

## APPENDIX

### LITHOLOGY AND PETROGRAPHY OF INDIVIDUAL LEAST-ALTERED MAFIC VOLCANIC ROCKS AND HYPABYSSAL ROCKS

**Sample Number:** MT-2  
**Grid Reference:** 964958, 1:50,000 Topographic Map,  
Sheet 4945 II (Amphoe Long)  
**Rock Name:** Andesite

**Megascopic Characters:** This rock sample shows a highly megacrystic texture and contains abundant pale green plagioclase (sizes up to 2 mm across) and subordinate greenish black (sizes up to 1 mm across) megacrysts. These megacrysts sit in the dense, very fine-grained groundmass, with a brownish black color. Greenish gray veinlets have been locally detected in minor amount. The rock is non-magnetic, and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts in this sample are mainly plagioclase, with subordinate unidentified mafic mineral, and minor Fe-Ti oxide and apatite. The megacrysts form as isolated crystals, monomineralic clusters of plagioclase and unidentified mafic mineral, and polymineralic clusters of plagioclase – unidentified mafic mineral, Fe-Ti oxide and apatite. The groundmass is very fine-grained and holocrystalline (grain sizes almost totally less than 1 mm across), and consists largely of mildly trachytic plagioclase laths with subordinate patches of hematite/iron hydroxide, and minor secondary patches of chlorite/serpentine, sericite and Fe-Ti oxide. The presence of relatively abundant hematite/iron hydroxide is responsible for the brownish black color of the sample.

Plagioclase phenocrysts/microphenocrysts largely have euhedral to subhedral outlines, whereas the groundmass plagioclase laths largely show subhedral outlines. All the plagioclase phases are moderately to highly altered to abundant sericite, and minor chlorite, epidote, carbonates, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Megacrysts of unidentified mafic mineral are anhedral to euhedral, but commonly anhedral to subhedral. They are totally pseudomorphed by abundant chlorite/serpentine, and minor epidote, carbonates, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Primary apatite and Fe-Ti oxide occur as microphenocrysts and megacrysts in respective manner. The former is subhedral to euhedral, while the latter is anhedral to subhedral. The Fe-Ti megacrysts have been replaced by hematite/iron hydroxide along their margins.

**Sample Number:** MT-4  
**Grid Reference:** 962924, 1:50,000 Topographic Map,  
 Sheet 4945 II (Amphoe Long)  
**Rock Name:** Andesite/Basalt

**Megascopic Characters:** This rock sample is highly megacrystic, with megacrysts of abundant pale green plagioclase and subordinate greenish black mineral (sizes up to 3 mm across). The groundmass is very fine-grained, and has a dark greenish gray color. The rock shows slight magnetism and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts consist largely of plagioclase, with small amounts of clinopyroxene and unidentified mafic mineral, and occasional Fe-Ti



oxide. These megacrysts may form as isolated crystals, monomineralic clusters of plagioclase and clinopyroxene, and as polymineralic clusters of plagioclase – clinopyroxene, clinopyroxene – mafic mineral, and plagioclase – clinopyroxene – mafic mineral. A few xenoliths of microdiorite/microgabbro have been observed. The groundmass is very fine-grained and holocrystalline (grain sizes largely 0.01 – 0.02 mm across), and shows a well-defined trachytic texture. It is composed largely of plagioclase laths, with minor clinopyroxene, interstitial quartz, and secondary patches of chlorite/serpentine, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide. Very few veinlets of quartz + chlorite, and carbonates have been detected in the sample.

Plagioclase phenocrysts/micropenocrysts and groundmass plagioclase grains commonly have euhedral to subhedral outlines. The plagioclase phenocrysts/micropenocrysts are largely altered, while the groundmass plagioclase crystals are slightly altered. Their alteration products include abundant sericite, sphene/leucoxene and epidote minerals (zoisite/clinozoisite and epidote), and minor carbonates, Fe-Ti oxide and/or hematite/iron hydroxide.

Clinopyroxene megacrysts show anhedral to subhedral outlines, whereas the groundmass clinopyroxene grains largely show anhedral outlines and are intergranular to plagioclase laths. All phases of clinopyroxene are slightly to moderately altered to chlorite, amphibole, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide. The secondary amphibole commonly occurs as rims of the clinopyroxene megacrysts.

Unidentified mafic megacrysts have anhedral to subhedral outlines and are totally altered. Their replacement minerals include abundant chlorite/serpentine, subordinate amphibole and carbonates, and minor epidote, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide. In similar manner to clinopyroxene megacrysts, megacrysts of unidentified mineral are commonly rimmed with secondary amphibole.

Fe-Ti oxide microphenocrysts are subhedral to euhedral. They may be slightly replaced by hematite/iron hydroxide.

**Sample Number:** MT-5  
**Grid Reference:** 962915, 1:50,000 Topographic Map,  
 Sheet 4945 II (Amphoe Long)  
**Rock Name:** Andesite

**Megascopic Characters:** This rock sample shows a highly megacrystic texture, with abundant, pale green and white plagioclase (sizes up to 2 mm across), and occasional black minerals (sizes up to 1 mm across). The groundmass is fine-grained, and has a grayish green color. Tiny veinlets of pale green mineral have been locally detected in minor amount. The rock is slightly magnetic, and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts in this sample include abundant plagioclase, subordinate clinopyroxene and unknown mafic mineral, and minor apatite and Fe-Ti oxide. These megacrysts may form as isolated crystals, plagioclase clusters, and polyminerals clusters of plagioclase - clinopyroxene, Fe-Ti oxide - unidentified mafic mineral, and plagioclase - clinopyroxene - Fe-Ti oxide - unidentified mafic mineral. The groundmass is very fine-grained and holocrystalline (grain sizes largely about 0.01 mm across), with a felty texture. It consists largely of plagioclase laths, with subordinate secondary patches of sericite, chlorite/serpentine, epidote, Fe-Ti oxide, sphene/leucoxene and carbonates. The pale green veined mineral is carbonates.

Plagioclase phenocrysts/micropheocrysts and groundmass plagioclase grains are largely subhedral, and variably altered. Their alteration products include sericite, epidote, chlorite, Fe-Ti oxide, sphene/leucoxene and/or carbonates.



Clinopyroxene megacrysts have anhedral outlines and are slightly altered to chlorite, Fe-Ti oxide and/or carbonates. The groundmass clinopyroxene grains are completely altered to minerals compositionally similar to those of the clinopyroxene megacrysts.

Unidentified mafic megacrysts have anhedral to euhedral outlines and are totally altered. Their alteration products are abundant chlorite/serpentine and epidote, with minor Fe-Ti oxide, sphene/leucoxene, hematite/iron hydroxide and/or carbonates. The relicts of their shapes and alteration nature signify that they are orthopyroxene.

Fe-Ti oxide occurs as megacrysts and groundmass grains. They may be slightly replaced by sphene/leucoxene and/or hematite/iron hydroxide. Apatite forms microphenocrysts and shows subhedral to euhedral outlines.

**Sample Number:** MP-1  
**Grid Reference:** 954912, 1:50,000 Topographic Map,  
 Sheet 4751 I (Amphoe Long)  
**Rock Name:** Andesite

**Megascopic Characters:** This medium bluish gray sample is a dense, fine-grained rock and shows a highly megacrystic texture. The megacrysts consist of pale green plagioclase (sizes up to 3.0 mm across) and black minerals (sizes up to 1.0 mm across). Tiny milky white veinlets are occasionally present. The rock has a weak sign of magnetism and does not react with diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts consist largely of plagioclase, with minor clinopyroxene and unidentified mafic minerals. These megacrysts may occur as isolated grains, monomineralic clusters, and polymineralic clusters of plagioclase –

unidentified mafic mineral. They are embedded in the fine-grained, holocrystalline groundmass (grain sizes largely in a range of 0.01 – 0.02 mm across), with a well-defined trachytic texture. The groundmass is composed largely of plagioclase laths, with minor clinopyroxene, unidentified mafic minerals, and secondary patches of epidote, pumpellyite, carbonates, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide. The veined mineral present in the sample is quartz.

Plagioclase megacrysts and groundmass plagioclase grains commonly have anhedral to subhedral outlines. The plagioclase megacrysts are highly altered, whereas the groundmass plagioclase grains are moderately altered. Their alteration products are sericite, clay minerals, chlorite, epidote, pumpellyite, carbonates, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Clinopyroxene megacrysts show irregular, anhedral outlines and are often thinly rimmed with secondary green amphibole. The groundmass clinopyroxene grains largely show anhedral outlines and are intergranular to plagioclase laths. Apart from the replacement green amphibole, clinopyroxene may be occasionally replaced by chlorite, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Unidentified mafic minerals have anhedral to subhedral outlines, with brownish rims, and are completely altered. Their alteration products are almost totally chlorite/serpentine, with minor epidote, carbonates, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide. The brownish rims of the unidentified mineral are sphene/leucoxene.



**Sample Number:** MP-4  
**Grid Reference:** 953917, 1:50,000 Topographic Map,  
 Sheet 4945 II (Amphoe Long)  
**Rock Name:** Andesite

**Megascopic Characters:** This greenish gray sample is a fine-grained rock and shows a highly megacrystic texture. Megacrysts in this sample include abundant pale green plagioclase and occasionally greenish black mineral, with sizes up to 2.0 mm and 1.0 mm across, respectively. The rock has no sign of magnetism and does not react with diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts in this sample include plagioclase, clinopyroxene, unidentified mafic mineral, and apatite. Of these, plagioclase and clinopyroxene are the most abundant megacrysts, while megacrysts of unidentified mafic mineral, and apatite microphenocrysts are uncommon. These megacrysts may occur as isolated grains, monomineralic clusters, and as polymineralic clusters of clinopyroxene – plagioclase, and clinopyroxene – unidentified mafic mineral. The groundmass is fine-grained, holocrystalline (grain sizes largely less than 0.02 mm across), and consists largely of trachytic plagioclase laths, with small amounts of clinopyroxene, unidentified mafic mineral, interstitial quartz, and secondary patches of chlorite, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Plagioclase megacrysts commonly have anhedral to subhedral outlines, while groundmass plagioclase grains are largely subhedral. All the plagioclase phases are moderately to largely altered, with abundant sericite, subordinate chlorite, epidote minerals (zoisite/clinozoisite and epidote) and sphene/leucoxene, and rare Fe-Ti oxide and/or hematite/iron hydroxide as alteration products.

Clinopyroxene megacrysts show anhedral to subhedral outlines and are often thinly rimmed with brownish amphibole. The groundmass clinopyroxene grains largely show anhedral outlines and are intergranular to plagioclase laths. Both the

clinopyroxene phases have been slightly to moderately altered. Their additional alteration products to brownish amphibole are chlorite and Fe-Ti oxide (partly replaced by sphene/leucoxene and/or hematite/iron hydroxide).

Unidentified mafic minerals have shapes ranging from anhedral to euhedral, but are largely subhedral. The euhedral one shows a typical outline of pyroxene and accordingly it is highly possible to be orthopyroxene. These mafic minerals are totally altered, with chlorite/serpentine as the major alteration product. The minor alteration products may include epidote, quartz, Fe-Ti oxide, sphene/leucoxene and hematite/iron hydroxide.

**Sample Number:** MP-6  
**Grid Reference:** 950917, 1:50,000 Topographic Map,  
 Sheet 4945 II (Amphoe Long)  
**Rock Name:** Andesite/Basalt

**Megascopic Characters:** This dark gray rock sample is fine-grained, and shows a highly megacrystic texture. Megacrysts include abundant pale green plagioclase (sizes up to 2.0 mm across) and minor greenish black minerals (sizes up to 0.5 mm across). Tiny fractures sealed by milky white and pale green minerals are present in minor amount.

**Microscopic Characters:** The megacrysts in this sample include plagioclase, clinopyroxene, unidentified mafic mineral, and Fe-Ti oxide. These megacrysts may form as isolated crystals, monomineralic clusters, and polymineralic clusters of clinopyroxene – plagioclase, clinopyroxene – unidentified mafic mineral, and clinopyroxene – Fe-Ti oxide. The groundmass is fine-grained, holocrystalline (grain sizes largely 0.01 – 0.02 mm across), and consists largely of felty plagioclase laths, with minor clinopyroxene, unidentified mafic mineral, Fe-Ti oxide and interstitial



quartz. Secondary patches of epidote, sphene/leucoxene and hematite/iron hydroxide have been observed from place to place in minor amount. The veined minerals include quartz, epidote and carbonates.

All plagioclase phases commonly have subhedral outlines and are largely to totally altered to white mica, chlorite, epidote minerals (zoisite/clinozoisite and epidote) and/or Fe-Ti oxide (commonly replaced by sphene/leucoxene and uncommonly replaced by hematite/iron hydroxide).

Clinopyroxene megacrysts show anhedral to subhedral outlines, while the groundmass clinopyroxene grains largely show anhedral outlines and are intergranular to plagioclase laths. All phases of clinopyroxene are slightly altered to chlorite, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Unidentified mafic minerals are anhedral to subhedral, and completely altered. They are almost totally replaced by chlorite/serpentine, with minor epidote, carbonates, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Fe-Ti oxide crystals occur either as a megacryst phase or as a groundmass phase of both primary and secondary origins. They have anhedral to subhedral outlines and are partially replaced by sphene/leucoxene and/or hematite/iron hydroxide.

**Sample Number:** MP-7  
**Grid Reference:** 951918, 1:50,000 Topographic Map,  
 Sheet 4945 II (Amphoe Long)  
**Rock Name:** Andesite/Basalt

**Megascopic Characters:** This medium bluish gray sample is highly megacrystic, with megacrysts (sizes up to 2.5 mm across) of abundant plagioclase (pale green), and rare clinopyroxene (greenish black), sitting in the dense, fine-grained groundmass. Tiny whitish veinlets have been sporadically detected. The rock is non-magnetic, and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts consist largely of plagioclase, with minor clinopyroxene, unidentified mafic mineral and Fe-Ti oxide. These megacrysts may form as isolated crystals, monomineralic clusters of plagioclase and clinopyroxene, and as polymineralic clusters of plagioclase – clinopyroxene, and plagioclase – unidentified mafic mineral. The groundmass is fine-grained, holocrystalline (grain sizes largely 0.01 – 0.02 mm across), and consists largely of felty plagioclase laths, with subordinate clinopyroxene, and minor unidentified mafic mineral and Fe-Ti oxide. Secondary patches of chlorite, epidote minerals (zoisite/clinozoisite and epidote), sphene/leucoxene and/or hematite/iron hydroxide have been observed in minor amount. The veined minerals include quartz and epidote minerals (zoisite/clinozoisite and epidote).

Plagioclase phenocrysts/micropenocrysts and groundmass plagioclase grains commonly have euhedral to subhedral outlines. The plagioclase phenocrysts/micropenocrysts are highly to completely altered, while the groundmass plagioclase grains are slightly altered. Their alteration products include sericite, white mica, chlorite, sphene/leucoxene, Fe-Ti oxide and/or hematite/iron hydroxide.

Clinopyroxene megacrysts show anhedral to subhedral outlines and are often rimmed with secondary, brownish green amphibole. Some clinopyroxene megacrysts



show ophitic/subophitic relationship to plagioclase laths. The groundmass clinopyroxene grains also show anhedral to subhedral outlines and are intergranular to plagioclase laths. All phases of clinopyroxene are slightly altered to amphibole, chlorite, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Unidentified mafic minerals are anhedral to subhedral, and completely altered. They are almost totally replaced by chlorite/serpentine, with minor epidote, carbonates, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Fe-Ti oxide crystals occur either as a megacryst phase or as a groundmass phase of both primary and secondary origins. They have anhedral to subhedral outlines and are partially replaced by sphene/leucoxene and/or hematite/iron hydroxide.

**Sample Number:** MP-9  
**Grid Reference:** 935960, 1:50,000 Topographic Map,  
 Sheet 4945 II (Amphoe Long)  
**Rock Name:** Andesite

**Megascopic Characters:** This rock sample is fine-grained, and has a dark gray color. It shows a highly megacrystic texture, with pale green plagioclase megacrysts of which sizes are up to 3 mm across. Tiny reddish brown and pale green veinlets are rarely present. The rock is moderately magnetic, and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts in this sample are made up mainly of plagioclase, with subordinate clinopyroxene, and minor unidentified mafic mineral, and Fe-Ti oxide. These megacrysts may form as isolated crystals, monomineralic clusters, and as polymineralic clusters of plagioclase – clinopyroxene, plagioclase –

clinopyroxene - Fe-Ti oxide, and plagioclase – clinopyroxene – unidentified mafic mineral - Fe-Ti oxide. Also present is a xenolith of highly porphyritic basalt of which grain sizes are largely in a range of 0.01 – 0.02 mm across. The groundmass is fine-grained, holocrystalline (grain sizes largely less than 0.01 mm across), and shows a felty texture. It is composed mainly of plagioclase laths, with minor clinopyroxene, interstitial quartz and Fe-Ti oxide. Secondary patches of chlorite/serpentine, epidote, sphene/leucoxene and hematite/iron hydroxide have been observed in minor amount.

Plagioclase megacrysts show anhedral to euhedral outlines and are variably altered to sericite, chlorite, epidote, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide. Groundmass plagioclase crystals are lath-shaped. They have similar alteration products to plagioclase megacrysts but are much less altered.

Clinopyroxene occurs as megacrysts and a groundmass phase, with anhedral to subhedral outlines. The clinopyroxene megacrysts are often rimmed with secondary greenish amphibole. The groundmass clinopyroxene grains are intergranular to plagioclase laths. Both phases of clinopyroxene are slightly altered to amphibole, chlorite, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Unidentified mafic minerals are anhedral to subhedral, and completely altered. Their common alteration products are chlorite/serpentine, epidote and/or sphene/leucoxene, whereas Fe-Ti oxide and/or hematite/iron hydroxide are uncommon alteration products.

Fe-Ti oxide crystals occur either as a megacryst phase or as a groundmass phase of both primary and secondary origins. They have anhedral to subhedral outlines and are partially replaced by sphene/leucoxene and/or hematite/iron hydroxide.



**Sample Number:** MP-10

**Grid Reference:** 941909, 1:50,000 Topographic Map,  
Sheet 4945 II (Amphoe Long)

**Rock Name:** Andesite

**Megascopic Characters:** This rock sample shows a highly megacrystic texture, with megacrysts of pale green and black minerals (sizes up to 2 mm across). The black megacrysts are almost totally replaced by reddish brown mineral. The groundmass is fine-grained, and has a grayish green color. Reddish brown and pale green veinlets have been occasionally detected. The rock is non-magnetic and does not give effervescence when cold diluted hydrochloric acid is applied.

**Microscopic Characters:** The megacrysts in this sample include abundant plagioclase, subordinate clinopyroxene and Fe-Ti oxide, and rare apatite. These megacrysts may form as isolated crystals; monomineralic clusters of plagioclase, and polymineralic clusters of plagioclase – clinopyroxene, and plagioclase – clinopyroxene - Fe-Ti oxide. The groundmass is very fine-grained and holocrystalline (grain sizes are largely about 0.01 mm across), and consists largely of felted plagioclase laths, with subordinate secondary patches of sericite, chlorite/serpentine, epidote, Fe-Ti oxide, sphene/leucoxene, hematite/iron hydroxide and carbonates.

Plagioclase, either as megacrysts or as groundmass grains, show euhedral to anhedral (largely subhedral) outlines. These plagioclase crystals are highly to almost totally altered to sericite, clay mineral, epidote minerals (zoisite/clinozoisite and epidote), chlorite, Fe-Ti oxide, sphene/leucoxene, hematite/iron hydroxide and/or carbonates.

Clinopyroxene megacrysts commonly show anhedral to subhedral outlines and are slightly replaced by carbonates and/or Fe-Ti oxide. The groundmass clinopyroxene grains are totally altered. Their major alteration product is chlorite.

Apatite and Fe-Ti oxide occur only as microphenocrysts and as megacrysts, respectively. The former is subhedral to euhedral, while the latter has anhedral to subhedral outlines and is slightly replaced by hematite/iron hydroxide.

**Sample Number:** MP-12

**Grid Reference:** 939919, 1:50,000 Topographic Map,  
Sheet 4945 II (Amphoe Long)

**Rock Name:** Andesite

**Megascopic Characters:** This grayish green rock sample shows a highly megacrystic texture, with megacrysts of dark mineral (sizes up to 1.0 mm across) and pale green white plagioclase (sizes up to 1.5 mm across). These megacrysts sit in the grayish green, fine-grained groundmass. White veinlets are rarely present. The rock shows weak magnetism and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts in this sample include abundant plagioclase, subordinate clinopyroxene and unidentified mafic mineral, and minor apatite and Fe-Ti oxide. These megacrysts may form as isolated crystals, monomineralic clusters of plagioclase, and polymineralic clusters of plagioclase - clinopyroxene, clinopyroxene - unidentified mafic mineral, and plagioclase - clinopyroxene - unidentified mafic mineral. The groundmass is very fine-grained and holocrystalline (grain sizes largely about 0.02 mm across), with a weakly trachytic texture. It consists largely of plagioclase laths, with subordinate clinopyroxene, and secondary patches of sericite, chlorite/serpentine, epidote minerals (zoisite/clinozoisite and epidote), Fe-Ti oxide, sphene/leucoxene and carbonates.

Plagioclase phenocrysts/microphenocrysts and groundmass plagioclase grains are largely subhedral and variably altered. The plagioclase phenocrysts/microphenocrysts are highly altered, while groundmass plagioclase



grains are slightly altered. Their alteration products include sericite, epidote minerals (zoisite/clinozoisite and epidote), chlorite, Fe-Ti oxide, sphene/leucoxene, hematite/iron hydroxide and/or carbonates.

Clinopyroxene megacrysts have anhedral outlines and are slightly altered to chlorite, epidote minerals (zoisite/clinozoisite and epidote), Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Unidentified mafic megacrysts have anhedral to subhedral outlines and are totally altered. Their alteration products are abundant chlorite/serpentine, with minor epidote minerals (zoisite/clinozoisite and epidote), Fe-Ti oxide, sphene/leucoxene, hematite/iron hydroxide and/or carbonates.

Fe-Ti oxide occurs as megacrysts and groundmass grains. They may be slightly replaced by hematite/iron hydroxide. Apatite forms microphenocrysts and shows subhedral outlines.

**Sample Number:** MP-13

**Grid Reference:** 943911, 1:50,000 Topographic Map,  
Sheet 4945 II (Amphoe Long)

**Rock Name:** Andesite/Basalt

**Megascopic Characters:** This rock sample shows a highly megacrystic texture, with megacrysts of pale green and white plagioclase (sizes up to 4 mm across) and greenish black mineral (sizes up to 1 mm across). The groundmass is fine-grained and dense, with a grayish green color. Tiny veinlets of brownish white minerals have been locally detected. The rock has no magnetic property and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts phases consist largely of plagioclase, with a small amount of clinopyroxene, and occasional apatite and Fe-Ti oxide. These megacrysts may form as isolated grains, monomineralic clusters, and polymineralic clusters of clinopyroxene - plagioclase, clinopyroxene – mafic mineral, mafic mineral – Fe-Ti oxide, and clinopyroxene – plagioclase – unidentified mafic mineral. The groundmass is holocrystalline and fine-grained (grain sizes largely in a range of 0.01 – 0.02 mm across), and consists chiefly of trachytic plagioclase laths, with subordinate clinopyroxene, and rare interstitial quartz and Fe-Ti oxide. Secondary patches of sphene/leucoxene, chlorite/serpentine, amphibole, epidote minerals (zoisite/clinozoisite and epidote), sericite, Fe-Ti oxide and carbonates are minor.

Plagioclase phenocrysts/microphenocrysts and groundmass plagioclase grains have subhedral to euhedral outlines. The plagioclase phenocrysts/microphenocrysts are highly altered, whereas the groundmass plagioclase grains are slightly altered. Their alteration products include sericite, epidote minerals (zoisite/clinozoisite and epidote), chlorite/serpentine, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Clinopyroxene megacrysts and groundmass clinopyroxene grains commonly show anhedral to subhedral outlines. Both phases of clinopyroxene are slightly altered to chlorite, amphibole, Fe-Ti oxide and/or hematite/iron hydroxide altered. Amphibole commonly occurs at rims of clinopyroxene.

Unidentified mafic minerals have anhedral to euhedral (largely subhedral) outlines and are completely altered. Their alteration products include abundant chlorite/serpentine, with minor ?amphibole, epidote minerals (zoisite/clinozoisite and epidote), carbonates, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Apatite and Fe-Ti oxide as sparse microphenocrysts have subhedral to euhedral outlines. Fe-Ti oxide is slightly replaced by sphene/leucoxene and/or hematite/iron hydroxide.



**Sample Number:** MP-14  
**Grid Reference:** 946917, 1:50,000 Topographic Map,  
 Sheet 4945 II (Amphoe Long)  
**Rock Name:** Andesite/Basalt

**Megascopic Characters:** This rock sample is highly megacrystic, with megacrysts of pale green plagioclase and greenish black clinopyroxene (sizes up to 2 mm across). Of these, plagioclase megacrysts is the most abundant. The groundmass is fine-grained and dense, with a dark greenish gray color. Very few veinlets of brownish minerals have been detected. The sample has a weak magnetic property and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts in this sample include abundant plagioclase, with subordinate clinopyroxene and unidentified mafic mineral. These megacrysts may form as isolated crystals, and as polyminerally clusters of clinopyroxene – plagioclase – unidentified mafic mineral. The groundmass is holocrystalline and fine-grained (grain sizes largely 0.01 mm across), and consists largely of trachytic plagioclase laths, with minor clinopyroxene, interstitial quartz, and secondary patches of chlorite/serpentine, epidote minerals (zoisite/clinozoisite and epidote), sericite, Fe-Ti oxide, sphene/leucoxene and hematite/iron hydroxide. In addition to the tiny veined brownish hematite/iron hydroxide as observed in hand specimen, tiny veined quartz + epidote has been locally detected in sparse amount.

Plagioclase megacrysts show anhedral to subhedral outlines and are highly altered. The groundmass plagioclase grains are largely subhedral, and are slightly altered. Their alteration products include sericite, chlorite, epidote minerals (zoisite/clinozoisite and epidote), Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Clinopyroxene forms as megacrysts and as a groundmass constituent. They show anhedral to subhedral outlines and are slightly to moderately altered. Their

replacement minerals are abundant chlorite and ?amphibole, and minor Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide. The replacement amphibole often forms as rims of clinopyroxene.

Unidentified mafic minerals are anhedral to subhedral, and are totally pseudomorphed by abundant chlorite/serpentine, and minor ?amphibole, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide. The secondary ?amphibole often occurs as rims of unidentified mafic mineral.

**Sample Number:** MR-5

**Grid Reference:** 952947, 1:50,000 Topographic Map,  
Sheet 4945 II (Amphoe Long)

**Rock Name:** Andesite

**Megascopic Characters:** This rock sample shows a highly megacrystic texture. Megacrysts (sizes up to 2 mm across) are largely pale green plagioclase with occasional black minerals. The groundmass is very fine-grained, and has a greenish black color. Tiny white veinlets are occasionally present. The rock is slightly magnetic, and very few places slightly react with cold diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts in this sample include abundant plagioclase, subordinate clinopyroxene, and minor unidentified mafic mineral. These megacrysts may form as isolated crystals, monomineralic clusters of plagioclase and clinopyroxene, and as polymineralic clusters of plagioclase - clinopyroxene, and clinopyroxene – unidentified mafic mineral. The groundmass is very fine-grained and holocrystalline, with grain sizes of about 0.01 mm across. It is made up mainly of felted plagioclase laths, with subordinate chlorite, and minor secondary patches of sericite, quartz, Fe-Ti oxide and sphene/leucoxene. Tiny cavities with chlorite



infillings have been observed in minor amount. The veined minerals are epidote and carbonates.

Plagioclase crystals, either phenocrysts/microphenocrysts or groundmass grains, largely show subhedral outlines and are variably altered. Their alteration products are abundant sericite, and minor chlorite, carbonates and/or sphene/leucoxene.

Clinopyroxene megacrysts largely show anhedral to subhedral outlines. They are slightly to moderately altered to abundant chlorite, with minor quartz and/or sphene/leucoxene.

Unidentified mafic megacrysts are largely anhedral to subhedral, and are totally altered to abundant chlorite/serpentine, and minor carbonates, quartz and/or sphene/leucoxene.

**Sample Number:** MR-53  
**Grid Reference:** 952947, 1:50,000 Topographic Map,  
 Sheet 4945 II (Amphoe Long)  
**Rock Name:** Andesite

**Megascopic Characters:** The rock sample has a highly megacrystic texture and the discernable megacrysts are milky white plagioclase, with sizes up to 1.5 mm across. The groundmass is generally very fine-grained, and has a dark greenish gray color. A few of tiny fractures sealed by reddish brown are locally present. The rock shows weak magnetism, and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts phases consist largely of plagioclase, with occasional unidentified mafic mineral, Fe-Ti oxide and apatite. These megacrysts

may form as isolated grains, monomineralic clusters of plagioclase, and as polyminerallc clusters of plagioclase – unidentified mafic mineral, and plagioclase – Fe-Ti oxide. The groundmass is very fine-grained and holocrystalline, with grain sizes largely less than 0.05 mm across, and shows a felty texture. It is composed of plagioclase laths, and secondary patches of chlorite, epidote, carbonates and sphene/leucoxene. Veinlets of carbonates and epidote have been rarely detected.

Plagioclase phenocrysts/microphenocrysts and groundmass plagioclase grains commonly have subhedral outlines. The plagioclase phenocrysts/microphenocrysts are largely to almost totally altered, while the groundmass plagioclase grains are slightly to moderately altered. Their alteration minerals include abundant sericite, and minor carbonates and/or sphene/leucoxene.

Megacrysts of unidentified mafic minerals are anhedral to subhedral, and are totally altered to abundant chlorite/serpentine, with minor carbonates and/or sphene/leucoxene.

Microphenocrysts of apatite and Fe-Ti oxide commonly have subhedral to euhedral outlines. The Fe-Ti oxide microphenocrysts are slightly altered to sphene/leucoxene.

**Sample Number:** MR-6

**Grid Reference:** 956952, 1:50,000 Topographic Map,  
Sheet 4945 II (Amphoe Long)

**Rock Name:** Andesite/Basalt

**Megascopic Characters:** This is a highly megacrystic rock, with abundant pale green plagioclase and occasionally greenish black megacrysts (sizes up to 2 mm across). Also present are ?microdiorite/microgabbro xenoliths. These megacrysts and xenoliths sit in greenish gray, very fine-grained groundmass. White veinlets have



been rarely detected. The rock has a weak magnetic property and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts in this sample include abundant plagioclase, small amounts of clinopyroxene and unidentified mafic mineral, and rare Fe-Ti oxide. These megacrysts may form as isolated crystals, monomineralic clusters of unidentified mafic mineral, and polymineralic clusters of plagioclase - clinopyroxene, plagioclase - unidentified mafic mineral, clinopyroxene - unidentified mafic mineral, and Fe-Ti oxide - unidentified mafic mineral. The groundmass is fine-grained and holocrystalline, with grain sizes largely 0.01 - 0.03 mm across. Its constituents are made up mainly of felted plagioclase laths, with minor Fe-Ti crystals and replacement quartz, chlorite/serpentine, carbonates, epidote minerals (zoisite/clinozoisite and epidote), Fe-Ti oxide, sphene/leucoxene and hematite/iron hydroxide. The veined minerals are carbonates, quartz and chlorite.

Plagioclase crystals largely show subhedral outlines. The plagioclase phenocrysts/microphenocrysts are moderately to highly altered, while the groundmass plagioclase grains are slightly to moderately altered. Their replacement mineralogies are abundant sericite, and minor epidote minerals (zoisite/clinozoisite and epidote), carbonates, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Clinopyroxene megacrysts show anhedral to subhedral (largely subhedral) outlines. They are slightly to moderately altered to abundant chlorite, with minor carbonates, Fe-Ti oxide and sphene/leucoxene.

Unidentified mafic megacrysts are largely anhedral to subhedral (largely subhedral), and are totally altered to abundant chlorite/serpentine, and minor carbonates, Fe-Ti oxide and/or sphene/leucoxene.

Fe-Ti oxide as megacrysts show anhedral outlines, whereas that as a groundmass constituent is subhedral to euhedral.

**Sample Number:** MR-8

**Grid Reference:** 957958, 1:50,000 Topographic Map,  
Sheet 4945 II (Amphoe Long)

**Rock Name:** Andesite

**Megascopic Characters:** This rock sample shows a highly megacrystic texture. The discernable megacrysts are largely milky white plagioclase (sizes up to 1.5 mm across), with minor dark minerals (sizes up to 1 mm across). The groundmass is fine-grained, with a dark greenish gray color. Pale green veinlets have occasionally been observed. The rock has a weak sign of magnetism and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts consist largely of clinopyroxene, with subordinate unidentified mafic minerals. These megacrysts may form as isolated crystals, monomineralic clusters of clinopyroxene, and as polymineralic cluster of clinopyroxene – unidentified mafic mineral. The groundmass is very fine-grained and holocrystalline (grain sizes largely 0.01 – 0.03 mm across) and shows a moderately defined trachytic texture. It is composed largely of plagioclase laths and clinopyroxene grains, with minor secondary patches of chlorite/serpentine, epidote minerals (zoisite/clinozoisite and epidote), sphene/leucoxene and Fe-Ti oxide. The pale green veinlets as observed in hand specimen are epidote minerals (zoisite/clinozoisite and epidote).

Plagioclase groundmass grains largely have subhedral outlines and are slightly altered to sericite, sphene/leucoxene and epidote minerals (zoisite/clinozoisite and epidote).

Clinopyroxene megacrysts and groundmass clinopyroxene grains have anhedral to subhedral (largely anhedral) outlines. The groundmass clinopyroxene grains are intergranular to plagioclase laths. All the clinopyroxene crystals show no sign of alteration.



Megacrysts of unidentified mafic minerals are anhedral to subhedral (largely anhedral), and are totally altered. Their alteration products are almost totally chlorite/serpentine, with minor sphene/leucoxene and Fe-Ti oxide.

**Sample Number:** MR-9

**Grid Reference:** 959958, 1:50,000 Topographic Map,  
Sheet 4945 II (Amphoe Long)

**Rock Name:** Microdiorite

**Megascopic Characters:** *Sample is not available for lithologic study*

**Microscopic Characters:** The sample is a seriate-textured, fine-grained rock that contains plagioclase and clinopyroxene as the principal constituents. Secondary patches of chlorite, sphene/leucoxene and carbonates are present in minor amount. Tiny cavities sealed by quartz and tiny fractures sealed by carbonates have been occasionally detected.

Plagioclase crystals have sizes up to 0.5 mm across, and commonly show subhedral to euhedral outlines. They are slightly to highly altered, and have sericite as a common alteration product, and chlorite and/or sphene/leucoxene as minor alteration products.

Clinopyroxene crystals have sizes up to 0.8 mm across (largely 0.4 mm across) and are anhedral to euhedral. They are slightly altered to chlorite and/or sphene/leucoxene.

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**Sample Number:** MR-10  
**Grid Reference:** 957962, 1:50,000 Topographic Map,  
 Sheet 4945 II (Amphoe Long)  
**Rock Name:** Andesite

**Megascopic Characters:** This highly megacrystic rock sample has milky white plagioclase (sizes up to 1.5 mm across) as the dominant megacrysts and black minerals (sizes up to 1 mm across) as the minor megacrysts. The groundmass has a grayish green color, and is fine-grained and dense. Tiny pale green and reddish brown veinlets are occasionally present. The rock is weakly magnetic, and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The megacrysts phases consist largely of plagioclase, with minor unidentified mafic minerals, apatite and Fe-Ti oxide. These megacrysts may form as isolated grains, monomineralic clusters of plagioclase, and as polyminerale clusters of plagioclase – Fe-Ti oxide, plagioclase – unidentified mafic mineral, unidentified mafic mineral – apatite, and plagioclase – unidentified mafic mineral – Fe-Ti oxide. The groundmass is fine-grained and holocrystalline (grain sizes almost totally less than 0.05 mm across), and consists chiefly of felty plagioclase laths, with minor secondary patches of chlorite/serpentine and sphene/leucoxene. The veined minerals include carbonates, chlorite and/or epidote.

Plagioclase phenocrysts/microphenocrysts and groundmass plagioclase grains largely have subhedral outlines. They are moderately to almost totally altered to abundant sericite, with minor epidote, chlorite and/or sphene/leucoxene.

Unidentified mafic minerals are anhedral, and are totally altered to abundant chlorite/serpentine and/or carbonates, and minor sphene/leucoxene and/or epidote.



Apatite microphenocrysts show subhedral to euhedral outlines. Fe-Ti oxide megacrysts are anhedral to euhedral (largely subhedral). They are slightly replaced by sphene/leucoxene along their margins.

**Sample Number:** MR-10.3  
**Grid Reference:** 957962, 1:50,000 Topographic Map,  
 Sheet 4945 II (Amphoe Long)  
**Rock Name:** Andesite

**Megascopic Characters:** This rock sample shows a moderately megacrystic texture, with megacrysts of abundant pale green and subordinate black minerals (sizes up to 1.5 mm across). The groundmass is fine-grained, and has a dark greenish gray color. Tiny fractures sealed by olive green mineral (epidote) are abundantly present. The rock is slightly magnetic, and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The rock is highly megacrystic, with abundant plagioclase, and minor unidentified mafic mineral, apatite and Fe-Ti oxide megacrysts. These megacrysts may form as isolated grains, monomineralic clusters of plagioclase, and as polymineralic clusters of clinopyroxene – plagioclase – Fe-Ti oxide, plagioclase – unidentified mafic mineral – Fe-Ti oxide, unidentified mafic mineral – Fe-Ti oxide – clinopyroxene, and plagioclase - unidentified mafic mineral – Fe-Ti oxide - apatite. The groundmass is very fine-grained and holocrystalline (grain sizes almost totally less than 0.005 mm across). It is highly altered, and consists chiefly of felty plagioclase laths and clay minerals, with occasional epidote. The fracture-infillings are chlorite, epidote, quartz and/or hematite/iron hydroxide.

Plagioclase megacrysts and groundmass plagioclase grains have anhedral to subhedral outlines. They are almost totally altered to abundant sericite and clay mineral, with minor epidote, chlorite and/or sphene/leucoxene.

Megacrysts of unidentified mafic minerals largely have anhedral outlines, and are totally altered to abundant chlorite/serpentine, with minor sphene/leucoxene, epidote, carbonates, quartz and/or hematite/iron hydroxide.

Apatite microphenocrysts are subhedral to euhedral, while Fe-Ti oxide megacrysts show anhedral to euhedral outlines and are largely replaced by sphene/leucoxene.

**Sample Number:** MR-11

**Grid Reference:** 957965, 1:50,000 Topographic Map,  
Sheet 4945 II (Amphoe Long)

**Rock Name:** Andesite/Basalt

**Megascopic Characters:** The rock sample shows a moderately megacrystic texture, with grayish green and greenish black megacrysts (sizes up to 1.0 mm across). The groundmass is generally fine-grained and dense, and has a greenish black color. The rock is non-magnetic and non-calcareous.

**Microscopic Characters:** The megacryst phases consist largely of plagioclase, with occasional clinopyroxene and unidentified mafic minerals. These megacrysts may form as isolated grains and as polymineralic clusters of clinopyroxene - plagioclase. The groundmass is fine-grained and holocrystalline (grain sizes largely 0.02 – 0.03 mm across), and consists chiefly of felty plagioclase laths, with subordinate clinopyroxene, and minor secondary patches of chlorite/serpentine, Fe-Ti oxide, sphene/leucoxene, epidote and quartz. The veined minerals include carbonates, chlorite, epidote and quartz.



Plagioclase phenocrysts/microphenocrysts and groundmass plagioclase grains largely have subhedral outlines. They are variably altered to sericite, epidote, chlorite, carbonates, quartz, Fe-Ti oxide and/or sphene/leucoxene.

Clinopyroxene crystals occur as megacrysts and as a groundmass constituent, and largely show anhedral outlines. They are slightly altered to chlorite, epidote, Fe-Ti oxide and/or sphene/leucoxene.

Unidentified mafic minerals are anhedral, and are totally altered to abundant chlorite/serpentine, and minor sphene/leucoxene, Fe-Ti oxide and/or carbonates.

**Sample Number:** MR-12

**Grid Reference:** 960973, 1:50,000 Topographic Map,  
Sheet 4945 II (Amphoe Long)

**Rock Name:** Andesite

**Megascopic Characters:** This rock sample shows a moderately megacrystic texture, with megacrysts of milky white and black minerals (sizes up to 2 mm across). The groundmass is fine-grained, with a medium bluish gray color. An olive green epidote patch and occasionally tiny veinlets have been observed in the sample. The rock shows no sign of magnetism and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The sample is an accumulative rock, with megacrysts greater than 75 modal%. The most abundant megacrysts are plagioclase; clinopyroxene and unidentified mafic minerals are minor. The groundmass was originally glassy, with quench crystals, and almost totally altered to clay minerals. The veinlets as observed in hand specimen contain chlorite and epidote.

Plagioclase megacrysts show anhedral to subhedral (largely subhedral) outlines. They are slightly to highly altered to abundant sericite and clay minerals, with minor carbonates.

Larger clinopyroxene crystals are mainly subhedral, while smaller ones are largely anhedral. They are slightly to moderately altered to abundant chlorite, and minor carbonates and/or sphene/leucoxene.

Unidentified mafic minerals are largely anhedral, and are totally altered to abundant chlorite/serpentine, and minor quartz and/or sphene/leucoxene.

**Sample Number:** PM-1

**Grid Reference:** 025094, 1:50,000 Topographic Map,  
Sheet 4945 II (Amphoe Long)

**Rock Name:** Andesite

**Megascopic Characters:** This rock sample has a slightly megacrystic texture, with milky white, pale green and black megacrysts (sizes up to 2 mm across). The groundmass is fine-grained, and generally has a medium bluish gray color. Tiny milky white veinlets have been locally detected in minor amount. The sample is slightly magnetic, and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** In contrast to the feature observed in hand specimen, the sample is an accumulative rock with megacrysts greater than 70 modal%. The megacrysts include abundant plagioclase and subordinate clinopyroxene and unidentified mafic mineral, and occasional apatite and Fe-Ti oxide. The groundmass is very fine-grained (grain sizes less than 0.01 mm across), consisting of plagioclase laths, clay mineral, chlorite, sphene/leucoxene and Fe sulfide. Tiny irregular cavities sealed by quartz and chlorite are present in the groundmass in small amount. These



cavities commonly have discontinuous quartz crystals along their walls and chlorite at cores. Very few are sealed by drusy quartz grains.

Plagioclase megacrysts show anhedral to euhedral outlines, while the groundmass plagioclase grains are largely anhedral to subhedral. All the plagioclase phases are slightly to moderately altered to sericite, clay mineral, chlorite, sphene/leucoxene, quartz and/or Fe sulfide.

Clinopyroxene forms as a megacryst and as a groundmass constituent. They show anhedral to euhedral (largely anhedral – subhedral) outlines and are slightly to moderately altered to chlorite, quartz, Fe-Ti oxide and/or sphene/leucoxene.

Unidentified mafic megacrysts show anhedral to euhedral outlines, but are largely subhedral. They are totally altered, and have been largely replaced by chlorite/serpentine, with subordinate sphene/leucoxene, and minor Fe-Ti oxide and/or quartz.

Apatite and Fe-Ti oxide microphenocrysts have subhedral to euhedral outlines. Fe-Ti oxide microphenocrysts are slightly replaced by sphene/leucoxene and/or hematite/iron hydroxide.

**Sample Number:** PM-4

**Grid Reference:** 027092, 1:50,000 Topographic Map,  
Sheet 4945 II (Amphoe Long)

**Rock Name:** Andesite

**Megascopic Characters:** This rock sample shows a moderately megacrystic texture, with grayish black megacrysts of which sizes are up to 1 mm across. These megacrysts sit in the dense, fine-grained groundmass that has a dark gray color. Tiny

brownish white veinlets are occasionally present. The rock shows no sign of magnetism and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** The sample is strongly megacrystic, with abundant plagioclase, subordinate unidentified mafic mineral, and minor clinopyroxene and Fe-Ti oxide megacrysts. These megacrysts may occur as isolated crystals, monomineralic clusters of plagioclase, unidentified mafic mineral and clinopyroxene, and as polymineralic clusters of plagioclase – unidentified mafic mineral – clinopyroxene, and unidentified mafic mineral – clinopyroxene – Fe-Ti oxide. The groundmass is severely altered to abundant sericite, carbonates, chlorite and/or sphene/leucoxene, and minor Fe-Ti oxide and/or hematite/iron hydroxide.

Plagioclase megacrysts show anhedral-subhedral (largely subhedral) outlines and are largely to almost totally altered. Their alteration products include abundant sericite, chlorite, carbonates and/or sphene/leucoxene, and minor Fe-Ti oxide and/or hematite/iron hydroxide.

Microphenocrysts of unidentified mafic mineral are largely subhedral, and are totally altered. Their alteration products include abundant chlorite/serpentine, with minor carbonates, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Clinopyroxene microphenocrysts are largely subhedral, and are slightly to moderately altered. Their alteration products include chlorite, carbonates, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Microphenocrysts of apatite and Fe-Ti oxide have subhedral to euhedral outlines. The Fe-Ti oxide microphenocrysts are slightly altered to hematite/iron hydroxide.



**Sample Number:** PM-5  
**Grid Reference:** 030092, 1:50,000 Topographic Map,  
 Sheet 4945 II (Amphoe Long)  
**Rock Name:** Andesite/Basalt

**Megascopic Characters:** The rock sample exhibits a slightly megacrystic texture and has a grayish black mineral as megacrysts (sizes up to 2 mm across). The groundmass is generally fine-grained, and has a dark gray color. Brown and white veinlets have been rarely detected. The rock has no magnetic property and does not react with cold diluted hydrochloric acid.

**Microscopic Characters:** Although the rock is slightly megacrystic in hand specimen, it is highly megacrystic under the microscope. Megacrysts in this sample make up greater than 50% of the rock and consist largely of plagioclase, with subordinate unidentified mafic mineral and clinopyroxene, and minor apatite and Fe-Ti oxide. Also present in minor amount are xenoliths of microdiorite/microgabbro that may have brown amphibole as microphenocrysts and groundmass grains. These megacrysts may form as isolated crystals, monomineralic clusters of clinopyroxene, and polymineralic clusters of clinopyroxene – unidentified mafic mineral – Fe-Ti oxide. The groundmass is highly altered to sericite, chlorite, sphene/leucoxene, quartz, epidote minerals (zoisite/clinozoisite and epidote), carbonates, Fe-Ti oxide and hematite/iron hydroxide.

Plagioclase phenocrysts/microphenocrysts commonly have subhedral outlines and have largely to almost totally undergone alteration, giving rise to abundant sericite, and minor chlorite, carbonates, epidote minerals (zoisite/clinozoisite and epidote), Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Unidentified mafic phenocrysts/microphenocrysts are largely subhedral, and are completely altered. Their alteration products include chlorite/serpentine, with minor Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide. The euhedral

unidentified mafic microphenocrysts have typical outlines of pyroxene. Their shapes and alteration nature signify that they are highly possible to be orthopyroxene.

Clinopyroxene megacrysts range texturally from anhedral to euhedral, but subhedral outlines are very common. They are slightly to moderately altered to chlorite, Fe-Ti oxide and/or hematite/iron hydroxide.

Apatite and Fe-Ti oxide microphenocrysts are subhedral to euhedral. The Fe-Ti oxide microphenocrysts are partly replaced by hematite/iron hydroxide.

**Sample Number:** BK-2

**Grid Reference:** 809996, 1:50,000 Topographic Map,  
Sheet 4945 II (Amphoe Long)

**Rock Name:** Microgabbro

**Megascopic Characters:** This fine-grained rock sample shows a moderately megacrystic texture and has a dark gray color. The megacrysts are composed largely of pale green minerals, with sizes up to 2.0 mm across, and black minerals, with sizes up to 1.0 mm across. Tiny veinlets of greenish black and pale green minerals have been locally detected in minor amount. The rock is slightly magnetic, and does not react with diluted hydrochloric acid, except for the veined minerals that slightly reacts with warm diluted hydrochloric acid.

**Microscopic Characters:** The rock sample has abundant plagioclase, clinopyroxene and occasionally unidentified mafic megacrysts. These megacrysts occur as isolated grains, monomineralic clusters, and polymineralic clusters of plagioclase + unidentified mafic mineral + clinopyroxene, plagioclase + clinopyroxene, and clinopyroxene + unidentified mafic mineral. The groundmass constituents have largely undergone alteration, however, the relatively unaltered portions are still



existent as irregular patches. The least-altered groundmass portions are fine-grained, with grain sizes largely in a range of 0.05 – 0.15 mm across. They are made up largely of felty plagioclase laths and clinopyroxene, with subordinate unidentified mafic mineral. The severely altered portions contain secondary patches of sericite, epidote minerals (zoisite/clinozoisite and epidote), pumpellyite, chlorite/serpentine, Fe-Ti oxide and sphene/leucoxene. Tiny veined minerals are carbonates, chlorite and epidote minerals (zoisite/clinozoisite and epidote).

Plagioclase phenocrysts/microphenocrysts and groundmass plagioclase grains largely show subhedral outlines and are almost totally altered. Their alteration products include abundant sericite, and minor chlorite, carbonates, pumpellyite, epidote minerals (zoisite/clinozoisite and epidote), Fe-Ti oxide and sphene/leucoxene.

Clinopyroxene megacrysts and groundmass clinopyroxene grains are anhedral to subhedral, and are slightly altered to chlorite, Fe-Ti oxide and/or sphene/leucoxene.

Unidentified mafic mineral as megacrysts and as groundmass constituents have anhedral to subhedral outlines. They are completely altered to abundant chlorite/serpentine and occasional epidote, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

**Sample Number:** BK-3  
**Grid Reference:** 810996, 1:50,000 Topographic Map,  
 Sheet 4945 II (Amphoe Long)

**Rock Name:** Andesite/Basalt

**Megascopic Characters:** This rock sample shows a slightly megacrystic texture, with black megacrysts of which sizes are up to 0.5 mm across. The groundmass is very fine-grained, and has a dark greenish gray color. The sample shows a slight

magnetic property, and does not yield effervescence when diluted hydrochloric acid is applied.

**Microscopic Characters:** In contrast to the slightly megacrystic nature as observed in hand specimen, the sample is strongly megacrystic, with abundant megacrysts of unidentified mafic mineral and occasional plagioclase microphenocrysts. These megacrysts sit in the trachytic, fine-grained, holocrystalline groundmass (grain sizes largely in a range of 0.01 – 0.03 mm across), consisting largely of plagioclase laths, with minor unidentified mafic mineral. Secondary patches of Fe-Ti oxide and sphene/leucoxene are present in minor amount.

Plagioclase microphenocrysts and groundmass plagioclase grains have subhedral to euhedral outlines. They are slightly to moderately altered to abundant sericite, and minor pumpellyite, epidote, carbonates, Fe-Ti oxide, Fe sulfide and/or sphene/leucoxene.

Unidentified mafic crystals, either as megacrysts or as groundmass constituents, have anhedral to subhedral (almost totally anhedral) outlines and are totally replaced by abundant chlorite/serpentine, with minor epidote, quartz, Fe-Ti oxide, Fe sulfide and/or sphene/leucoxene.

**Sample Number:** BK-5

**Grid Reference:** 803997, 1:50,000 Topographic Map,  
Sheet 4945 II (Amphoe Long)

**Rock Name:** Andesite/Basalt

**Megascopic Characters:** This rock sample is fine-grained, and generally has a dark gray color. It shows a megacrystic texture and occasionally contains fractures sealed



by whitish minerals. The rock, itself, is slightly magnetic, and does not react with diluted hydrochloric acid, but fracture-infilling minerals do.

**Microscopic Characters:** The sample is slightly megacrystic, with megacrysts of plagioclase and unidentified mafic minerals. The groundmass shows trachytic texture and is composed mainly of sericitized plagioclase (sizes ranging largely from 0.01 to 0.03 mm across), with minor secondary patches of chlorite/serpentine, quartz, carbonates and Fe-Ti oxide (partly replaced by sphene/leucoxene and/or hematite/iron hydroxide). The fracture-infilling minerals are chlorite, carbonates and Fe-Ti oxide (partly replaced by sphene/leucoxene and/or hematite/iron hydroxide).

Plagioclase microphenocrysts and groundmass plagioclase grains are largely subhedral to euhedral outlines. They are almost totally sericitized, leading to abundant sericite, with minor chlorite, quartz, carbonates, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

Unidentified mafic minerals are largely anhedral, and are totally replaced by chlorite/serpentine, with minor quartz, carbonates, Fe-Ti oxide, sphene/leucoxene and/or hematite/iron hydroxide.

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