Petrography

Abbreviations

Abbreviations used in the annotation of images of thin sections are as follows:- plag or Plg=plagioclase, cpx=clinopyroxene, alt=alteration (typically chlorite), ol=olivine, mag or Mgt=magnetite, px=pyroxene, Bt=biotite, Po=pyrrhotite, ser=sericite, amyg=amygdale, cal=calcite, qz=quartz, pseud=pseudomorph, ilm=ilmenite.

Thin section 02KK14 (Figure B01)

The sample is a fine-grained igneous rock dominated by plagioclase (70%), and clinopyroxene (20%), with minor olivine (6%) and opaque minerals (magnetite and ilmenite). Plagioclase crystals are euhedral to subhedral laths up to 0.7 mm in length and 0.05 mm in width, orientated, show Carlsbad twinning. The needle-like plagioclase crystals have skeletal hollow structures typical of quench crystallisation. Clinopyroxene crystals are euhedral to subhedral (hexagonal and prisms) up to 0.2 mm in diameter. Olivine crystals are subhedral, up to 0.4 mm, and are affected by minor alteration along cracks and rims. Magnetite crystals occur as cubes, up to 0.1mm in diameter. Localised alteration is evident along a crack with the development of chlorite.

Thin section 01KK14 (Figure B02)

The sample is a medium-grained igneous rock dominated by plagioclase (55%), clinopyroxene (30%), olivine (10%), with minor magnetite (5%). Plagioclase crystals are euhedral to subhedral laths up to 1.6 mm in length and 0.2mm in width, show polysynthetic and Carlsbad twinning, with some grains showing skeletal hollow crystal shapes, typical of quench textures. Olivine crystal are euhedral to subhedral in shape, up to 0.7 mm in diameter. Clinopyroxene crystals are euhedral to subhedral in shape, up to 0.5 mm in diameter, surrounded by small crystals of opaque minerals. Olivine is locally altered to greenish serpentine.

Thin Section 09KK14 (Figure B03)

The sample is a fine-grained igneous rock dominated by plagioclase (70%) and clinopyroxene (20%), with minor olivine (8%) and magnetite. Plagioclase crystals are euhedral to subhedral laths up to 0.6 mm long and 0.1 mm wide, and show combined Carlsbad Albite twinning. Clinopyroxene crystals are euhedral to subhedral up to 0.7 mm in diameter, occurring interstitially between plagioclase crystals. Olivine crystals are up to 1.2 mm in diameter and form poikilitic skeletal grains with plagioclase inclusions and are altered along fractures to serpentine. Magnetite forms euhedral cubes up to 0.2 mm in diameter.

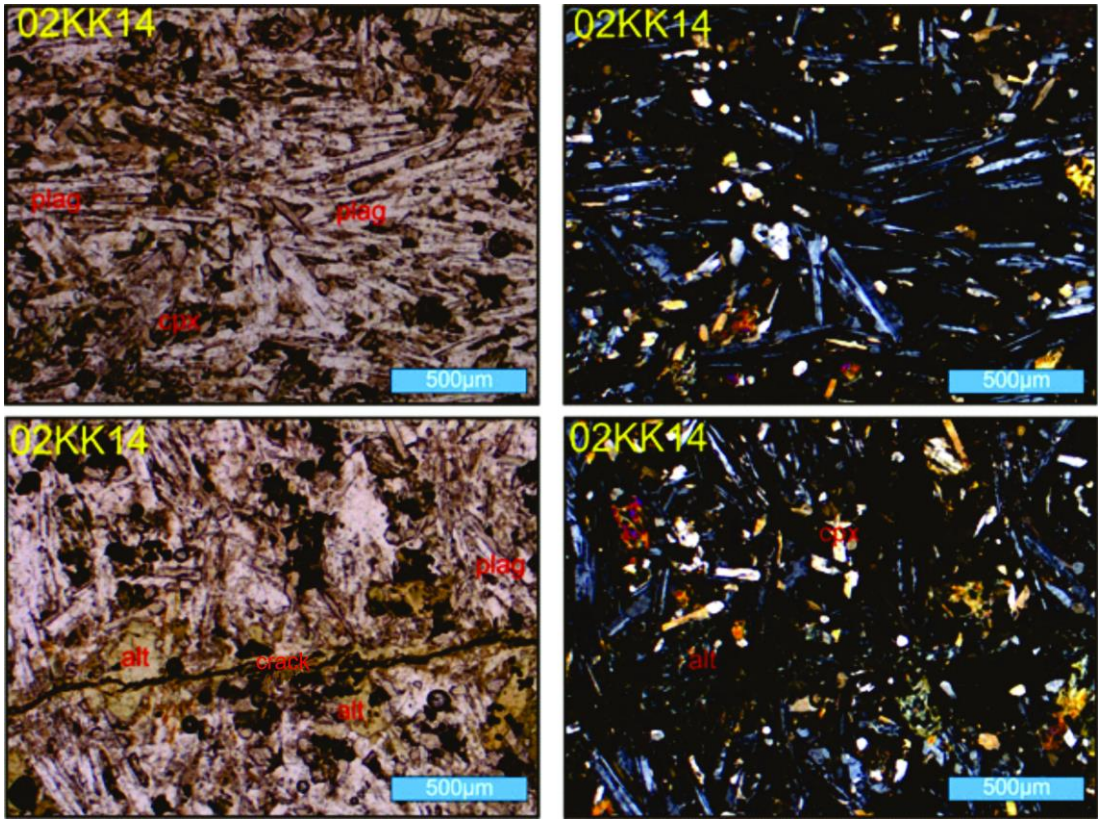

Figure B01: Photomicrographs of sample 02KK14. PPL (left) and XPL (right).

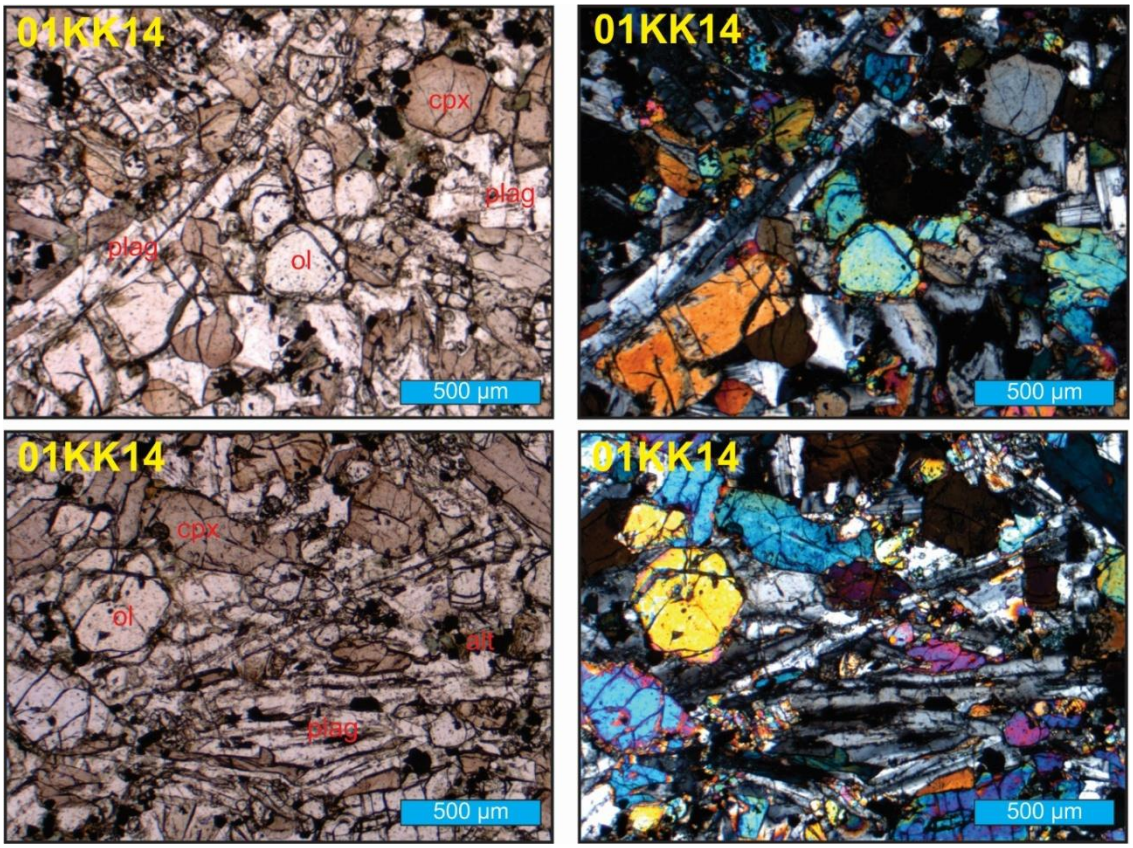

Figure B02: Photomicrographs of sample 01KK14. PPL (left) and XPL (right).

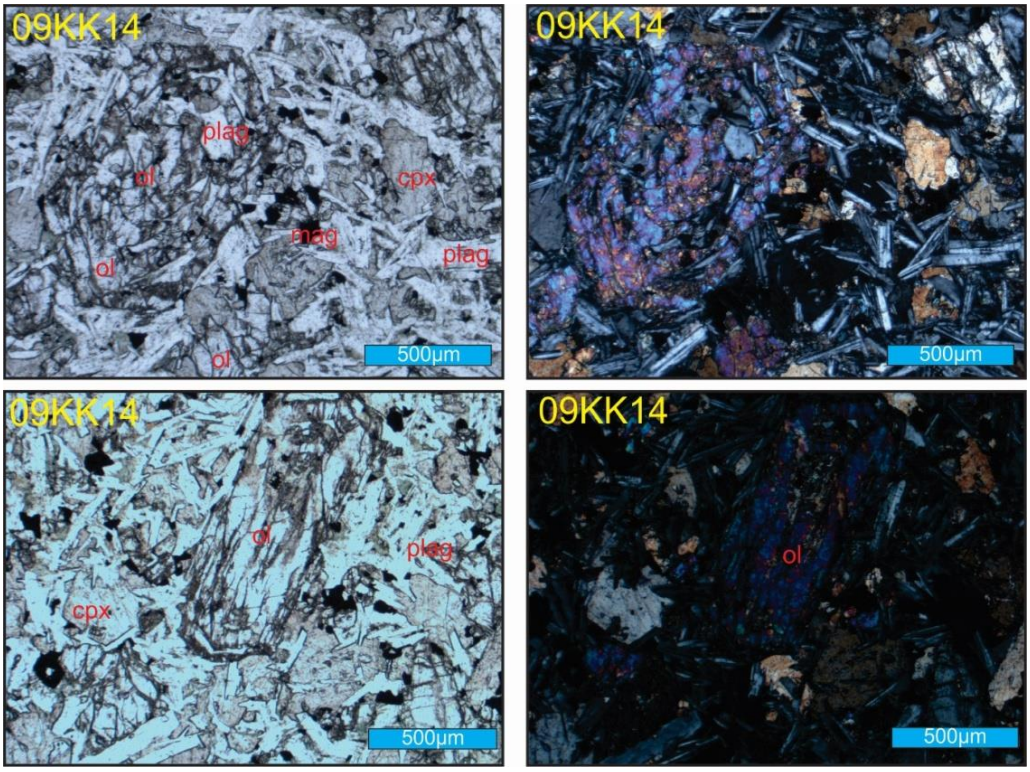

Figure B03: Photomicrographs of sample 09KK14. PPL (left) and XPL (right).

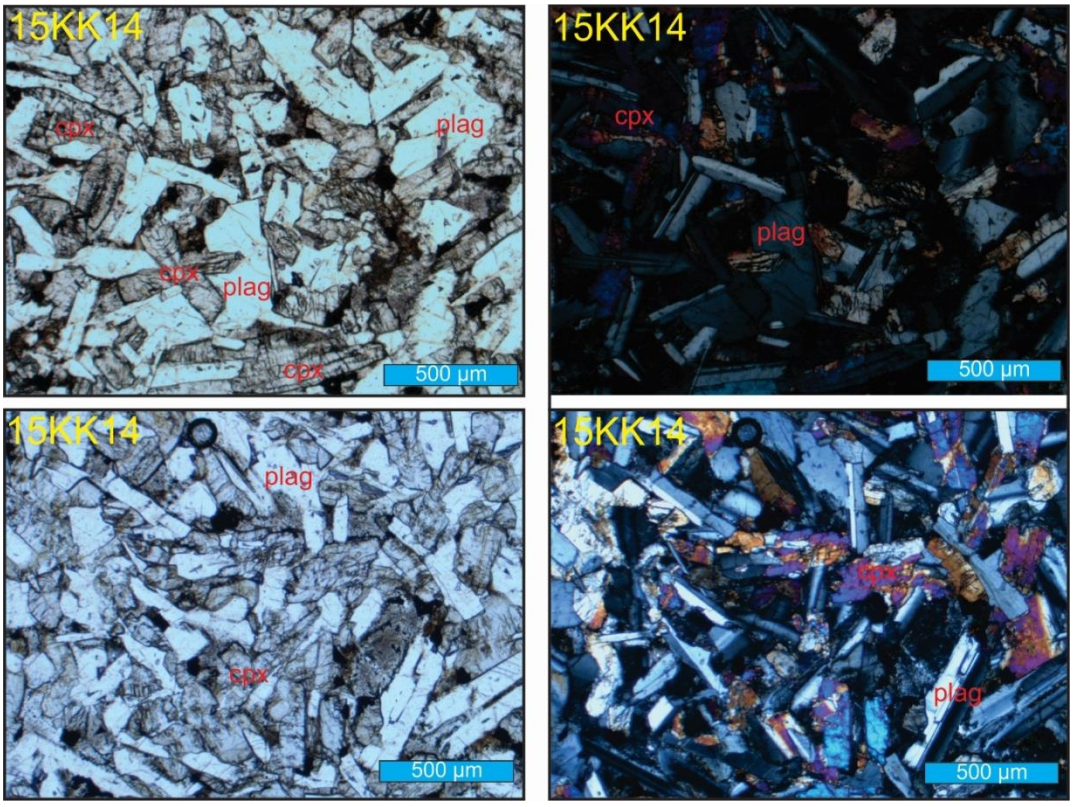

Figure B04: Photomicrographs of sample 15KK14. PPL (left) and XPL (right).

Thin Section 15KK14(Figure B04)

The sample is a medium-grained igneous rock dominated by plagioclase (65%) and clinopyroxene (30%), with minor magnetite (5%). Plagioclase forms euhedral to subhedral laths up to 1 mm long and 0.15 mm wide, showing combined Albite and Carlsbad twinning and oscillatory zoning. Clinopyroxene crystals are subhedral, up to 0.65 mm in diameter, occuring interstitially to plagioclase with some grains showing hollow cores, typical of quench textures. Magnetite crystals are euhedral cubes up to 0.2 mm in diameter.

Thin Section 10RH15 (Figure B05)

This sample was used for both Ar-Ar and paleomagnetism measurements. The sample is a coarse-grained dolerite (Px:Plg = 40:60) with euhedral plagioclase (~1.5-2.0 mm x 0.20-0.80 mm) and interstitial pyroxene (~0.50-0.70 mm in diameter). It shows incipient alteration along cracks and cleavages typically in the form of biotite. Fox red-brown biotite is locally developed adjacent to magnetite grains, with the total modal proportion of biotite at ~5% of the thin-section. Fox red biotite is typical of Ti-rich biotite consistent with high temperature crystallisation (Henry et al., 2005) and is inferred as a late stage igneous crystallisation phase. Sample 10RH15 consists of ~10% magnetite, ~0.20-0.60 mm in diameter and appear homogeneous with no clear evidence for alteration. Pyrrhotite was found in minor amounts, disseminated through the thin-section.

Thin Section 11RH15 (Figure B06)

This sample was used for both Ar-Ar and paleomagnetism measurements and consists of medium grained dolerite (Px:Plg = 40:60) that consists of euhedral plagioclase (~0.30 mm x 0.10 mm) and pyroxene (commonly as interstitial ~0.10-0.15 mm crystals, but also as ~1.0-1.5 mm megacrysts in rare occasions). Biotite forms ~5% of the rock which is commonly found around the opaque minerals (magnetite?). The biotite is interstitial to other grains, typically adjacent to opaque minerals and is also seen locally in cracks suggesting that some biotite formed as a late crystallisation product. Magnetite (~10% in modal proportion and ~0.10 mm in diameter) was mostly found to have ‘globular’ forms, with skeletal growth patterns in rare occasions. The magnetite has parallel lamellae of different shades located along the cracks, inferred to be from exsolution of ilmenite.

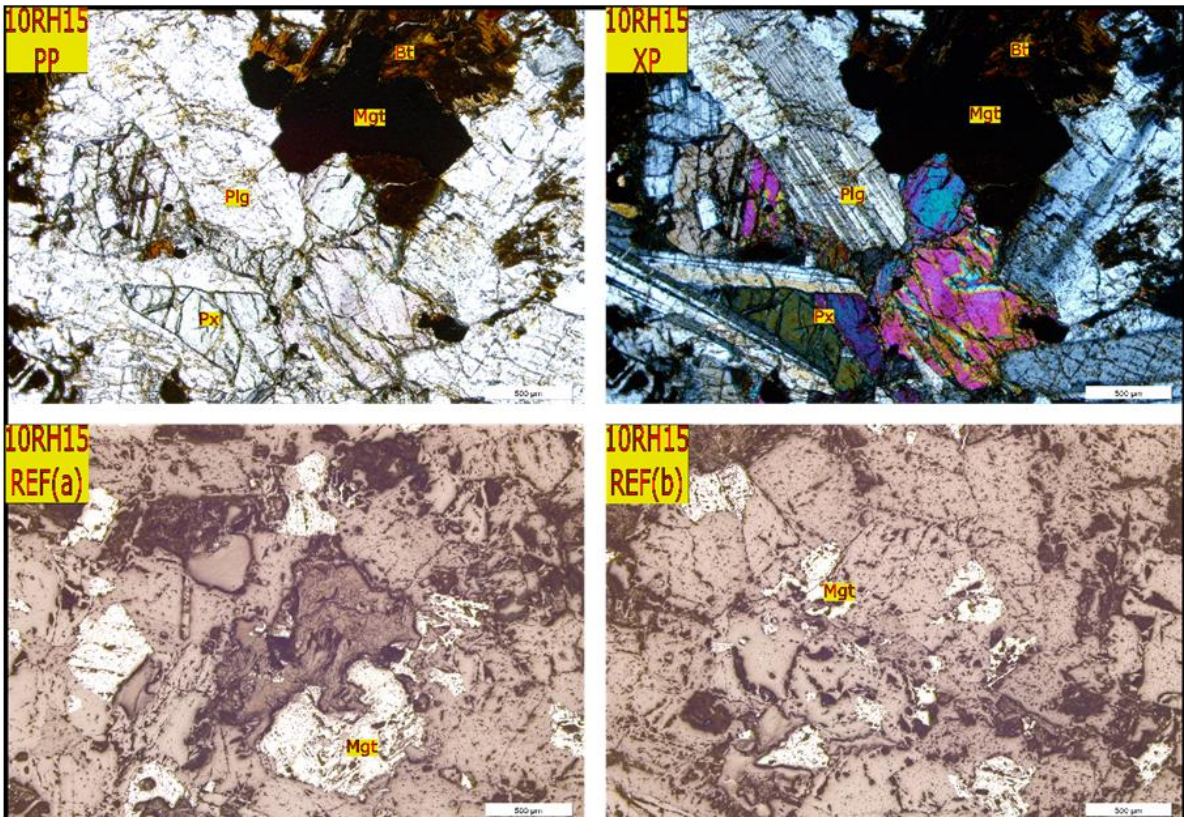

Figure B05. Photomicrographs of samples 10RH15. Transmitted light above and reflected light below

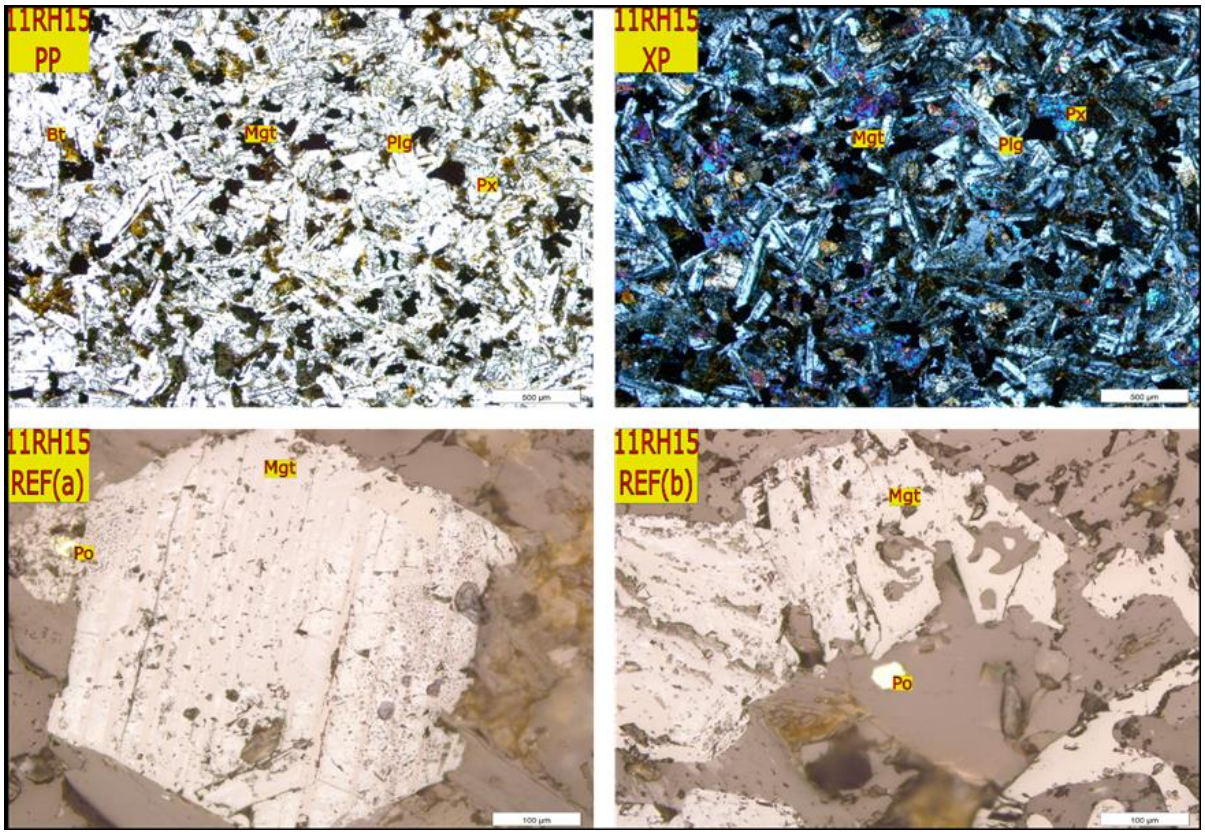

Figure B06. Photomicrographs of samples 11RH15. Transmitted light above and reflected light below

Thin Section 04KK14(Figure B07)

The sample is a fine-grained igneous rock dominated by feldspar (80%), opaque minerals (magnetite and ilmentite, 15%) and biotite. Plagioclase crystals are subhedral laths up to 0.5 mm long and 0.1 mm wide. Amygdales filled with calcite are up to 0.6 mm diameter. Magnetite crystals are cubic, up to 0.2 mm in diameter, and ilmenite occur as dendritic crystal arrays up to 0.25 mm in length. Chemistry from this rock shows a high loss on ignition, reflecting alteration and oxidation.

Thin Section 11KK14 (Figure B08)

The sample is a fine-grained porphyritic igneous rock dominated by plagioclase (70%), opaque mineral grains, presumably ilmenite and magnetite (10%) and a fine-grained pinkish mineral inferred to be clinopyroxene (20%). Plagioclase crystals are subhedral laths up to 0.3 mm long and 0.01 mm wide and shows subordinate sericitisation. Magnetite crystals are euhedral cubes up to 0.5 mm in diameter. Calcite-filled amygdales are up to 0.8 mm in diameter. Quartz phenocrysts are up to 1 mm wide, with a reaction rim of an olive green mineral inferred to be amphibole.

Thin Section 08FU14(Figure B09)

The sample is a fine-grained equigranular rock dominated by plagioclase (75%), clinopyroxene (20%) with minor magnetite (3%) and olivine (2%). Plagioclase crystals are subhedral laths up to 0.4 mm long and <0.1 mm wide, show Carlsbad twinning, and are partially sericitized. Clinopyroxene is subhedral, up to 0.1 mm long and partially altered to chlorite. Olivine grains are <0.1 mm. Calcite-filled amygdales are up to 1.5 mm in diameter. Magnetite crystals occur as cubes, up to 0.1 mm wide.

Thin Section 03HA15 (Figure B10)

The sample is a medium-grained rock dominated by plagioclase (55%), clinopyroxene (35%), and olivine (5%), with minor magnetite and ilmenite. Plagioclase crystals are euhedral to subhedral laths up to 1.6 mm long and 0.3 mm wide, show polysynthetic and Carlsbad twinning, and subordinate marginal sericitization. Clinopyroxene crystals are subhedral, up to 0.8 mm in diameter, occur interstitially to plagioclase crystals. Olivine crystals are euhedral to subhedral equants, are highly fractured and slightly serpentinised along cracks. Magnetite crystals are euhedral cubes up to 0.3 mm in diameter. Ilmenite crystals are euhedral grains up to 0.3 mm in diameter.

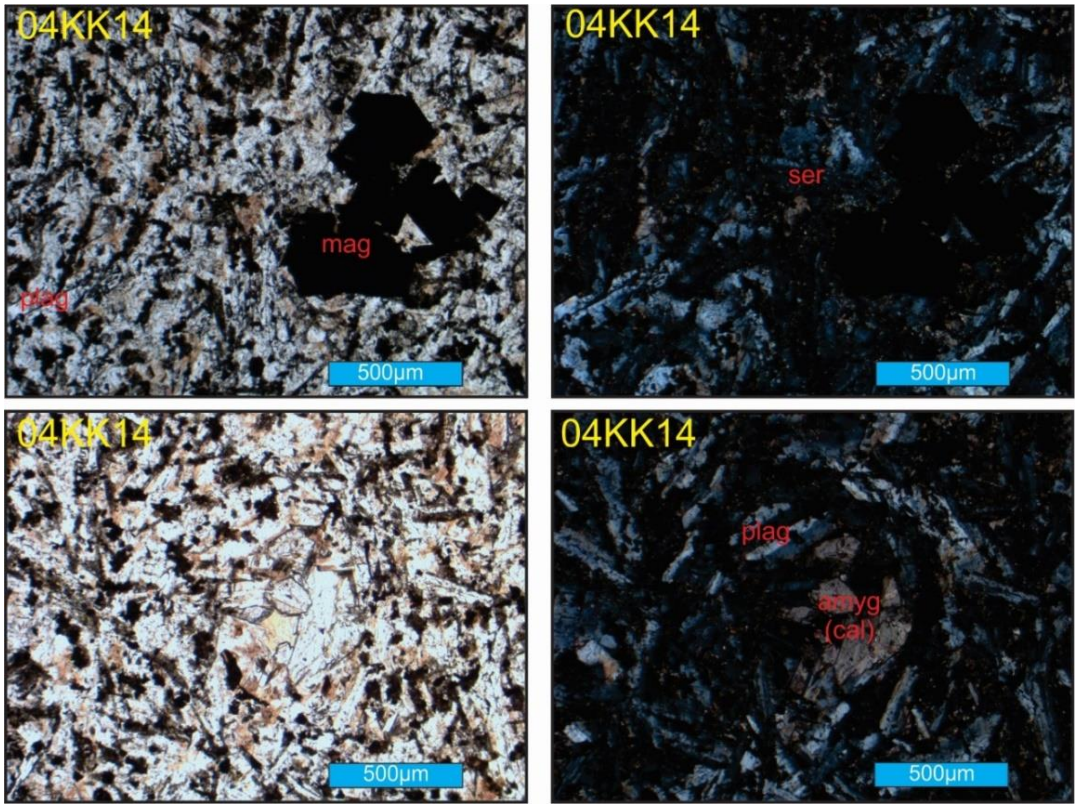

Figure B07: Photomicrographs of sample 04KK14. PPL (left) and XPL (right).

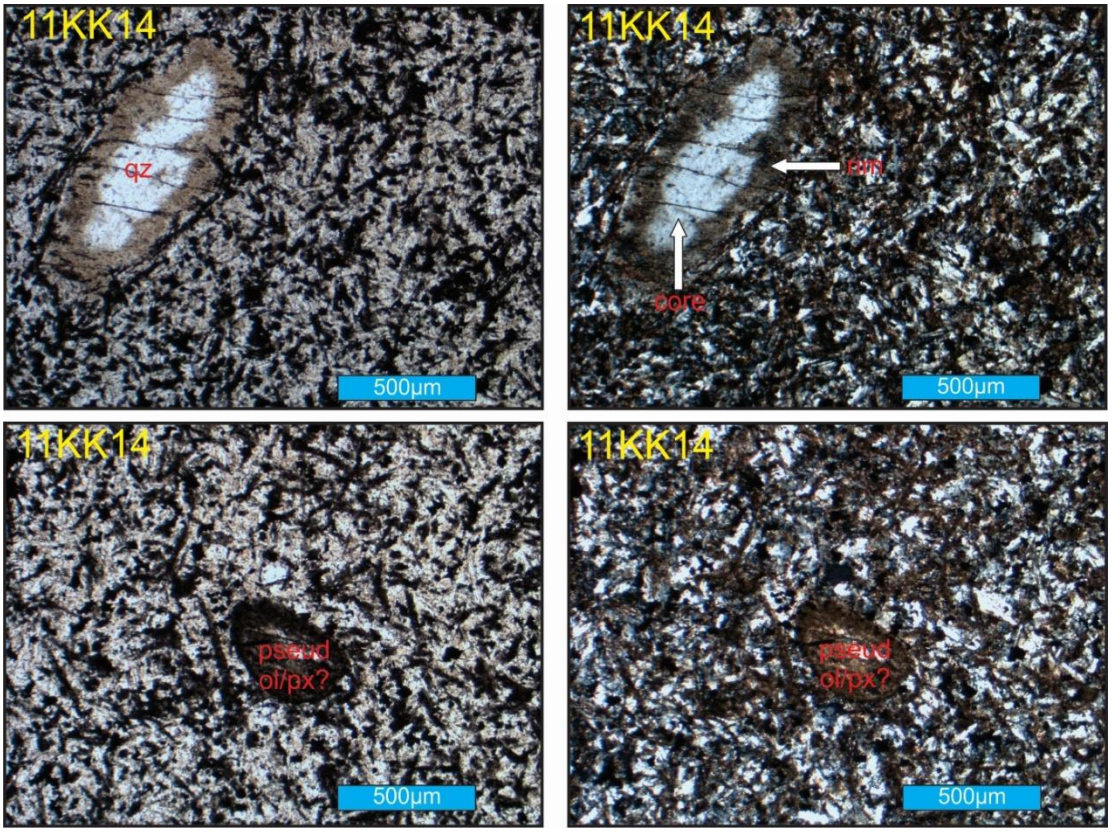

Figure B08: Photomicrographs of sample 11KK14. PPL (left) and XPL (right).

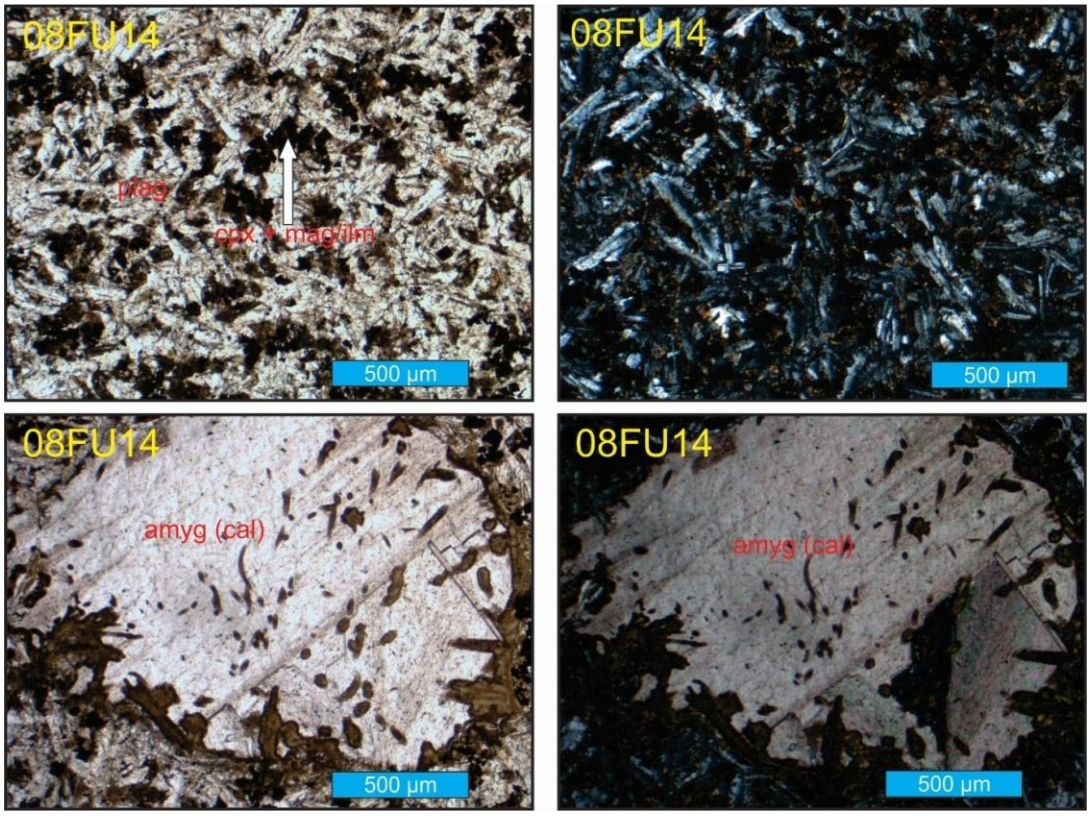

Figure B09: Photomicrographs of sample 08FU14. PPL (left) and XPL (right).

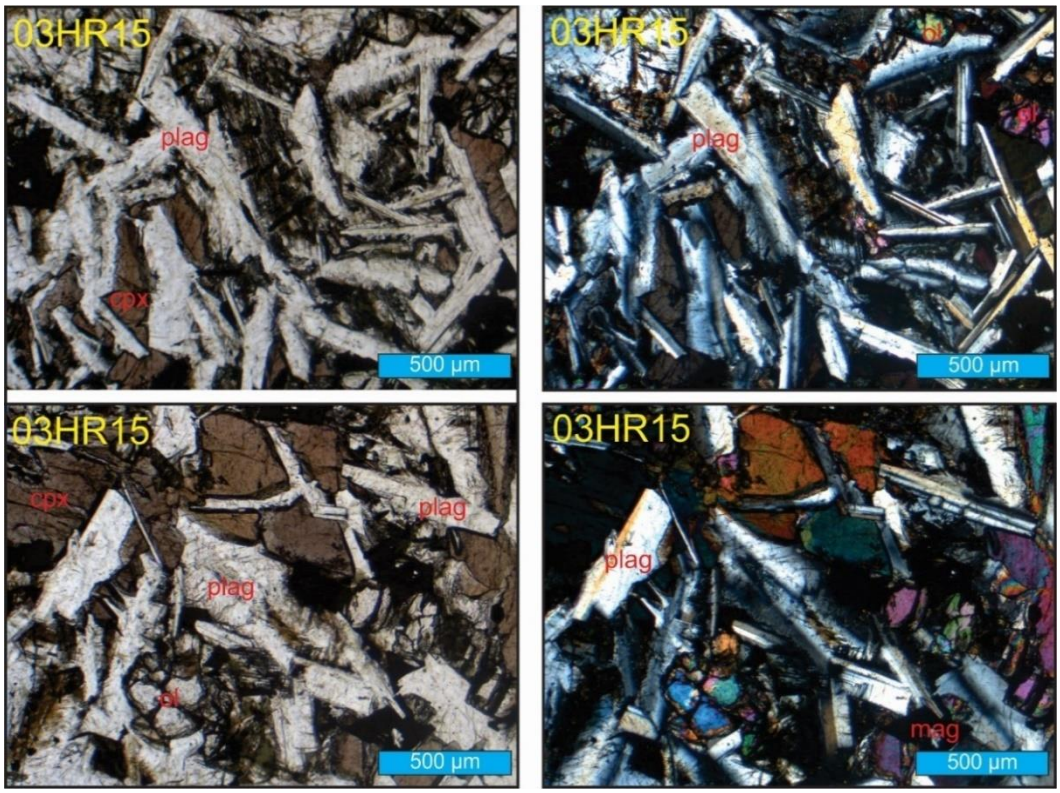

Figure B10: Photomicrographs of sample 03HR15. PPL (left) and XPL (right).

Thin Section 01FU14 (Figure B11)

The sample is a fine-grained porphyritic rock dominated by plagioclase (60%), clinopyroxene (20%), olivine (16%), and minor opaque minerals (ilmenite and magnetite). The sample has a porphyritic texture, with phenocryst proportions of olivine (80%), clinopyroxene (19%), and orthopyroxene (1%). Plagioclase crystals are euhedral to subhedral laths up to 0.5 mm in length and 0.1 mm in width and show polysynthetic and Carlsbad twinning. Clinopyroxene crystals are euhedral, up to 1 mm in diameter, and show oscillatory zoning. Olivine is partially serpentinised around grain margins and in cracks. Groundmass consists of small crystals of clinopyroxene (<0.1 mm), plagioclase and olivine. Ilmenite and magnetite occur as grain equant grains and elongate aggregates up to 0.4 mm in length. Calcite- and quartz- filled amygdales are up to 0.4 mm in diameter.

Thin Section 04TA14(Figure B12)

The sample is a fine-grained porphyritic igneous rock with clinopyroxene (40%) phenocrysts embedded in a fine grained equigranular ophitic textured groundmass with mineral proportions of plagioclase (70%) and clinopyroxene (25%) and opaque minerals (5%). Plagioclase phenocrysts are euhedral to subhedral laths up to 0.5 mm long and 0.07 mm wide. Clinopyroxene phenocrysts are subhedral to anhedral in shape, up to 0.6 mm. Calcite filled amygdales are up to 0.5 mm diameter.

Thin Section 01GN14 (Figure B13)

The sample is a fine-grained equigranular medium-grained igneous rock dominated by plagioclase (60%) and clinopyroxene (30%), with minor olivine (6%) and magnetite (4%). Plagioclase crystals are euhedral to subhedral laths up to 0.65 mm in length and 0.1 mm in width, show polysynthetic and Carlsbad twinning. Clinopyroxene crystals are euhedral to subhedral up to 0.5 mm in diameter. Olivine crystals are euhedral to subhedral, up to 0.5 mm in diameter with some grains being partially replaced by greenish serpentine at margins and cracks. Magnetite crystals are euhedral to subhedral cubes up to 0.1 mm in diameter interstitially to silicate minerals.

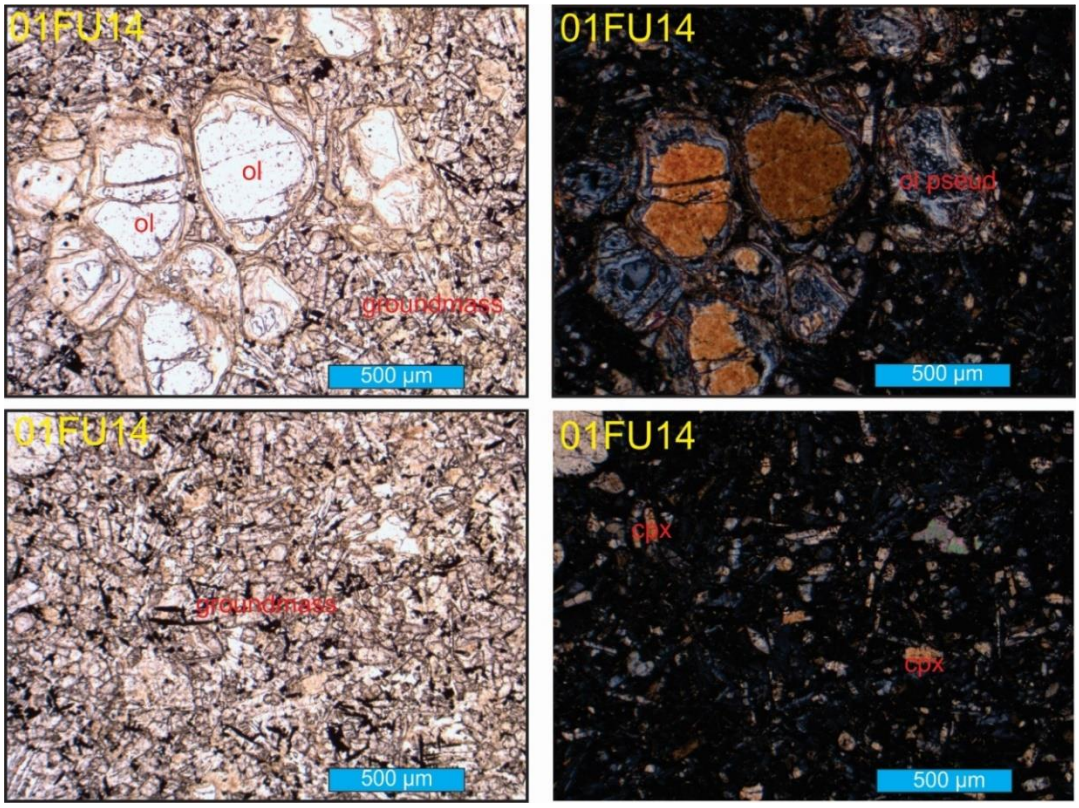

Figure B11: Photomicrographs of sample 01FU14. PPL (left) and XPL (right).

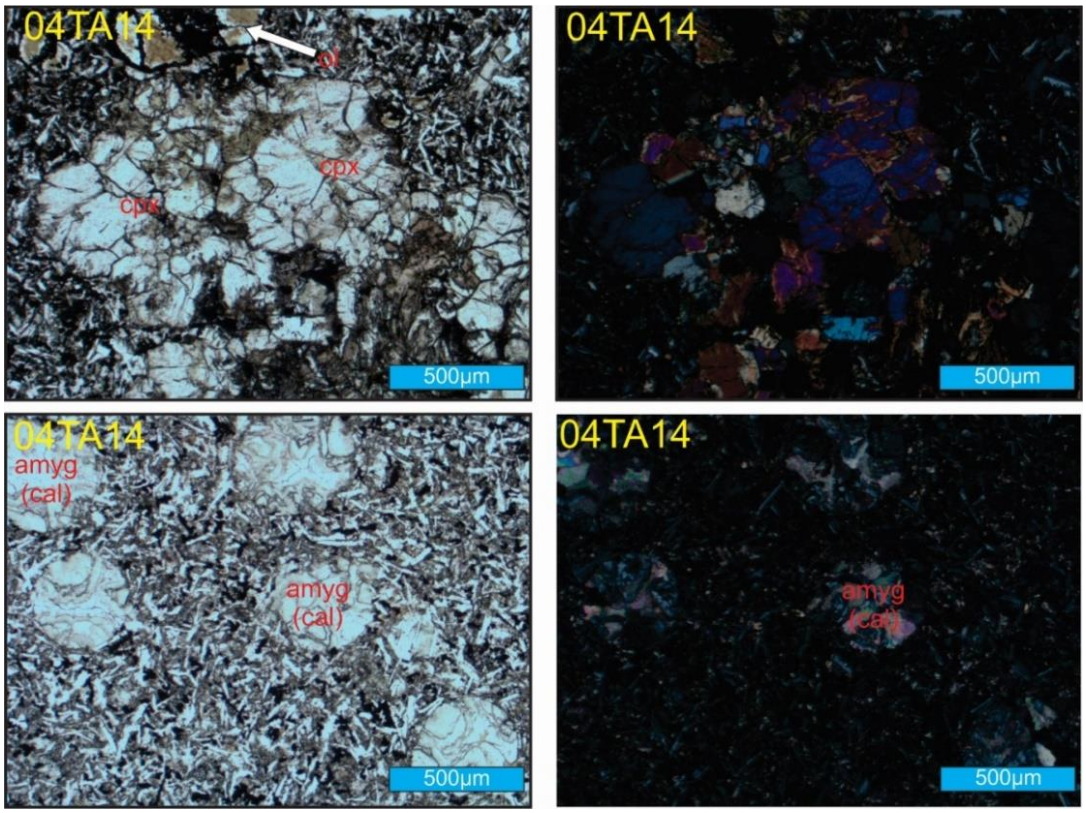

Figure B12: Photomicrographs of sample 04TA14. PPL (left) and XPL (right).

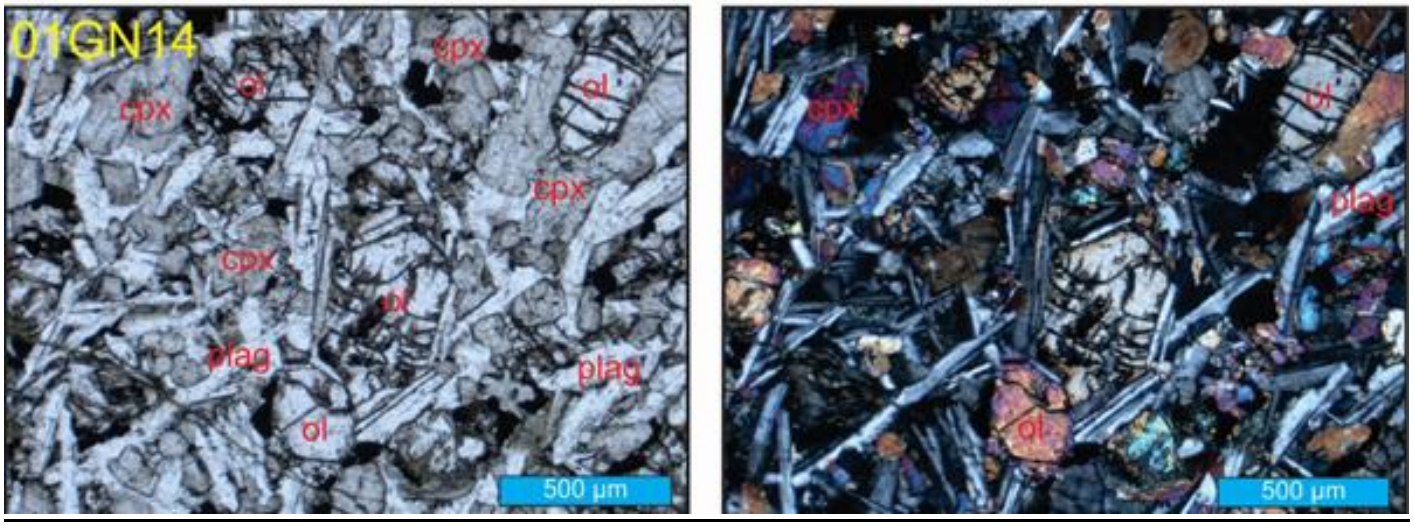

Figure B13: Photomicrographs of sample 01GN14. PPL (left) and XPL (right).

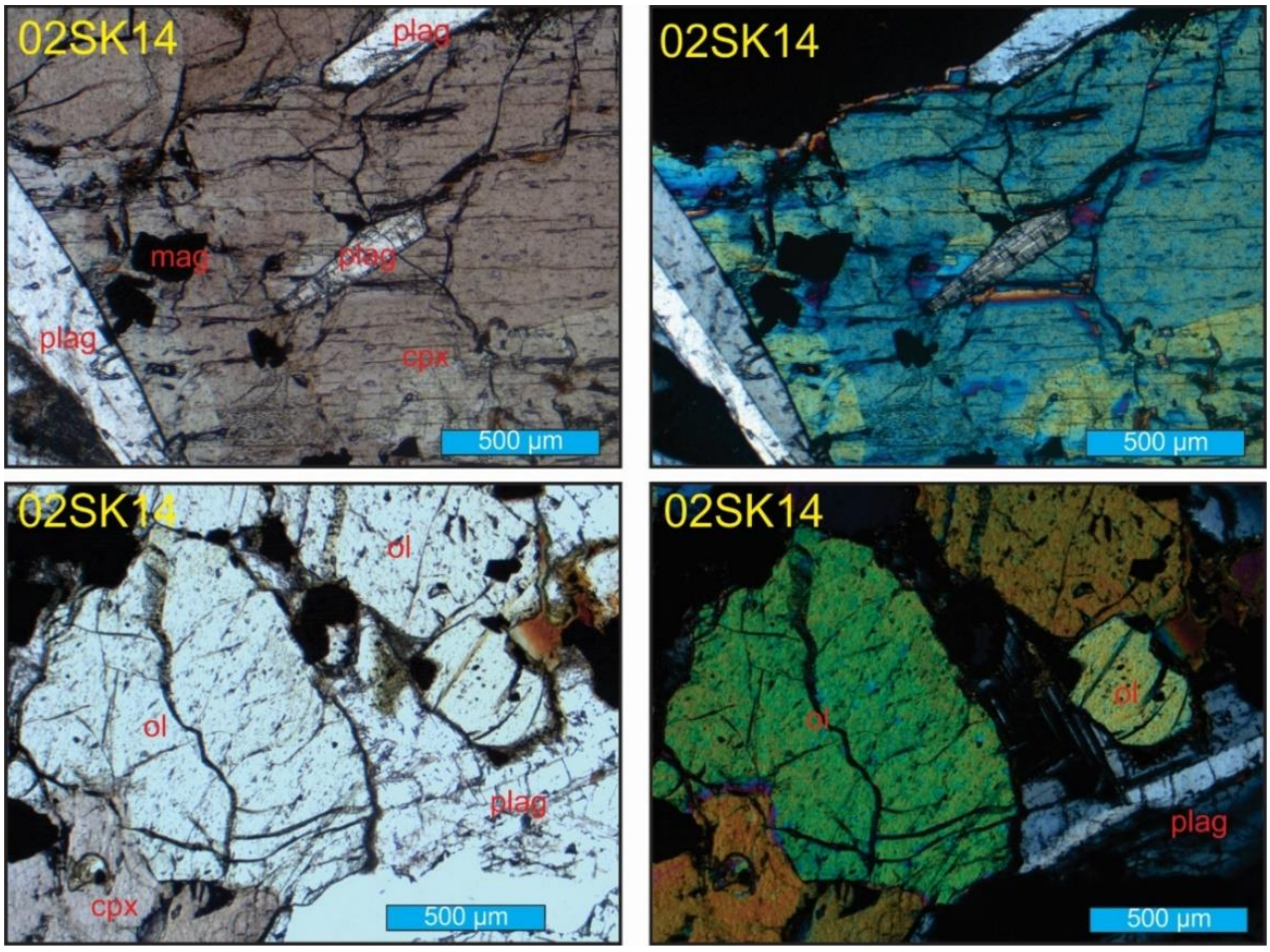

Figure B14: Photomicrographs of sample 02SK14. PPL (left) and XPL (right).

Thin Section 02SK14 (Figure B14)

The sample is a coarse-grained igneous rock dominated by plagioclase (50%), clinopyroxene (30%), and olivine (10%), with minor biotite (6%) and magnetite (4%). Plagioclase crystals are euhedral to subhedral laths up to 3.5 m min length and 0.4 mm in width, show polysynthetic twinning and locally sericitized. Clinopyroxene crystals are subhedral in shape, up to 2 mm in diameter, show perfect cleavage in two directions (90°), and Carlsbad twinning. Fox red biotite crystals form tabular grains, up to 0.2 mm long, and inferred to represent late stage crystallisation products from limited fluid ingress. Olivine crystals are euhedral to subhedral up to 1.2 m min diameter and are locally serpentinised along the edges.

Thin Section 06KK14(Figure B15)

The sample is a fine-grained equigranular igneous rock dominated by plagioclase (70%), a groundmass comprising partially altered clinopyroxene (20%), and opaque minerals probably comprising magnetite and ilmenite (10%). Plagioclase crystals are euhedral to subhedral laths up to 0.5 mm long and 0.1 mm wide, zoned, and partially sericitized. Calcite-filled amygdales up to 2.5 mm in diameter are evident.

Thin Section 02TA14 (Figure B16)

The sample is a fine-grained igneous rock dominated by plagioclase (60%) and clinopyroxene (30%), with minor opaque minerals (magnetite and ilmenite). Plagioclase crystals are euhedral to subhedral laths, up to 0.5 mm long and 0.15 mm wide, show polysynthetic and simple twinning, and exhibit radial crystallisation. Clinopyroxene crystals are euhedral to subhedral in shape up 0.65 mm in diameter, occur in between the plagioclase crystals, and are slightly affected by green alteration around cracks and along the edges. There is an amygdale with a quartz core and calcite on the rim.

Discussion and conclusions

Most samples examined were free from or contained weak alteration. This is mostly in the form of chlorite along cracks or at clinopyroxene grain boundaries, fox red biotite inferred as late stage magmatic crystallisation products, serpentine in cracks in olivine and minor incipient sericitization in some samples. The absence of significant secondary hydration alteration in these rocks combined with the preservation of skeletal and dendritic magnetite grains, devoid of exsolution can be used to infer that the rocks have not experienced significant subsolidus thermal re-equilibration and/or alteration and are consequently likely to preserve primary magnetic signatures and undisturbed Ar/Ar age spectra.

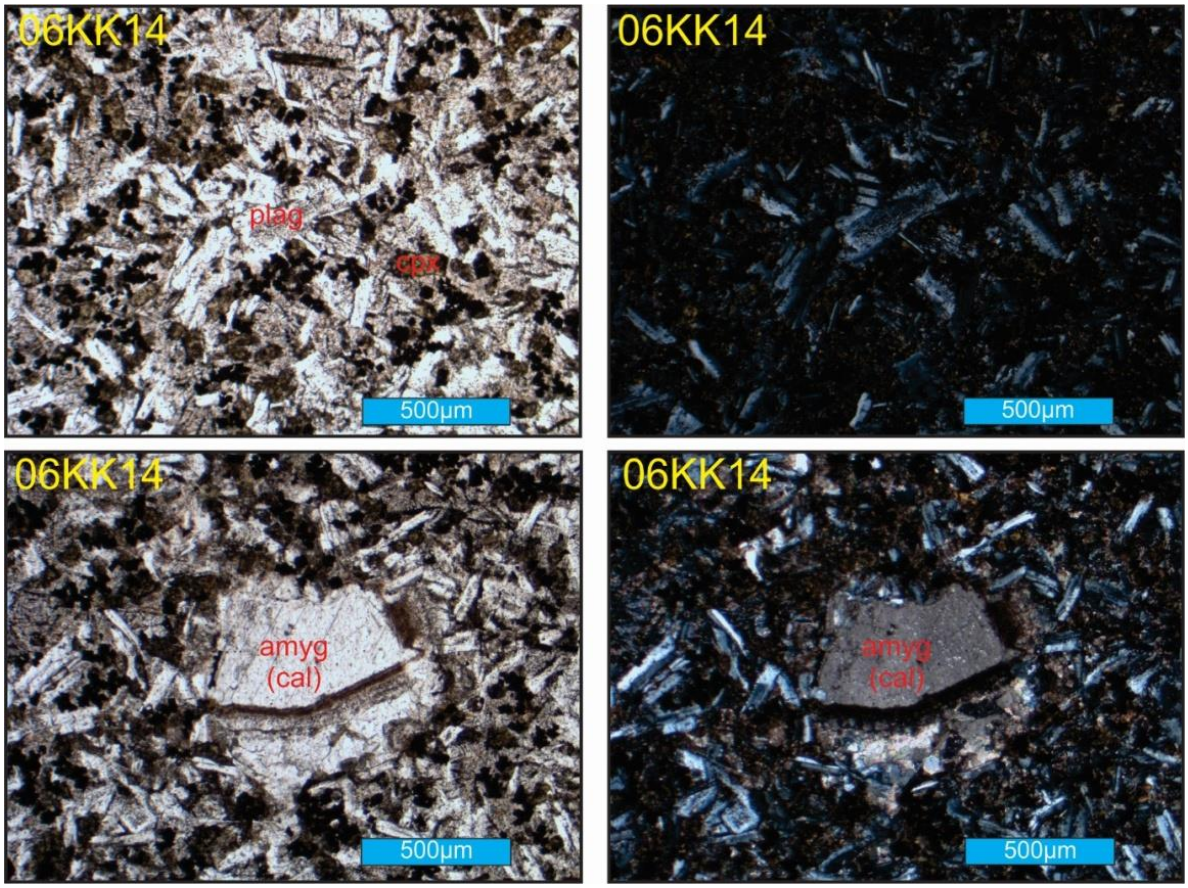

Figure B15: Photomicrographs of sample 06KK14. PPL (left) and XPL (right).

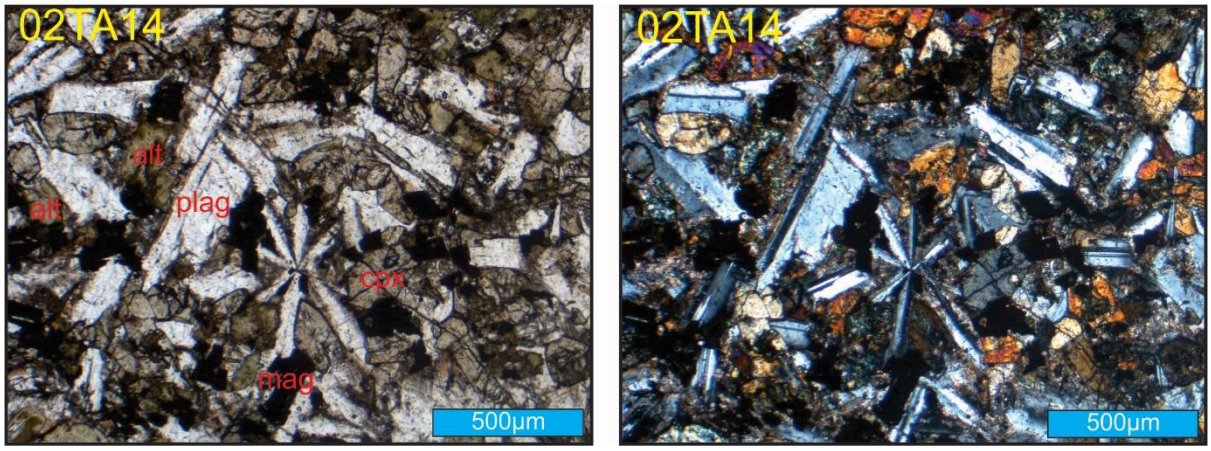

Figure B16: Photomicrographs of sample 02TA14. PPL (left) and XPL (right).

References

Henry, D.J., Guidotti, C.V. & Thomson, J.A. 2005. "The Ti-saturation surface for low-to-medium pressure metapelitic biotites: Implications for geothermometry and Ti-substitution mechanisms." *American Mineralogist* 316-328.