CHAPTER 3

PETROGRAPHY

3.1 Representative Samples

The samples petrochemically presented in this study include thirteen coherent facies basaltic outcrop samples and thirty-three core samples from five drill holes in the Ban Sap Sawat area, Wichian Buri District, Phetchabun Province (Figure 3.1). All the samples collected from outcrop and twenty-two of core samples are least-altered, while the remainders (11 samples) are relatively altered. The least-altered outcrop samples are those of coherent facies basaltic lava. Of the least-altered core samples, three are those of coherent facies basaltic lava, whereas nineteen are those of coherent facies basaltic clasts of cobble and boulder grades in basalt breccia. The relatively altered core samples are those of matrix-supported basalt breccia that consists of poorly sorted, basaltic gravel clasts loosely embedded in the finer-grained matrix. The least-altered samples in this account are those characterized by the scarcity of

(1) extensive development of mesoscopic domains of secondary minerals, e.g. quartz resulted from silicification, epidote minerals and chlorite;
(2) xenoliths and xenocrysts;
(3) abundant of vesicles and amygdale minerals; and
(4) quartz, epidote or calcite veining or patches totaling more than approximately 5 modal %.

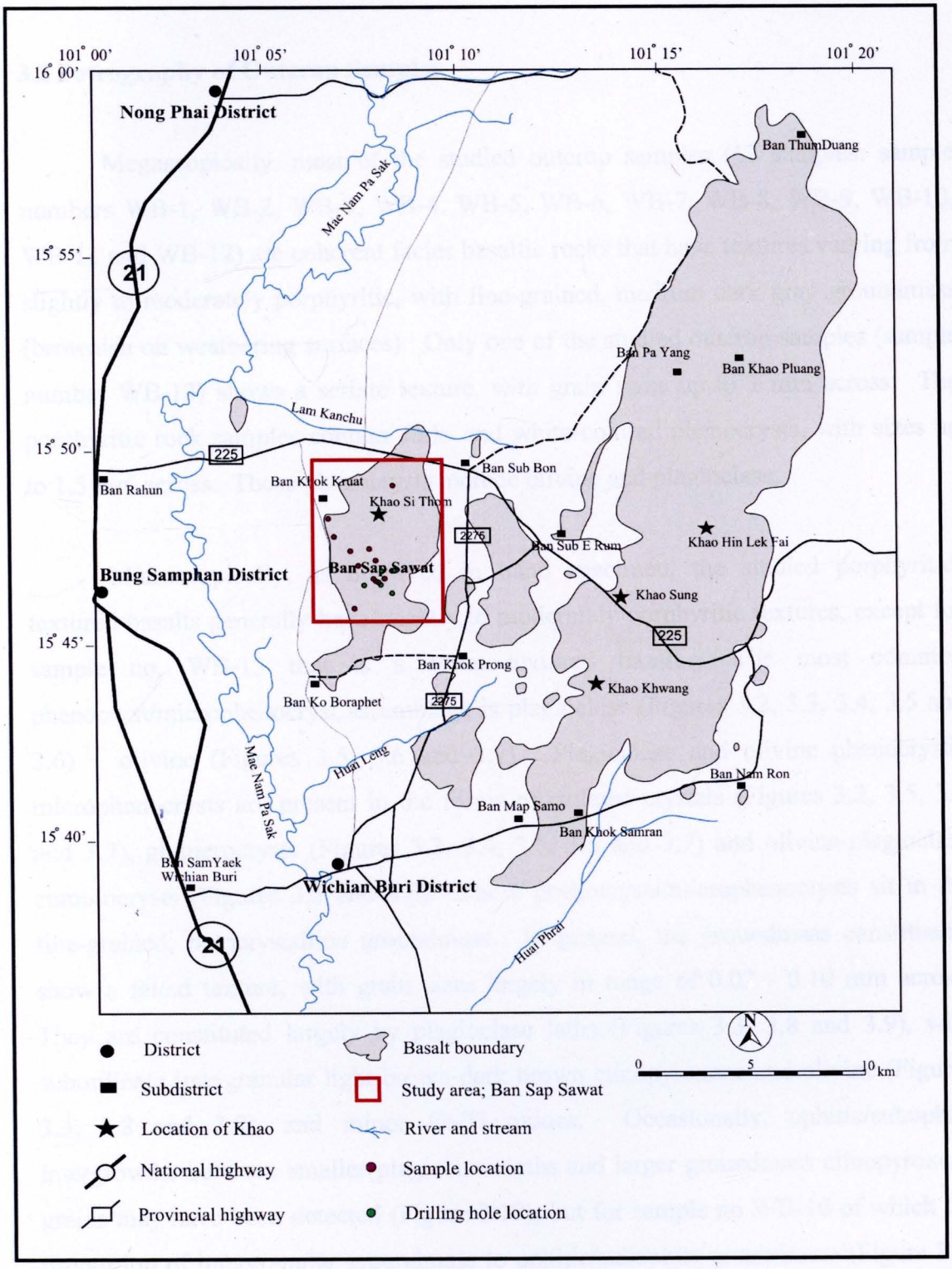

Figure 3.1 Map showing the distribution of Wichian Buri basalt and sample locations and drill hole locations in the Ban Sap Sawat area (modified from Vichit *et al.*, 1988 and Jungyusuk and Sinsakul, 1989)

3.2 Petrography of Outcrop Samples

Megascopically, most of the studied outcrop samples (12 samples: sample numbers WB-1, WB-2, WB-3, WB-4, WB-5, WB-6, WB-7, WB-8, WB-9, WB-10, WB-11 and WB-12) are coherent facies basaltic rocks that have textures varying from slightly to moderately porphyritic, with fine-grained, medium dark gray groundmass (brownish on weathering surfaces). Only one of the studied outcrop samples (sample number WB-13) shows a seriate texture, with grain sizes up to 1 mm across. The porphyritic rock samples contain dark- and white-colored phenocrysts, with sizes up to 1.5 mm across. These phenocrysts include olivine and plagioclase.

Microscopically, as observed in hand specimen, the studied porphyritic-textured basalts generally have slightly to moderately porphyritic textures, except for sample no. WB-13 that is a seriate-textured basalt. The most common phenocryst/microphenocryst assemblage is plagioclase (Figures 3.2, 3.3, 3.4, 3.5 and 3.6) + olivine (Figures 3.5, 3.6 and 3.7). Plagioclase and olivine phenocrysts/ microphenocrysts are present in the forms of isolated crystals (Figures 3.2, 3.5, 3.6 and 3.7), glomerocrysts (Figures 3.3, 3.4, 3.5, 3.6 and 3.7) and olivine-plagioclase cumulocrysts (Figures 3.5 and 3.6). These phenocrysts/microphenocrysts sit in the fine-grained, holocrystalline groundmass. In general, the groundmass constituents show a felted texture, with grain sizes largely in range of 0.02 - 0.10 mm across. They are constituted largely by plagioclase laths (Figures 3.3, 3.8 and 3.9), with subordinate intergranular light brown-dark brown clinopyroxene and olivine (Figures 3.3, 3.8 and 3.9), and minor Fe-Ti oxides. Occasionally, ophitic/subophitc intergrowths between smaller plagioclase laths and larger groundmass clinopyroxene grains may have been detected (Figure 3.10), but for sample no WB-10 of which the proportion of intergranular groundmass to ophitic/subophitc groundmass (Figure 3.9) is close to unity. The studied seriate-textured basalt is made up largely of variably sized plagioclase laths and clinopyroxene that almost totally show ophitic/subophitic relationships (Figure 3.11). The subordinate and minor constituents include variously sized olivine and Fe-Ti oxide grains, respectively.

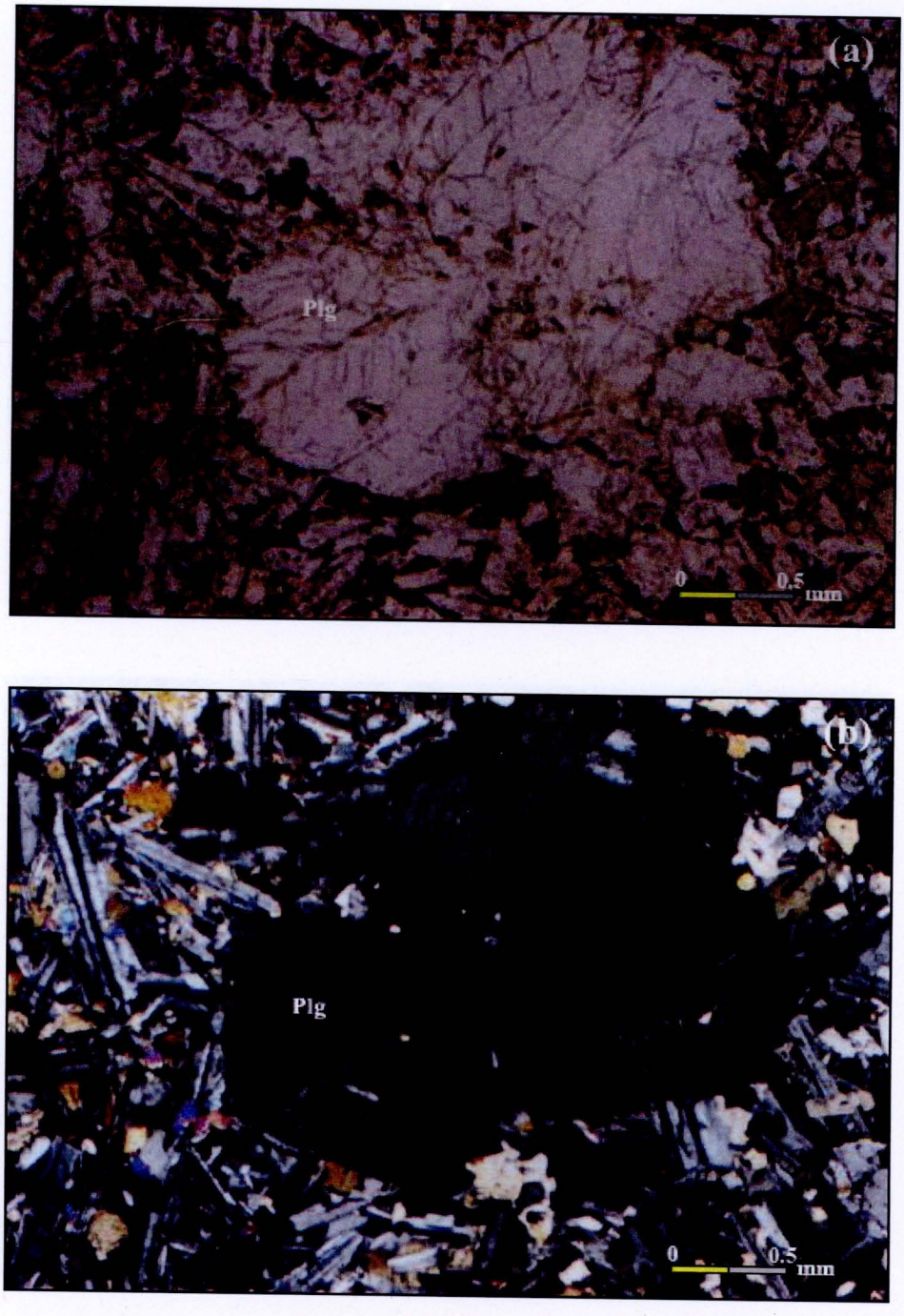

Figure 3.2 Photomicrographs of a coherent facies basaltic lava (outcrop sample) showing a plagioclase (Plg) phenocryst with complex zonation, and holocrystalline groundmass, Sample number WB-1, (a) ordinary light (b) crossed polars

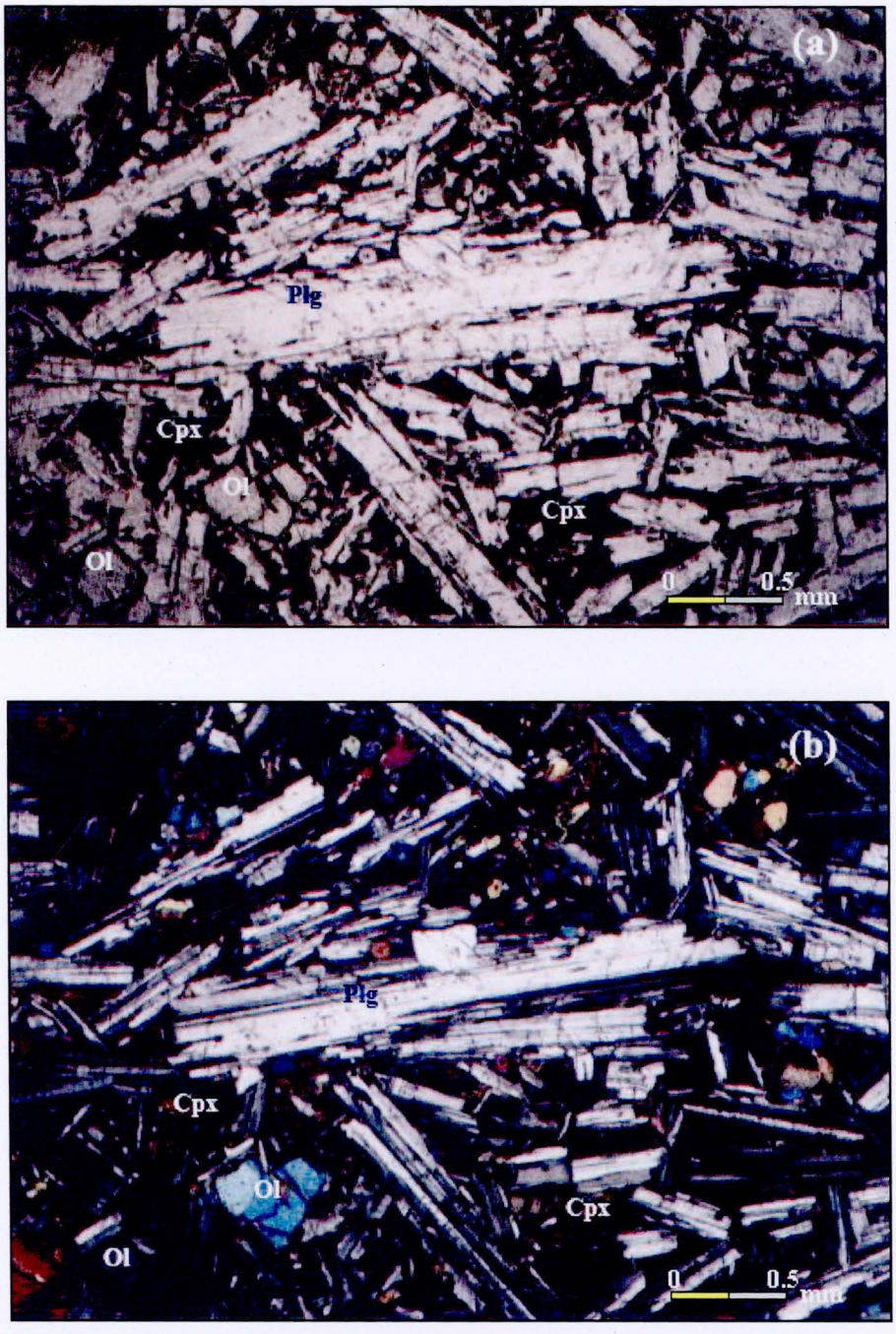

Figure 3.3 Photomicrographs of a coherent facies basaltic lava (outcrop sample) displaying a plagioclase (Plg) glomerocrysts, and groundmass plagioclase, clinopyroxene (Cpx) and olivine (Ol) grains, Sample number WB-8, (a) ordinary light, (b) crossed polars

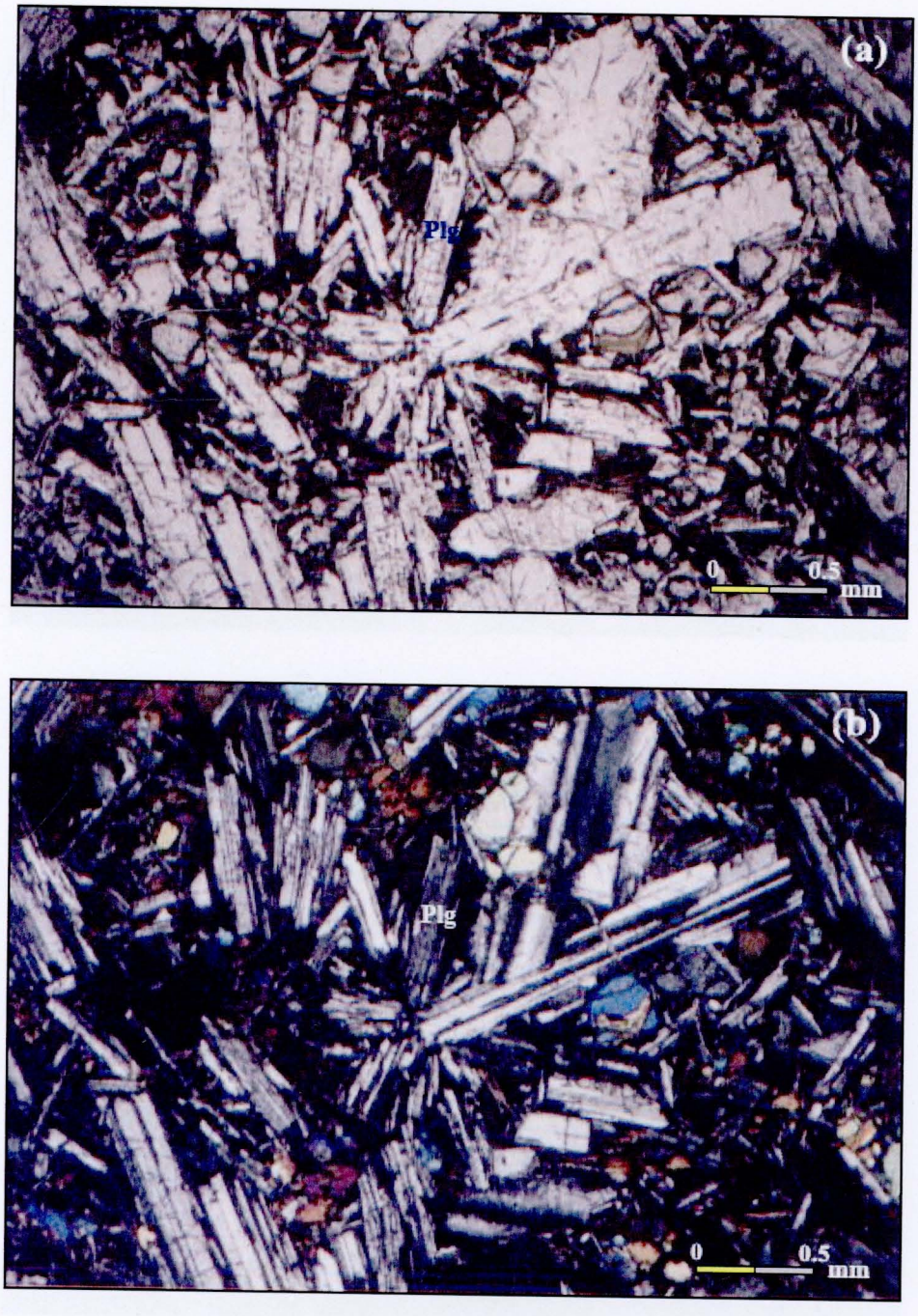

Figure 3.4 Photomicrographs of a coherent facies basaltic lava (outcrop sample) displaying plagioclase (Plg) phenocrysts/microphenocryts that are largely subhedral, and may form as a stellate pattern, Sample number WB-8, (a) ordinary light, (b) crossed polars

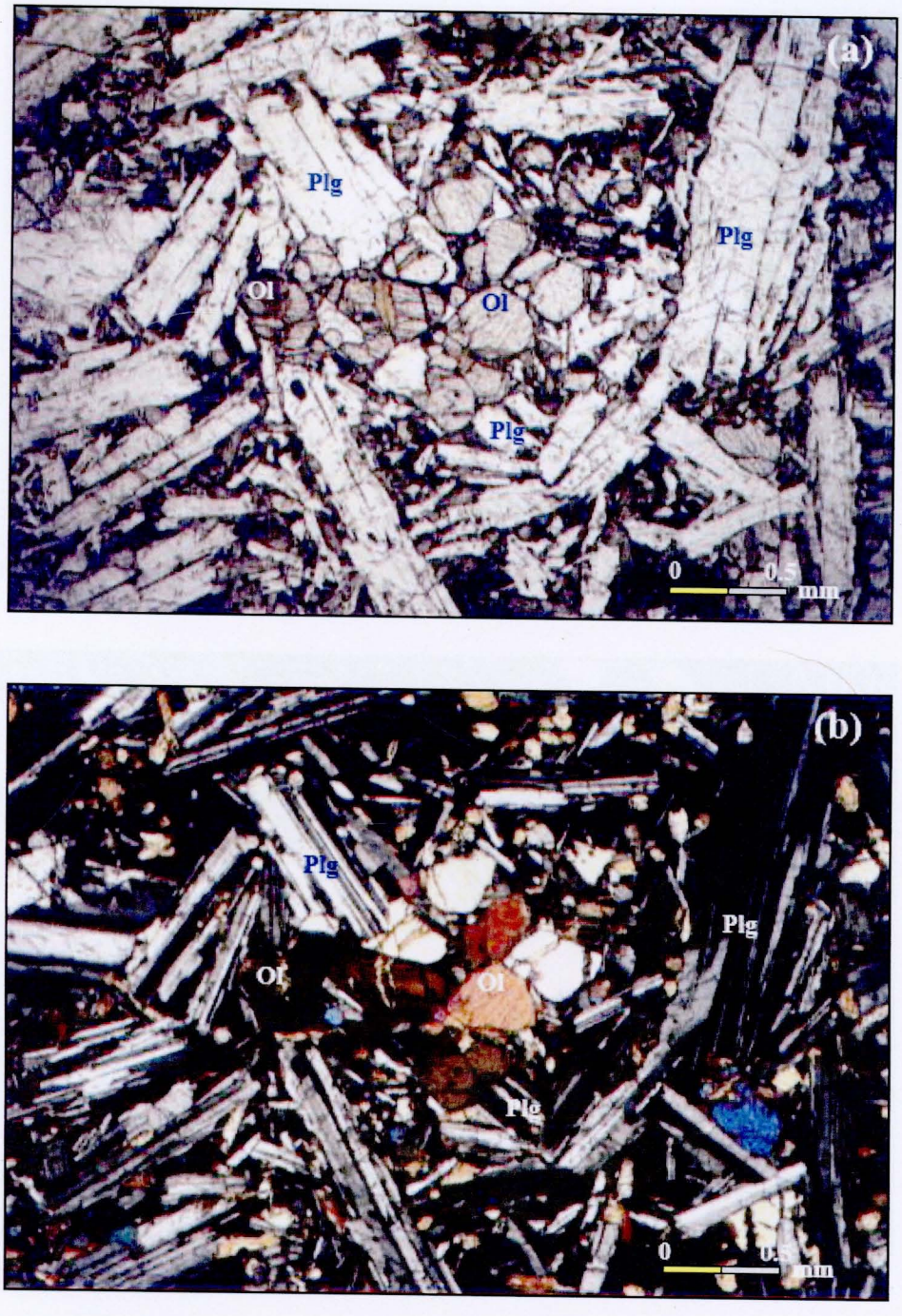

Figure 3.5 Photomicrographs of a coherent facies basaltic lava (outcrop sample) showing phenocrysts/microphenocryts of plagioclase (Plg) and olivine (Ol), Sample number WB-6, (a) ordinary light, (b) crossed polars

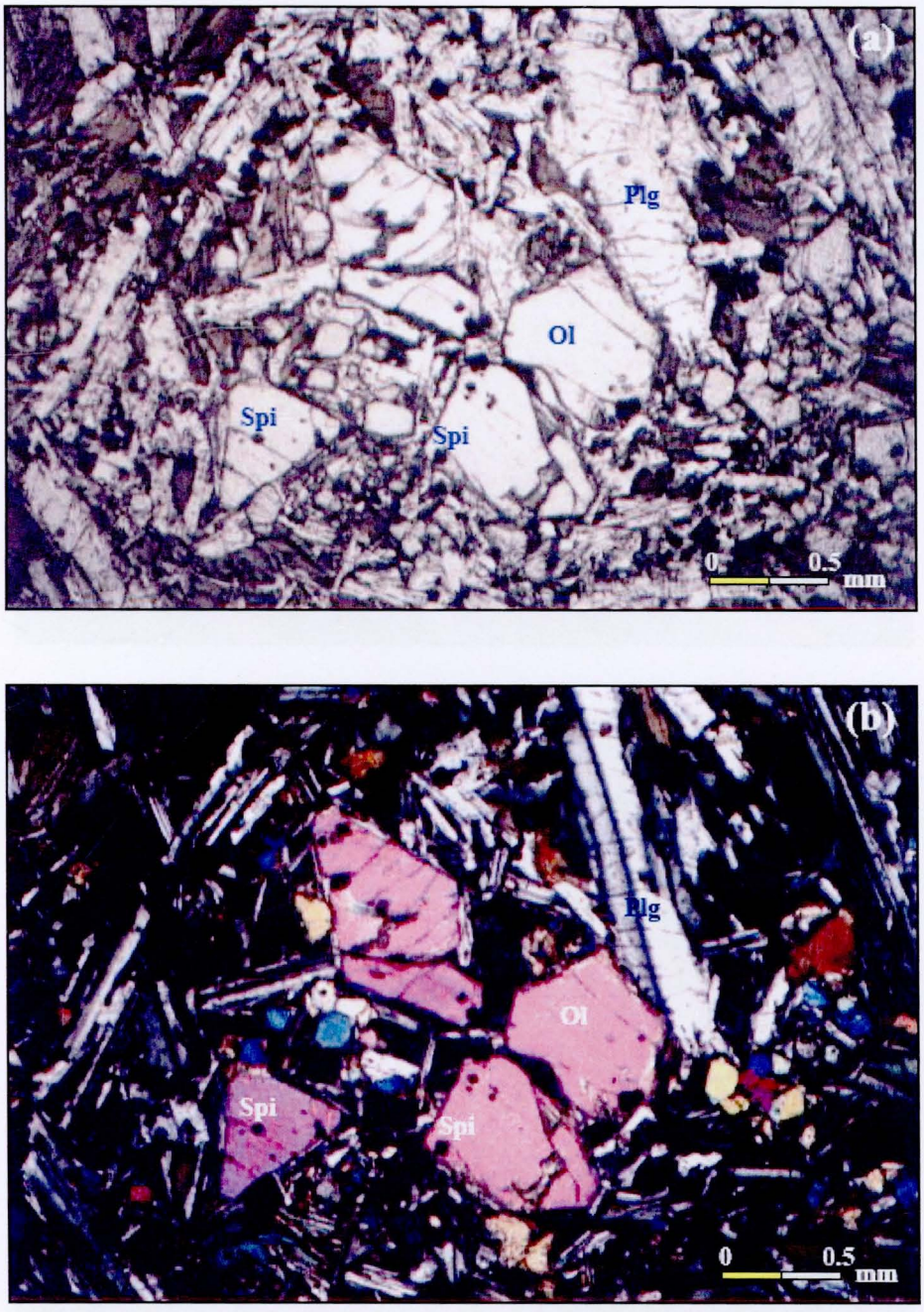

Figure 3.6 Photomicrographs of a coherent facies basaltic lava (outcrop sample) showing phenocrysts/microphenocryts of plagioclase (Plg) and olivine (Ol) that may have rounded edges and chromian spinel inclusions (Spi), Sample number WB-10, (a) ordinary light, (b) crossed polars

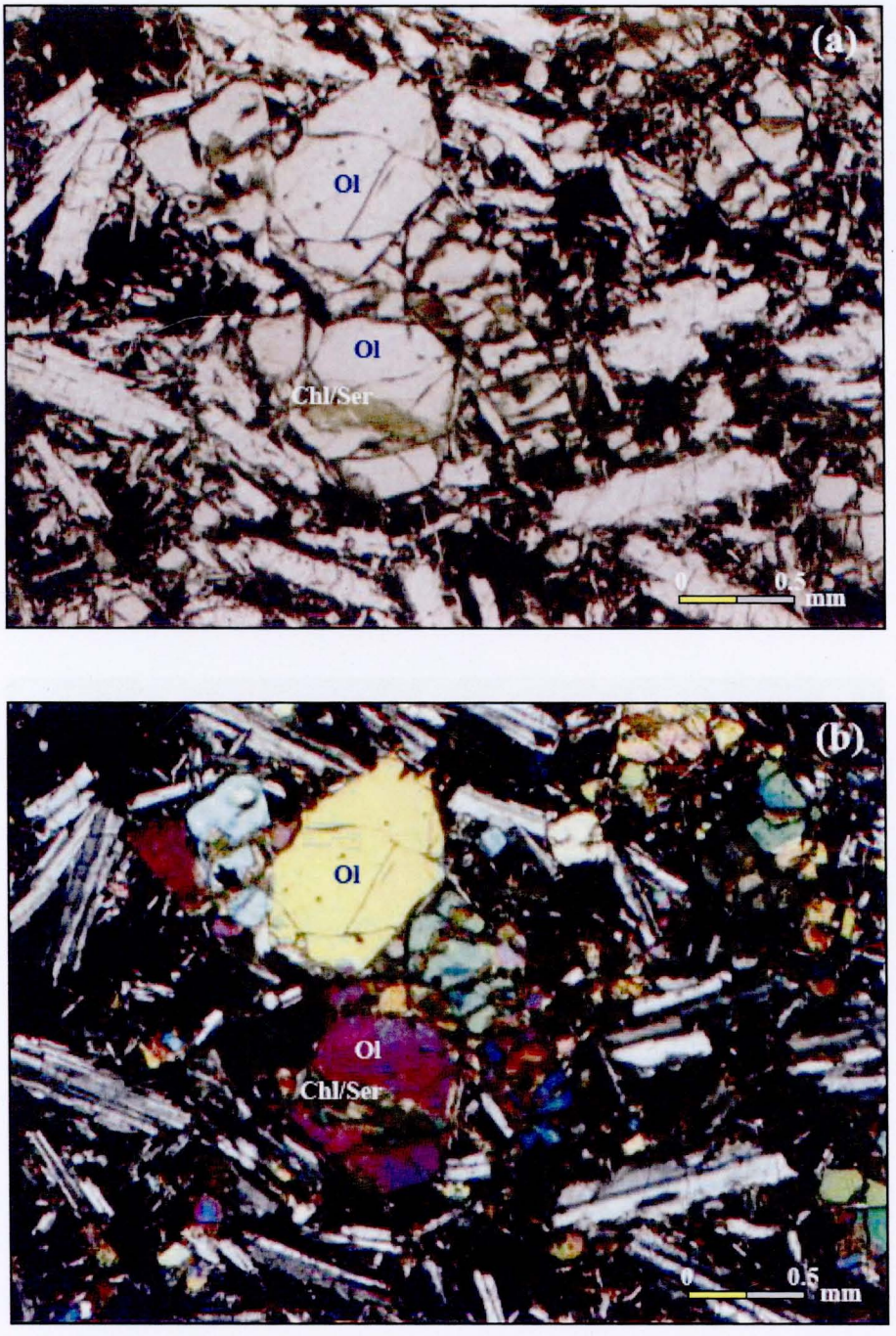

Figure 3.7 Photomicrographs of a coherent facies basaltic lava (outcrop sample) showing olivine (Ol) phenocrysts that occur as an isolated crystal and as a glomerocrysts, and have been partly replaced by chlorite/serpentine (Chl/Ser), Sample number WB-4, (a) ordinary light, (b) crossed polars

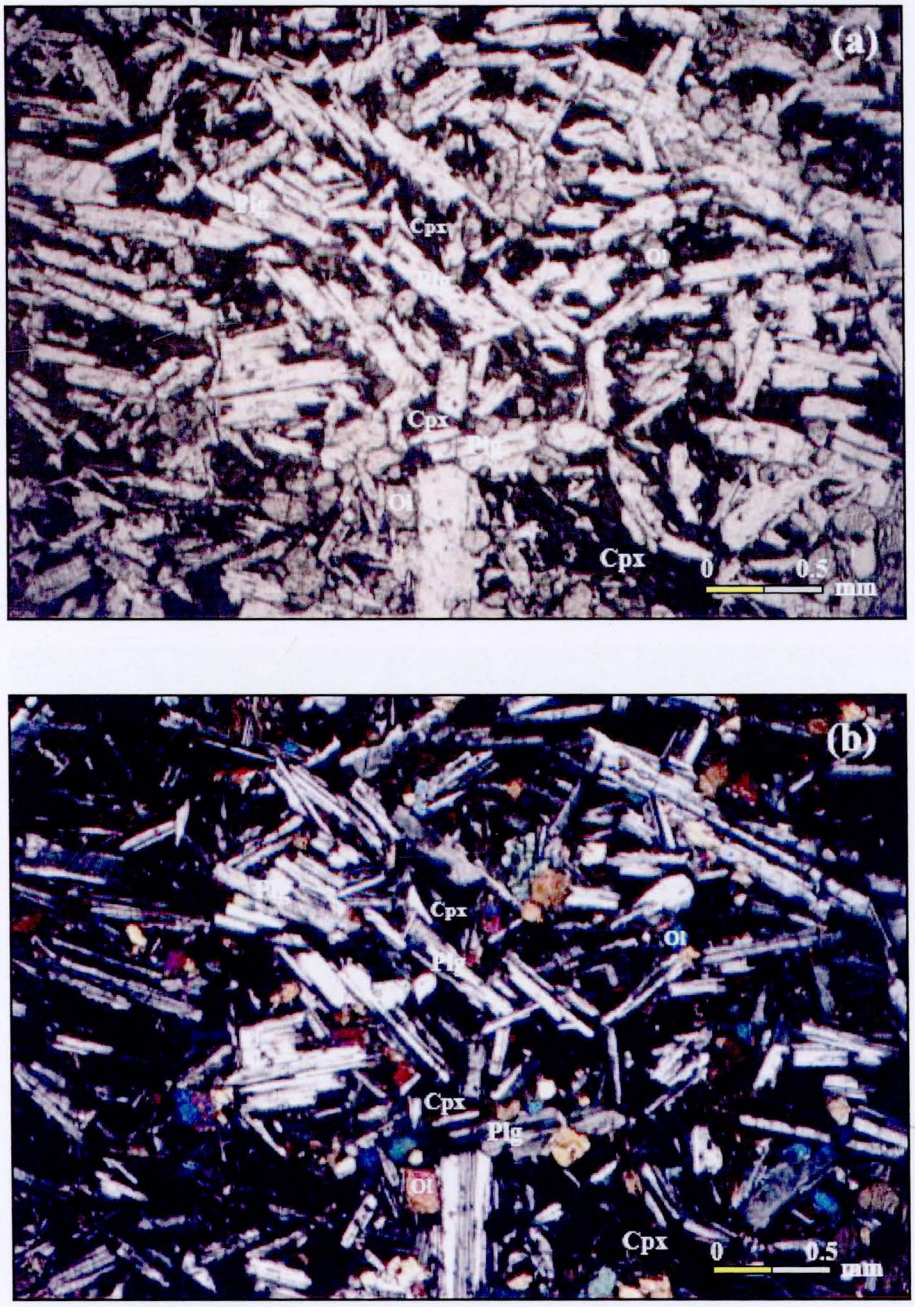

Figure 3.8 Photomicrographs of a coherent facies basaltic lava (outcrop sample) displaying felty-textured groundmass that contains plagioclase (Plg), clinopyroxene (Cpx) and olivine (Ol), Sample number WB-9, (a) ordinary light, (b) crossed polars

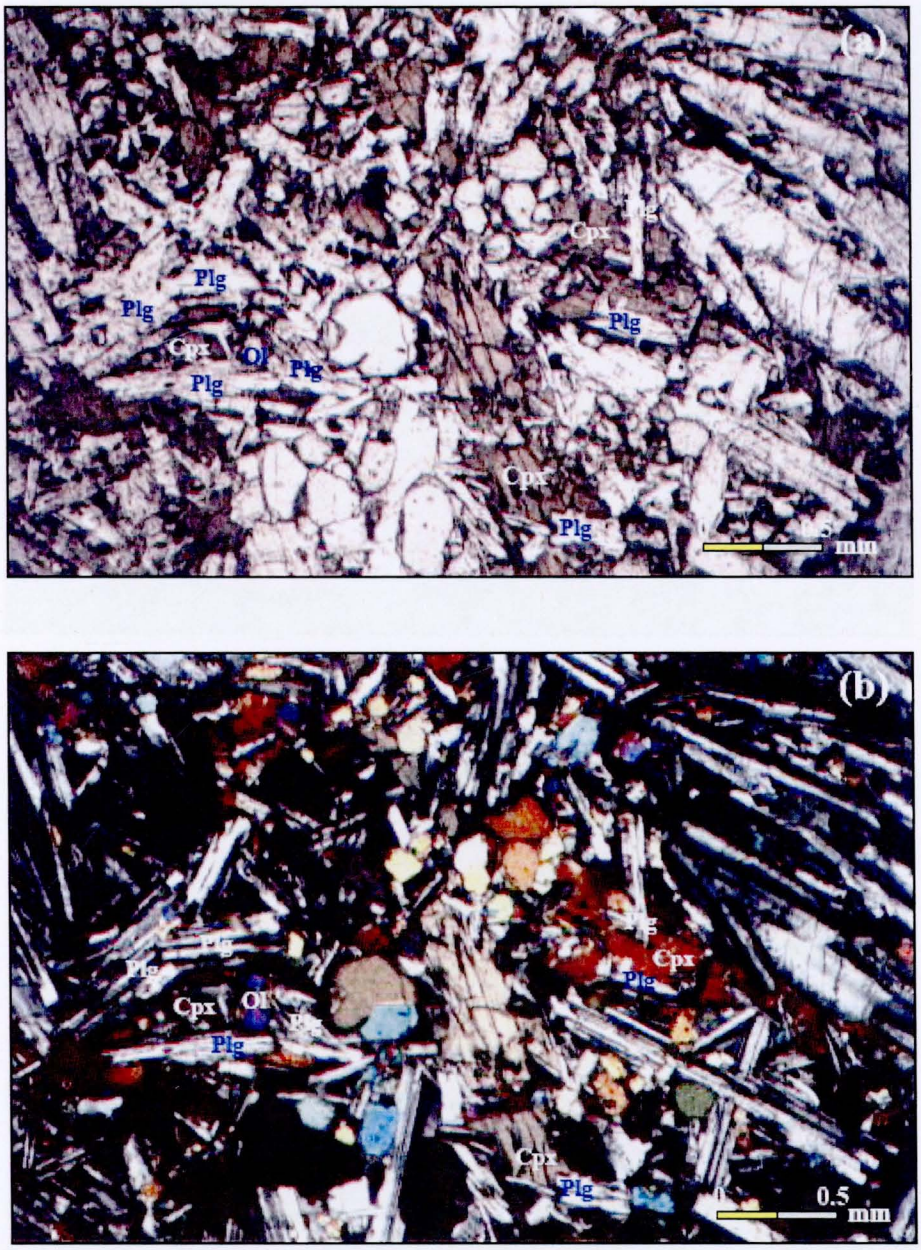

Figure 3.9 Photomicrographs of a coherent facies basaltic lava (outcrop sample) displaying intergranular clinopyroxene (Cpx) and olivine (Ol) grains and ophitic/subophitic intergrowths between clinopyroxene oikocrysts and plagioclase (Plg) chadacrysts, Sample number WB-10, (a) ordinary light, (b) crossed polars

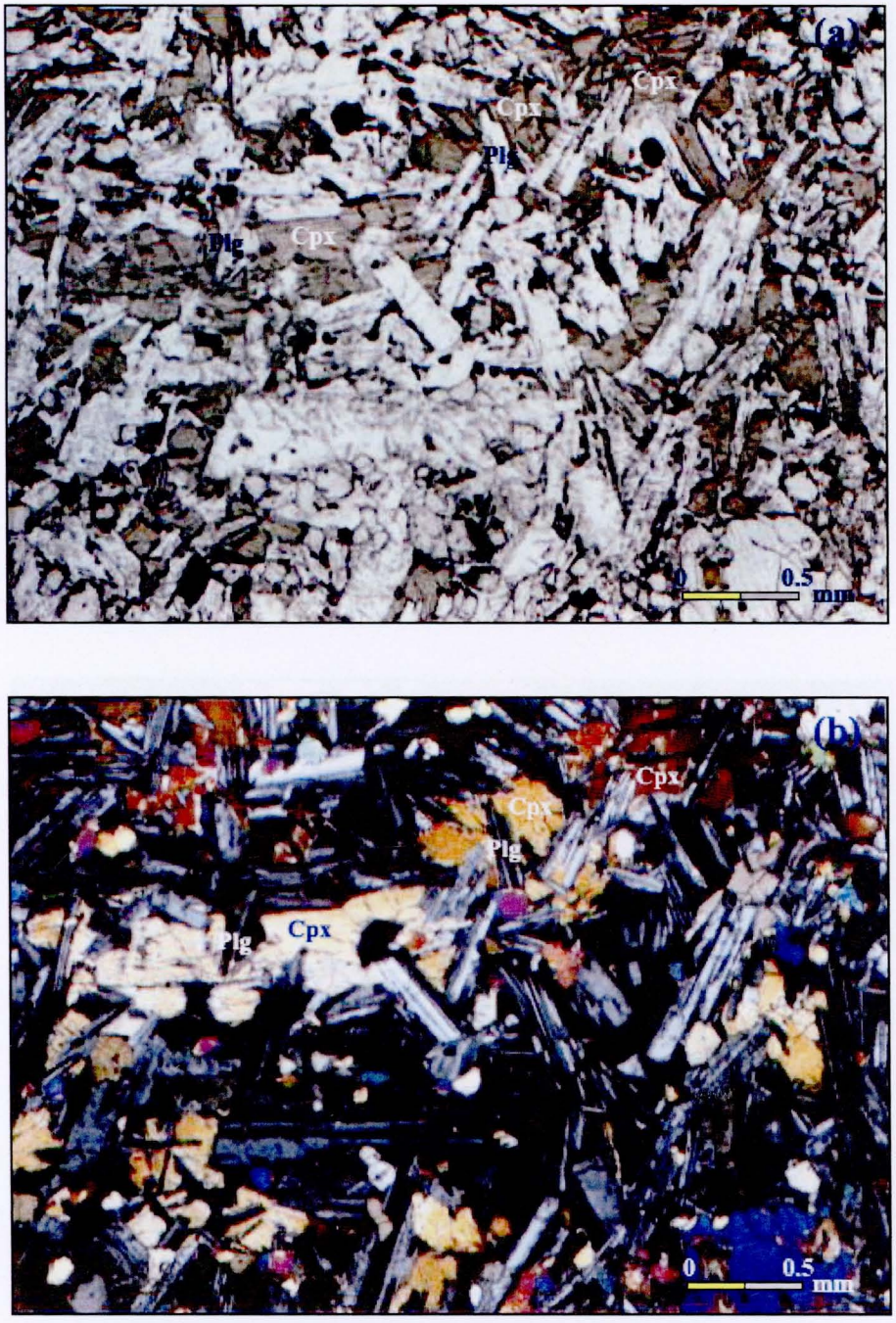

Figure 3.10 Photomicrographs of a coherent facies basaltic lava (outcrop sample) displaying ophitic/subophitic intergrowths between clinopyroxene (Cpx) oikocrysts and plagioclase (Plg) chadacrysts, Sample number WB-2, (a) ordinary light, (b) crossed polars

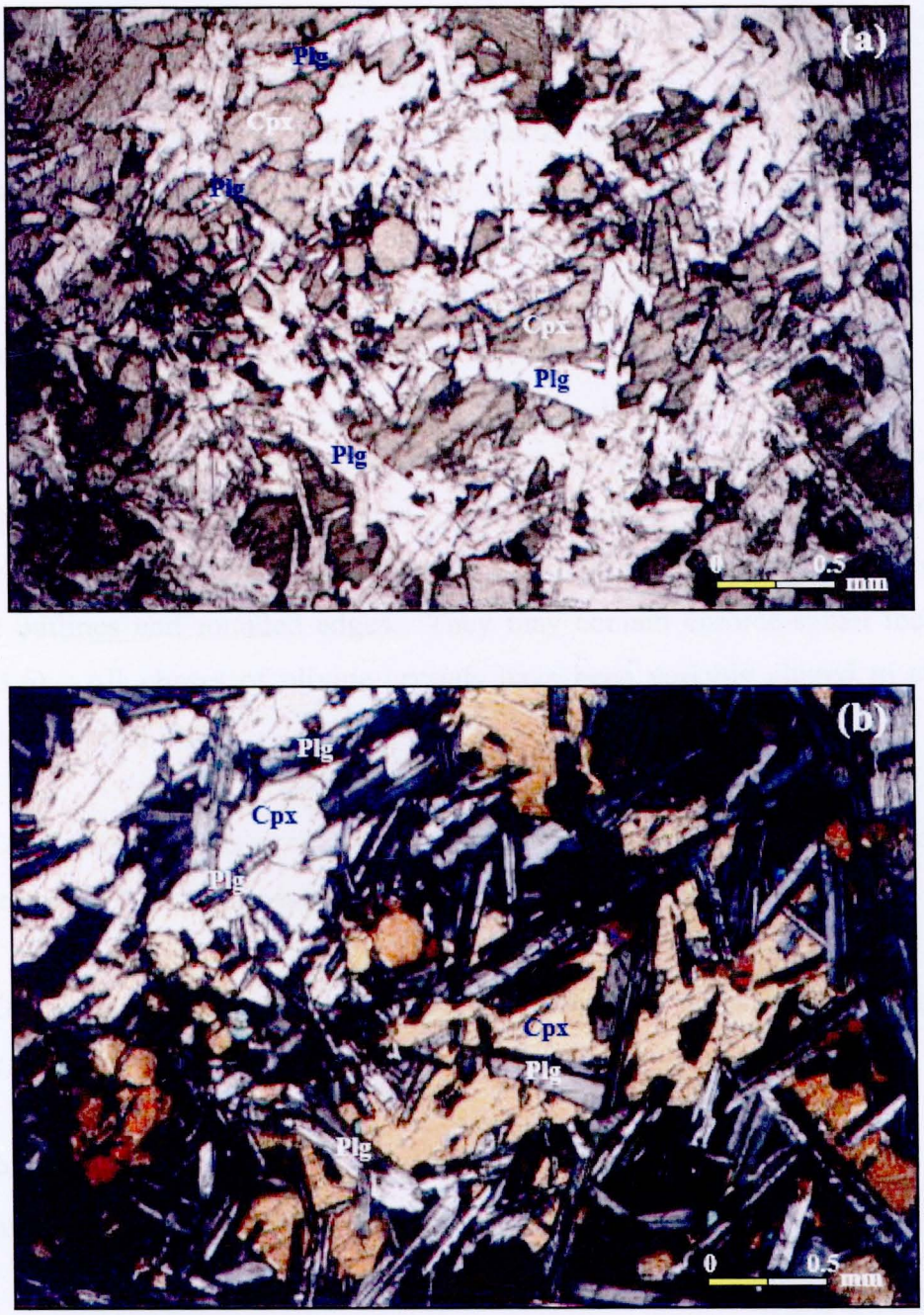

Figure 3.11 Photomicrographs of a coherent facies basaltic lava (outcrop sample) showing ophitic/subophitic intergrowths between smaller plagiolclase (Plg) chadacrysts and larger clinopyroxene (Cpx) oikocrysts, Sample number WB-13, (a) ordinary light, (b) crossed polars

Plagioclase phenocrysts/micophenocrysts commonly show subhedral outlines and polysynthetic twins, and rarely show complex zonation (Figure 3.2). Rare plagiolcase microphenocrysts with stellate patterns have been detected (Figure 3.4). The groundmass plagioclase grains generally have subhedral outlines. Determination of An-content using a petrographic technique shows that the plagioclase phenocrysts/microphenocrysts have An-content ranging from 25 to 88 (oligoclase to bytownite).

Olivine phenocrysts/microphenocrysts are commonly anhedral to subhedral, while groundmass olivine grains are commonly anhedral. Olivine phenocrysts/microphenocrysts may display disequilibrium features as they have embayed outlines and rounded edges. They may contain chrome-spinel inclusions (Figure 3.6). All phases of olivine crystals have been variably altered to chlorite/ serpentine (Figure 3.7).

Clinopyroxene occurs only as a groundmass constituent and shows a brownish color in ordinary light. They largely have subhedral to anhedral outlines.

Groundmass Fe-Ti oxide occurs as subhedral to euhedral crystals and irregular, anhedral patches.

Petrographic features of individual outcrop samples of coherent facies basaltic lavas (sample nos. WB-1 to WB-13) are shown in Appendix A.

3.3 Petrography of Core Samples

3.3.1 Coherent facies basaltic lava

Megascopically, the least-altered core samples of coherent facies baslatic lavas (sample nos. WB-27, WB-30 and WB-36) show slightly to moderately porphyritic texture. The phenocrysts have sizes up to 1 mm across and show dark green and

black colors. The groundmass is fine-grained, and has colors varying from dark gray to black color.

Microscopically, the core samples and the outcrop samples of coherent facies basaltic lavas have similar features. The phenocrysts/microphenocrysts of basaltic lavas observed in drill holes are plagioclase and olivine (Figures 3.12, 3.13 and 3.14) that occur as isolated crystals, glomerocrysts and as olivine-plagioclase cumulocrysts. These phenocrysts/microphenocrysts sit in the holocrystalline or the hypohyaline groundmass that has grain sizes largely in a range of 0.02 - 0.1 mm across. The holocrystalline groundmass (sample numbers WB-27 and WB-30) consists mainly of felted plagioclase laths, with subordinate clinopyroxene and olivine, and a small amount of Fe-Ti oxide grains. The hypohyaline groundmass (sample number WB-36) consists mainly of felted plagioclase laths and tachylite, and a small amount of olivine grains (Figure 3.14). Some groundmass plagioclase grains in sample no. WB-27 and WB-30 are enclosed by larger clinopyroxene grains in anophitic/subophitic styles (Figures 3.12 and 3.15).

Plagioclase phenocrysts/microphenocrysts and groundmass plagioclase grains largely have subhedral outlines and rarely show complex zonation. The An-content of plagioclase crystals are largely varying from 43 (andesine) to 83 (bytownite), on the basis of petrographic technique.

Olivine phenocrysts/microphenocrysts are largely anhedral to subhedral, while groundmass olivine grains are largely anhedral. Olivine phenocrysts/ microphenocrysts may contain chrome spinel inclusions (Figures 3.13 and 3.14) and have a sieve texture, rounded edges (Figure 3.13) and/or embayed outlines (Figure 3.13). All phases of olivine crystals have been variably replaced by chlorite/serpentine (Figure 3.12).

Clinopyroxene occurs only as a groundmass constituent. It has a brownish color in ordinary light and largely shows subhedral to anhedral outlines.

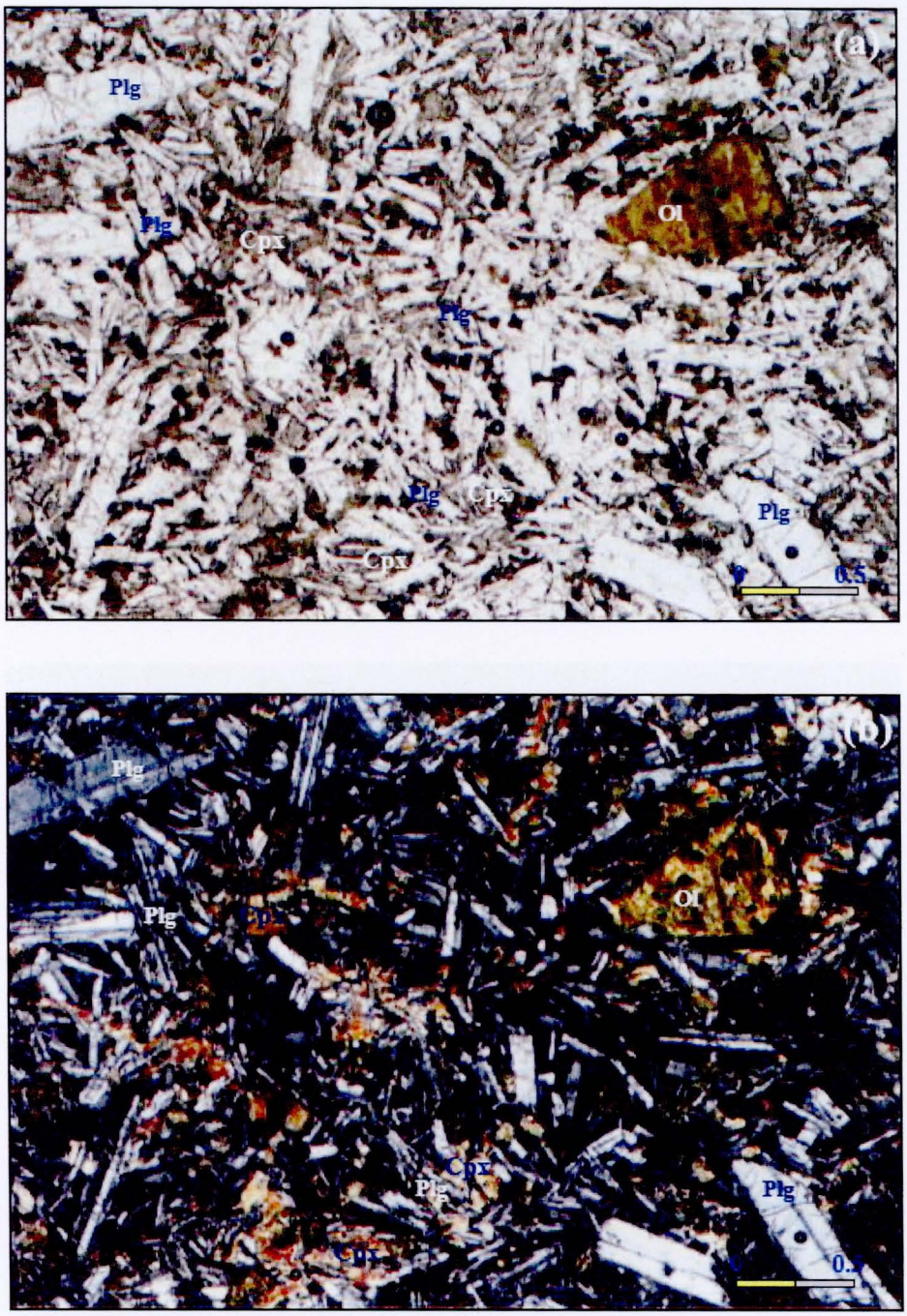

Figure 3.12 Photomicrographs of a coherent facies basaltic lava (core sample) showing plagioclase (Plg) and olivine (Ol) phenocrysts and displaying ophitic/subophitic intergrowths between clinopyroxene (Cpx) oikocrysts and plagioclase chadacrysts, Sample number WB-27 (a) ordinary light, (b) crossed polars

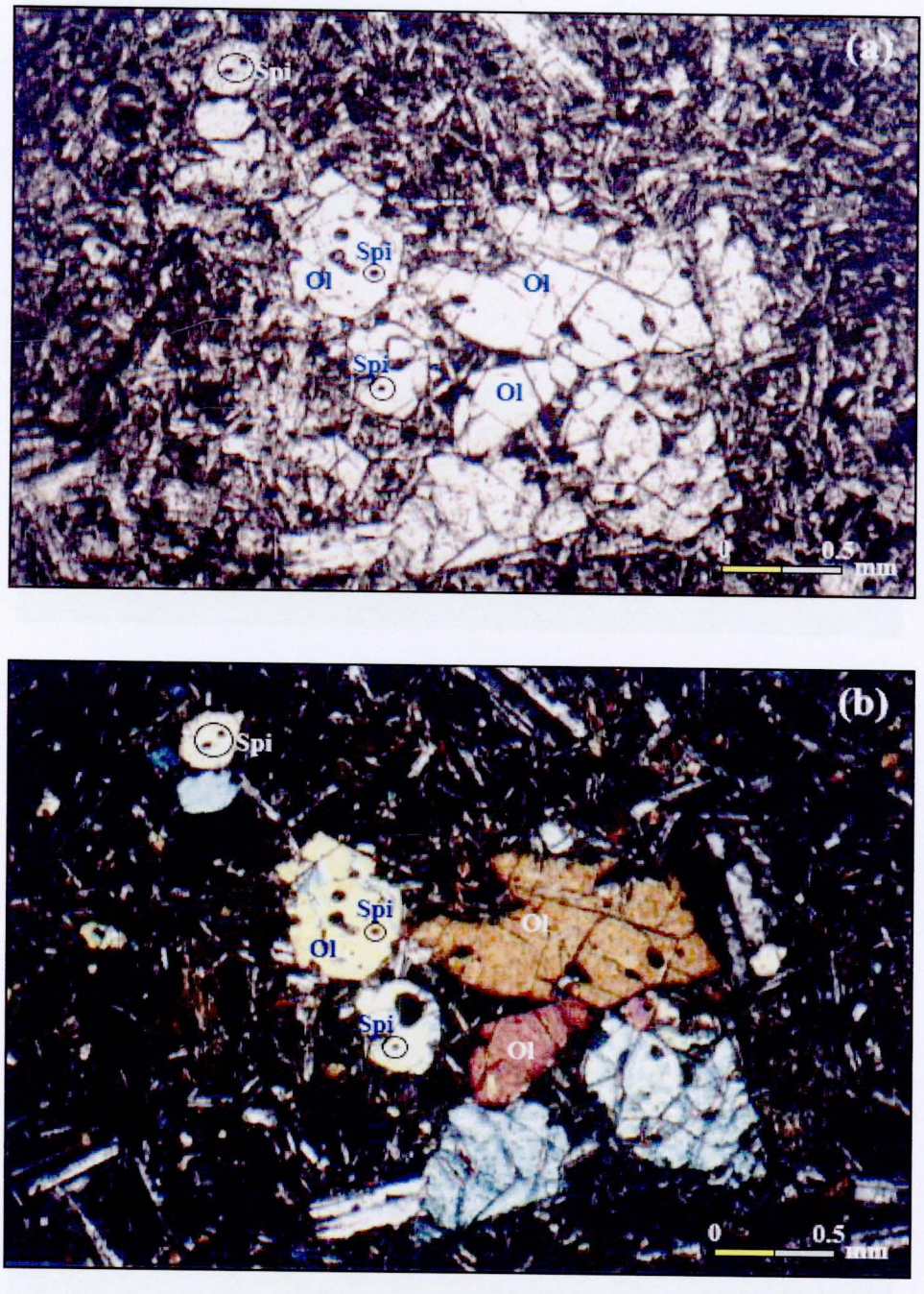

Figure 3.13 Photomicrographs of a coherent facies basaltic lava (core sample) displaying olivine (Ol) phenocrysts and microphenocrysts that may contain opaque chrome spinel inclusions (Spi), and have rounded edges and embayed outlines, Sample number WB-30, (a) ordinary light, (b) crossed polars

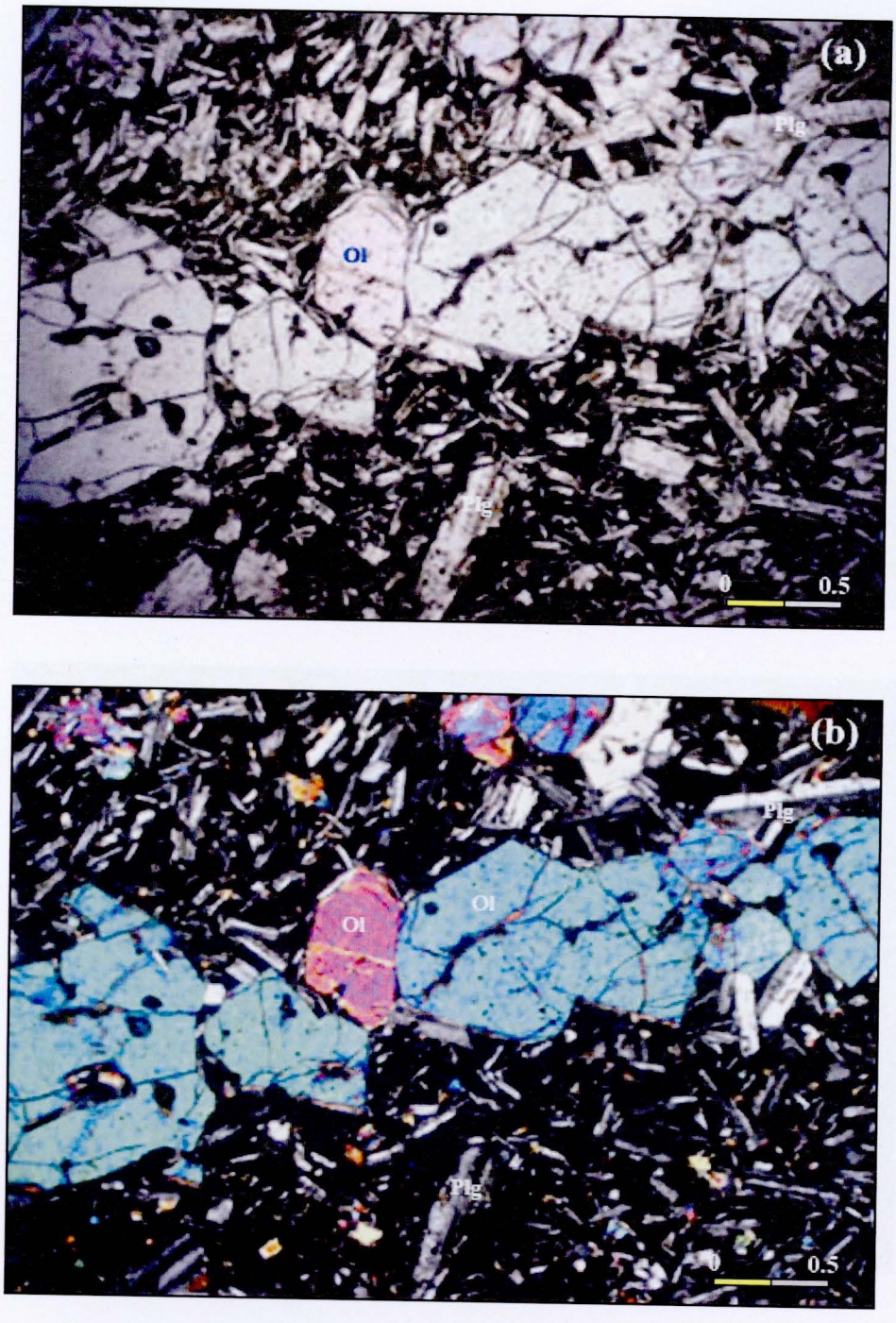

Figure 3.14 Photomicrographs of a coherent facies basaltic lava (core sample) showing olivine (Ol) phenocrysts/microphenocrysts with chromian spinel inclusions, and hypohyaline-textured groundmass, Sample number WB-36, (a) ordinary light, (b) crossed polars

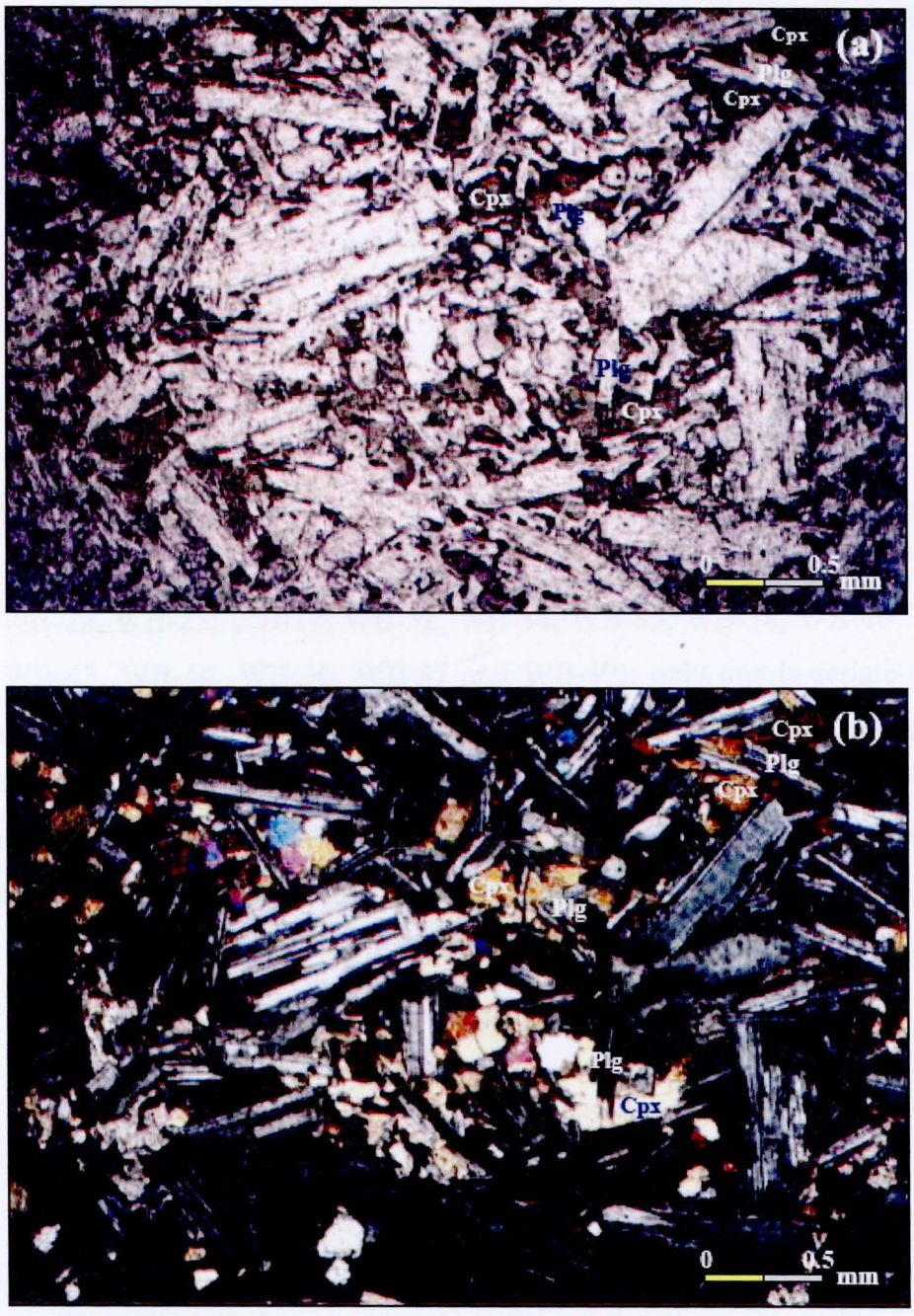

Figure 3.15 Photomicrographs of a coherent facies basaltic lava (core sample) displaying ophitic/subophitic intergrowths between clinopyroxene (Cpx) oikocrysts and plagioclase (Plg) chadacrysts, Sample number WB-27, (a) ordinary light, (b) crossed polars

Fe-Ti oxide crystals occur as subhedral to euhedral grains and as irregular, anhedral patches (Figure 3.15).

Petrographic features of individual core samples of coherent facies basaltic lavas (sample nos. WB-27, WB-30 and WB-36) are shown in Appendix B.

3.3.2 Basaltic Cobbles and Boulders in Basalt Breccia

Megascopically, the core samples of cobble- and boulder-grade clasts almost totally show slightly to strongly porphyritic textures (sample nos. WB-17, WB-19, WB-21, WB-22, WB-25, WB-29, WB-32, WB-34, WB-35, WB-38, WB-40, WB-41, WB-42, WB-43, WB-44, WB-46, WB-47 and WB-49); only one is seriate-textured (sample no. WB-14). The porphyritic-textured samples commonly have dark green to black phenocrysts, with sizes up to 1 mm across, and dark gray, fine-grained groundmass. The non-porphyritic variety is also fine-grained, with a dark gray color. A few of the studied cobbles and boulders slightly contain vesicles, irregular cavities and/or fractures sealed by whitish minerals. Very few of them locally have abundant vesicles.

Petrographically, the studied cobble- and boulder-grade clasts almost totally show a porphyritic texture, with phenocrysts/microphenocrysts of plagioclase (Figures 3.16, 3.17, 3.18 and 3.19) and olivine (Figures 3.19, 3.20, 3.21 and 3.22), except for sample no. WB-14 that shows a seriate texture. These phenocrysts/ microphenocrysts commonly occur as isolated crystals, glomerocrysts (Figures 3.19 and 3.21), and olivine-plagioclase cumulocrysts (Figures 3.19 and 3.20). They sit in the hypohyaline groundmass of which grain sizes are largely about 0.01 - 0.05 mm across (Figures 3.16, 3.17, 3.18, 3.20 and 3.22).

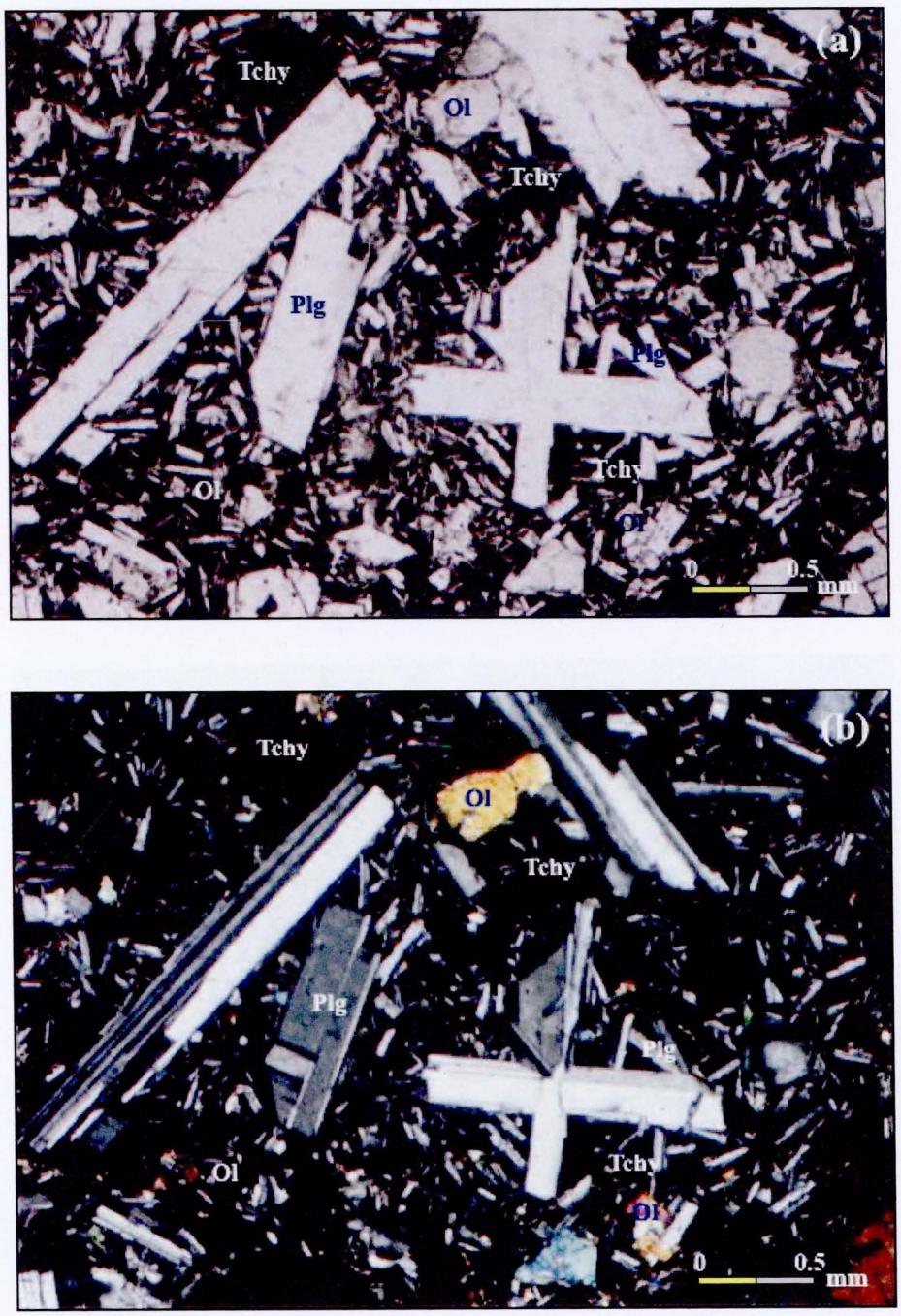

Figure 3.16 Photomicrographs of a basaltic clast in basalt breccia (core sample) showing plagioclase (Plg) phenocrysts in the hypohyaline groundmass that is made up largely felted plagioclase laths, with subordinate blackish tachylite (Tchy) and a small amount of olivine grains (Ol), Sample number WB-21, (a) ordinary light, (b) crossed polars

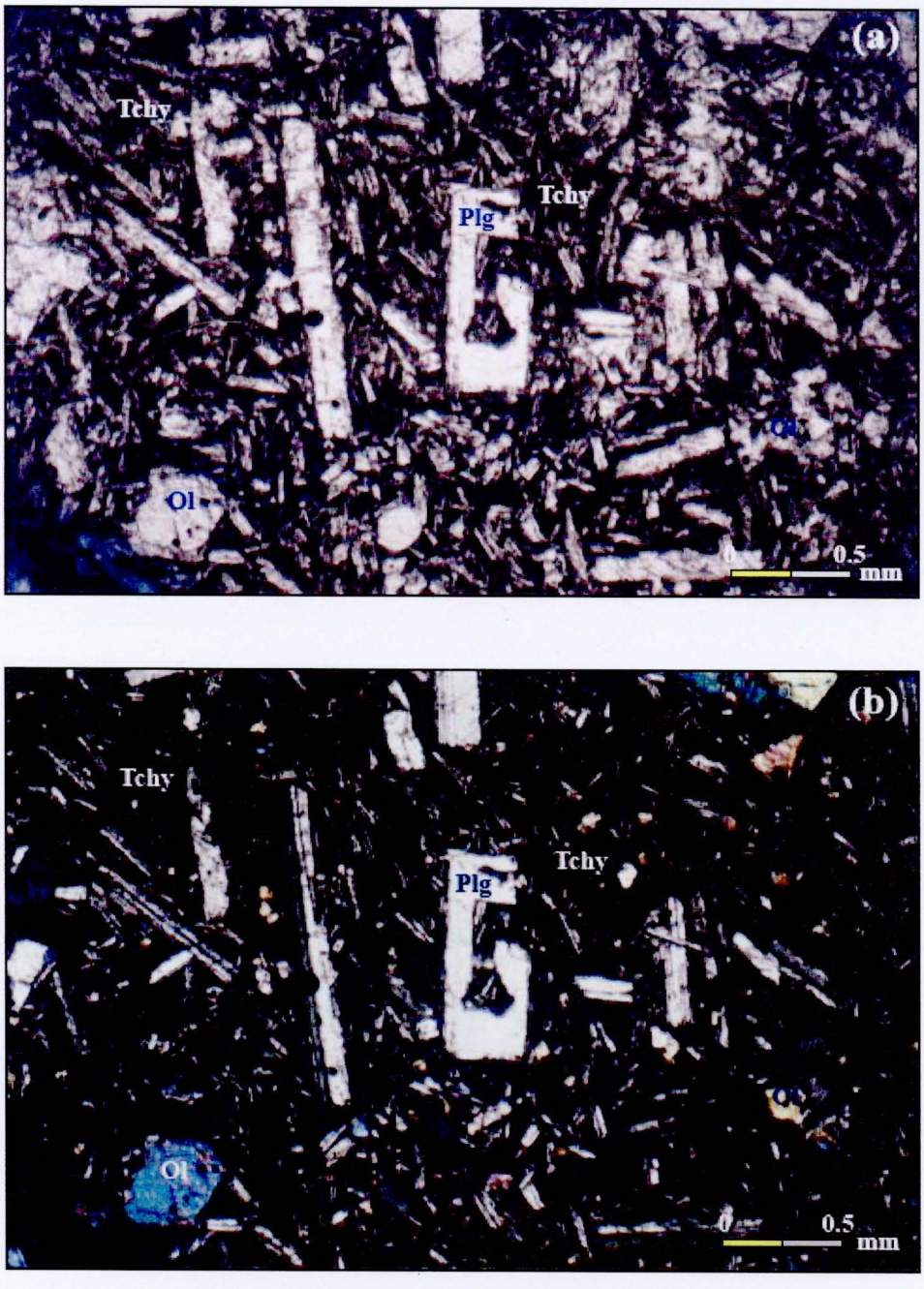

Figure 3.17 Photomicrographs of a basaltic clast in basalt breccia (core sample) showing an embayed plagioclase (Plg) phenocryst, and the hypohyaline groundmass that consists largely felted plagioclase laths, with subordinate blackish tachylite (Tchy) and a small amount of olivine (Ol) grains, Sample number WB-29, (a) ordinary light, (b) crossed polars

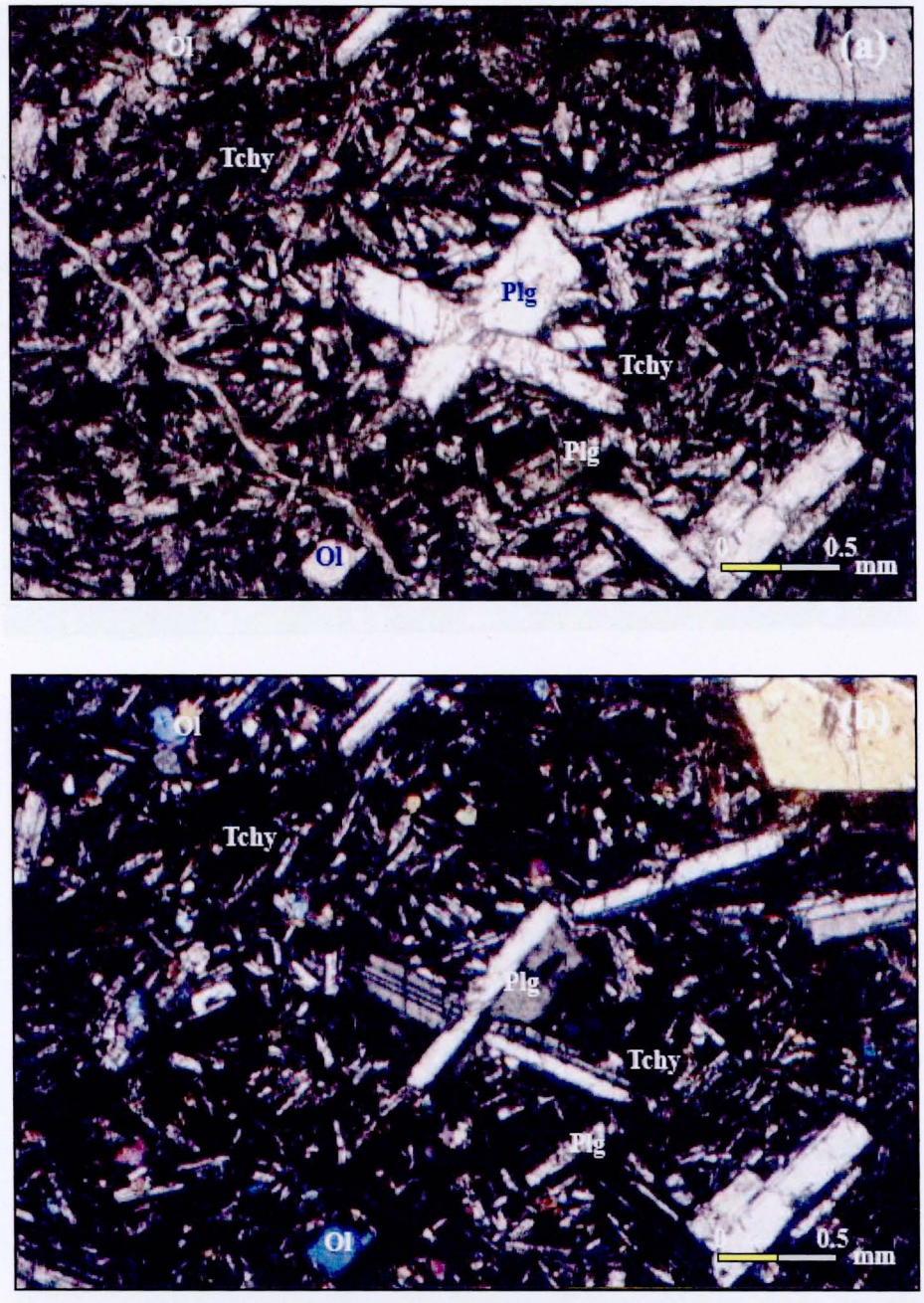

Figure 3.18 Photomicrographs of a basaltic clast in basalt breccia (core sample) showing a stellate aggregate of plagioclase (Plg) phenocrysts, and the interstitial minerals to felted plagioclase laths that include blackish tachylite (Tchy) and olivine (Ol) grains, Sample number WB-32, (a) ordinary light, (b) crossed polars

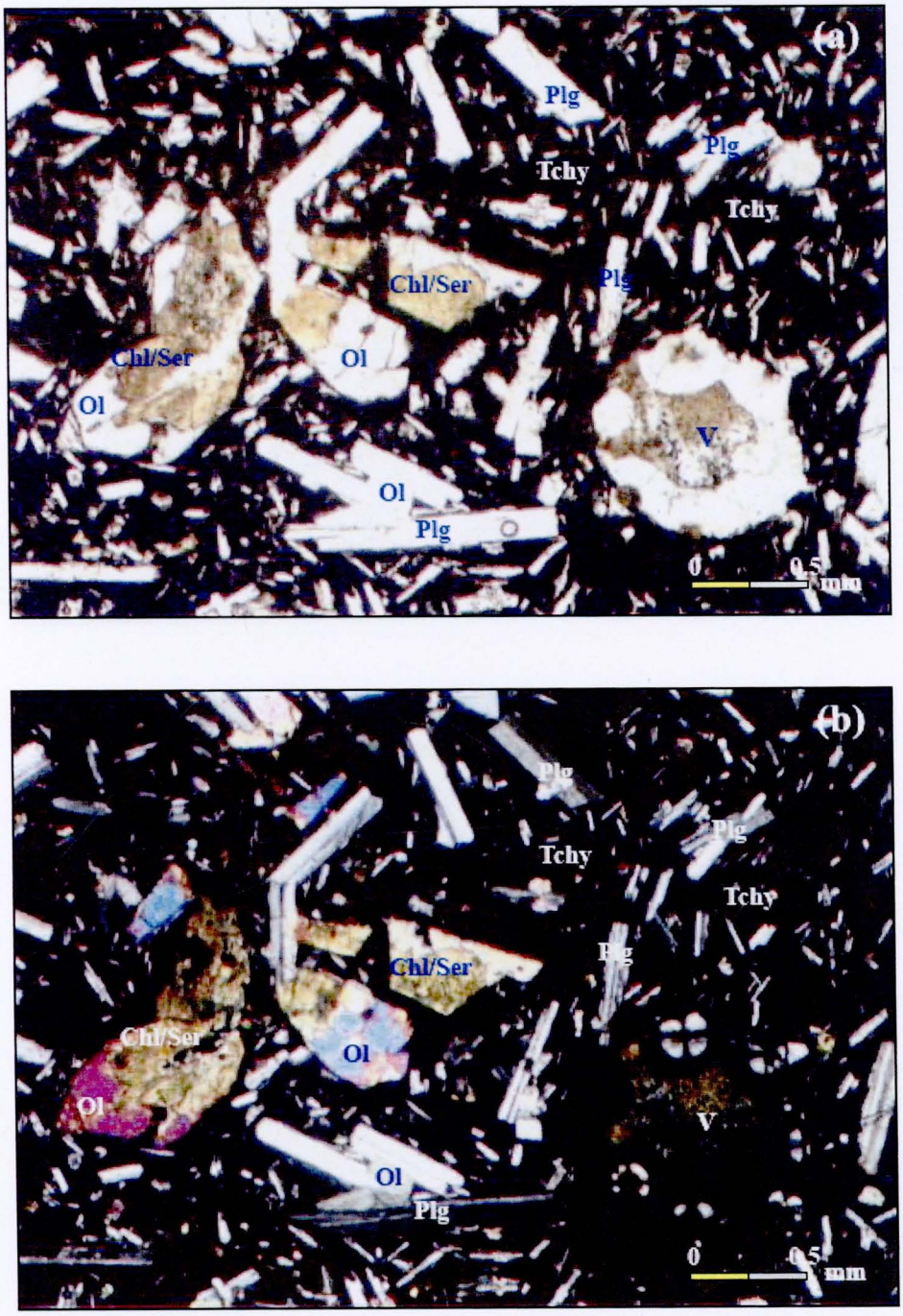

Figure 3.19 Photomicrographs of a basaltic clast in basalt breccia (core sample) displaying olivine (Ol), phenocrysts/microphenocrysts, that is partly replaced by chlorite/serpentine (Chl/Ser), olivine-plagioclase cumulocrysts, hypocrystalline groundmass, with felty plagioclase laths and blackish tachylite (Tchy), and vesicle (V) - infilling zeolite and clay minerals, Sample number WB-19, (a) ordinary light, (b) crossed polars

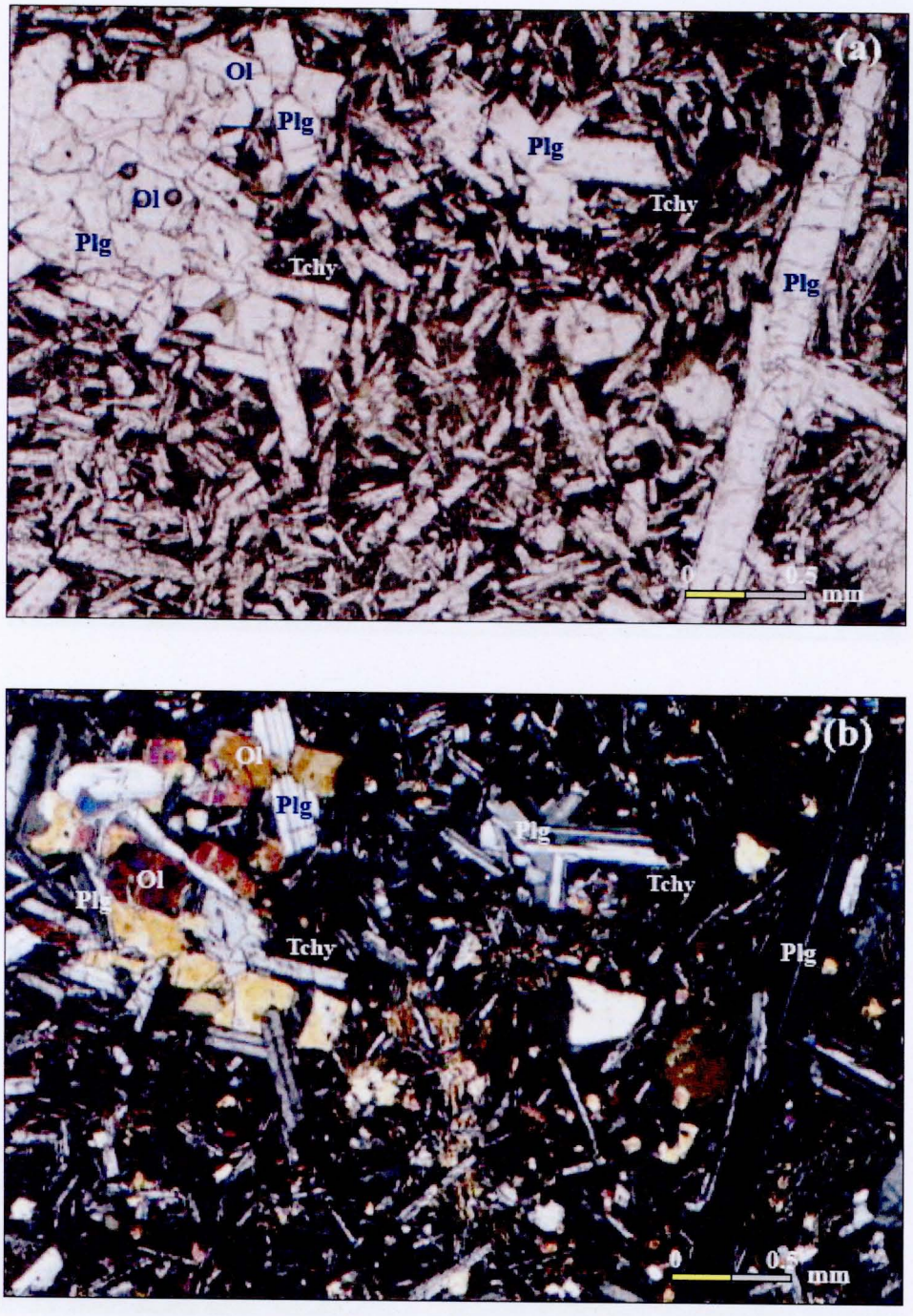

Figure 3.20 Photomicrographs of a basaltic clast in basalt breccia (core sample) showing plagioclase (Plg) phenocrysts/microphenocrysts, olivine (Ol) - plagioclase (Plg) cumulocrysts, and the interstitial blackish tachylite (Tchy), Sample number WB-25, (a) ordinary light, (b) crossed polars

Figure 3.21 Photomicrographs of a basaltic clast in basalt breccia (core sample) displaying an embayed olivine (Ol) crystals and the groundmass that is made up mainly of plagioclase laths, quench crystals; microlite (Mi) and tachylite (Tchy), Sample number WB-35, (a) ordinary light, (b) crossed polars

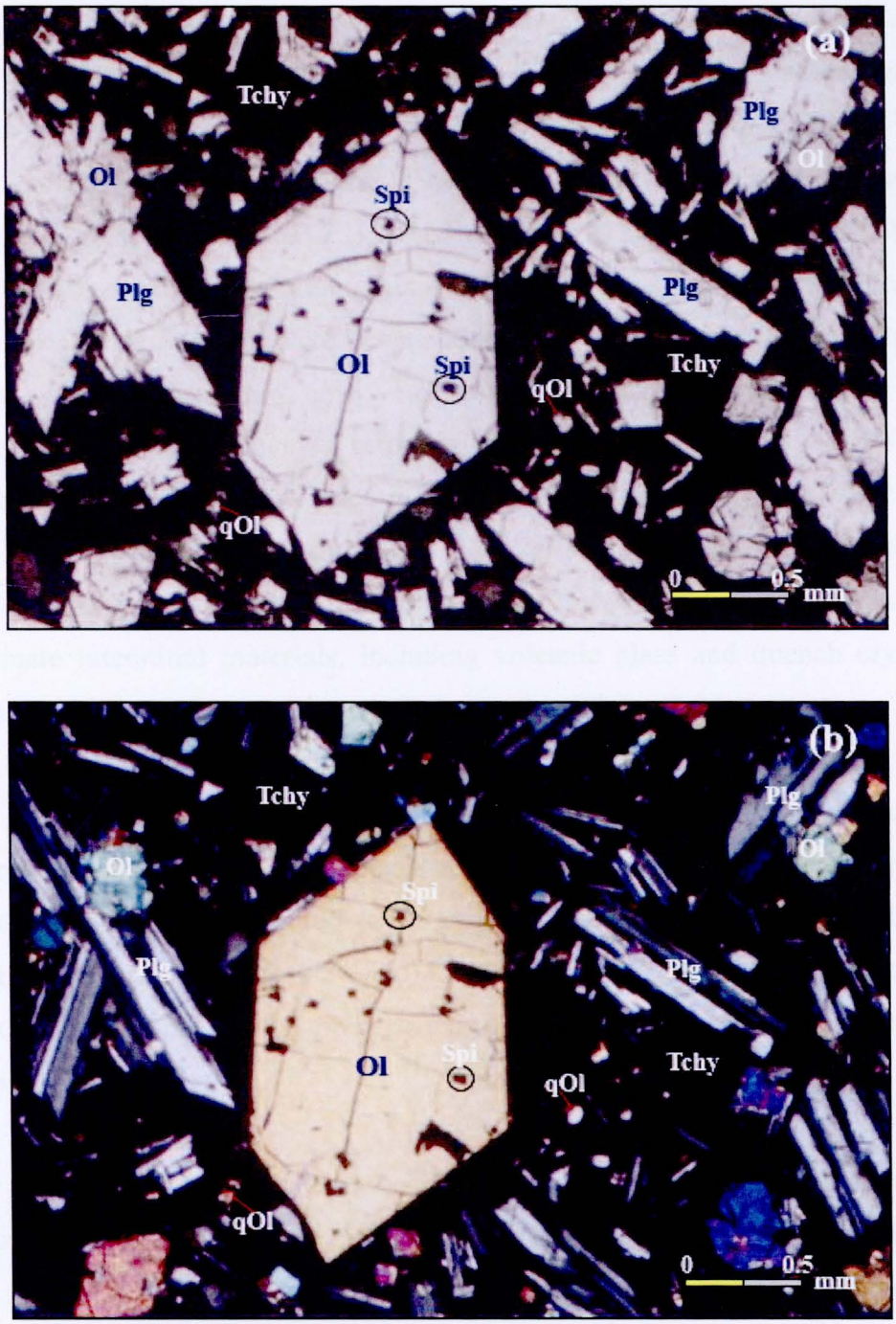

Figure 3.22 Photomicrographs of a basaltic clast in basalt breccia (core sample) displaying a euhedral olivine (Ol) phenocryst with chromian spinel (Spi) inclusions, an olivine-plagioclase glomerocryst, and the hyalophitic-textured groundmass that is made up mainly of plagiocase laths, quench olivine (qOl) and glass (Tchy), Sample number WB-42, (a) ordinary light, (b) crossed polars

The groundmass constituents include abundant plagioclase laths and dark brown tachylite (Figures 3.16, 3.17, 3.18, 3.19 and 3.20), and subordinate/minor amounts of olivine (Figures 3.16, 3.17 and 3.18) clinopyroxene and Fe-Ti oxide grains. A few core samples (sample nos. WB-42 and WB-43) have hyalophitic-textured groundmass (Figure 3.22), consisting mainly of tachylite, with subordinate felty plagioclase laths and olivine grains. Quench crystals, such as microlites (Figure 3.21) and skeletal crystals, have been observed in the volcanic glass (Figure 3.22). The glassy groundmass may have vesicles and cavities that are filled by common zeolites and/or uncommon clay minerals (Figure 3.19). Xenoliths of vitrophyric basalt have been observed in cobble-grade, basaltic clast in sample no WB-22 (Figure 3.23). The only one seriate-textured core sample (sample no. WB-14) has grain sizes up to 1.0 mm across and is made up of mainly felted plagioclase laths, with subordinate interstitial materials, including volcanic glass and quench crystals (i.e. microlites and skeletal crystals), and olivine grains (Figure 3.24).

Plagioclase phenocrysts/microphenocrysts and groundmass plagioclase grains are largely subhedral. The plagioclase phenocrysts/microphenocrysts rarely show complex zonation, stellate patterns and embayed outlines (Figure 3.17). They have An-content varying from 30 (andesine) to 90 (bytownite), on the basis of petrographic technique. All phases of plagioclase may be slightly replaced by sericite and clay minerals.

Olivine phenocrysts/microphenocrysts are largely subhedral to anhedral, and may show rounded edges and embayed outlines (Figure 3.21), and contain chrome spinel inclusions (Figure 3.22). Groundmass olivine grains commonly have anhedral outlines. Both of the olivine phenocrysts/microphenocrysts and groundmass olivine grains are variably altered to chlorite/serpentine (Figure 3.19).

Petrographic features of individual core samples of basaltic cobbles and boulders in basalt breccia (sample nos. WB-14, WB-17, WB-19, WB-21, WB-22, WB-25, WB-29, WB-32, WB-34, WB-35, WB-38, WB-40, WB-41, WB-42, WB-43, WB-44, WB-46, WB-47 and WB-49) are shown in Appendix C.

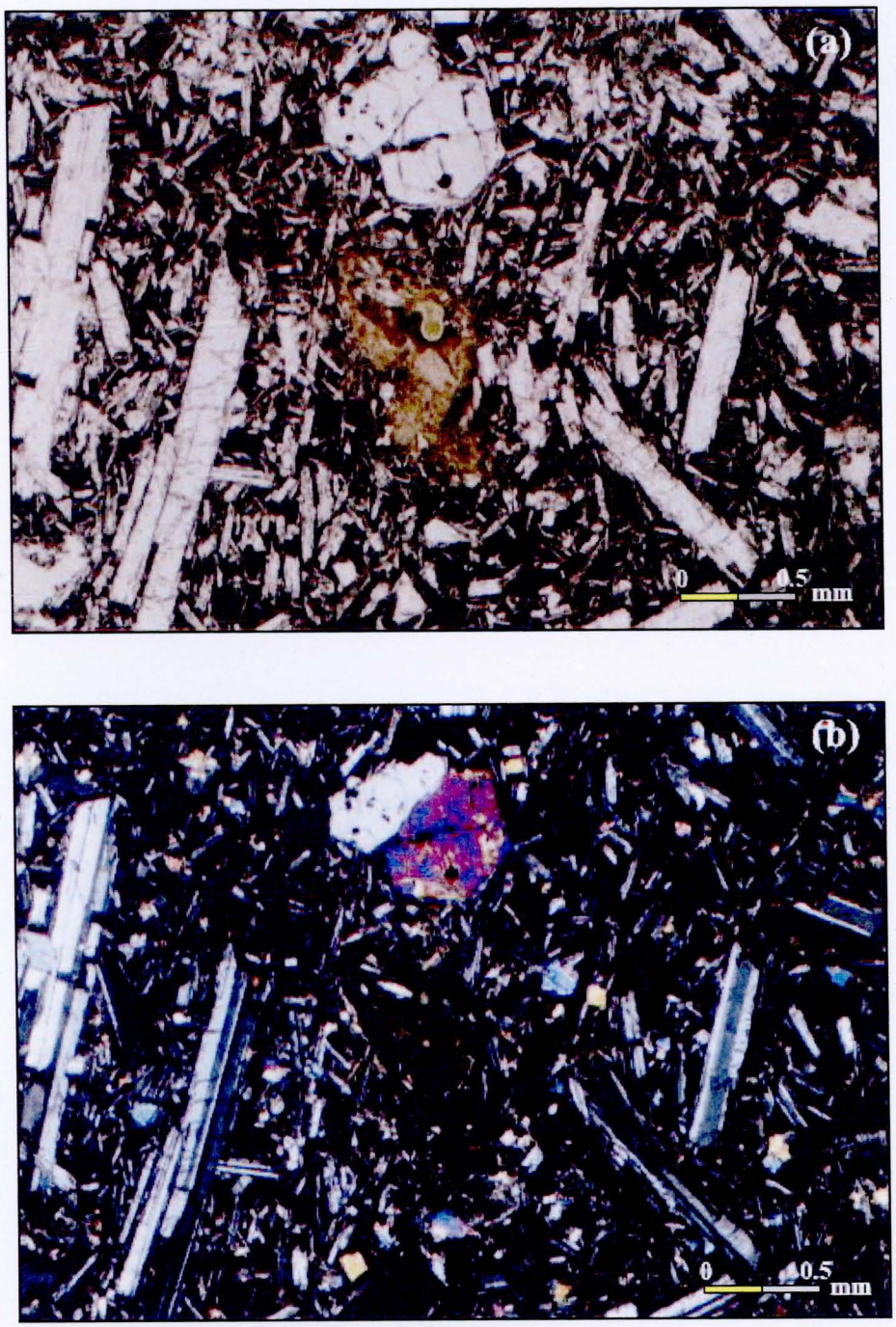

Figure 3.23 Photomicrographs of a basaltic clast in basalt breccia (core sample) showing a vitrophyric-textured xenolith (brownish color), Sample number WB-22, (a) ordinary light, (b) crossed polars

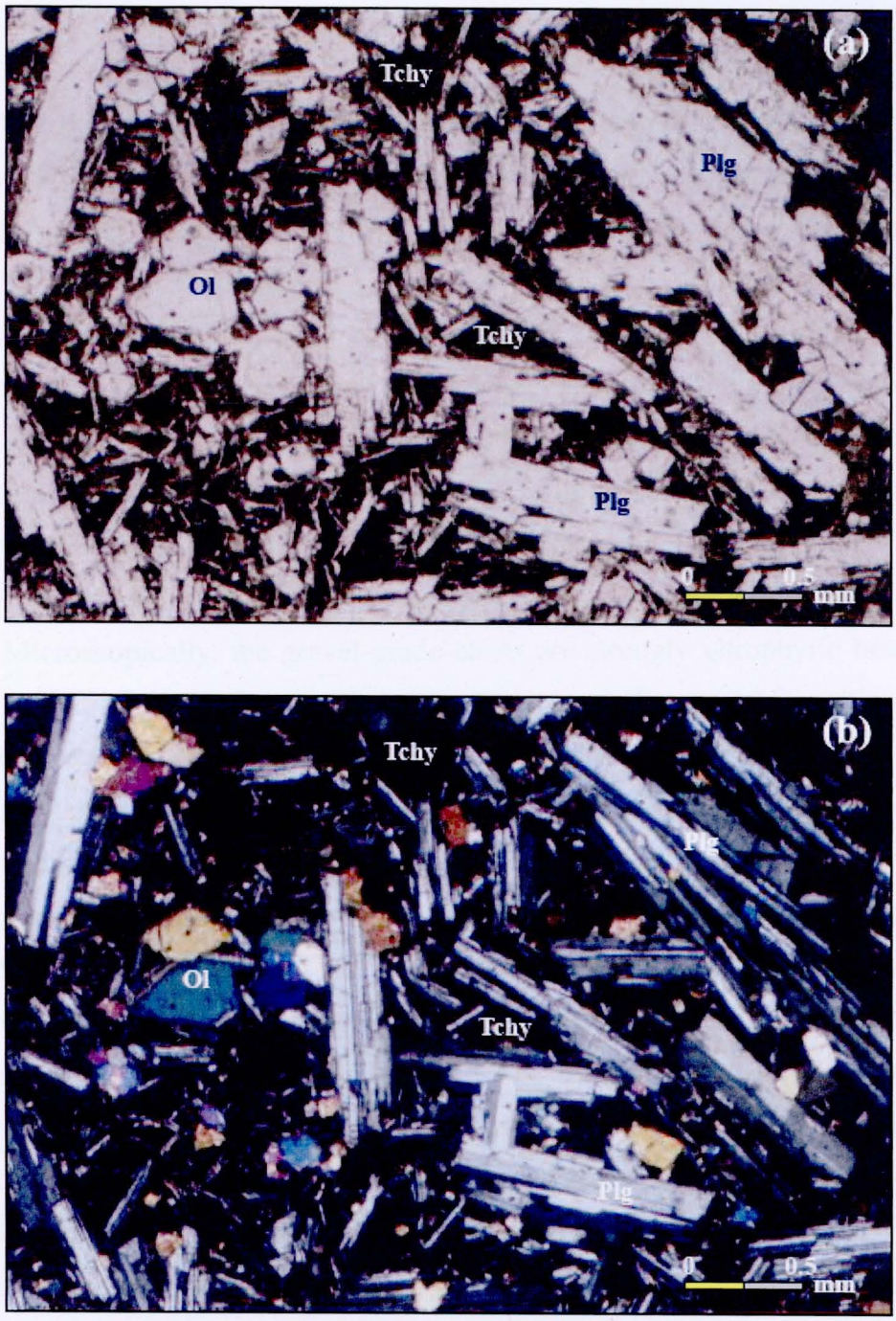

Figure 3.24 Photomicrographs of a basaltic clast in basalt breccia (core sample) illustrating seriate-textured plagioclase (Plg) laths with interstitial tachylite (Tchy) and olivine (Ol) grains, Sample number WB-14, (a) ordinary light, (b) crossed polars

3.3.3 Matrix-supported basalt Breccia

Megascopically, the eleven core samples of representative matrix-supported basalt breccia (sample nos. WB-15, WB-16, WB-18, WB-20, WB-24, WB-26, WB-28, WB-31, WB-33, WB-37 and WB-39) are constituted by clay- to pebble-grade clasts (up to 5 cm in diameter). The clay- to sand-grade clasts are much more abundant relative to granule- to pebble-grade clasts, resulting in matrix-supported fabric. The gravel-grade clasts are much lesser altered than the finer-grained matrix, which turns to a yellowish brown color, and have subangular to rounded shapes and low to high sphericity. Cementing and cavity-infilling minerals in these core samples are whitish in color.

Microscopically, the gravel-grade clasts are strongly vitrophyric basalts, with olivine and plagioclase phenocrysts/microphenocrysts (Figure 3.25). Clinopyroxene microphenocrysts are, however, present in sample no WB-39. These phenocrysts/microphenocrysts occur as isolated crystals, glomerocrysts (Figure 3.25), and as olivine-plagioclase and plagioclase-clinopyroxene cumulocrysts. Plagioclase phenocrysts/microphenocrysts are largely subhedral, and have An-content varying from 25 (oligoclase) to 82 (bytownite), on the basis of petrographic technique. Olivine phenocrysts/microphenocrysts are largely subhedral to anhedral, and may contain chrome spinel inclusions (Figure 3.26), show rounded edges, sieve textures and embayed outlines. They are variably replaced by chlorite/serpentine and/or clay minerals. The groundmass constituents show a glassy texture that is made up largely of yellowish brown volcanic glass (sideromelane), as shown in Figures 3.25, 3.26, 3.27 and 3.28 and minor quench crystals of olivine and plagioclase. The dark or blackish brown volcanic glass (tachylite) is uncommon in the vitrophyric basalts (Figure 3.29). At rim of individual clasts, the original groundmass sideromelane has been commonly replaced by brownish palagonite, with minor bluish and bluish green palagonite (Figures 3.25, 3.26 and 3.27). Vesicles are variably present in some vitrophyric clasts, and are sealed by zeolites and clay minerals. The glassy walls of vesicles are commonly replaced by brownish/bluish green palagonite and/or chloritic materials (Figure 3.25).

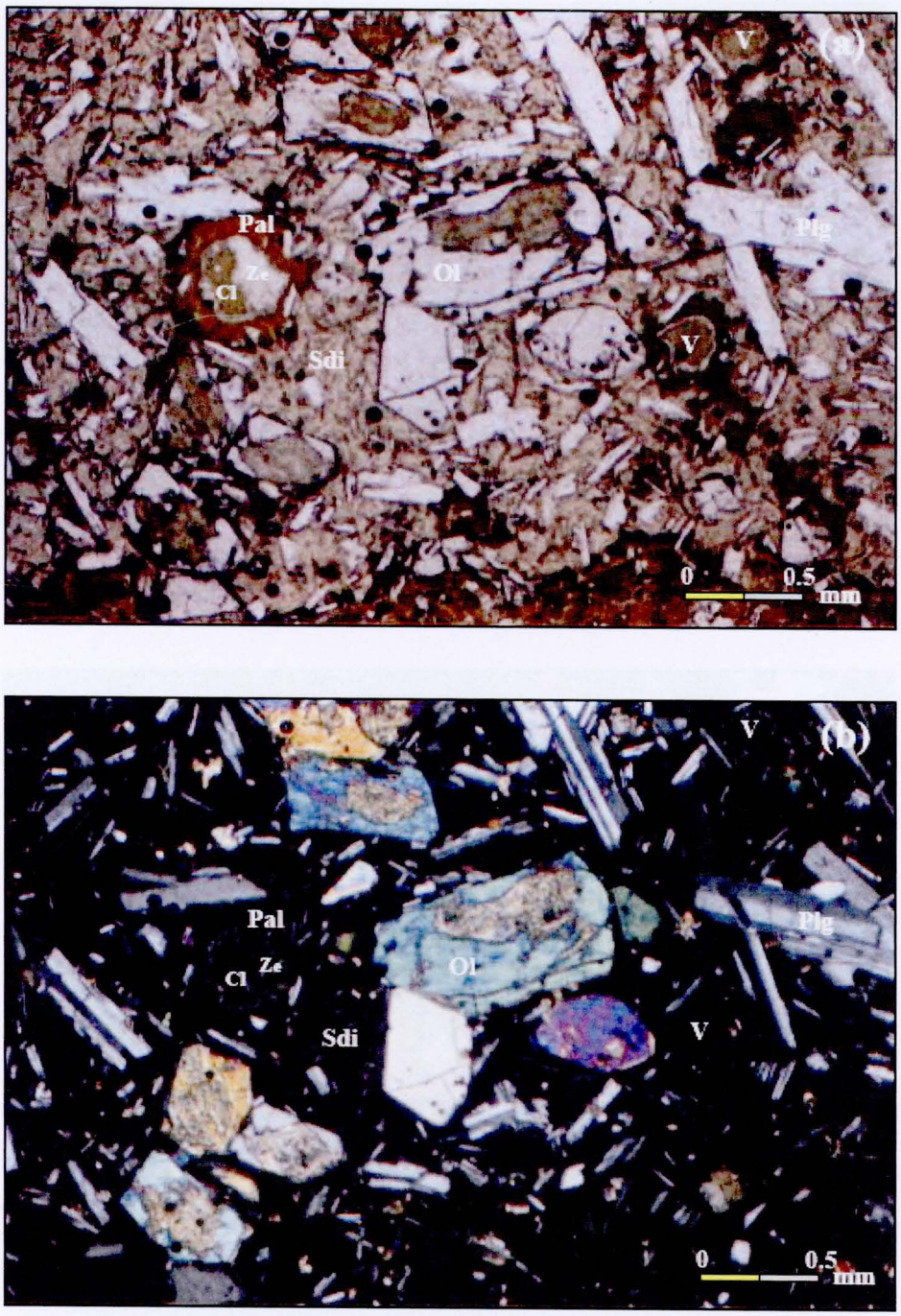

Figure 3.25 Photomicrographs of basalt breccia (core sample) showing a coherent basaltic clast with plagioclase (Plg) glomerocryst, olivine (Ol) phenocrysts/ microphenocrysts, pale brown sideromelane (Sdi), and vesicle (V) -infilling zeolites (Ze) and clay (Cl) minerals, The glassy walls of vesicles are commonly replaced by brownish palagonite (Pal). Sample number WB-37, (a) ordinary light, (b) crossed polars

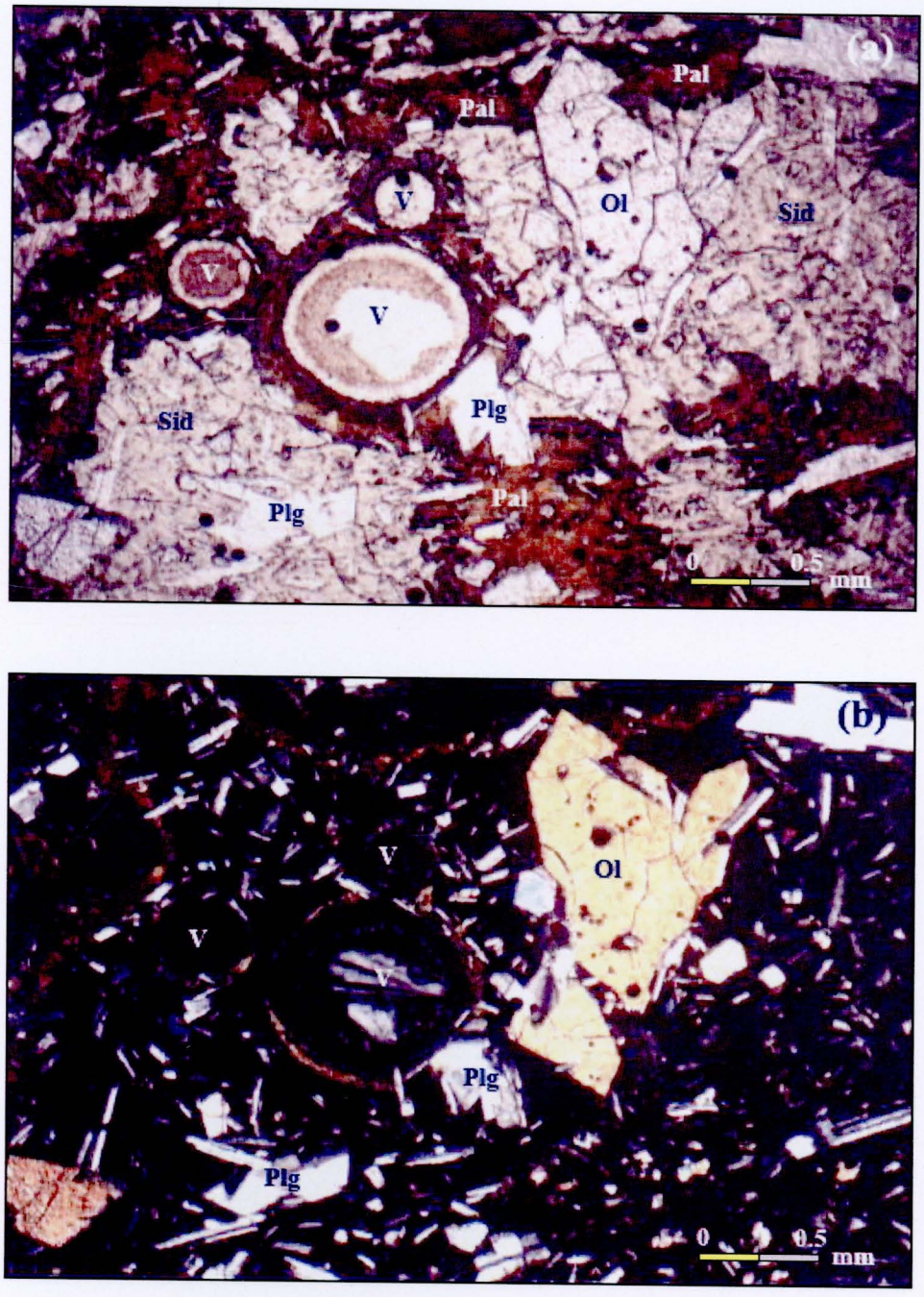

Figure 3.26 Photomicrographs of basalt breccia (core sample) showing a coherent basaltic clast with olivine (Ol) phenocrysts and their chromian spinel inclusions, pale brown sideromelane (Sdi) rimmed by dark brown and green colored palagonite (Pal), and vesicle (V) - infilling zeolites and clay minerals, Sample number WB-28, (a) ordinary light, (b) crossed polars

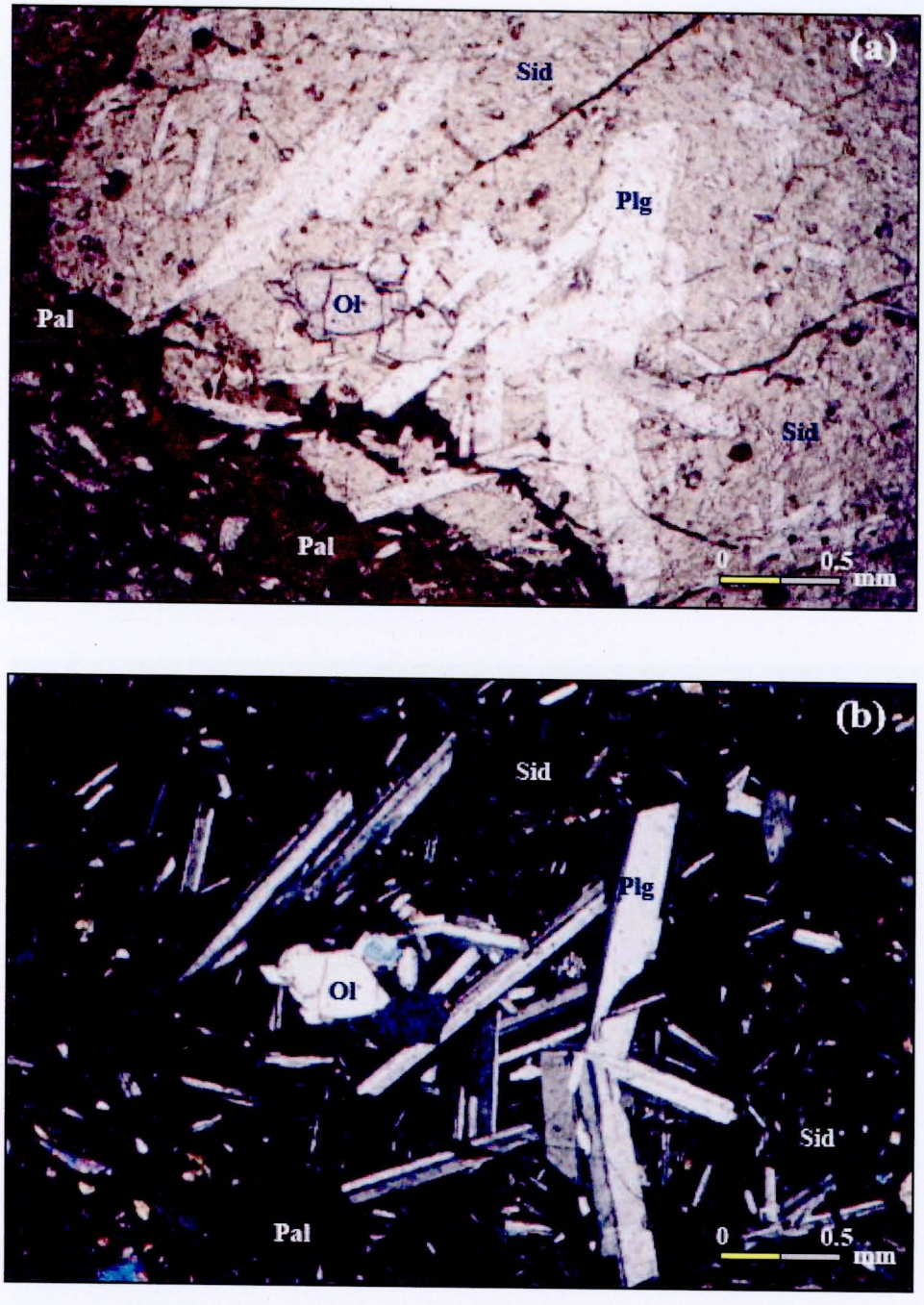

Figure 3.27 Photomicrographs of basalt breccia (core sample) showing a coherent olivine (Ol) – plagioclase (Plg) phyric clast and the matrix made up of yellowish brown sideromelane (Sdi) that is rimmed with dark brown and greenish palagonite (Pal), Sample number WB-20, (a) ordinary light, (b) crossed polars

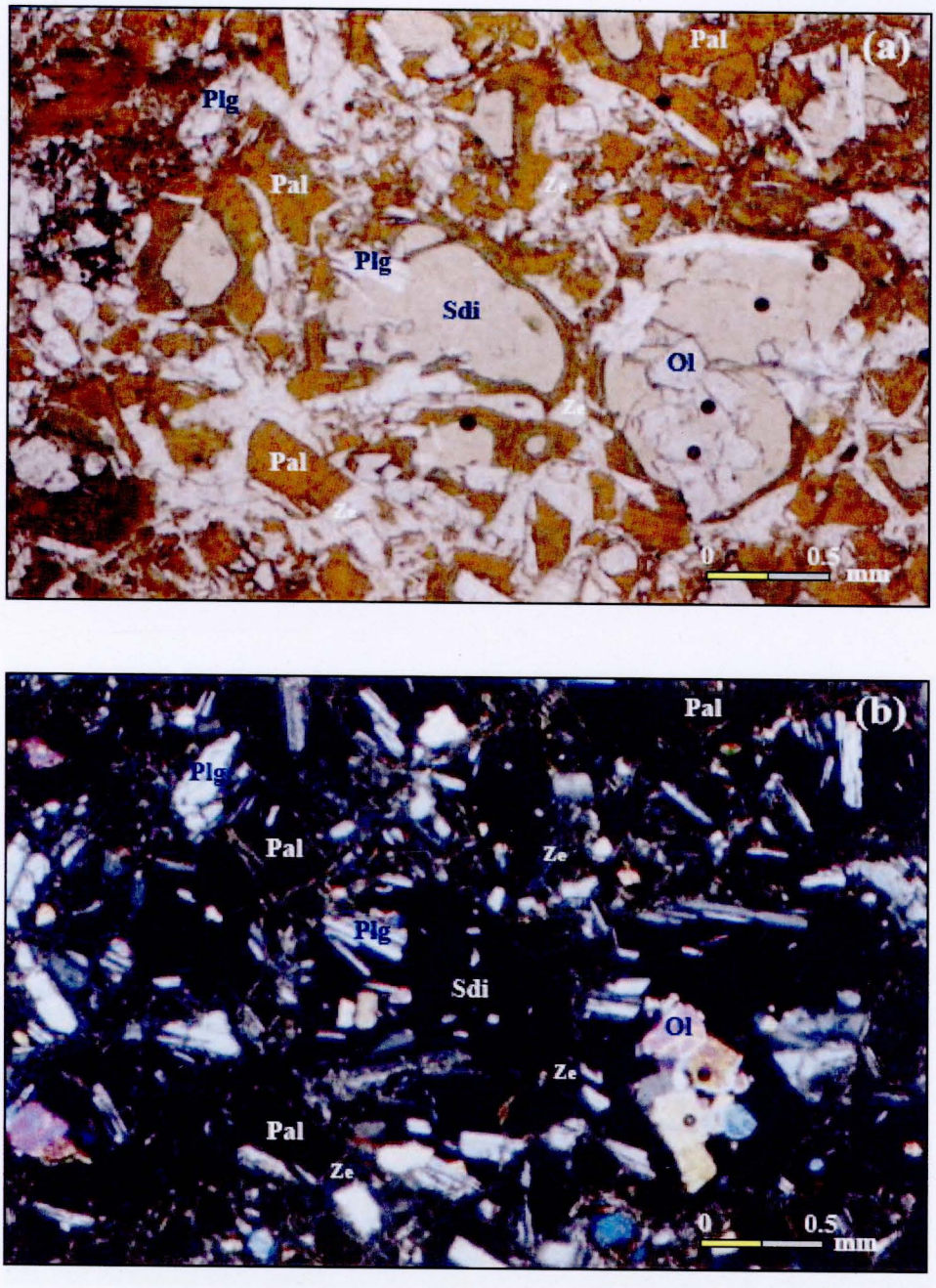

Figure 3.28 Photomicrographs of basalt breccia (core sample) displaying the matrix vitrophyric clasts, glassy fragments, and crystal fragments, and zeolite (Ze) cement, The common sideromelane (Sdi) fragments are totally replaced by dark brown or bluish green palagonite (Pal). Sample number WB-16, (a) ordinary light, (b) crossed polars

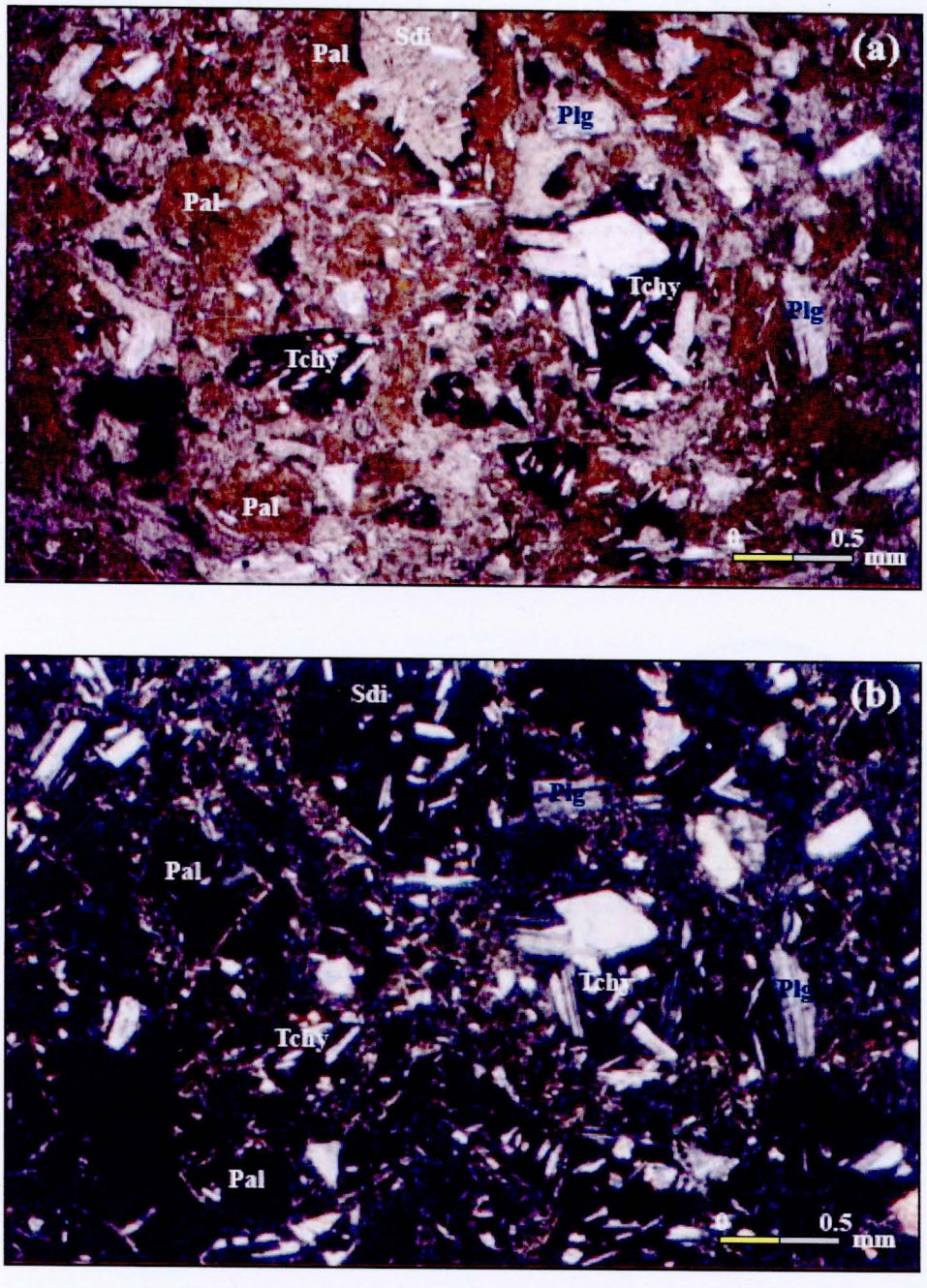

Figure 3.29 Photomicrographs of basalt breccia (core sample) showing the matrix portion that consists of vitrophyric, blackish brown tachylite (Tchy) clasts, and sideromelane (Sdi) clasts totally replaced by brownish palagonite (Pal), Sample number WB-20, (a) ordinary light, (b) crossed polars

The matrix of basalt breccia is composed mainly of vitrophyric clasts similar to gravel-grade clasts, glassy fragments and crystal fragments, i.e. olivine and plagioclase. The original sideromelane in these vitrophyric clasts has been commonly replaced by dark brown palagonite (Figures 3.28 and 3.29) and/or green palagonite/chloritic material. The whitish minerals, observed in core samples as cementing material, and as cavity- and fracture-infillings, are zeolites and clay minerals (Figure 3.28).

Petrographic features of individual core samples of matrix-supported basalt breccia (sample nos. WB-15, WB-16, WB-18, WB-20, WB-24, WB-26, WB-28, WB-31, WB-33, WB-37 and WB-39) are shown in Appendix D.