrograph of sphalerite-galena mineralization (stage I) showing intimate intergrowth of sphalerite (Sp), galena (Ga), tetrahedrite (Tt), dolomite (Do) and quartz (Qz). Note small pyrite (Py) grains in galena. Sphalerite contains tiny inclusions of chalcopyrite. (Bar-scale = 0.23 mm; reflected light).

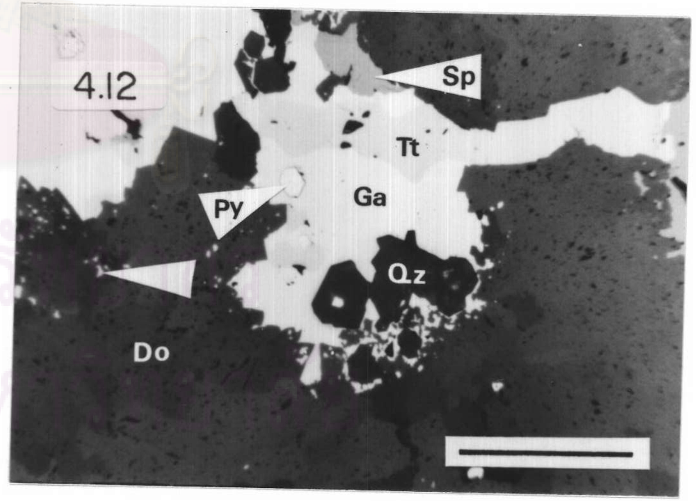
Figure 4.11 Photomicrograph of sphalerite-galena mineralization (stage I) showing galena (Ga) with curve grain outline in contact with sphalerite (Sp) and well developed crystal face toward ferroan dolomite (dark color). A portion marked by circle is enlarged in Figure 4.13. (Bar-scale = 0.23 mm; reflected light).

Figure 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 right).


4.9
0 1 2 3
CM


4.10
Sp
Ga
Qz
Py
Do
Tt


4.11
Sp
Ga


4.12
Sp
Tt
Py
Ga
Qz
Do

The stage II mineralization is also volumetrically less significant.It is probably accounted for approximately 10% of the total metal mineralization in the Chae Sorn area. This mineralizing stage is mainly found in the open pit of southern portion of the main mineralized zone and has been encountered by DDH nos. 9, 11 and 12. This stage is characterized by arsenopyrite-pyrite-quartz mineralization that cemented wall rock fragments (Figure 4.14). This stage also includes large quartz veins with sparse pyrite-arsenopyrite mineralization found at the open pit. Here, the massive stage II material overprinted by later mineralized stages (Figure 4.15). No obvious zonation can be observed in this stage. Several fragments of stage II mineralization (i.e., arsenopyrite-pyrite) are cemented by stibnite-quartz matrix of stage III (see Figure 4.14). Moreover, some quartz veinlets containing arsenopyrite probably of stage II were cross-cut by stibnite bearing quartz veins of stage III. Besides, the weakly mineralized vein material of stage II is cross-cut by stage IV (see also Figure 4.15). These evidences suggest that stage II predated stage III mineralization.

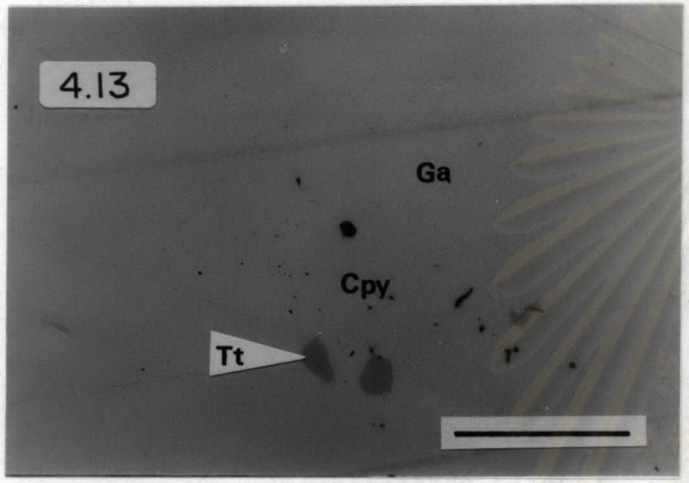
Arsenopyrite is the major sulfide of this stage with subordinate pyrite, minor marcasite and trace molybdenite. Quartz forms as a major gangue with small amount of muscovite and tourmaline. Arsenopyrite usually forms as very fine rhomb-shaped crystals or aggregates intimately intergrown with subordinate pyrite, quartz and muscovite (Figures 4.16, 4.17A,B, 4.18A,B, 4.19, 4.20). These textural relationship reveal that they were precipitated contemperaneously. Some pyrite might have been transformed from marcasite (Figures 4.21A and B). Molybdenite occurs in trace amount

Figure 4.13 Sphalerite - galena mineralization (stage I), galena (Ga) contains inclusions of chalcopyrite (Cpy) and tetrahedrite (Tt). (Bar-scale = 0.06 mm; reflected light).

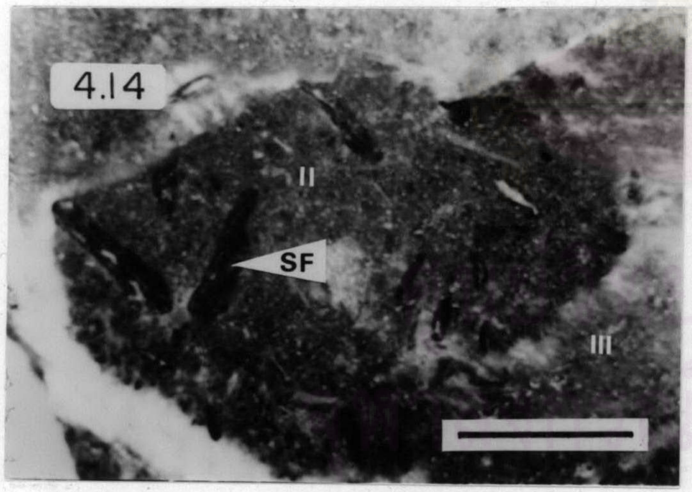
Figure 4.14 Hand specimen showing two episodes of brecciation and cementation. Fragments of stage II mineralization (II), which also contains small silicified rock fragments (SF), is cemented by stage III mineralization (III).

Figure 4.15 Hand specimen of stage II mineralization (dark) cross-cut by stage IV mineralization (light).

Figure 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).


4.13
Ga
Cpy
Tt


4.15
CM
0 1 2 3


4.14
II
SF
III

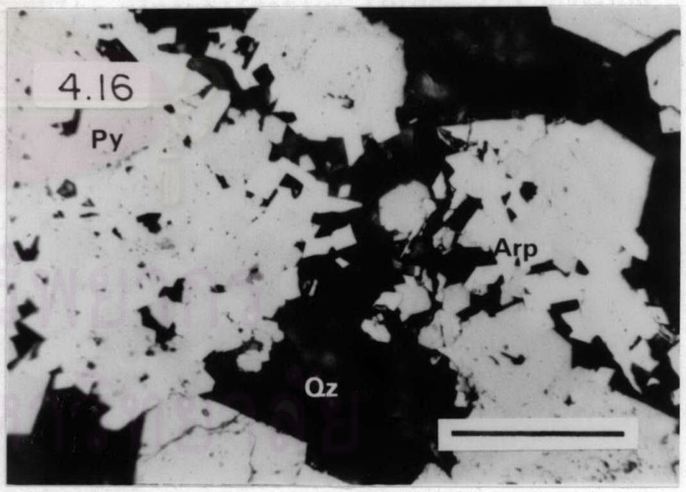
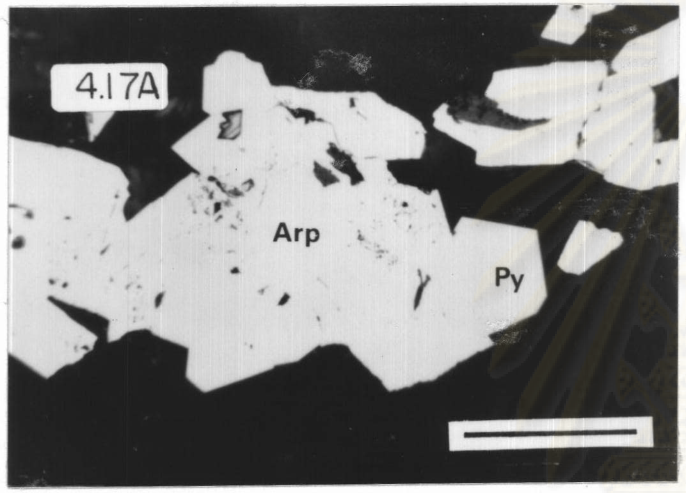
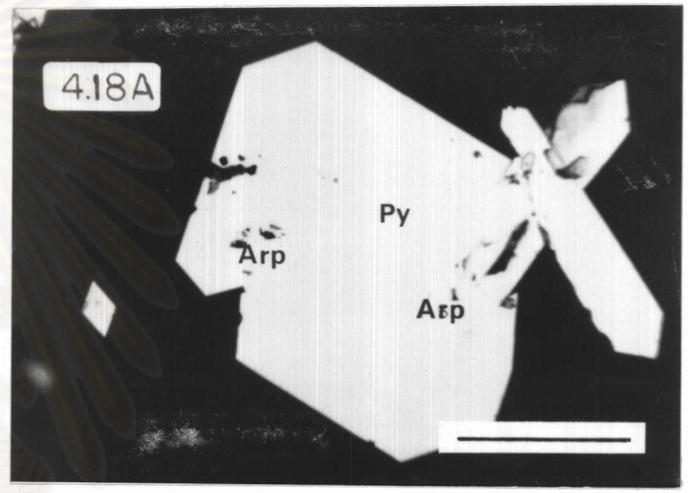
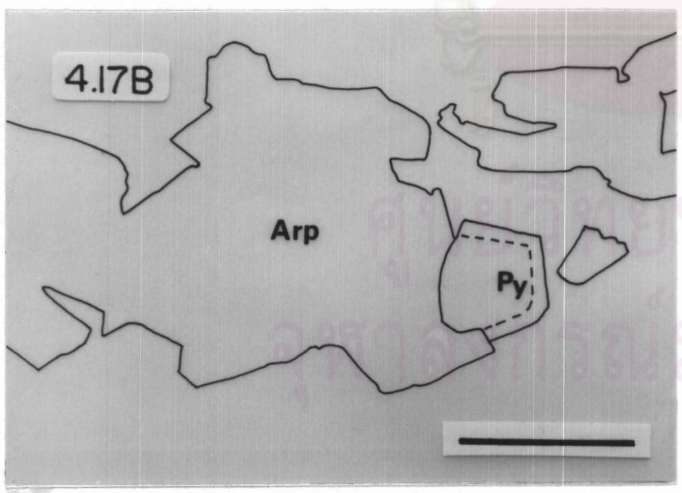

4.16
Py
Arp
Qz

Figure 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).

Figure 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 (A).


4.17A
Arp
Py


4.18A
Py
Arp
Arp


4.17B
Arp
Py

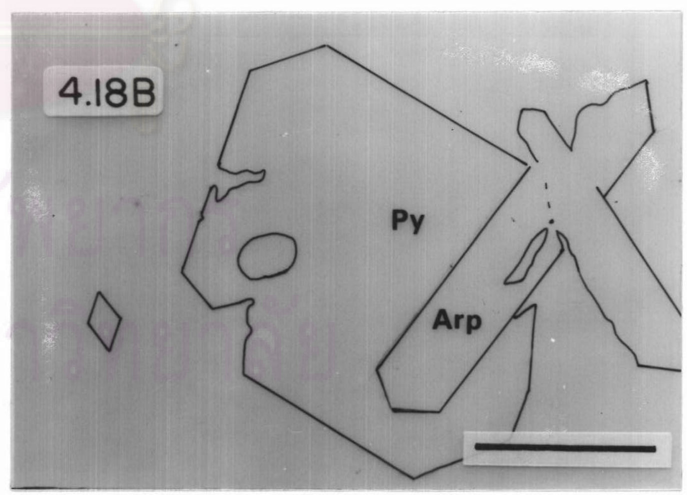
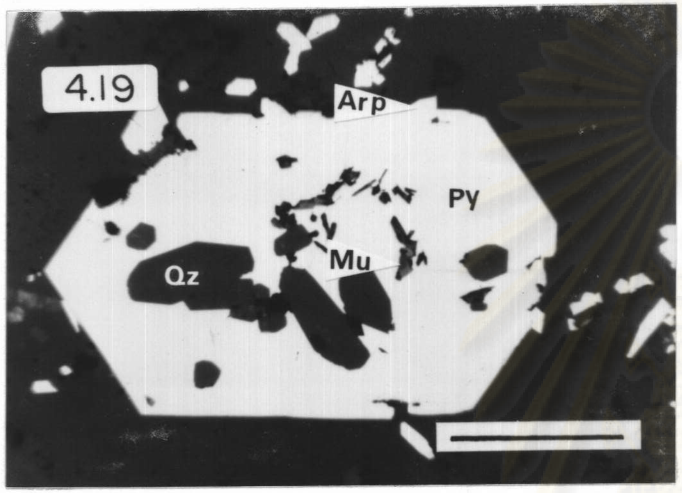
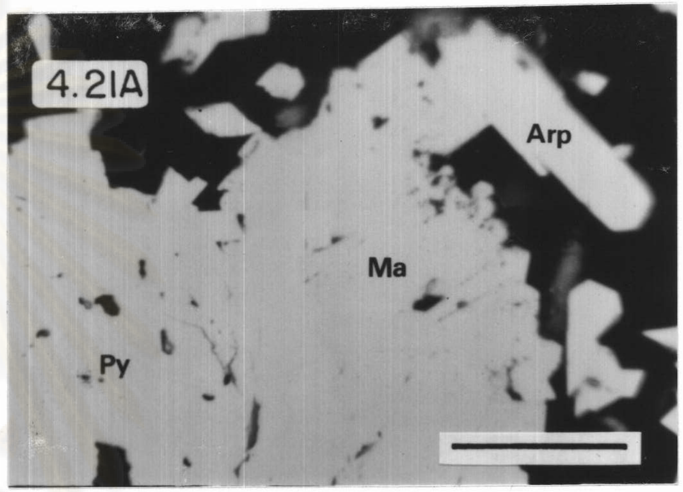

4.18B
Py
Arp

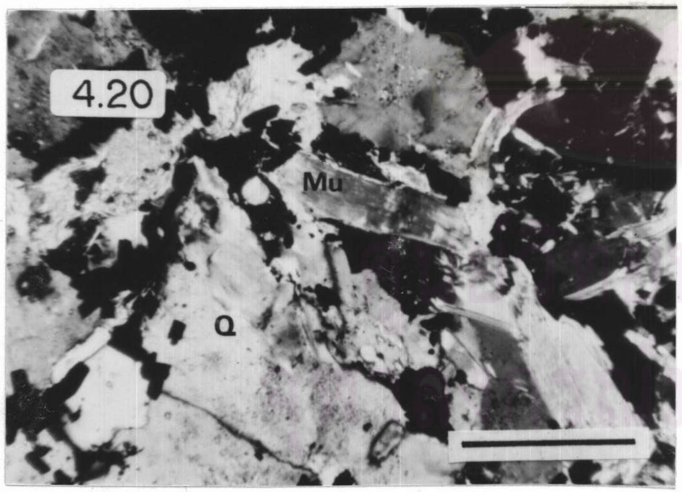
Figure 4.19 Photomicrograph of stage II mineralization showing euhedral pyrite (Py) contains inclusions of euhedral quartz (Qz) and muscovite (Mu)?. Note arsenopyrite (Arp) partly trapped in pyrite. (Bar-scale = 0.23 mm; reflected light, uncrossed nicols).

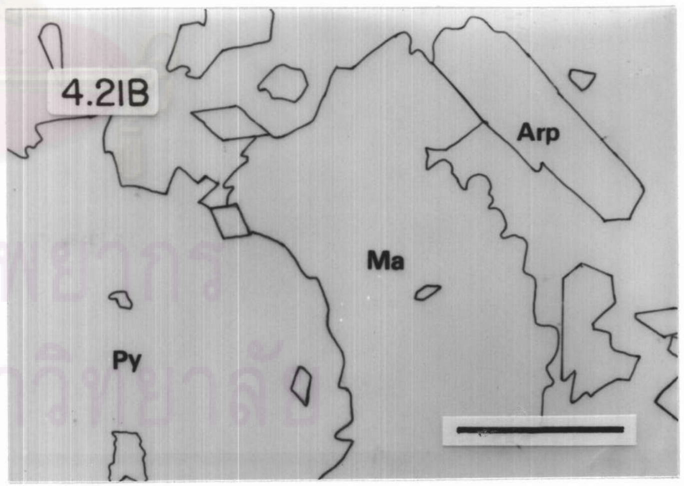
Figure 4.20 Photomicrograph of arsenopyrite-pyrite-quartz mineralization (stage II) showing quartz (Q), muscovite (Mu) and associated arsenopyrite and pyrite (opaque). (Bar-scale = 0.23 mm;transmitted light, crossed nicols).

Figure 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.


4.19
Arp
Py
Qz
Mu


4.21A
Arp
Ma
Py


4.20
Mu
Q


4.21B
Arp
Ma
Py

(Figure 4.22). It is probably formed more or less contemporanously with other sulfide minerals (i.e.,arsenopyrite and pyrite).

4.2.3 Stage III (Early Stibnite-Quartz Mineralization)

Prior to stage III mineralization, extensive open-fracturing, some brecciation and subsequently widespread silicification took place. The pre-stage III silicification was probably responsible for wide spread introduction of barren quartz infilling open fracture and cementing wall rock fragments found in mineralized zone as well as in hanging wall and foot wall rocks (Figures 4.23 and 4.24). The major wall rock silicification in the Chae Sorn area was probably taken place during this time (see section 4.4.2).

Stage III is the early and main stibnite mineralization which is rather widespread especially at southern main mineralized zone and at the three discrete thinner mineralized zones (i.e., DDH no.5).The stage III stibnite can be estimated to be approximately 65% of the total metal mineralization in the Chae Sorn area . The stage III mineralization is characterized by the assemblages of major stibnite and quartz accompanying by minor associated pyrite, pyrrhotite, calcite, arsenopyrite and muscovite. The style of stage III mineralization is commonly in the forms of open-fracture or vein filling often containing fragments of silicified wallrocks (Figure 3.25) and unsilicified phyllonite. Minor mineralization is also found as breccia or vug filling and as dissemination in the wallrock. No obvious zonation can be noticed in the stage III mineralization.

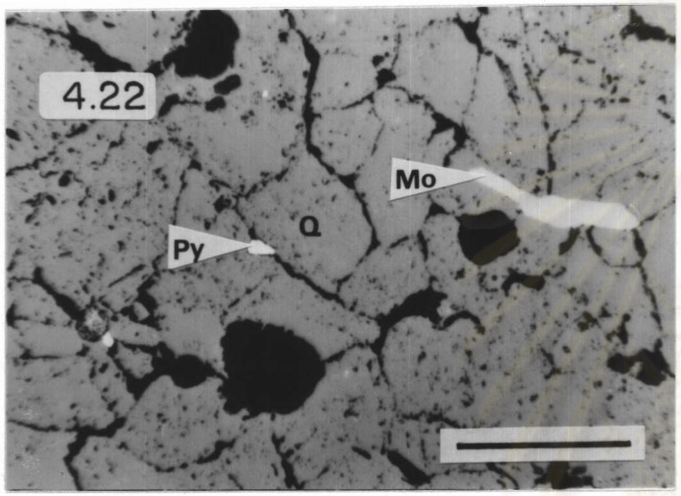
Stibnite of stage III mineralization generally forms as fine-

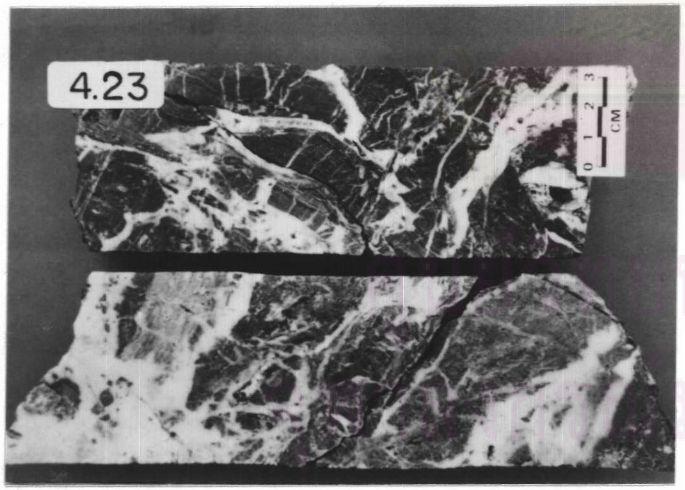
Figure 4.22 Photomicrograph of stage II mineralization showing molybdenite (Mo) associated with quartz (Q) and pyrite (Py). (Bar-scale = 0.23 mm; reflected light).

Figure 4.23 Core specimen of silicified phyllite showing intense fractures infilled by barren quartz marking the major silicification.

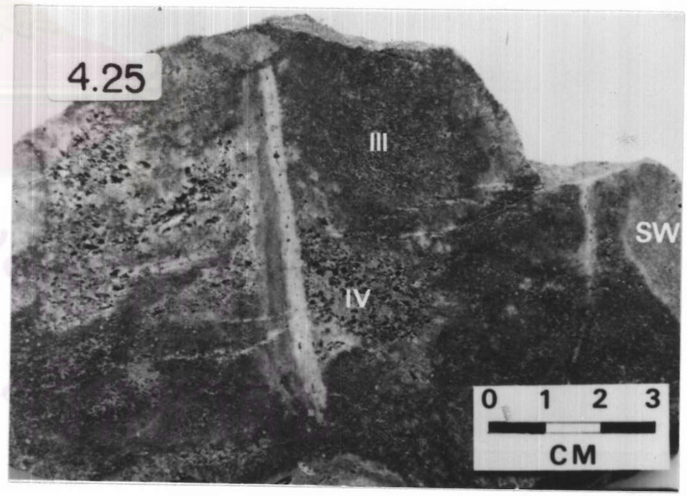
Figure 4.24 Breccia showing mainly unsilicified fragments (grey) of phyllonite cemented by barren quartz (white) marking the major pre-stage III silicification.

Figure 4.25 Hand specimen of open space filling stage III mineralization (dark, III) containning silicified wall rock (SW). Note the infiltration of stage IV mineralization (IV, white).


4.22
Mo
Q
Py


4.23
0 1 2 3
CM


4.24


4.25
III
IV
SW
0 1 2 3
CM

grained acicular or irregular-shape crystal, it is intimately intergrown mainly with fine-grained quartz (Figures 4.26 and 4.27) and, to some extend, with pyrite, arsenopyrite (Figures 4.28 and 4.29) and calcite (see Figure 4.27). Occasionally, stage III stibnite also occurs as needle-shaped crystals trapped as inclusions in quartz and calcite (Figure 4.30). Besides, thin-film stage III stibnite occurs between quartz grain boundary (Figure 4.31). In stage III mineralization, stibnite occasionally appears as open space infilling between euhedral qaurtz (Figure 4.32). Calcite also forms a close association with quartz and stibnite (Figure 4.33). Amount of pyrrhotite in stage III is higher as compared to that of stage IV and usually is intimately intergrown with stibnite, calcite and quartz (Figure 4.34). These microscopic evidences clearly indicate that stibnite, quartz as well as pyrite, arsenopyrite, calcite and pyrrhotite precipitated more or less contemporaneausly.

Cross-cutting relationship reveals that stage III mineralization was cut and infilled by quartz of stage IV (Figure 4.35). Moreover, large composite fragments of stage III mineralization were cemented by stage IV mineralization (Figure 4.36). Small veinlets of the stage III were occasionally cross-cut by the stage IV mineralization (Figure 4.37). These again imply that the stage III mineralization is pre-dated stage IV mineralization.

4.2.4 Stage IV (Late-Stibnite-Quartz Mineralization)

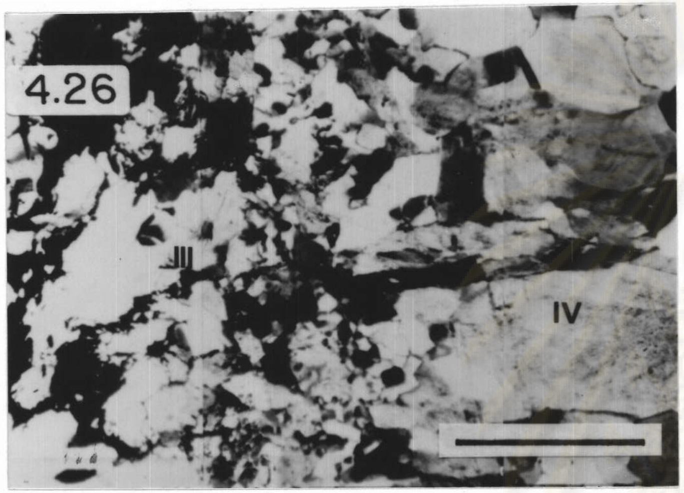
The stage IV mineralization is the final stibnite mineralizing episode. Stibnite mineralization of this stage is approximately 25% of the total metal mineralization of the Chae Sorn

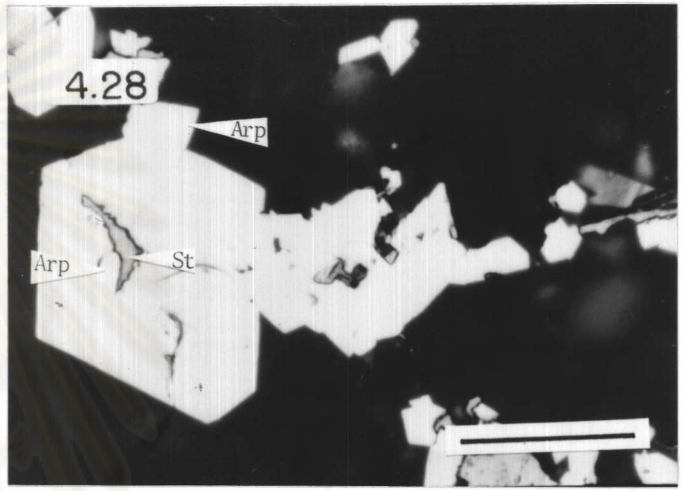
Figure 4.26 Photomicrograph showing cross-cutting relationships of stage III and stage IV mineralizations. The stage III mineralization is intimately intergrowth of quartz and stibnite (dark, left). (Bar-scale = mm; transmitted light, crossed nicols).

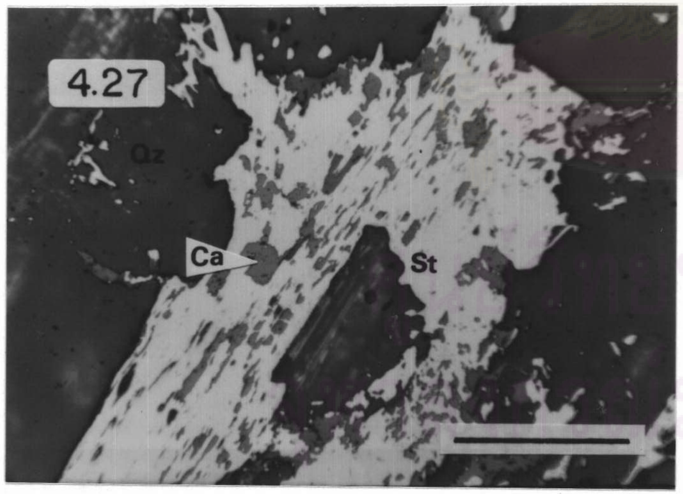
Figure 4.27 Photomicrograph of stage III mineralization showing the intergrowth of stibnite (St), calcite (Ca) and quartz (Qz). (Bar-scale = 0.23 mm; reflected light).

Figure 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).

Figure 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. (Bar-scale = 0.06 mm; reflected light).


4.26
III
IV


4.28
Arp
Arp
St


4.27
Qz
Ca
St

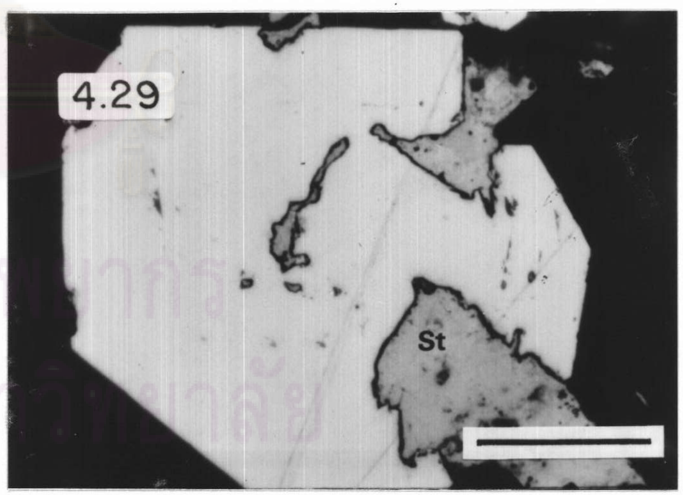
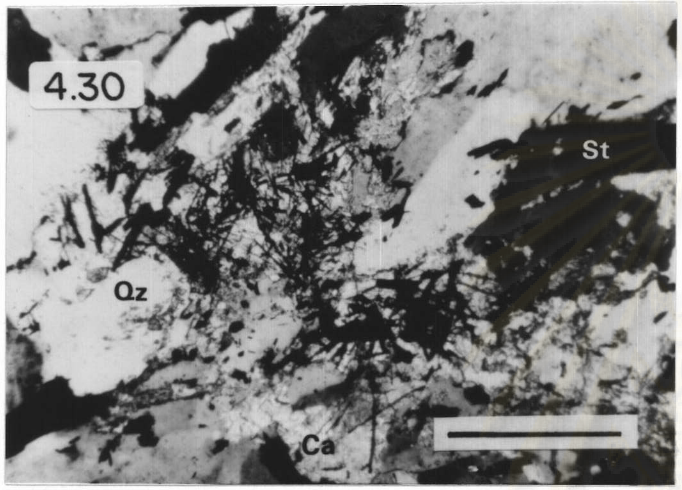

4.29
St

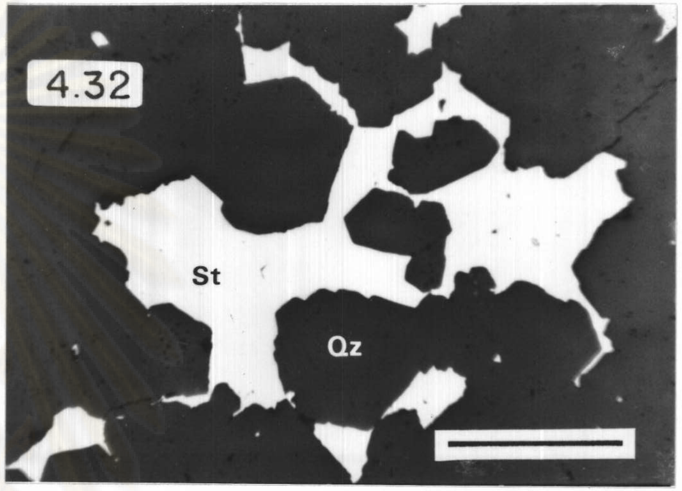
Figure 4.30 Photomicrograph of stage III mineralization showing bundles of stibnite needle (dark) partly trapped (center) in calcite (Ca) and quartz (Qz). Note that the coarser stibnite (St) grains are also present. (Bar-scale = 0.45 mm; transmitted light, crossed nicols).

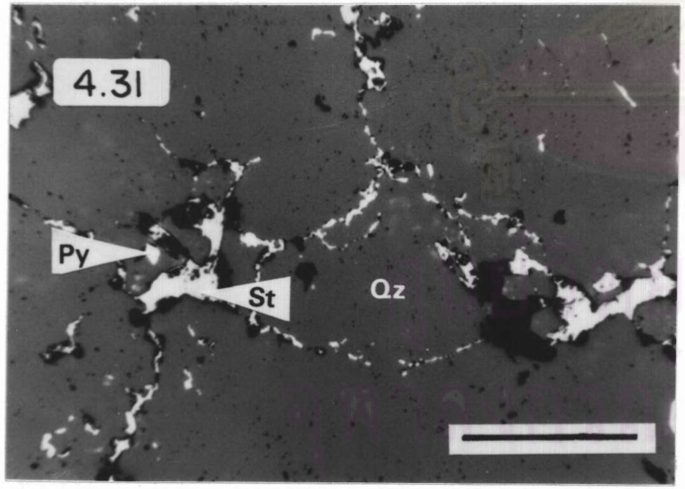
Figure 4.31 Photomicrograph showing thin -film stibnite (St) along quartz (Qz) grain boundary. Pyrite (Py) is also noted. (Bar-scale = 0.23 mm; reflected light).

Figure 4.32 Photomicrograph of stage III mineralization showing stibnite (St) associated with quartz (Qz). (Bar-scale = 0.45 mm; reflected light).

Figure 4.33 Photomicrograph showing an association of quartz (Qz), stibnite (St) and calcite (Ca). (Bar - scale = 0.23 mm; transmitted light, crossed nicols).


4.30
St
Qz
Ca


4.32
St
Qz


4.31
Py
St
Qz

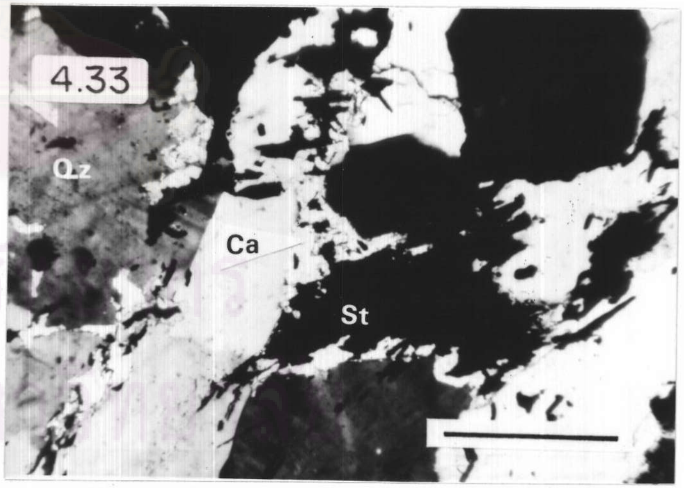
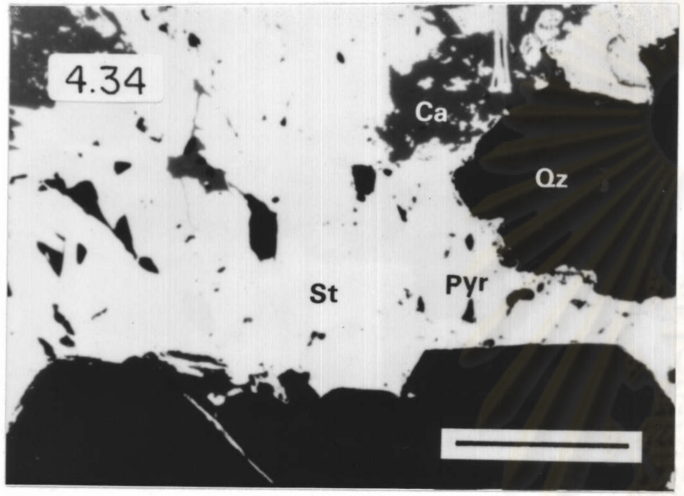

4.33
Qz
Ca
St

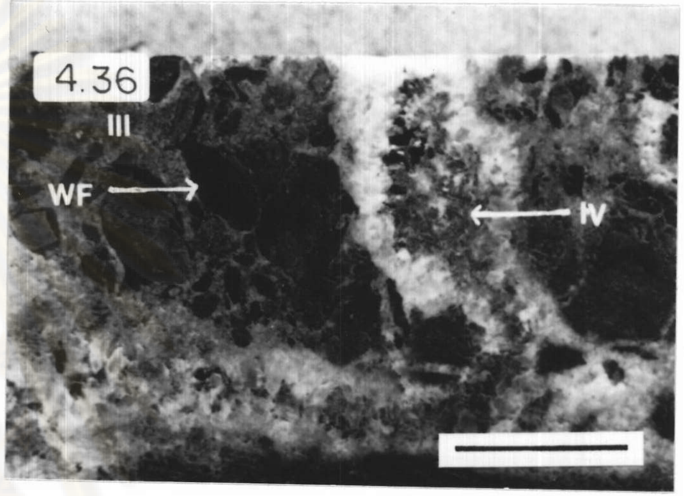
Figure 4.34 Photomicrograph of stage III mineralization showing an intergrowth of pyrrhotite (Pyr), stibnite (St), calcite (Ca) and quartz (Qz). (Bar-scale = 0.45 mm; reflected light).

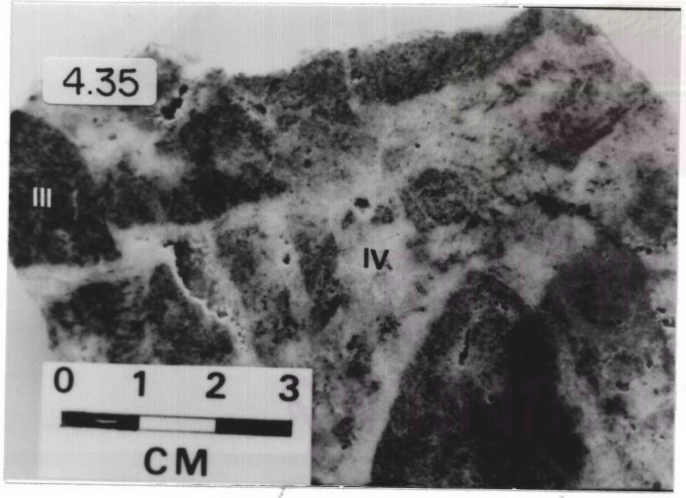
Figure 4.35 Slab specimen showing stibnite-quartz of stage III mineralization (dark, III) infilled by milky quartz of stage IV (light, IV) along fractures.

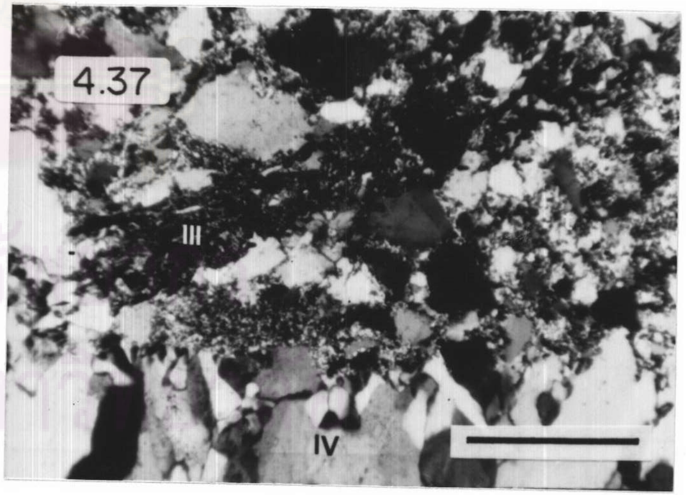
Figure 4.36 Core specimen showing the relationship between stage III and stage IV mineralization. Larger composite fragments of stage III mineralization (III) are cemented by stage IV mineraliztion (IV). Note that the stage III fragments also contains wall rock fragments (WR).

Figure 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).


4.34
Ca
Qz
St
Pyr


4.36
III
WF
IV


4.35
III
IV
0 1 2 3
CM


4.37
III
IV

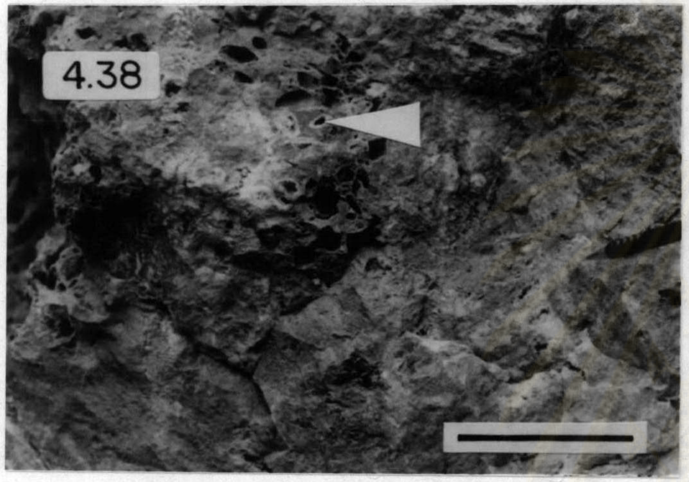
area. The stage IV is rather widespread in the main mineralized zone and minor at the three thinner discrete mineralized zones. The mineralization is essentially superimposed on the earlier stage III mineralization. However, prior to stage IV mineralization, dissolution of phyllic-altered-wallrock-fragments took place (Figure 4.38). The style of stage IV mineralization can be distinctly recognized by open-fracture-filling, vug (due to dissolution) filling of mainly milky quartz and coarsely crystalline stibnite with occasionally calcite. The coarsely crystalline quartz was the earliest mineral and marked the beginning of stage IV mineralization. It is commonly lining the wall of open-fracture (Figure 4.39), dissolved vugs (Figure 4.40), surrounding fragments of wall rocks (Figure 4.41) or stage III minerals (Figure 4.42) as well as filling the small veins and veinlets crosscutting into earlier mineralization (Figure 4.43). The stage IV milky quartz occasionally form a beautiful comb structure (Figures 4.44 and 4.45). Following the milky quartz precipitation toward the center of the open-fractures or vugs is the formation of coarsely crystalline stibnite which occasionally forms rather massive aggregates of large stibnite ore pocket (previously been excavated by local miners). The stibnite of stage IV usually occurs as well developed lath-shaped crystal aggregate occasionally form intergrowth with coarsely crystalline calcite (Figures 4.45; 4.46A and B) minor pyrrhotite (Figure 4.47) and trace chalcopyrite. Occasionally, stage III stibnite also occurs as needle-shaped crystals traped as inclusions in calcite (see Figure 4.46A and B). The above evidences both megascopic and microscopic are clearly suggest that the milky qaurtz is the earliest mineral precipitated following by coprecipitation of qaurtz, stibnite, calcite, pyrite,

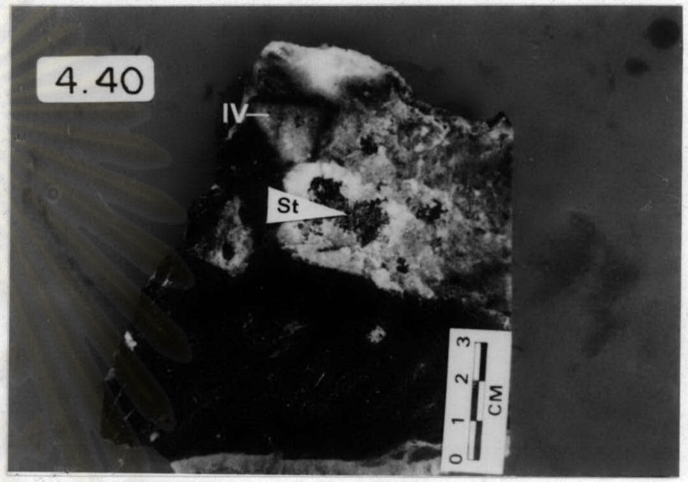
Figure 4.38 Blasted out crop showing dissolution of eariler phyllic-altered rock fragments indicated by vugs which some of them are partially infilled by stage IV mineralization (arrow).

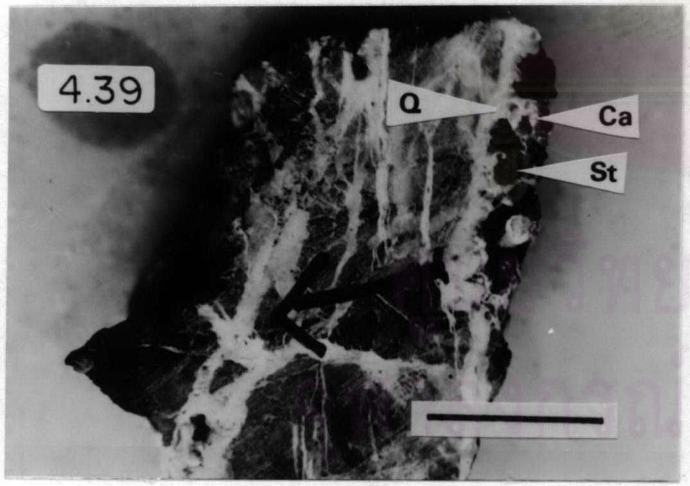
Figure 4.39 Core specimen of stage IV mineralization showing coarsely crystalline quartz (Qz) lining the wall of open fracture and coarsely acicular stibnite (St) plus minor calcite (Ca) in the interior of open-fracture. (Bar-scale = 2.50 cm.).

Figure 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.

Figure 4.41 Hand specimen of phyllonite cross-cut by quartz-stibnite mineralized vein (stage IV) showing wall rock fragments (WF) cemented eariler by milky quartz (white) and later by massive stibnite (St).


4.38


4.40
IV
St
0 1 2 3
CM


4.39
Q
Ca
St

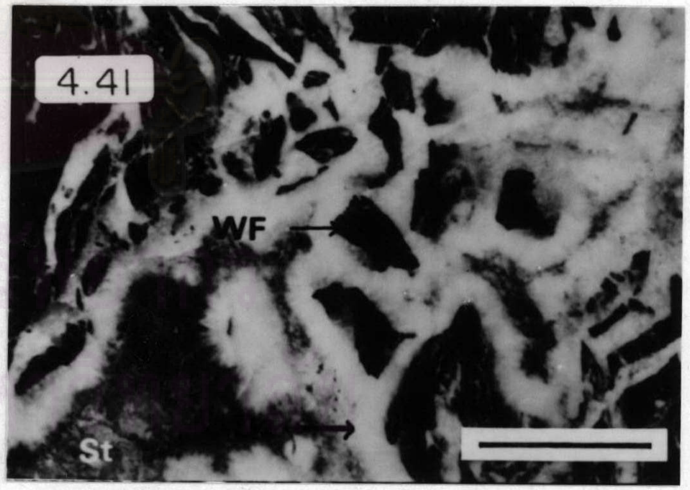
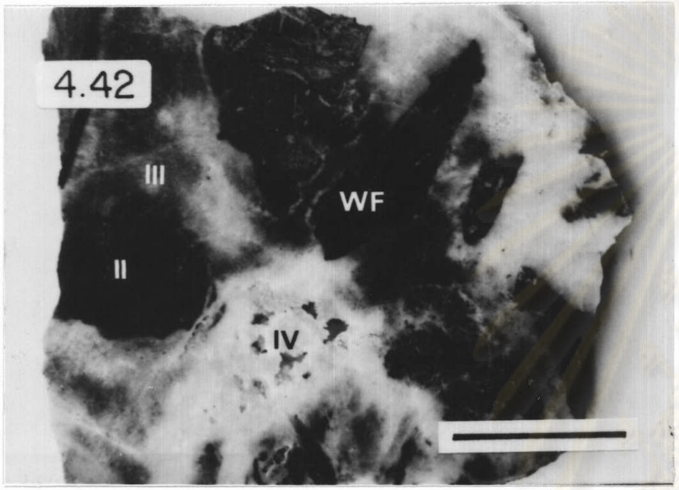

4.41
WF
St

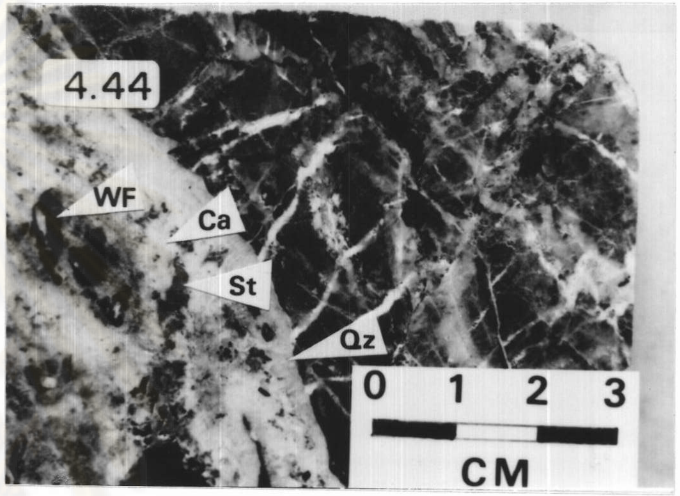
Figure 4.42 Slab of composite-mineralized breccia showing wallrock fragment (WF), stage II mineralized fragment (II) cemented by stage III mineralization (III). The milky quartz (IV) probably belongs to stage IV?.

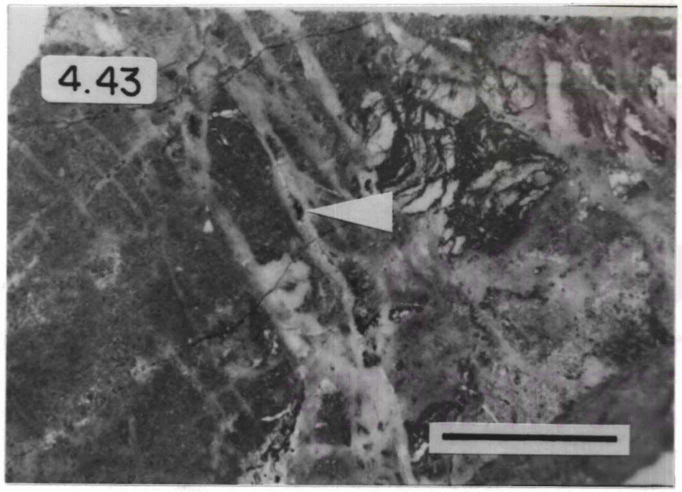
Figure 4.43 Core specimen of stage III mineralization post-dated by stage IV veinlets as indicated by milky quartz (arrow).

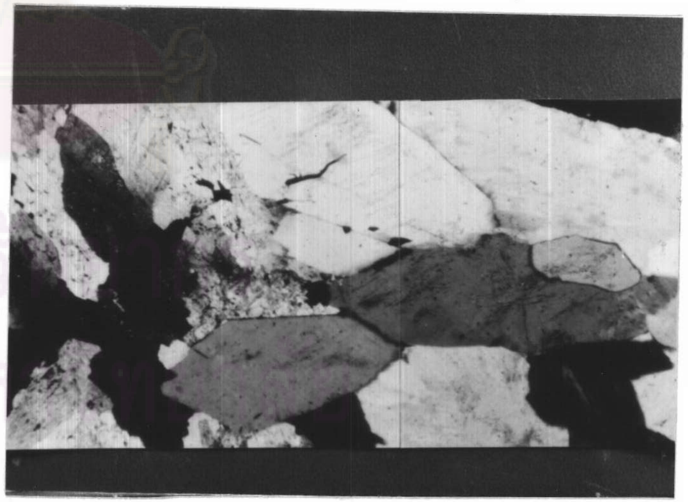
Figure 4.44 Core specimen of silicified sandstone (dark grey) showing zonation of stage IV mineralization overprinting . The comb quartz (Qz) lines the vein wall following by stibnite (St) and calcite (Ca) toward the center of the vein. Note also the silicified rock fragment (WF) in the vein. (Bar-scale = 0.45 mm; transmitted light).

Figure 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 = 0.45 mm; transmitted light, crossed nicols).


4.42
III
WF
II
IV


4.44
WF
Ca
St
Qz
0 1 2 3
CM


4.43



pyrrhotite and chalcopyrite.

4.3 Gold Mineralization

Over 60 polished thin-sections were examined microscopically to determine any possibly associated visible gold. Despite the fact that particular attention has been given on the possibly-gold associated minerals, such as pyrite, arsenopyrite, chalcopyrite, stibnite using high power objective; no physical gold has actually been observed in the samples. Gold has been reported by the analysis of Chae Sorn ore (i.e., 1.8% antimony and 1.9 g/t gold, SAC, 1987), microprobing and metallurgical test (SAC, 1987). Close correlation of arsenic and gold values was reported and suggested that much of the gold might be associated with arsenopyrite (SAC, 1987). Moreover, no gold was able to pan from the stream draining from Chae Sorn area. Hence, gold here is likely to occur as very fine particle, associated with sulfide minerals.

4.4 Wall Rock Alteration

Silicification is the principle and widely distributed wall rock alteration in Chae Sorn area. The alteration occurs not only within the main and the three discrete thinner mineralized zones but also extends into hanging wall and foot wall rocks. The extension and degree of alteration is, however, variable due to the rock types and the homogeneity of the rocks. In fact, the silicification is mainly confined to the stretched sandstone whereas the phyllitic rocks, such as phyllite and phyllonite are less or virtually uneffected as mentioned earlier. Neverthless, small fragments of phyllonite are occasionally undergone highly silicified (see in next paragraph). Sericitic or phyllic alteration has also been identified but it is less common.

The stage II mineralization that produced minor silicification, is particularly observed in small rock fragments. The major silicification is believed to occur subsequently to the major fracturing and brecciation which took place prior to stage III mineralization (early stibnite-qaurtz mineralization). Minor silicification was also accompanied stage III. However, in comparison with that accompanied by stage II mineralization it is considered to be more predominant. Minor sericitic alteration is also recognized during the stage II and III. Prior to stage IV mineralization, dissolution took place. The late stibnite-quartz mineralization of stage IV probably produced little silicification.

The alterations are described in paragenetic order related to stage of mineralization and fracturing as follows :-

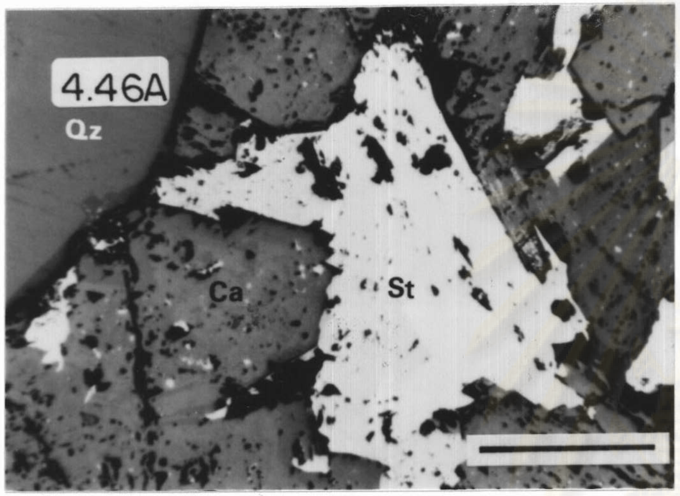
4.4.1 Alteration Related to the stage II Mineralization

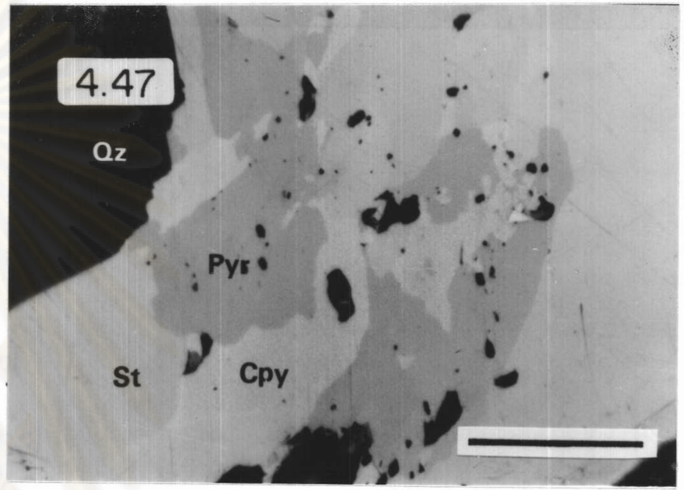
Two types of hydrothermal wallrock alteration have been observed in accompanying stage II mineralization, namely silicification and sericitic alteration. The silicification has been observed particularly on small rock fragments scattered in the matrix of arsenopyrite-pyrite-quartz mineralization or stage II mineralization (see Figure 4.14). Some of these fragments are highly silicified by the replacement of very fine-grained quartz plus minor arsenopyrite and pyrite (Figure 4.48). Small phyllonite fragments are also highly silicified (Figure 4.49). However, some fragments of

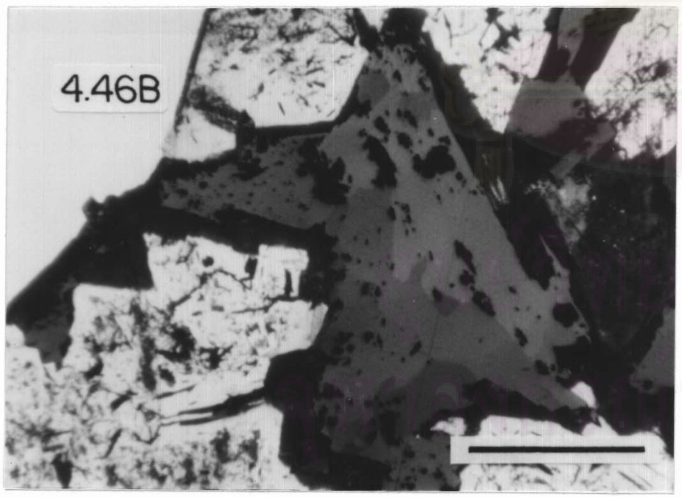
Figure 4.46 Photomicrograph of late-stibnite-quartz mineralization (stage IV) showing an intergrowth of stibnite (St), calcite (Ca) and quartz (Qz). Note that calcite also contains small stibnite inclusions. (Bar-scale = 0.23 mm; (A) reflected and (B) combination of reflected and transmitted light).

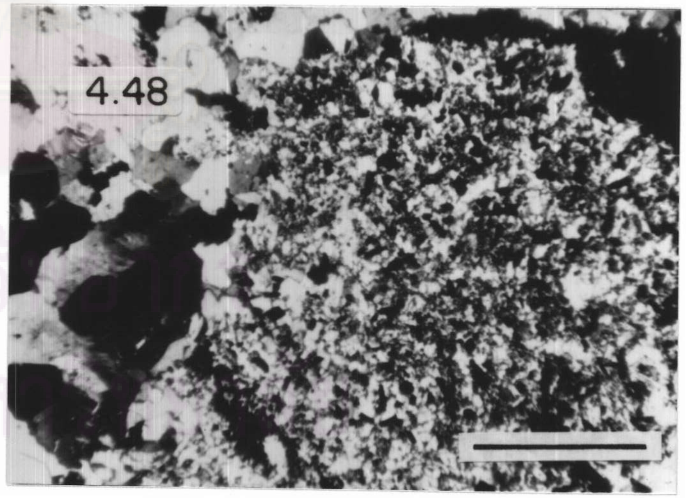
Figure 4.47 Photomicrograph of late-stibnite-quartz (stage IV) mineralization showing an intergrowth of stibnite (St), pyrrhotite (Pyr) and chalcopyrite (Cpy) and Quartz (Qz). The dark color at the lower right and upper left corners is calcite. (Bar-scale = 0.06 mm; reflected light).

Figure 4.48 Photomicrograph showing 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).


4.46A
Qz
Ca
St


4.47
Qz
Pyr
St
Cpy


4.46B


4.48

phyllonite particularly the larger fragments (see Figure 4.21) has undergone slightly sericitic alteration (Figure 4.50).

4.4.2 Alteration Accompanying Major Fracturing and Brecciation.

This hydrothermal alteration is represented by the major silicification and it is believed to be the most widespread in Chae Sorn area. It was formed subsequently to the major fracturing and brecciation in the area and was related to a major introduction of silica that gave rise to major barren quartz as mentioned earlier. In hand specimen the rock is apparently as shown Figure 4.51. This silicification is characterized by the introduction of almost pure quartz. Some other minerals like siricite (Figure 4.52) are considered as original minerals present in the wall rock. However, in highly silicified rock sericite is totally absent. This silicification is minefested by very fine-grained quartz replaces matrix of sandstone (Figure 4.53) and phyllitic rock (Figure 4.54).

4.4.3 Wall Rock Alteration Related to Stage III Mineralization

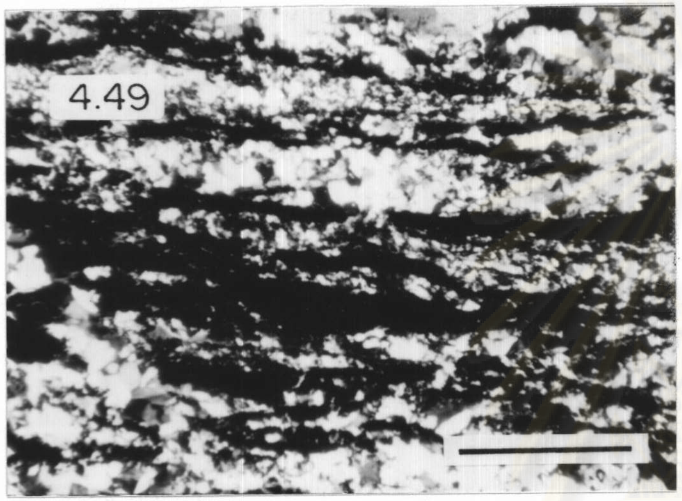
The alteration accompanying stage III mineralization is represented by minor silicification and minor phyllic alteration. It is confined to the rocks that hosts stage III mineralization both as rock fragments and wall rock. Silicification is mainly observed in sandstone especially that hosts networks of small veins and veinlets within the main mineralized zone such as DDH nos. 10, 11, 12 and in discrete mineralized zone i.e., DDH no 5. This stage of

Figure 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 cosists mainly of fine-grained quartz. (Bar-scale = 0.23 mm; transmitted , crossed nicols).

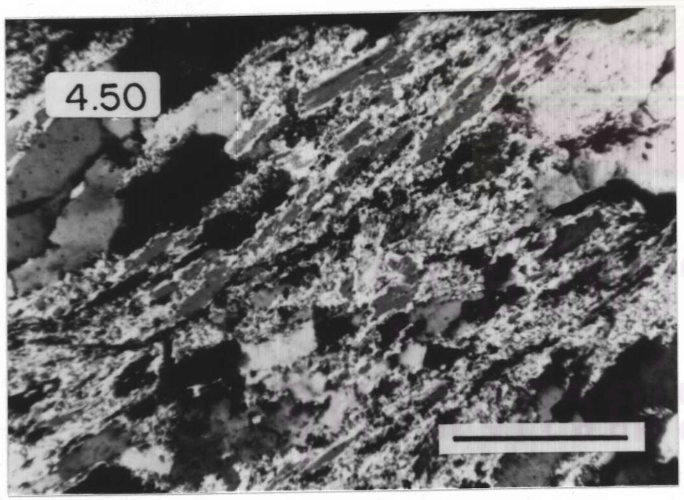
Figure 4.50 Photomicrograph of sericitized phyllonite fragment showing coarser muscovite replaced by sericite (very fine-grained) . (Bar-scale = 0.23 mm; transmitted, crossed nicols).

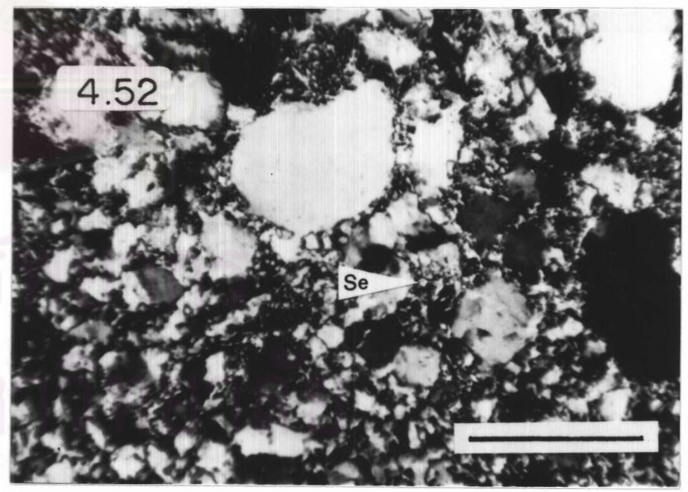
Figure 4.51 Hand specimen of silicified sandstone related to the major silicification. Detailed of this silicified wall rock is given in Figures 4.52 and 4.53. Note that it is cross cut by stage IV quartz.

Figure 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 (Se) are also present. (Bar-scale = 0.23 mm; transmitted light, crossed nicols).


4.49


4.51
0 1 2 3
CM


4.50


4.52
Se

silicification is typically characterized by the replacement of quartz with minor stibnite and pyrite which are different from the major silicification that contains no stibnite. In hand specimen, the rock appears as sandstone (Figure 4.55). Here the silicification is manefested by fine-grained quartz infilling open fractures , pore spaces as well as replacement original grains (Figure 4.56). This silicified rock occasionally cross cuts by late stibnite-quartz mineralized veins and veinlets of stage IV mineralization (Figure 4.57). The presence of disseminated stibnite in wallrock and cross cutting relationship suggest that this silicification is predated stage IV mineralization.

Phyllic alteration occurs in minor amount, especially in wallrock fragments that were observed at the open pit. The fragments are apparently white in color, friable (Figure 4.58) and cementing by matrix of stage III mineralization. This evidence probably suggests that this phyllic alteration is related to stage III mineralization. The XRD determination reveals that the fragments are composed mainly of sericite and quartz. The fragments are probably of granitic origin. Besides, minor phyllic alteration has been recognized in stretched sandstone encountered by DDH no. 11. Here the sandstone is cross cut by small quartz-sericite veins and veinlets. (Figure 4.59).

4.4.4 <u>Wall rock Alteration Related to Stage IV Mineralization</u>

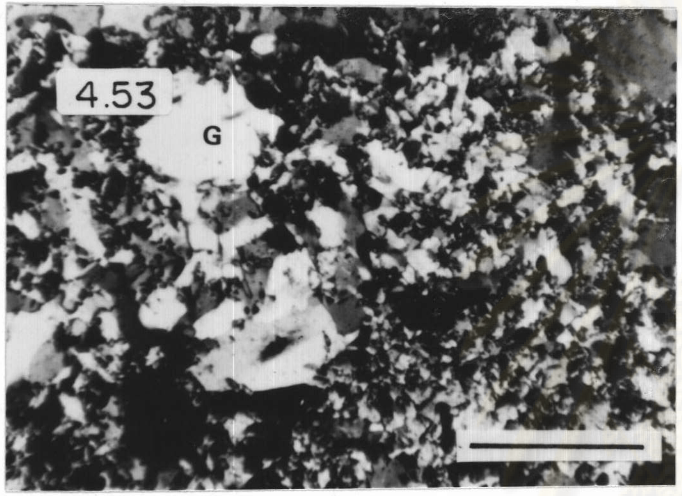
Stage IV mineralization (late - stibnite - quartz mineralization) is believed to produce weakly silicification based on study on the rock that host stage IV mineralization.

Figure 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 (G). (Bar-scale = 0.23 mm ;transmitted light, crossed nicols).

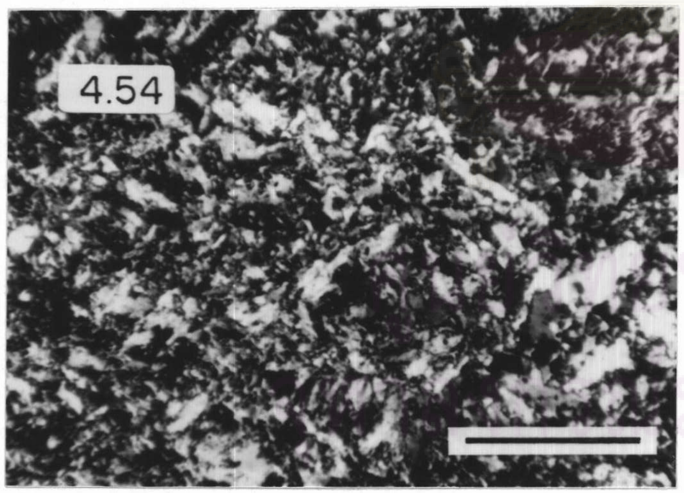
Figure 4.54 Photomicrograph of silicified phyllitic rock showing fine-grained quartz and minor sericite (top left corner). (Bar-scale = 0.45 mm; transmitted light, crossed nicols).

Figure 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).

Figure 4.56 Photomicrograph of silicified sandstone? related to stage III mineralization showing quartz and stibnite (St) infilling vugs (right and center) and partly disseminated in wall rock (arrow). (Bar-scale = 0.45 mm; transmitted light , crossed nicols).


4.53
G


4.55
0 1 2 3CM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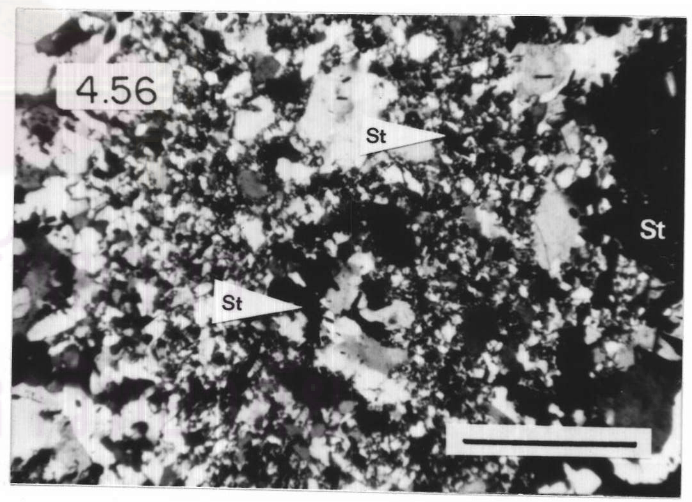
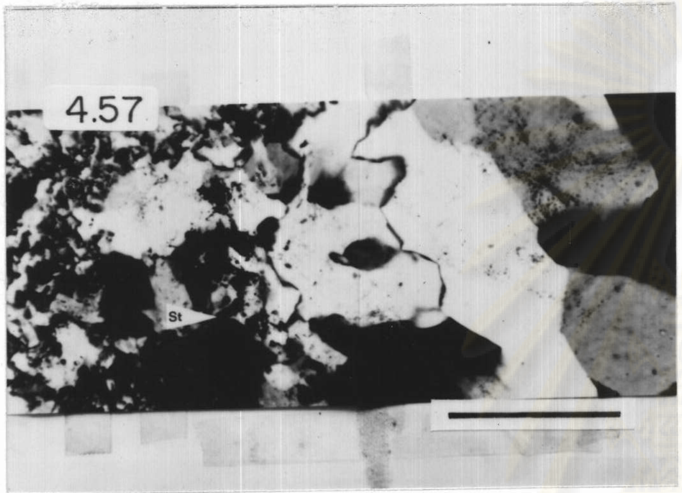
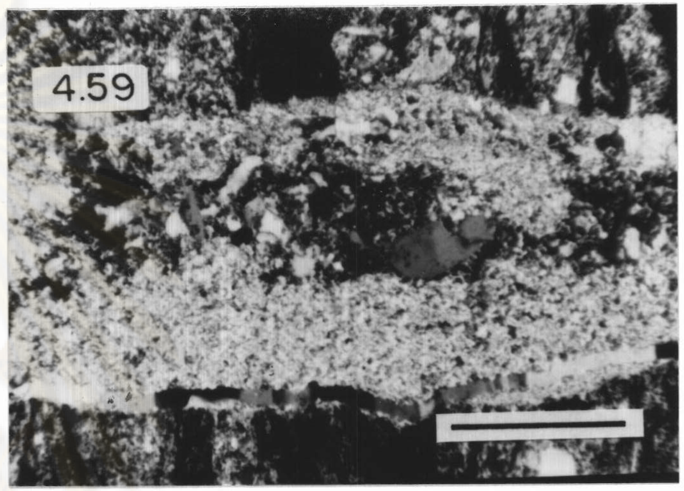

4.56
St
St
St

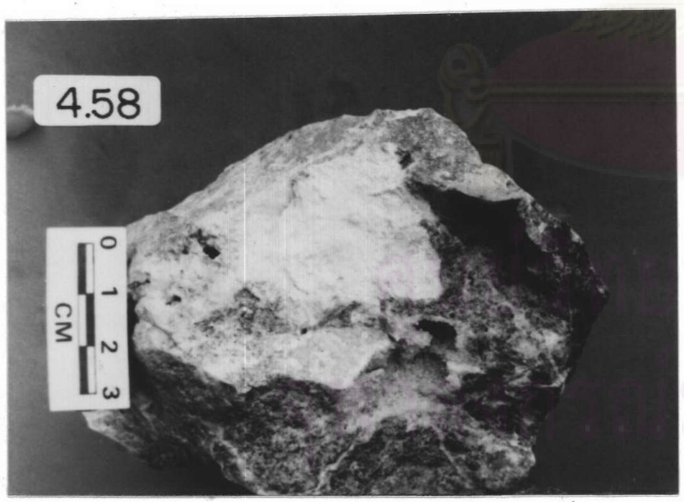
Figure 4.57 Photomicrograph of silicified sandstone showing silicification related to stage III mineralization which contains disseminated fine-grained quartz and stibnite (left, arrow). The sandstone is cross cut by stage IV mineralized veinlet (right most) containing coarse-grained quartz and stibnite in the interior of veinlet (St). (Bar- scale = 0.45 mm; transmitted light , crossed nicols).

Figure 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.

Figure 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).


4.57
St


4.59


4.58
0 1 2 3
CM