CHAPTE1R IV

PETROGRAPHY

Based solely upon geographical distribution, basalts of the study area (Fig. 3.2) can be subdivided into 2 distinctive masses, namely the north basaltic mass or Nam Cho basalt and the south basaltic mass or Sop Prab-Ko Kha basalt. The Nam Cho basalt covers an area of approximately 3 km^2 at Ban Nong, Thambon Nam Cho, Amphoe Mae Tha, Changwat Lampang (Fig. 4.1), and the Sop Prab - Ko Kha basalt covers approximately 55 km^2 of the area in between Amphoe Ko Kha and Amphoe Sop Prab, Changwat Lampang (Fig. 4.2). Its type section is located between kms 559 to 571 on Highway number 1 (Phahonyothin Road).

Nam Cho Basalt

The Nam Cho basalt extruded Permo-Triassic volcanic/volcaniclastics rocks and covered parts of Quaternary sediments. It occurs as east-west flows following hill slopes (Fig. 4.1) of the Triassic rocks of the Phra That Formation. The reddish brown soils (weathered basalts) frequently cover Quaternary sediments. The basalt is megascopically characterized by thin reddish brown vesicular layer on the top, and black dense layer at the bottom. It is generally dark, dense, fine-grained, and porphyritic textures. The rock specimens of the Nam Cho basalt collected from exposures are relatively fresher than those from the Sop Prab - Ko Kha basalt. Ultramafic nodules of lherzolites (Fig. 4.3) containing aggregates of olivine, pyroxene, and spinel are rather common. Megacrysts of olivine, pyroxene, and spinel are often found in this basalt. Lherzolite nodules vary in

Fig.4.1. The Nam Cho basalt flows following hill slope of the Phra That Formation to the bottom plain.

Fig.4.2. Typical location at kms 568 to 569 on the Highway number 1 comprising 5 basaltic flows with total thickness of about 20 m thick of the Sop Prab-Ko Kha basalt.

size from 1 to 5 cm, and size of megacrysts ranges from 0.2 to larger than 2 cm. The total thickness of this basaltic flow is at least 2 m.

Microscopically, the Nam Cho basalt is generally hypocrystalline. Average grain size is virtually smaller than that of the Sop Prab - Ko Kha basalt. It always shows aphanitic granularity and locally grades to microporphyritic and porphyritic textures (Fig. 4.4). Trachytic texture is moderately found, whereas subophitic and skeleton textures rarely occur in this basalt. Calcite, as large as 0.5 cm in diameter, is often present as amygdules. Mineral compositions essentially contain plagioclase, pyroxene, olivine, and opaque minerals. The secondary minerals are often composed of calcite, and zeolite.

Plagioclase frequently contains about 10 to 15%. It always occurs as microlite habits, with small subhedral crystal. Average grain size range is between 0.01 and 0.06 mm, which is relatively smaller than plagioclase of the Sop Prab - Ko Kha basalt. Plagioclase in groundmass is hardly identified under microscope. When occurring as phenocrysts, plagioclase exhibits both Carlsbad-albite and albite twins. Its An - content appears to be ranging from andesine (An_{40}-An_{50}) to rarely labradorite (An_{51}-An_{55}). Plagioclase is found to be slightly or strongly altered.

Pyroxene is commonly in average range of 20 to 25% (up to 40%) of the total volume. It frequently occurs in groundmass and as phenocryst. In groundmass the size of the pyroxene is less than 0.01 to 0.02 mm, whereas phenocrystic pyroxene ranges from 0.1 to 1 mm. Pyroxene always shows anhedral and subhedral crystals, though some phenocrysts may form euhedral crystals, frequently with pale green to brown colours. Pyroxene in groundmass frequently forms short prismatic to rounded grains. It also shows crack, and one-direction cleavage is always prominent (Fig. 4.4). Almost

pyroxenes are characterized by clinopyroxene (mainly augite). Reaction rims are also present in pyroxene phenocrysts and megacrysts.

Olivine ranges from 10 to 15% of the total volume and occurs as anhedral to subhedral crystals (Fig. 4.4). It is mainly present as phenocrysts and megacrysts (Figs. 4.4, 4.5). Size of its phenocryst varies from 0.1 to larger than 1 mm, whereas in groundmass it ranges from 0.01 to 0.06 mm. Cracks and cleavages were frequently developed in olivine crystals. Skeleton texture is also encountered in olivine phenocryst. Some olivines are altered to be deep yellow to orange brown iddingsites. Olivine is optically negative very high, closed to 90°.

Opaque minerals frequently comprise up to 15% of the total volume. Their average grain size commonly ranges from less than 0.01 to 0.02 mm, and rarely larger than 0.03 mm. They always occur as anhedral to subhedral crystals, with rounded and polygonal shapes. Most opaque minerals generally accompany in groundmass.

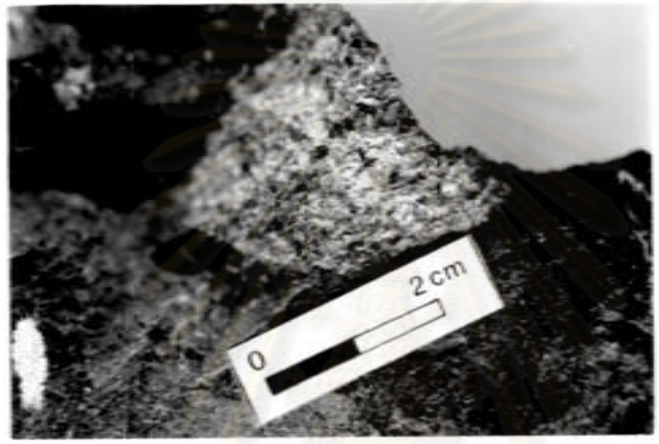
The secondary minerals are characterized by calcite and zeolite. Though calcite is rarely found in this basalt, but in some specimens calcite can contain up to 5% of total volume, with average grain size about 0.1 to 0.5 mm. Calcite frequently occurs as anhedral crystals along fractures and vugs. Zeolite occurs as small crystals (mostly 0.1 mm) and is much less abundant than calcite.

Xenoliths (Fig. 4.6) are always characterized by ultramafic nodules, frequently containing dark green pyroxene, green olivine, and black spinel. Size of these xenolith nodules are ranging from 1 to 5 cm. Microscopically, these lherzolites show equigranular, intergranular, and sugary-liked textures with fine-grained holocrystalline. They contain olivine

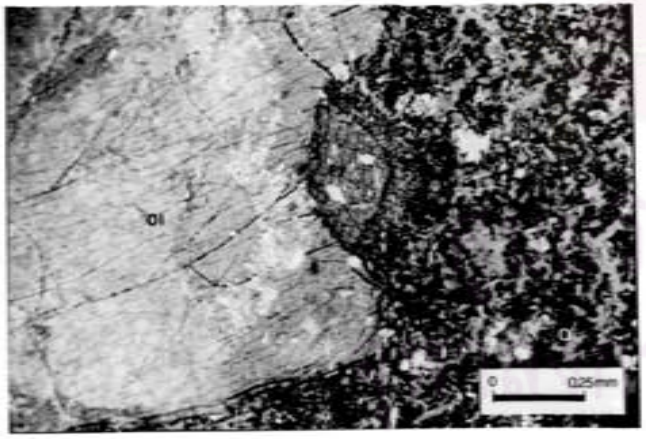
Fig.4.3. A specimen of the Nam Cho basalt contains lherzolite nodule and showing general characteristics of this rock.

Fig.4.4. Photomicrographs of the Nam Cho basalt showing large phenocrysts of olivine (Ol) and pyroxene (Py) in groundmass of plagioclase microlite, pyroxene, and opaque mineral (4.4a: uncross nicols, 4.4b: cross nicols).

4.3



4.4 a



4.4 b

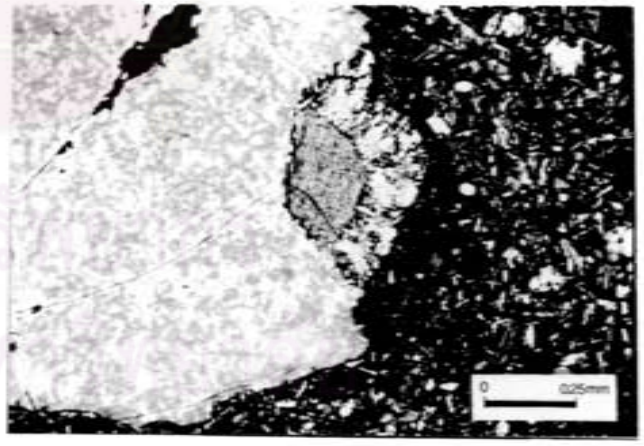
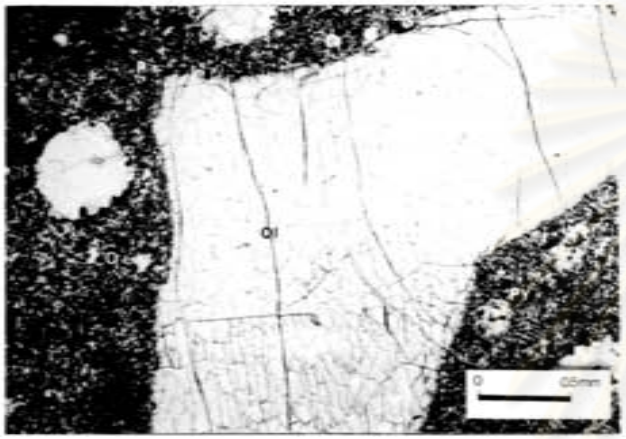


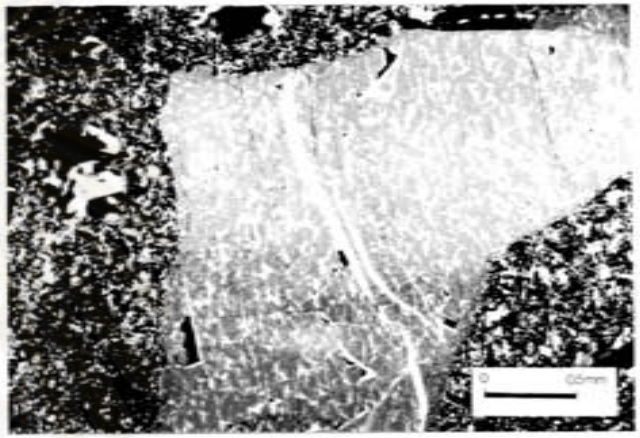
Fig.4.5. Olivine megacryst (Ol) in aphanitic opaque (O), pyroxene (Py), and plagioclase, and showing occurrences of anhedral zeolite in vesicle (4.5a: uncross nicols, 4.5b: cross nicols).

Fig.4.6. Spinel-lherzolite nodule comprises olivine (Ol), pyroxene (Py), and spinel (Sp), with equigranular, fine-grained holocrystalline (4.6a: uncross nicols, 4.6b: cross nicols).

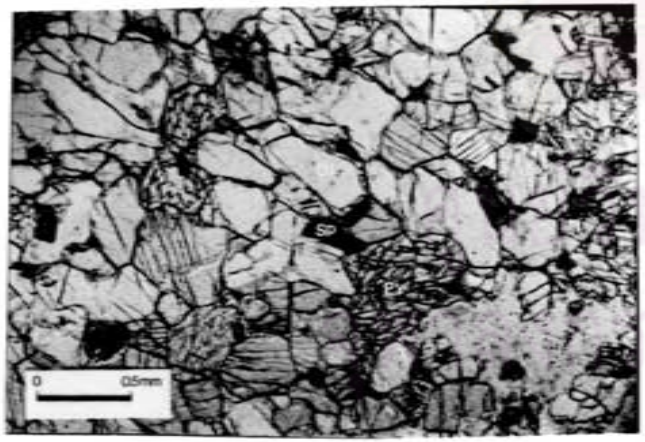
4.5 a



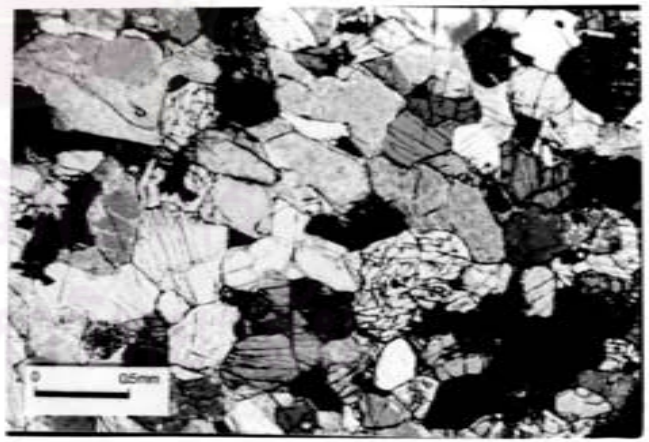
4.5b



4.6 a



4.6b



and pyroxene as the major constituents with minor amount of spinel (Fig. 4.6). Olivine commonly forms anhedral crystals. Pyroxene is also present as anhedral crystals with one-direction perfect cleavage. It is characterized by the presence of clinopyroxene (frequently augite). Spinel always exhibits anhedral to subhedral forms with brown isometric outline. Pyroxene megacryst moderately occurs nearby xenoliths. These ultramafic nodules are frequently altered along rims and sometimes whole nodules are totally replaced by secondary minerals.

Glass generally contains about 30 to 40%, and always distributes in vesicles and vugs. Glass frequently shows some devitrification.

The other minerals, as apatite and zircon, are rarely found. It is interesting to note that ultramafic nodule, pyroxene and opaque minerals are relatively more abundant than those of the Sop Prab - Ko Kha basalt.

Sop Prab-Ko Kha Basalt

The Sop Prab-Ko Kha basalt is enclosed by rocks of the Permo-Triassic to Triassic age and the Quaternary sediments (see Fig. 3.2). Volcanic crater in this area has been identified by using both landsat image- and aerial photograph- interpretations and field investigation. Volcanic bomb (Fig. 4.7) and scoriaceous spatter materials (Fig. 4.8) can be found nearby this crater. Five successive basaltic flows have been recognized with typical location at the road-cut quarry between kms 568 to 569 on the Highway number 1 (Fig. 4.2).This road cut quarry shows that the volcanic crater comprises these 5 flows with at least the total thickness of about 20 m thick. All the flows bear similarity in texture and mineralogy. They are characterized by vesicular to massive,

Fig.4.7. Characteristic of volcanic bomb occurring in the volcanic crater.

Fig.4.8. Scoriaceous spatter materials are found in volcanic crater.

microporphylitic-porphyritic, and fine-grained textures. Phenocrysts (up to 0.3 cm) of olivine frequently occur in most flows. The vesicular texture is commonly present in the upper parts of all flows. The channel-like structures, always present as yellowish brown weathered basaltic soils within cavities, are usually found between the second and the third basaltic flows. The columnar-like jointings predominantly appear in the second basaltic flow, and are sometimes found in the first and the fourth flows. The parting is quite distinctive, they are present in the lower parts of the second, the third and the fifth flows. The ropy structure (Fig. 4.9) indicating the "pahoehoe" flow (Fig. 4.10), always exposes around the lowest part of the first flow along steep slopes of this basaltic area.

1. The First Basaltic Flow

The first flow, the lowermost part of the Sop Prab - Ko Kha basalt, is at least 2 to 3 m thick. This basalt commonly shows layer vesiculars in the upper parts. The vesicles are about 0.5 to 2 cm. Vesicles tend to form alignment indicating local flow direction. It is always characterized by dark grey to black colour fine-grained, porphyritic textures (Fig. 4.11). It sometimes shows ropy or (pahoehoe) structure (Figs. 4.9, 4.10) implying flowages away from crater. Pahochoe is mainly found along slopes in the eastern and western regions. Microscopically, this basalt always exhibits porphyritic, interstitial, and intersertal textures. Plagioclase is partially enclosed by pyroxene, forming subophitic texture. This basalt frequently exhibits hypocrystalline with aphanitic to granularity textures. Mineral composition comprises 30 to 35% plagioclase, 10 to 20% pyroxene, 15 to 20% olivine, 10 to 15% opaques, 5 to 10% accessories, and 25 to 30% glassy materials.

Plagioclase (Figs. 4.13, 4.14) is more abundant than other minerals. It generally occurs as lath and microlite forms, with subhedral crystals. These crystals are generally

Fig.4.9. Ropy structure is frequently shown in the lower flows of the Sob Prab-Ko Kha basaltic area.

Fig.4.10. Pahoehoe flow comprising ropy structures along the slopes in the eastern and western.

ranging in size from 0.01x0.1 to 0.01x0.6 mm. Carlsbad-albite twins are more abundant than albite twins. Plagioclase is optically determined in terms of An content to range from andesine (An_{40}-An_{50}) to labradorite (An_{52}-An_{65}) with rare bytownite(An_{71}-An_{76}).

Pyroxene (Figs. 4.13, 4.14) appears to be anhedral to subhedral crystals, though short prismatic form is frequently present as euhedral habits. It is always assembled in groundmass, whereas pyroxene phenocryst rarely occurs. Pyroxene commonly occurs as rounded grains, and is often clustered, forming glomeroporphyritic texture. Cracks are better developed than cleavages. Pyroxene typically occurs as clinopyroxene (mostly augite).

Olivine (Figs. 4.12, 4.13) always occurs as anhedral to subhedral crystals, the latter being present as phenocryst rather than groundmass. Olivine in groundmass is ranging in size from 0.01 to 0.08 mm, whereas phenocrystic olivine is ranging from 0.2 to larger than 1 mm in size. It frequently develops skeleton texture. Deuteric alteration often occurs along rims and cracks of olivine crystals. Olivine is often cracked, and normally filled with iddingsite. It optically appears large 2V negative (nearly 90°).

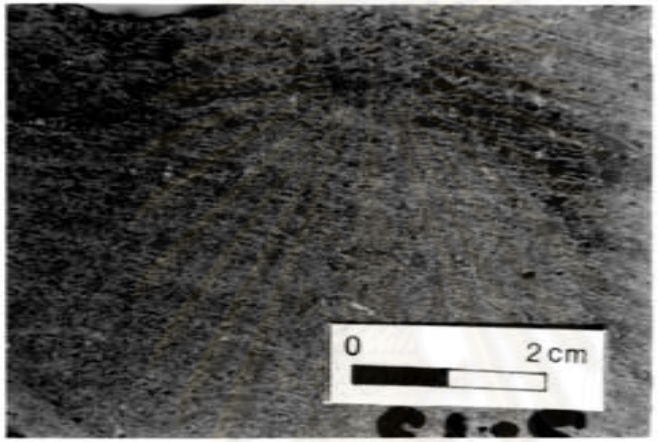
Opaque minerals (Figs. 4.13, 4.14) always occur as fine-grained, anhedral to subhedral crystals. Average grain size varies from 0.01 to 0.04 mm. It frequently forms skeleton shape, with rounded to polygonal forms.

Accessories include of apatite, zeolite, and calcite. Apatite (1 to 3%) is less abundant in this flow. It always occurs as subhedral short prismatic, that generally enclosed in grains of plagioclase. Zeolite, an uncommon secondary mineral, is always present in vugs and along veinlets. It commonly shows radiation of short prismatic forms,

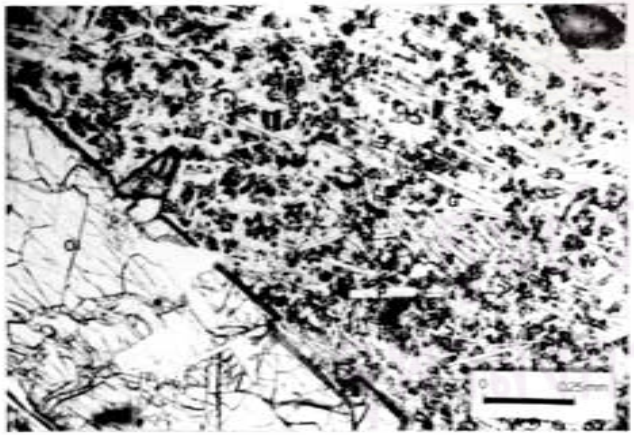
Fig.4.11. A specimen of the first flow of the Sop Prab-Ko Kha basalt showing fine-grained, porphyritic, olivine basalt.

Fig.4.12. Photomicrographs show olivine phenocryst (Ol) in trachytic plagioclase (P) microlites, interstitial of pyroxene (Py) and opaque, intersertal of glass, and some iddingsite (I) crystals (4.12a: uncross nicols, 4.12b: cross nicols).

4.11



4.12a



4.12b

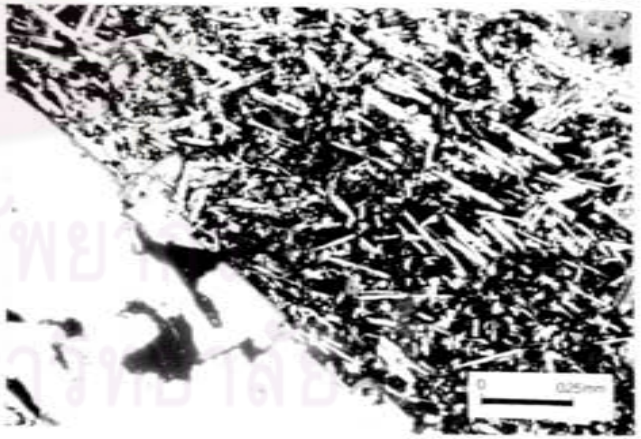


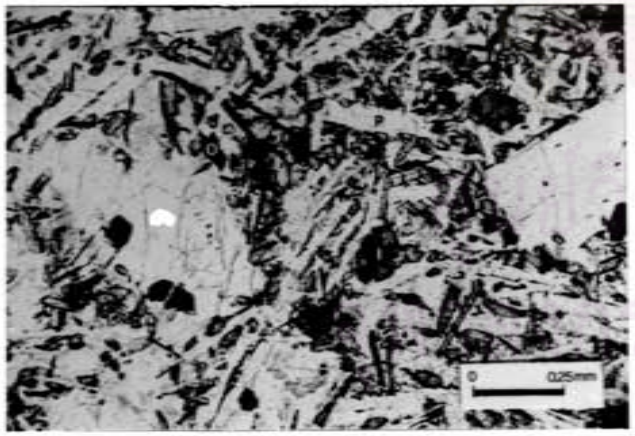
Fig.4.13. Interstitial of anhedral-subhedral pyroxene (Py) in plagioclase (P) lath, interstitial texture of glass (G), skeleton texture of opaque, short prismatic apatite, subhedral olivine (Ol) phenocryst, and iddingsite (I) in first basaltic flow (4.13a: uncross nicols, 4.13b: cross nicols).

Fig.4.14. Iddingsite (I), anhedral-subhedral opaque (O), rare prismatic apatite, lath of plagioclase is partially enclosed by pyroxene (Py) forming subophitic texture, with intersertal texture (4.14a: uncross nicols, 4.14b: cross nicols).

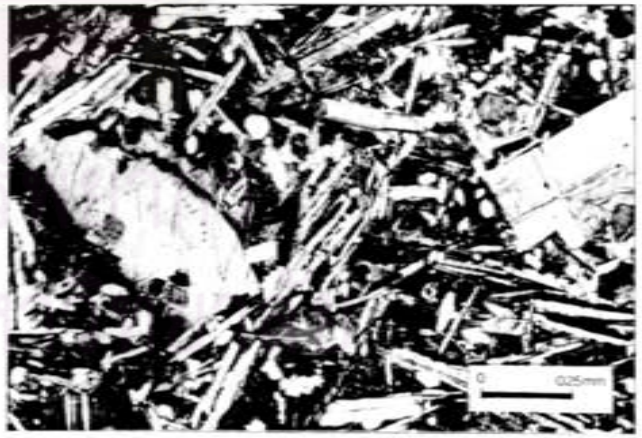
4.13a

4.13b

4.14a



4.14b



with small grain sizes. Calcite, a more common secondary mineral, frequently occurs as subhedral to anhedral crystals. It is mostly associated with pyroxene, olivine, and plagioclase. It sometimes fills in spaces between laths of plagioclase. Its content is about 5 to 10%.

Glass (Figs. 4.12, 4.13, and 4.14) comprises of 25 to 30 % by total volume and is always associated with opaque and pyroxene. Glass frequently fills in voids among plagioclase lathes, forming intersertal texture, and sometimes exhibits mild devitrification.

2. The Second Basaltic Flow

Overlying the first flow is the second basaltic flow (Fig. 4.2), about 3 to 4 meters thick at least. Megascopically, the upper surface is also indicated by vesicular olivine basalts followed by those with columnar-like jointings. The lower surface frequently appears as more massive olivine basalt, with parting almost parallel to the flow layer. This basaltic flow is always characterized by dark grey to black, fine-grained to aphanitic, porphyritic textures (Fig. 4.15). The channel-like structure averages 1 m x 2 m in diameters, indicating that flow direction can be traced as far as at least 200 m in this basaltic flow. Microscopically, this basalt generally appears to be holocrystalline (Fig. 4.18), with aphanitic granularity texture. Porphyritic, intersertal, interstitial, and subophitic textures (Figs. 4.16, 4.17, and 4.18) are also present under microscopic investigation. The alignment of microlites indicating trachytic texture are present in some samples. Mineral composition always contains 25 to 30% plagioclase, 10 to 15% pyroxene, 10 to 15% olivine, 5 to 15% opaques, 5 to 10% accessories, and 25 to 35 % glass.

Plagioclase is generally more abundant than other minerals. Its grains are frequently subhedral, with long rectangular outlines (Figs. 4.16, 4.17). These plagioclase grains occurring as lath form are more abundant than microlite form. The average grain size ranges from 0.02 x 0.3 mm to 0.2 x 0.6 mm. Both Carlsbad-albite and albite twins are equally present in this flow. Plagioclase ranges in composition from andesine (An_{38}-An_{49}) to labradorite (An_{53}-An_{70}). Laths of plagioclase always show interlocking, indicating intersertal or interstitial textures. Some plagioclase grains may be partially enclosed by pyroxene, representing subophitic texture.

Pyroxene averages from 0.01 to 0.08 mm in size. Its crystals always occur as anhedral to subhedral (Figs. 4.17, 4.18), colourless to pale green and brownish green. Phenocrysts of pyroxene are rarely found, when occur, they are ranging in size from 0.1 to 0.3 mm. Pyroxene is commonly assembled in groundmass. Rare euhedral crystals are present as short prismatic form. Pyroxene is predominantly clinopyroxene (mostly augite).

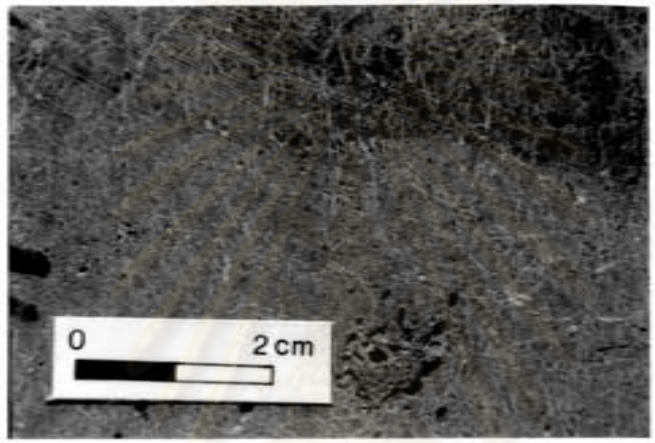
Olivine is typical phenocryst (Figs. 4.16, 4.18) of this basalt. Phenocryst is about 0.1 to 2 mm in size, whereas in groundmass olivine averages in size from 0.02 to 0.08 mm. It occurs as anhedral to subhedral crystals. It frequently shows skeleton texture. Cracks often develop in olivine crystals. Olivine is sometimes fresh, though deuteric alteration feature is always prominent along rims and cracks of crystal. It is optically found negative with large 2V angle.

Opaque minerals (Figs. 4.16, 4.18) always occur as anhedral to subhedral crystals, whose average grain size is ranging from less than 0.01 to 0.1 mm. Petrographic description indicated that opaque is always associated with pyroxene in groundmass. Skeleton texture may be also formed in opaque crystal, possibly indicating ilmenite form.

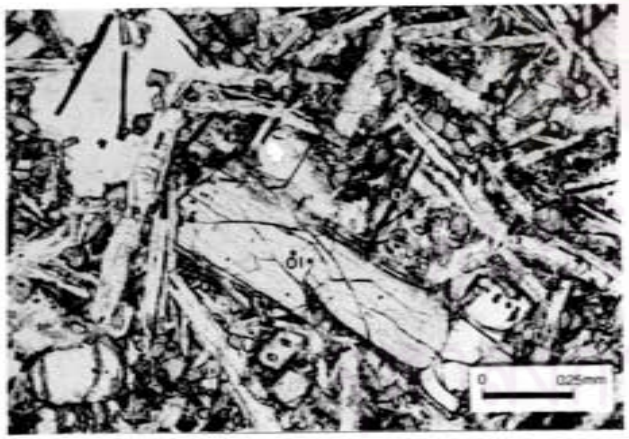
Fig.4.15. A specimen of the second flow of the Sop Prab-Ko Kha basalt showing fine-grained, porphyritic, olivine basalt, with vesicular texture.

Fig.4.16. Photomicrographs show phenocryst of subhedral olivine (Ol), skeleton opaque (O), with pyroxene (Py) form interstitial between plagioclase (P) laths, and some subophitic texture (4.16a: uncross nicols, 4.16b: cross nicols).

4.15



4.16a



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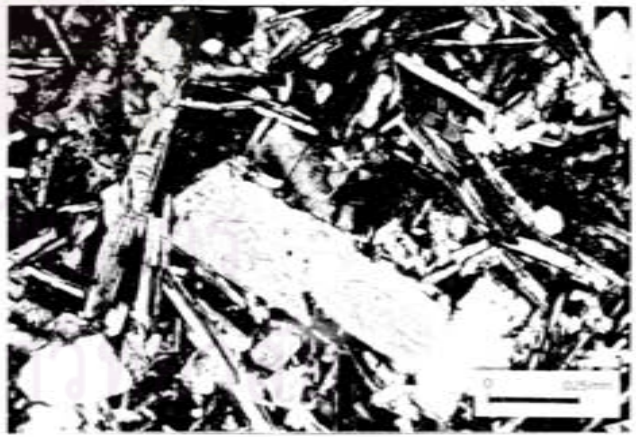
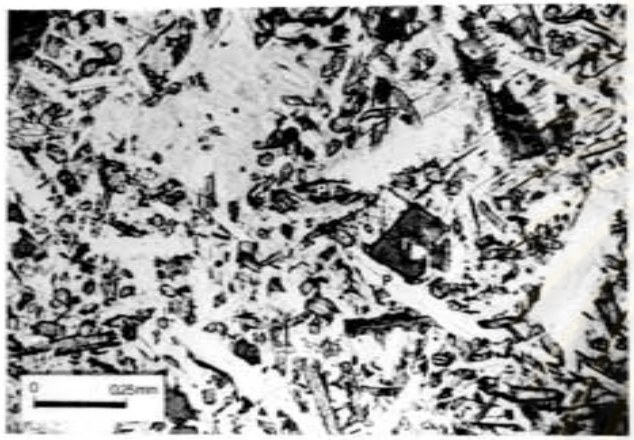


Fig.4.17. Iddingsite (I) altered from olivine, anhedral-subhedral pyroxene (Py), subhedral plagioclase (P), which form subophitic and interstitial with some intersertal textures (4.17a: uncross nicols, 4.17b: cross nicols).

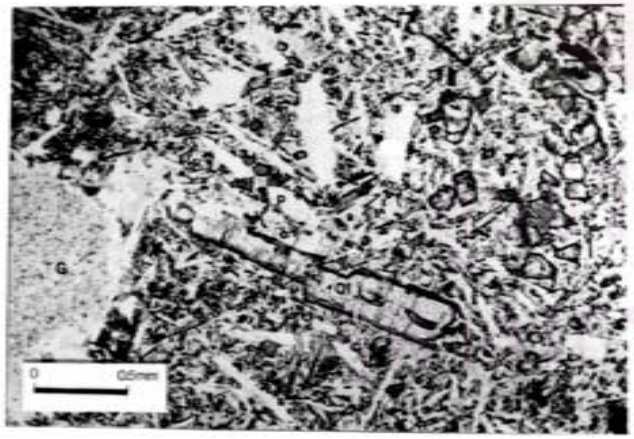
Fig.4.18. Subhedral phenocrysts of olivine (Ol), skeleton opaque, pyroxene groundmass, and glass (G) in vug, those show porphyritic, intersertal, interstitial, and subophitic texture (4.18a: uncross nicols, 4.18b: cross nicols).

4.17a

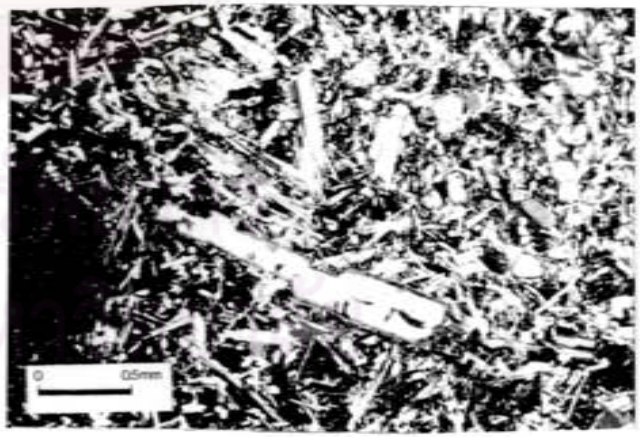


4.17b

4.18a



4.18b



Accessories include apatite, zeolite, and calcite. Apatite is always less abundant (average about 2%), with small size (much less than 0.01 mm). It is found only in few samples. Apatite is always assembled in plagioclase, and always forms short prismatic crystals. Zeolite occurs as secondary mineral with radiate forms. It can be rarely found in vugs. It is present subhedral short prismatic form with less abundance (about 3%). Calcite is rarely found as secondary mineral, that forms along cracks. It always shows anhedral crystals with less abundance (about 3%).

Glass contains averagely about 10 to 15% of total volume. It always occurs as intersertal texture and is frequently devitrified to form secondary mineral.

3. The Third Basaltic Flow

The third basaltic flow is lying over the second flow. The thickness of the third flow is about 4 to 5 m. It is still characterized by fine-grained, porphyritic, olivine basalt (Fig. 4.19), and somewhat partially similar to those of the second flow. Vesicle (about 1 to 5 mm long) also appears in the upper part. It often develops parting (0.1-0.3 m thick) in the thin lower part. Soil, a weathering product of basalt during a short quiescent period is present on top of this flow. Microscopically, this basalt typically occurs as hypocrystalline, with aphanitic granularity. It is invariably characterized by trachytic and porphyritic textures (Fig. 4.20 and Fig. 4.21). Intersertal, interstitial, and subophitic textures are quite common in this basalt. Skeleton texture of opaque and olivine crystals are also diagnostic. Mineral constituents generally include 25 to 35 % plagioclase, 10 to 15 % pyroxene, 10 to 20 % olivine, 5 to 15 % opaques, 5 to 10 % accessories, and 25 to 30 % glass.

Plagioclase (Figs. 4.21, 4.22) always occurs as subhedral lath or microlite forms. Its grain size averages from 0.02 x 0.3 mm to 0.1 x 0.6 mm . Plagioclase relatively forms Carlsbad-albite twin in more abundant than albite twin. The composition is optically classified in range from andesine (An_{33}-An_{49}) to labradorite (An_{51}-An_{66}). Plagioclase laths often interlock between grains, showing intersertal or interstitial textures. Plagioclase microlite is often exhibit trachytic texture, an indicative of flow lava.

Pyroxene is frequently found as groundmass, whose average grain size ranges from 0.01 to 0.3 mm. It always occurs as anhedral to subhedral crystals (Figs. 4.21, 4.22). It is rarely found as phenocryst. It mainly comprises clinopyroxene (frequently augite). It often forms short prismatic crystals, whose cracks and one-direction cleavages frequently occur.

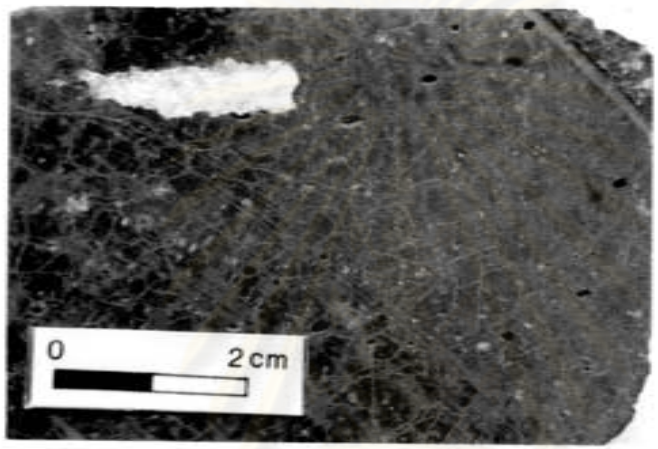
Olivine is mostly present as anhedral, subhedral, and euhedral crystals. Olivine phenocryst (Figs. 4.20, 4.21) certainly occurs more abundant than that of groundmass. Phenocryst is about 0.1 to 1 mm in size, whereas groundmass ranges from 0.01 to 0.08 mm. Skeleton texture often develops in this basalt. Olivine mainly forms cracks with moderately weathering (or deuteric alteration). It is optically present as biaxial negative with high 2V angle (closely 90°).

Opaque minerals (Fig. 4.22) always show anhedral to subhedral habits. They are often accompanied in groundmass, and associated with pyroxene and glass. Average grain size of opaques is 0.01 to 0.05 mm. Skeleton texture (significant outlines of ilmenite ?) also occur in opaque minerals

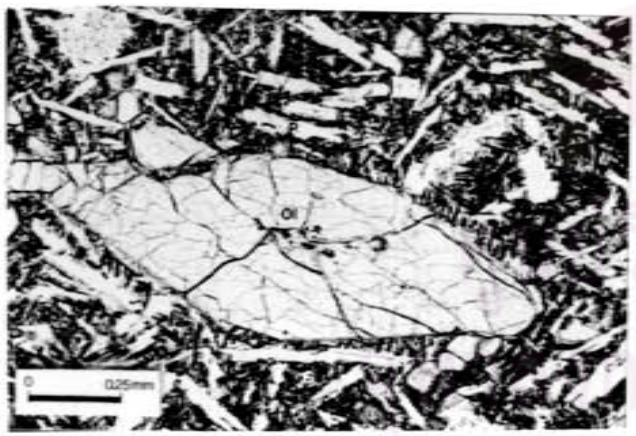
Fig.4.19. A specimen of the third flow of the Sop Prab-Ko Kha basalt showing vesicular, porphyritic, fine-grained, olivine basalt.

Fig.4.20. Photomicrographs show large olivine (Ol) phenocryst surrounded by plagioclase (P), pyroxene, opaque, and glass (G), and comprising trachytic, intersertal, interstitial textures (4.20a: uncross nicols, 4.20b: cross nicols).

4.19



4.20a

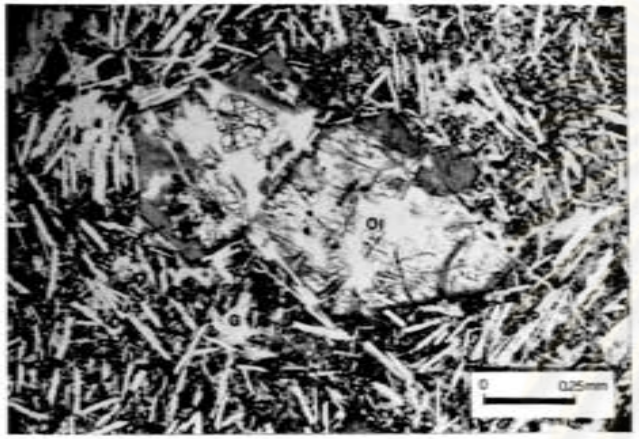


4.20b

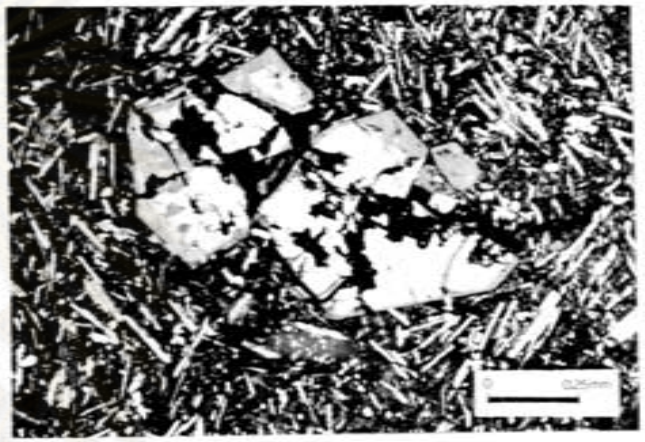
Fig.4.21. Olivine (Ol) phenocrysts surrounded by pyroxene (Py), plagioclase (P) microlite, glass (G), and opaque, forming mainly interstitial, intersertal, and trachytic textures (4.21a: uncross nicols, 4.21b: cross nicols).

Fig.4.22. Interstitial of subhedral olivine (Ol), opaque (O), and pyroxene between laths of plagioclase (P), and glass (G) form intersertal texture, with moderate subophitic texture (4.22a: uncross nicols, 4.22b: cross nicols).

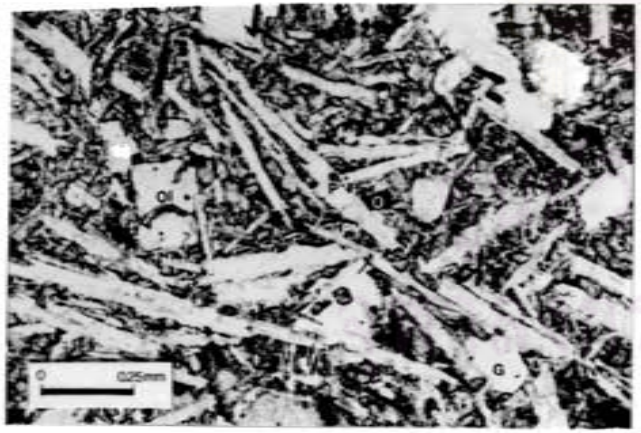
4.21 a



4.21 b



4.22 a



4.22 b

Accessories largely include calcite and apatite. Calcite is typically a secondary mineral that may be found as amygdules in some samples. Calcite constitutes 5 to 10% of the total volume, that always occurs as anhedral crystal nearby plagioclase, weathered pyroxene, and broken olivine. The calcite is often present in spaces and vugs. Apatite is frequently present as subhedral, short to stubby prismatic forms. It comprises about 1%, with small grain size (much smaller than 0.01 mm).

Glass ranges from 25 to 30 % content. Devitrification is always present in glassy groundmass, that also occurs as vugs and intersertally in voids.

4. The Fourth Basaltic Flow

The fourth basaltic flow is about 2 to 3 m thick and is overlying almost parallel to the third flow. The fourth flow generally contains vesicular olivine basalt in the upper, and massive olivine basalt in the lower part. Columnar jointing is frequently encountered in this flow, however jointing is obscured due to moderate weathering. Basalt is normally characterized by pale grey to dark grey, fine-grained to aphanitic, porphyritic rock (Fig. 4.23). Microscopically, this basalt mainly appears as hypocrystalline, with aphanitic granularity. Intersertal, interstitial, and porphyritic textures (Figs. 4.24, 4.25, and 4.26) are commonly present. Subophitic and trachytic textures are also widely distributed. Glass is more common in the upper flow than in the lower flow. Basalt is composed of 25 to 35 % plagioclase, 10 to 15 % pyroxene, 10 to 15 % olivine, 10 to 15 % opaque minerals, 5 to 15 % accessories, and 20 to 35 % glass.

Plagioclase (Figs. 4.24, 4.25, and 4.26) always occurs as tiny microlite in groundmass and subhedral lath forms as phenocrysts. Average grain size of plagioclase

is approximately 0.01 mm wide and 0.2 mm long in the groundmass. Phenocrystic plagioclase ranges in length from 0.3 to 0.5 mm and in width from 0.05 to 0.1 mm. Both Carlsbad-albite and albite twins are encountered, the former being more abundant. Petrographic evidence suggests that plagioclase ranges from andesine (An_{36}-An_{45}) to labradorite (An_{50}-An_{70}).

Pyroxene is always present in groundmass (Figs. 4.24, 4.25). Average grain size ranges from smaller than 0.01 to 0.05 mm. It is frequently pale green to greenish brown. It generally occurs as anhedral to subhedral crystals with plagioclase, pyroxene often forms interstitial in spaces between plagioclase laths. It also partially enclose plagioclase, becoming subophitic texture. Cracks are generally formed, whereas one-direction cleavage is also common. Pyroxene is commonly characterized by clinopyroxene (mostly augite).

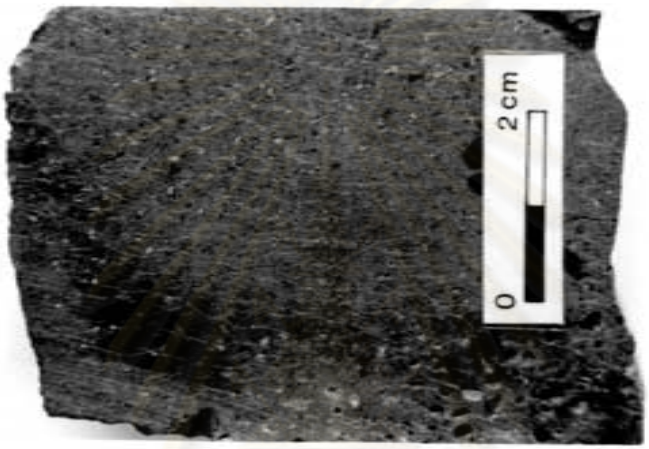
Olivine commonly forms as phenocrysts (Figs. 4.24, 4.26) and in groundmass. Phenocrysts of olivine range from 0.1 to larger than 1 mm, and olivine in the groundmass averages about 0.01 to 0.06 mm in size . Olivine always occurs as subhedral to euhedral crystals. Cracks are frequently developed, and they are filled with secondary mineral as serpentine. Reaction along rims are also common. Skeleton texture may be present in some sections. The optical investigation is rather difficulty due to moderate weathering . However, it also shows high 2V angle of biaxial negative.

Opaque minerals are smaller than 0.01 to 0.05 mm in size. They frequently form anhedral to subhedral crystals and are associated with pyroxene in the groundmass (Figs. 4.25, 4.26). The euhedral crystal is rarely found. Skeleton texture possibly signifies ilmenite habit. Opaques sometimes form square or rounded shapes.

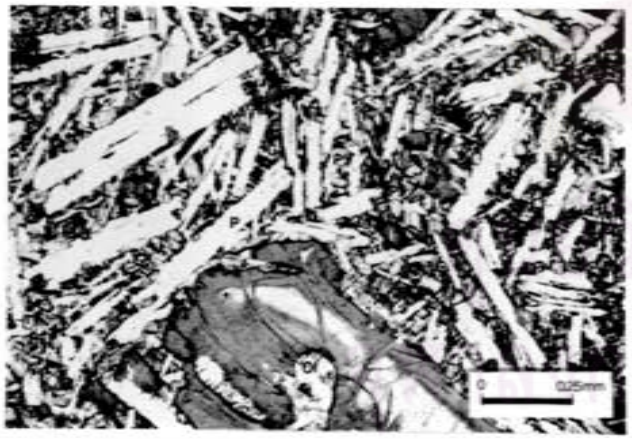
Fig.4.23. A specimen of the fourth flow of the Sop Prab-Ko Kha basalt showing vesicular, fine-grained, microporphyritic, olivine basalt.

Fig.4.24. Photomicrographs show engulf texture of olivine (Ol) phenocryst surrounded by plagioclase (P) laths, and interstitial of pyroxene (Py) and iddingsite (I),with intersertal texture (4.24a: uncross nicols, 4.24b: cross nicols).

4.23



4.24a



4.24b

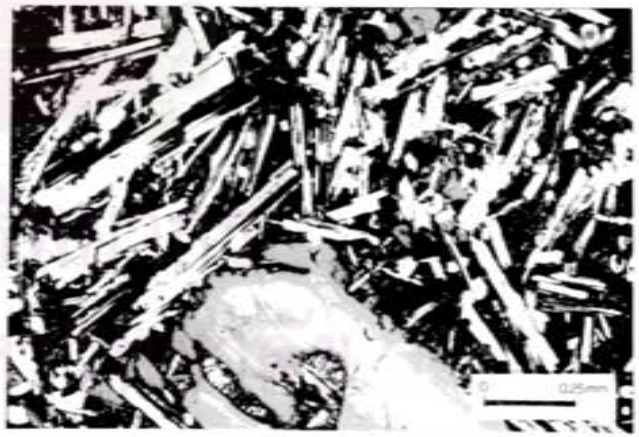
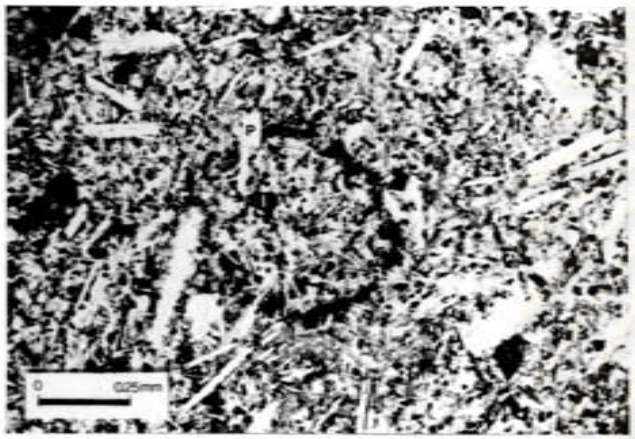


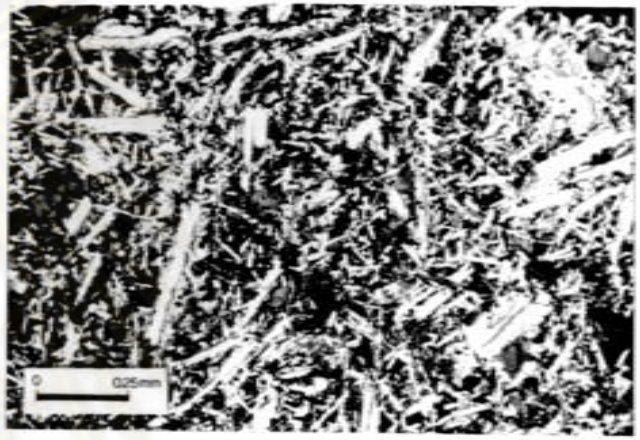
Fig.4.25. Subhedral plagioclase (P) forming lath and microlite forms, pyroxene (Py), opaque (O), and iddingsite (I), with intersertal, interstitial, and microporphyritic textures (4.25a: uncross nicols, 4.25b: cross nicols).

Fig.4.26. Anhedral olivine (Ol), and iddingsite (I) phenocrysts, with lath of plagioclase (P), opaque (O), and small pyroxene forming interstitial, subophitic, and intersertal textures (4.26a: uncross nicols, 4.26b: cross nicols).

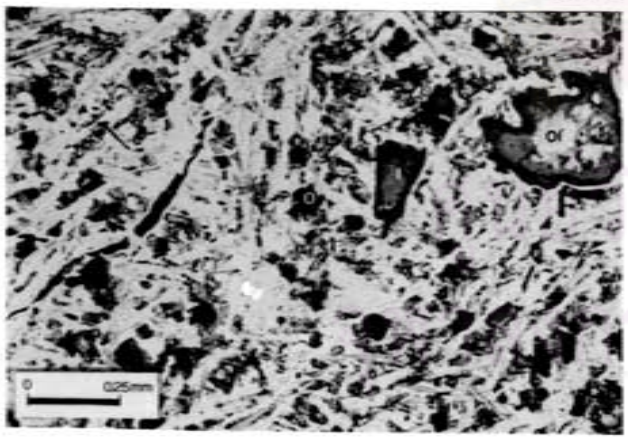
4.25a



4.25b



4.26a



4.26b

Accessories include apatite, zeolite, and calcite. Apatite is rarely found in this basaltic flow, and contains less than 2 % of total volume. It occurs as subhedral, short prismatic, with very fine-grained size. Apatite always inserts in grains of plagioclase and glass. The other uncommon secondary minerals, zeolite, iddingsite and calcite, can be found in less abundance in few samples.

Glass ranges from 20 to 35 % of total volume. Vesicular and vug-filled textures are also dominant in this basaltic flow. Glass always occurs in voids of plagioclase, formming intersertal texture. Devitrification is also recongnized in the upper part of the flow.

5. The Fifth Basaltic Flow

This basaltic flow is the uppermost unit of the Sop Prab-Ko Kha basalt. It is about 6 to 7 m thick at road cut section between kms 568 to 569 on the Highway number 1, immediately in the volcanic crater vicinity. The vesicular basalt (Fig. 4.27) with high weathering and parting are diagnostic features. Microscopically, this basalt mainly shows porphyritic and intersertal textures. Subophitic, trachytic, and amygdaloidal textures are subordinate. It is frequently characterized by hypocrystalline with aphanitic granularity. Amygdules of calcite (Fig. 4.30) and zeolite filled in vugs, vesicles, and other spaces. Interstitial texture (Figs. 4.29, 4.30) is often present by pyroxene that occurs in space between plagioclase laths. Mineral constitnent includes includes 25 to 35% plagioclase, 15 to 20% pyroxene, 10 to 15% olivine, 10 to 15% opaque minerals, 5 to 10% accessories, and 25 to 35 % glassy materials.

Plagioclase (Figs. 4.29, 4.30) commonly occurs as microlite crystals, though lath form is moderately present. It also forms subhedral crystals, with average grain size of about 0.05 mm wide and 0.2 mm long. Twinning of plagioclase include Carlsbad-albite and albite twins, both of which have nearly the same amount. Plagioclase is petrographically determined to be ranging from andesine (An_{30}-An_{49}) to labradorite (An_{50}-An_{60}).

Pyroxene also occurs as anhedral to subhedral short prismatic form and is often associated in groundmass (Figs. 4.29, 4.30). Its size averages from smaller than 0.01 to 0.06 mm. Pyroxene is often pale green with high relief. Pyroxene, predominantly clinopyroxene (with augitic composition), frequently shows cracks rather than cleavages (often one-direction). It always forms cluster, associated with opaque minerals. And it may be interstitial in spaces between plagioclase laths.

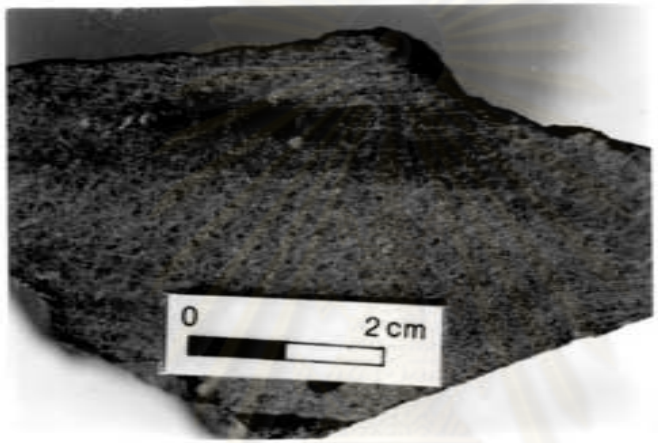
Olivine frequently appears subhedral crystal, though it is rarely present as anhedral and euhedral crystals. Olivine phenocryst (Figs. 4.28, 4.29, and 4.30) is as large as 1 mm, whereas olivine in groundmass ranges from smaller than 0.01 to 0.05 mm. Olivine often occurs as phenocryst in this basalt. Olivine frequently shows skeleton texture. It is frequently weathered, and most of olivine crystals show irregular cracks. Optically olivine is biaxial negative, with high 2V angle.

Opaque (Fig. 4.29) minerals always occur as anhedral to subhedral crystals, some mutually associated with pyroxene. Grain size of opaque averages from less than 0.01 to 0.05 mm. It is mainly present as square and rounded forms, suggesting the occurrence of pyrite. Opaque mineral sometimes shows skeleton texture, implying the ilmenite crystal.

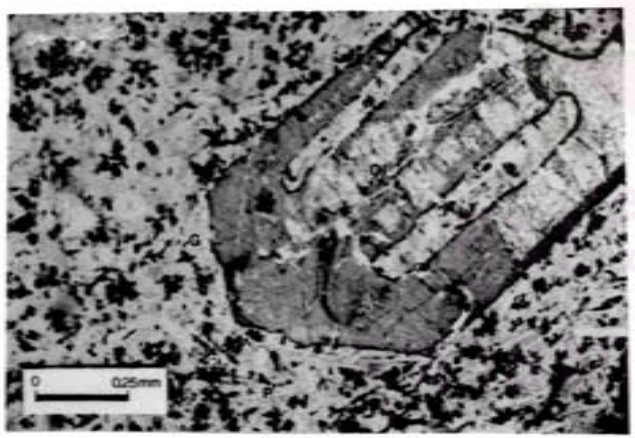
Fig.4.27. A specimen of the fifth flow of the Sop Prab-Ko Kha basalt showing fine-grained, porphyritic olivine basalt.

Fig.4.28. Photomicrographs show large olivine phenocryst in aphanitic groundmass of pyroxene (Py), plagioclase (P), and glass (G), and forming trachytic, intersertal, and interstitial textures (4.28a: uncross nicols, 4.28b: cross nicols).

4.27



4.28a



4.28b

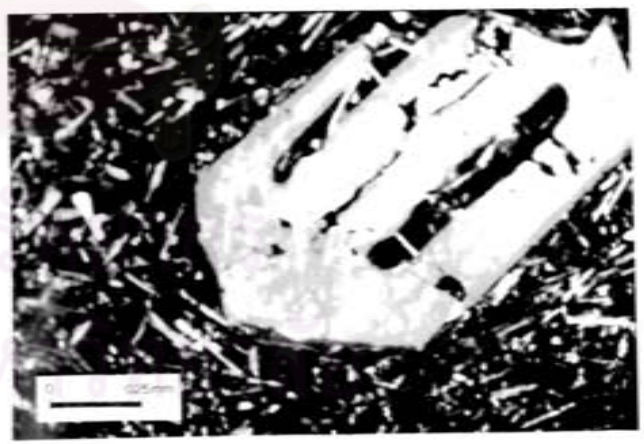
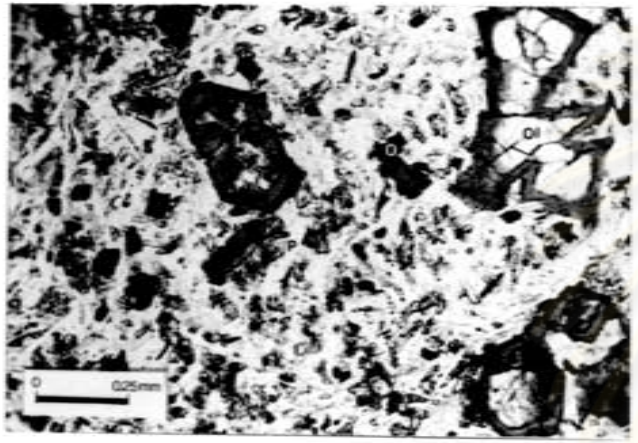


Fig.4.29. Phenocrysts of olivine (Ol) and iddingsite (I) surrounded by plagioclase (P) microlite, opaque (O) and pyroxene, showing intersertal, interstitial, and porphyritic textures (4.29a: uncross nicols, 4.29b: cross nicols).

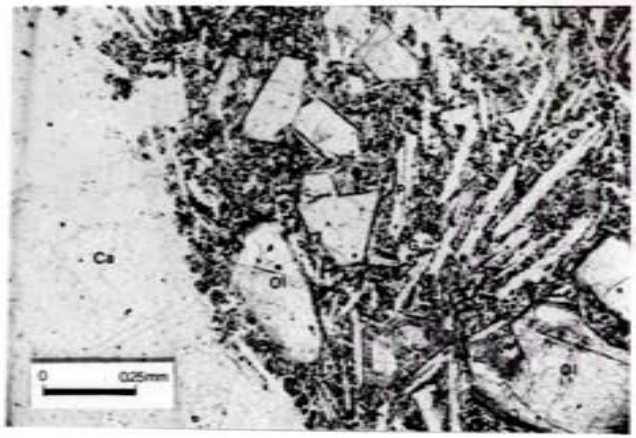
Fig.4.30. Subhedral olivine (Ol) phenocrysts and laths of plagioclase (P) surrounded by pyroxene, opaque, and glass (G) forming trachytic, intersertal, interstitial, and porphyritic textures, with calcite (Ca) occurring in fracture of basalt (4.30a: uncross nicols, 4.30b: cross nicols).

4.29a



4.29b

4.30a



4.30b

Accessories include apatite, and calcite (Fig. 4.30). Apatite is present as subhedral to euhedral short prismatic forms and usually associated with plagioclase. It invariably shows very small size (much less than 0.01 mm), and occurs in small amount (less than 3 %). Calcite, the other secondary minerals, is also found in this basalt. It occurs as anhedral crystals in vugs (Fig. 4.30) of few samples.

Glass is mainly present in this basaltic flow, ranging from 25 to 35 % of total volume. It also shows intersertal texture, and may be devitrified as dirt.