7. Petrographic Descriptions

Sample Number:	**Panda:**	**2594**
	WSP:	**BH2B_1105 17.40-17.90**
Rock Name:	**Mudstone**	

Petrographic Description

In hand specimen, this is a dull brownish grey mudstone that appears massive apart from a very subtle planar bedding. Fine silt sized grains of quartz, feldspar and mafic minerals are surrounded by a clay matrix. No veins are visible, and it is difficult to discern individual detrital grains within it. It is weakly magnetic.

Lithology: In thin section, this is a fine grained mudstone, in which there are scattered small (<0.2 mm) subangular detrital grains of quartz and albite, mica flakes, calcareous shell fragments, glauconite, opaque minerals, apatite and rare monazite in a clay-rich matrix. The shell fragments are up to 0.5 mm long, though most are less than 0.1 mm, and many are broken. Most are single chambers, but a few multi-chambered foraminifera tests are present. Small subhedral opaque crystals are up to 0.2 mm long, and most are made up of aggregates of very fine crystals (pyrite?). The clay-rich matrix is a dull brownish colour, and appears to be smectite.

Alteration: Most of these minerals appear to be detrital grains, although if there were detrital plagioclase crystals, they have mostly been replaced by albite. It is impossible to tell whether the smectite(?) clay is of detrital or diagenetic origin, or both. The opaque minerals appear to be largely secondary, particularly where they occur within foraminifera tests.

Veining: No veining or brecciation is visible within this sample.

Proportions (%): Smectite (50), quartz (20), calcite (14), albite (10), mica (3), opaques (2), glauconite (1), apatite (<1), monazite (<1)

XRD:

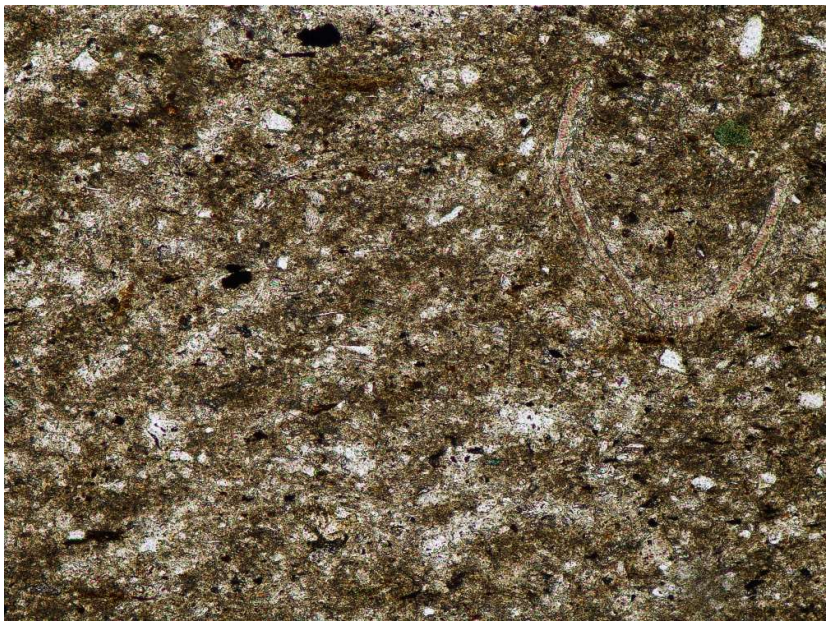

Photo 1: ***Sample 2594 (BH2B_1105 17.40):*** Mudstone containing shell fragments and small detrital grains in a clay matrix. Field of view = 1.2 mm, plane polarised light.

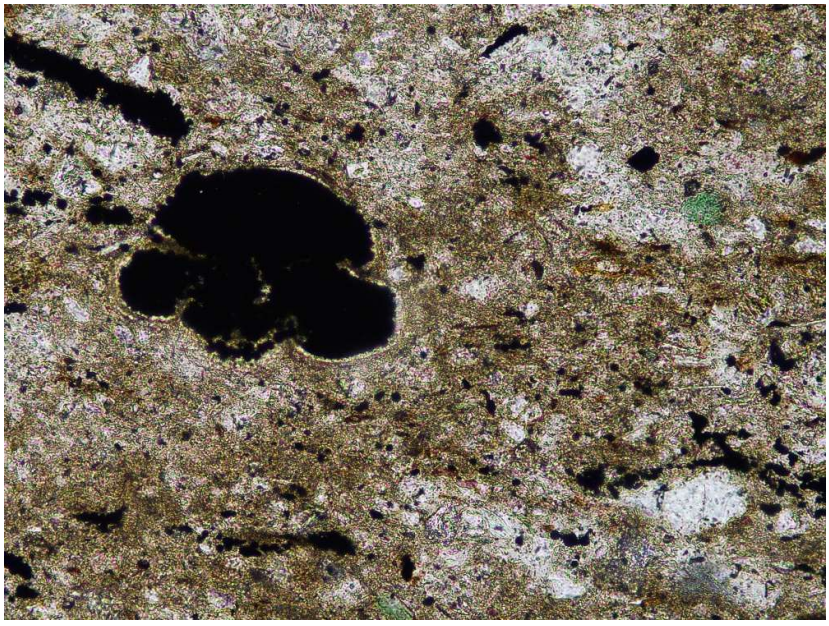

Photo 2: ***Sample 2594 (BH2B_1105 17.40):*** Foraminifera test infilled with opaque crystals. Field of view = 0.6 mm, plane polarised light.

Sample Number:	**Panda:**	**2595**
	WSP:	**BH2B_1105 21.60-22.00**
Rock Name:	**Mudstone**	

Petrographic Description

In hand specimen, this is a grey-brown mudstone that has very thin (~1 mm) planar bedding. It contains very small detrital grains of quartz, feldspar and mafic crystals in a muddy matrix. This sample is weakly magnetic. No veins are visible.

Lithology: In thin section, this rock contains fine (<0.1 mm) subangular fragments of quartz, calcite, albite and altered mafic crystals, disseminated opaque grains (magnetite?) and rare small apatite and zircon crystals in a matrix of very fine smectite and calcite. Fossil fragments include small calcareous shell fragments of foraminifera, rare bryozoans and what might have been sponge spicules. The bedding is not obvious in thin section.

Alteration: The mafic minerals have been altered to chlorite. In addition, at least some of the opaque minerals also appear to be secondary, including a few small (<0.2 mm) framboidal aggregates that are probably pyrite.

Veining: No veins were seen in this sample.

Proportions (%): Smectite (60), calcite (30), quartz (6), albite (2), opaques (1), apatite (<1), zircon (<1)

XRD:

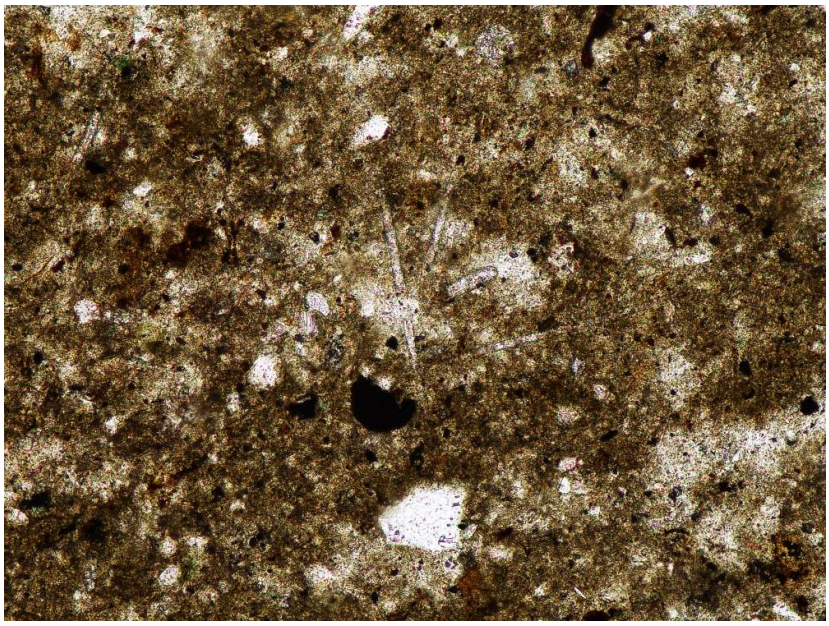

Photo 3: ***Sample 2595 (BH2B_1105 21.60):*** Mudstone with detrital crystal fragments and sponge spicules. Field of view = 1.2 mm, plane polarised light.

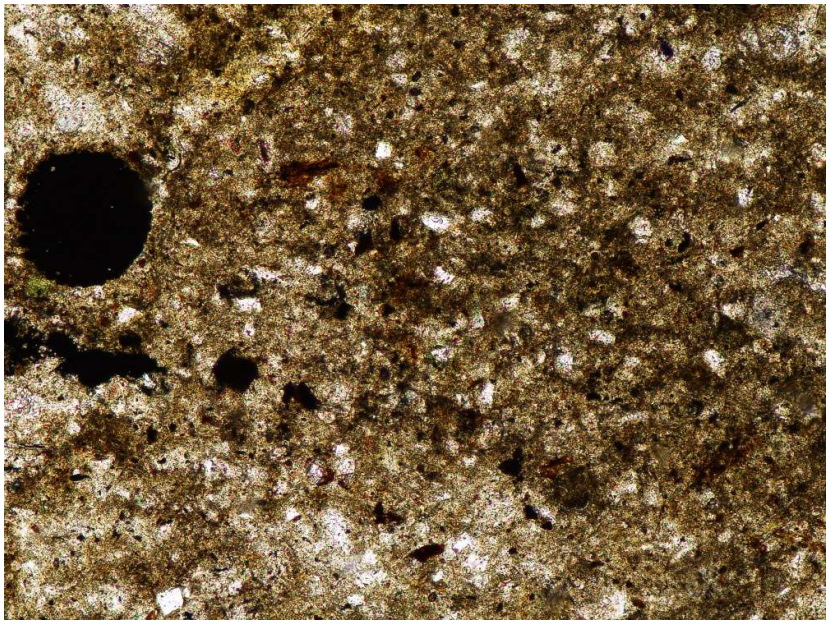

Photo 4: ***Sample 2595 (BH2B_1105 21.60):*** Framboidal pyrite(?) aggregate (left) in mudstone. Field of view = 1.2 mm, plane polarised light.

Sample Number:	**Panda:**	**2597**
	WSP:	**BH2B_1105 38.25**
Rock Name:	**Calcareous Siltstone**	

Petrographic Description

In hand specimen, this is a medium grey rock that is weakly bedded. It has a fine grained clastic texture, with various detrital crystals in a fine matrix. It is weakly magnetic, and contains elongate patches of very fine pyrite crystals. No veins are present.

Lithology: In thin section, this is a siltstone which contains common small calcareous fossil fragments and detrital crystals in a muddy carbonate matrix. The fossil fragments are mostly multi-chambered planktic foraminifera tests that are 0.1 to 0.2 mm across, along with a few equally small bryozoan fragments. The detrital grains are predominantly subangular quartz crystals, with a few crystals of albite, K-feldspar, plagioclase, opaque minerals (magnetite?), glauconite, biotite, apatite and zircon. The matrix surrounding the crystal and fossil fragments comprises fine calcite and minor clay (smectite), with opaque minerals in places.

Alteration: Some of the feldspar crystals are partly altered to calcite, and some to clay (smectite). Most of the foraminifera tests have been infilled with calcite, though some are filled with clay, and others with opaque minerals (pyrite?).

Veining: No veining or brecciation is visible in this sample.

Proportions (%): Calcite (45), quartz (25), smectite (5), albite (5), K-feldspar (2), plagioclase (1), opaques (1), glauconite (<1), biotite (<1), apatite (<1), zircon (<1)

XRD:

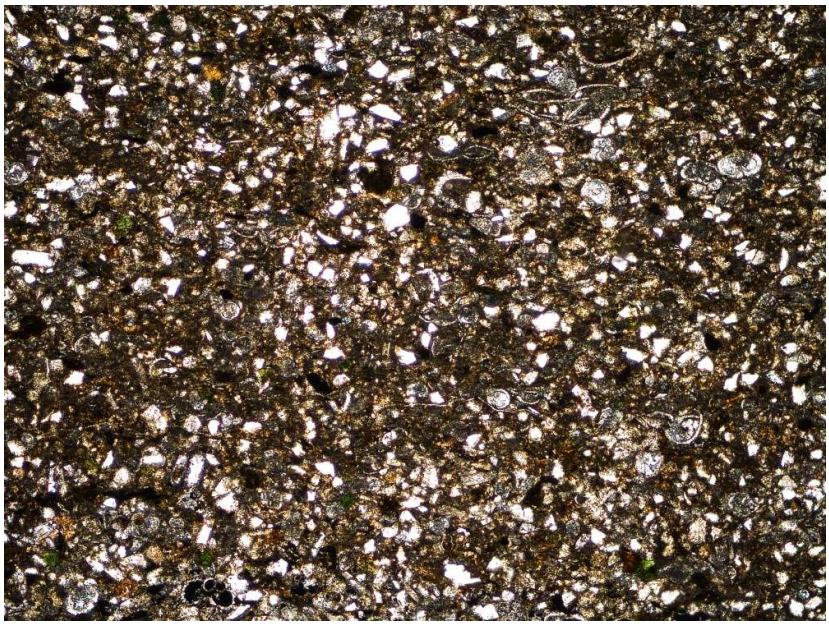

Photo 7: ***Sample 2597 (BH2B_1105 38.25):*** Calcareous siltstone, containing rounded foraminifera tests and subangular detrital crystals in a matrix of fine calcite and clay. Field of view = 3.0 mm, plane polarised light.

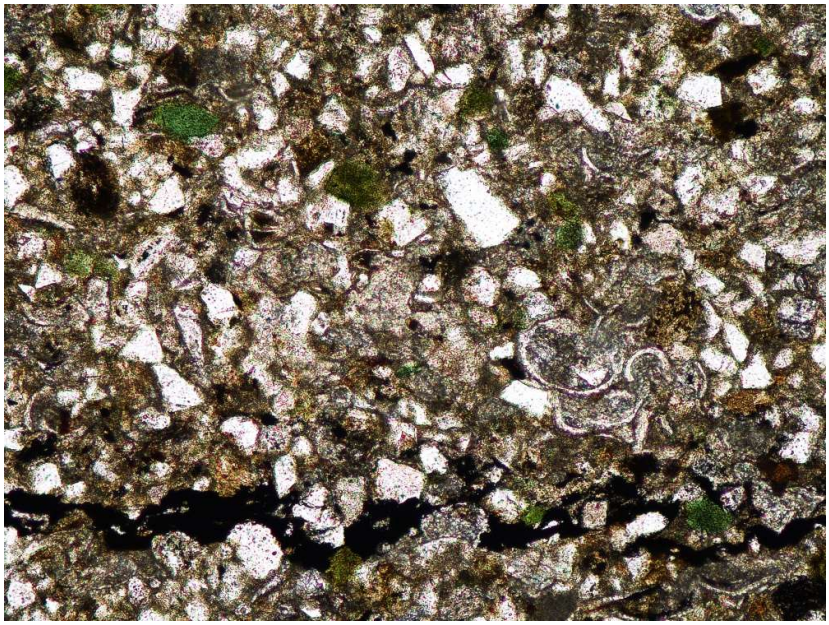

Photo 8: ***Sample 2597 (BH2B_1105 38.25):*** Enlargement, showing glauconite (top left), and a band of fine opaque minerals (bottom). Field of view = 1.2 mm, plane polarised light.

Sample Number:	**Panda:**	**2596**
	WSP:	**BH2B_1105 42.40**
Rock Name:	**Brecciated Veined Siltstone**	

Petrographic Description

In hand specimen, this is an indurated grey rock that has a chaotic brecciated texture. Parts are very fine grained and faintly bedded, while other parts are medium grained and massive. There are numerous thin veins that are mostly discontinuous, and range from white to pale greenish. Very small pyrite grains are sparsely disseminated, and this rock is non-magnetic.

Lithology: In thin section, textures vary, but the clasts are predominantly siltstone, containing small (up to 0.4 mm) subangular to subrounded detrital crystals of quartz, altered plagioclase and mafic minerals, and altered (volcanic?) rock fragments in a muddy matrix. Rare small primary apatite crystals were also seen. Parts of the rock are finer grained mudstones, in which there are fewer detrital crystals and more clay.

Alteration: Alteration of this sample is intense, with quartz and apatite the only remaining primary minerals. Plagioclase has been replaced by albite, which in turn has been largely replaced by fine grained clay (illite). The rock fragments also consist of secondary albite and illite, with minor quartz, chlorite and opaque minerals. Where mafic minerals could be identified, they have been replaced by chlorite and opaque minerals.

Veining: This rock is cut by a network of closely spaced thin fractures and veins at various orientations, and many of the breccia clasts are internally veined. Most of the veins are less than 0.1 mm thick, and composed of fine grained quartz. A few veins also contain minor illite and/or opaque minerals, and there are common clay-filled fractures. Most of these veins and fractures are discontinuous, and terminate where they intersect other veins or shear fractures. The rock is also cut by a number of open fractures at various orientations.

Brecciation: This rock has a chaotic brecciated texture, comprising millimetre to centimetre sized fragments of altered siltstone and mudstone, most of which are internally veined, with irregular equant to elongate outlines. The breccia clasts are tightly packed in a clay-rich matrix, and cut by numerous thin veins and shear fractures.

Proportions (%): Quartz (42), albite (25), illite (24), chlorite (7), opaques (2), apatite (<1)

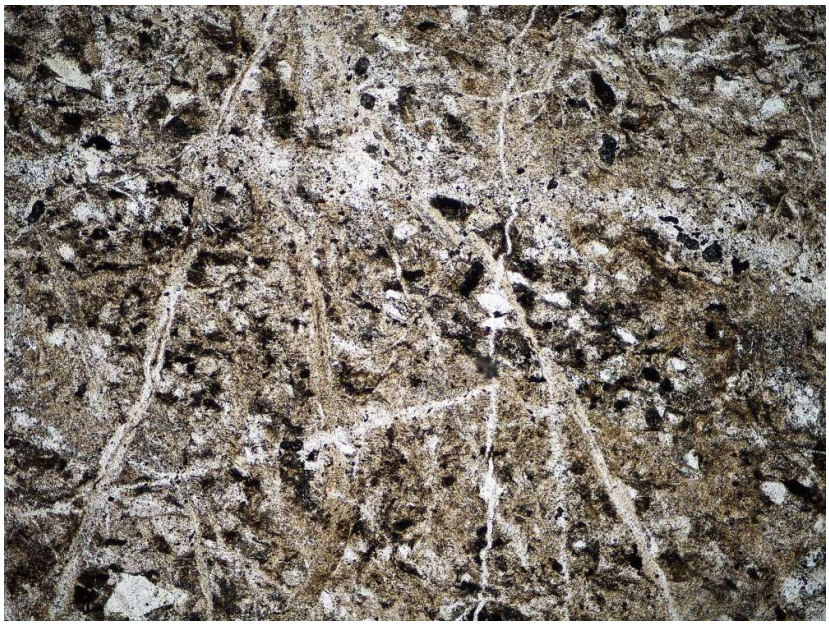

Photo 5: ***Sample 2595 (BH2B_1105 42.40):*** Siltstone with detrital quartz and altered feldspar, mafic minerals and rock fragments in a clay-rich matrix, cut by numerous thin veins. Field of view = 3.0 mm, plane polarised light.

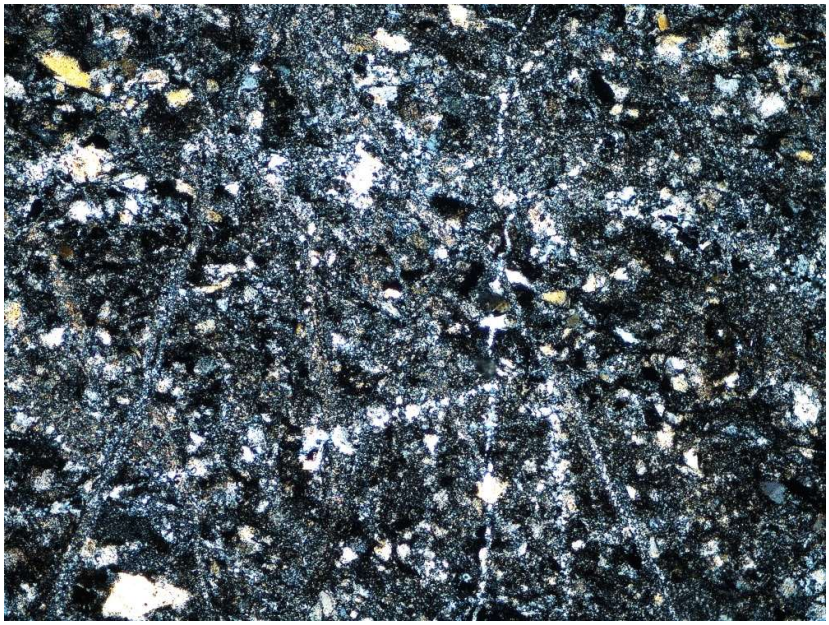

Photo 6: ***Sample 2595 (BH2B_1105 42.40):*** Same as above, crossed polarisers.

Sample Number:	**Panda:**	**2609**
	WSP:	**BH2B_1117 22.35**
Rock Name:	**Veined Sandstone**	

Petrographic Description

In hand specimen, this is an indurated grey sandstone which is cut by a number of white veins, many of which are subparallel, and which appear to be associated with shear fractures. In addition, there are a few short vein fragments. Fine pyrite is sparsely disseminated within the host rock. This sample is non-magnetic.

Lithology: In thin section, the sandstone contains mostly subrounded crystal fragments up to 1 mm long of quartz, plagioclase, K-feldspar, epidote, altered mafic minerals, opaque minerals, and rare biotite, white mica, apatite and zircon. In addition, there are fragments of altered volcanic rocks that contain altered plagioclase and mafic phenocrysts in a fine groundmass. These sand sized grains are tightly packed together, with no visible matrix between them, and no obvious bedding or alignment of the sand grains.

Alteration: Alteration is strong. Almost all of the plagioclase has been replaced by albite and illite, and K-feldspar by illite, while most of the mafic minerals (including within volcanic fragments) have been replaced by chlorite ± quartz, titanite and opaque minerals. Some of the volcanic rock fragments have been replaced by fine grained quartz, but most are now composed of fine albite, illite, chlorite, opaque minerals and titanite. Parts of the rock around some of the quartz-prehnite veins have been strongly altered to prehnite.

Veining: Within this sample, there is a 2 to 5 mm wide zone with common vein material, but in the form of brecciated elongate vein fragments. The vein fragments are up to 10 mm long, and occur together with equally large host rock fragments. The vein fragments include dense aggregates of prehnite; prehnite with quartz; and quartz enclosing prismatic prehnite crystals. Elsewhere in the sample there are veins and vein fragments containing prehnite; quartz and prehnite; and quartz with chlorite ± adularia. None of these veins are more than 0.5 mm wide.

Brecciation: The brecciated shear zone contains elongate angular host rock and quartz-prehnite vein fragments within a matrix of fine to medium grained quartz that in places encloses crystals of adularia, and in other parts, prismatic prehnite, plus minor chlorite. These minerals enclose and support the brecciated clasts, and

indicate that although brecciation was associated with shearing, it also coincided with a period of vein deposition.

Proportions (%): Quartz (42), prehnite (20), albite (12), K-feldspar (10), chlorite (8), illite (6), opaques (1), epidote (<1), plagioclase (<1), biotite (<1), white mica (<1), apatite (<1), zircon (<1), titanite (<1)

XRD:

Photo 23: ***Sample 2609 (BH2B_1117 22.35):*** Breccia, comprising elongate sandstone and vein fragments in a quartz-rich matrix. Field of view = 3.0 mm, plane polarised light.

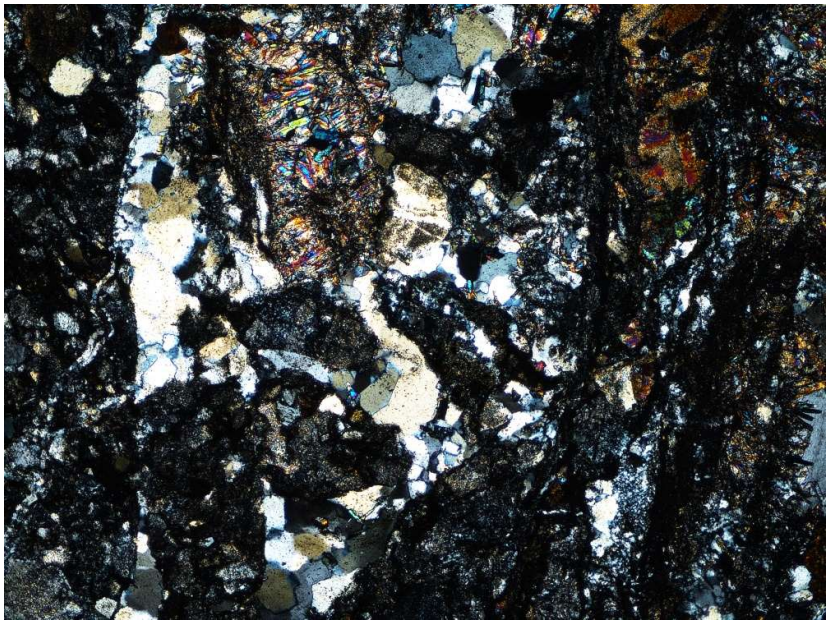

Photo 24: ***Sample 2609 (BH2B_1117 22.35):*** Same as above, crossed polarisers.

Sample Number:	**Panda:**	**2600**
	WSP:	**BH2B_1144 25.60**
Rock Name:	**Brecciated Veined Mudstone**	

Petrographic Description

In hand specimen, this is an indurated medium greenish grey fine grained rock that is cut by many thin veins at various orientations. The veins range from grey to white and pale greenish, and most are less than 1 mm wide. A few extend for several centimetres, but many are just a few millimetres long. This sample is non-magnetic.

Lithology: In thin section, this sample is very fine grained, with just a few scattered silt-sized (up to 0.1 mm) subangular detrital grains in a clay-rich matrix. The detrital grains are mostly quartz, along with plagioclase, K-feldspar and rare apatite, and indeterminate altered mafic minerals and rock fragments. The matrix appears to have been very fine grained, but now consists entirely of secondary minerals. In places, there is a planar texture that might reflect primary bedding, but could also result from shear deformation.

Alteration: Alteration of this sample is strong. The detrital quartz, apatite, and some of the plagioclase and K-feldspar crystals are preserved. The remainder of the rock, including the matrix and many of the detrital grains, has been replaced by prehnite and clay (illite), with minor chlorite, albite, quartz and opaque minerals.

Veining: Many of the veins within this sample are quartz-rich, but few contain only quartz. Some of the quartz veins contain minor to common adularia crystals, others contain prehnite, and a few quartz veins contain opaque minerals. The oldest brecciated veins consist entirely of prehnite.

Brecciation: This sample has a fragmented, brecciated texture, with veins and shear fractures separating blocks of mudstone, and truncating many of the older veins.

Proportions (%): Quartz (42), prehnite (34), illite-smectite (15), chlorite (3), adularia (2), albite (2), K-feldspar (1), opaques (1), apatite (<1)

XRD:

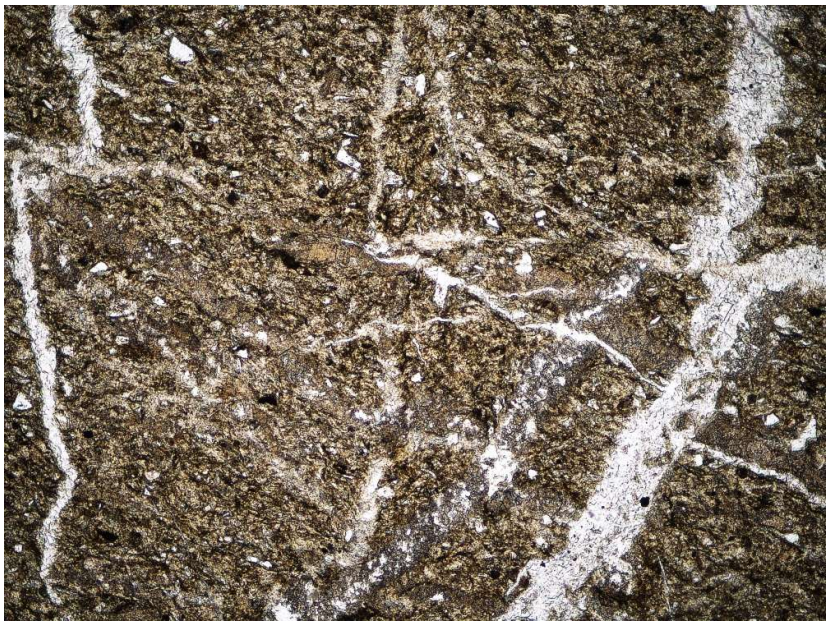

Photo 9: ***Sample 2600 (BH2B_1144 25.60):*** Mudstone cut by veins containing quartz, prehnite and adularia. Field of view = 3.0 mm, plane polarised light.

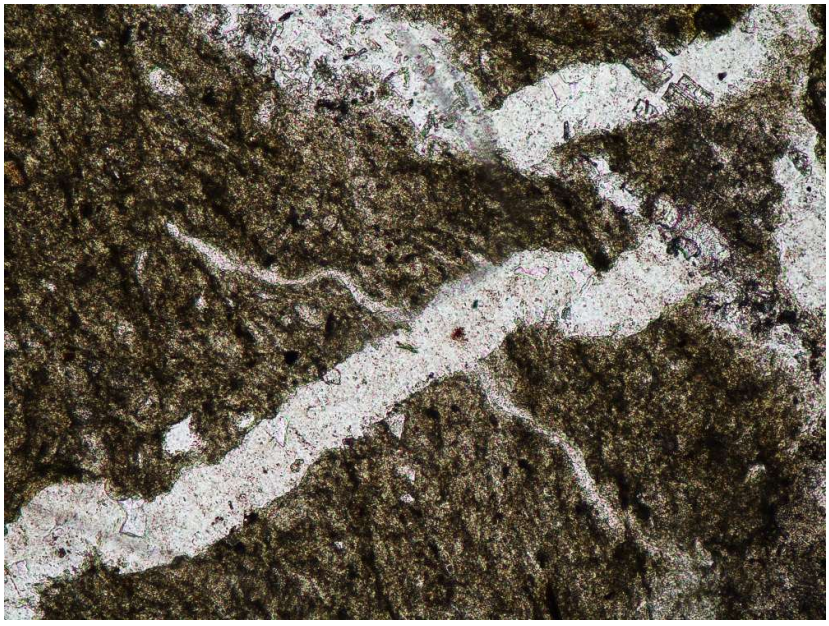

Photo 10: ***Sample 2600 (BH2B_1144 25.60):*** Veins of quartz with adularia (e.g. bottom left) and quartz with prehnite (top right). Field of view = 1.2 mm, plane polarised light.

±Sample Number:	**Panda:**	**2601**
	WSP:	**BH2B_1144 32.40**
Rock Name:	**Brecciated Veined Siltstone/Mudstone**	

Petrographic Description

This hand specimen is an indurated medium grey fine grained rock that is brecciated and cut by numerous thin veins and fractures. It appears to be a fine siltstone or mudstone. Veins are mostly less than 1 mm wide, and have two main orientations that are almost perpendicular. Very fine pyrite crystals are common on some of the fracture planes. This sample is very weakly magnetic.

Lithology: In thin section, the rock incorporates both siltstone and mudstone beds. Within the siltstone, there are common subangular detrital grains up to 0.2 mm of quartz, K-feldspar, opaque minerals, apatite and zircon, and completely altered plagioclase, mafic minerals and rock fragments in a clay-rich matrix. Some of the rock fragments retain porphyritic textures that point to a volcanic origin. The mudstone parts are similar, except that there are just scattered small detrital grains, and the clay-rich matrix predominates. Both siltstone and mudstone are vaguely bedded, with elongate detrital grains oriented parallel to the contacts between siltstone and mudstone beds.

Alteration: Alteration of this sample is very strong. Plagioclase has been replaced by albite and illite, and K-feldspar grains are partly altered to illite. The mafic minerals and rock fragments have been completely altered to a mixture of quartz, prehnite, albite, illite, chlorite and opaque minerals. The fine grained matrix is composed of chlorite and illite with scattered prehnite, quartz and opaque minerals.

Veining: Few of the veins in this sample are quartz-rich. Some contain prehnite ± quartz and opaque minerals, and some contain quartz with adularia ± chlorite. Many of the prehnite veins are fractured and broken into sections that might be as short as 1 mm. In addition, there are a few fractures that are lined with pale green chlorite.

Brecciation: This sample is strongly sheared and fractured, with both the host rock and the veins broken into millimetre to centimetre sized brecciated fragments that are tightly packed in a clastic matrix.

Proportions (%): Quartz (44), prehnite (18), chlorite (15), illite (12), albite (5), K-feldspar (3), adularia (2), opaques (1), apatite (<1), zircon (<1)

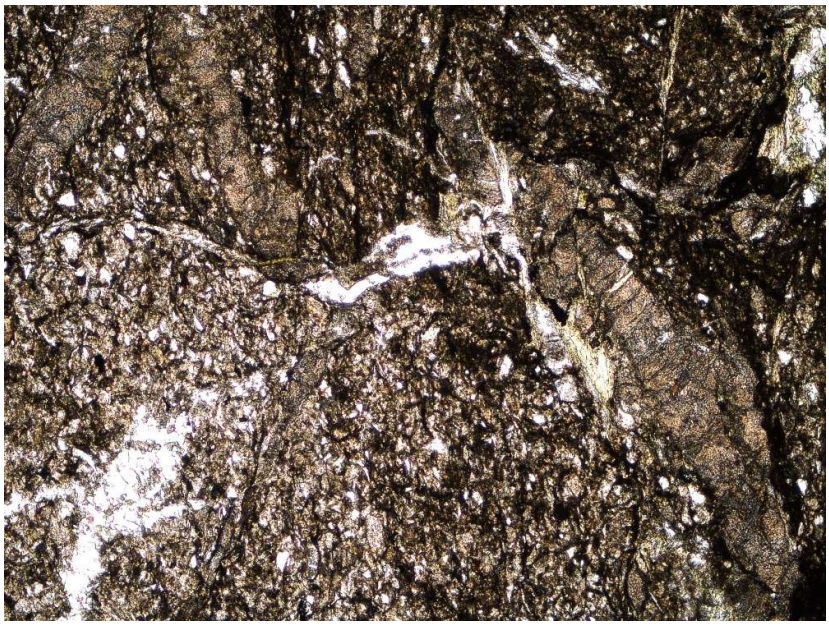

Photo 11: ***Sample 2601 (BH2B_1144 32.40):*** Brecciated veins of prehnite (e.g. top left), and quartz with adularia (bottom left) in siltstone and mudstone. Field of view = 3.0 mm, plane polarised light.

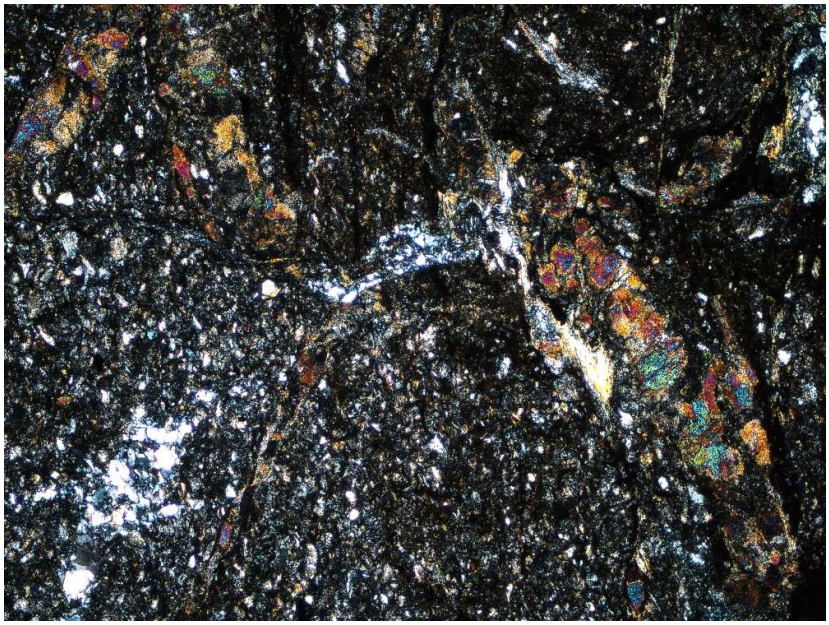

Photo 12: ***Sample 2601 (BH2B_1144 32.40):*** Same as above, crossed polarisers.

Sample Number:	**Panda:**	**2603**
	WSP:	**BH2B_1144 40.50**
Rock Name:	**Veined Siltstone**	

Petrographic Description

In hand specimen, this is an indurated grey fine grained rock that has a fine clastic texture. It is cut by a number of thin veins, many of which are white, though some are orange-brown. Several of these veins end abruptly or are offset on fractures. This sample is non-magnetic.

Lithology: In thin section, the siltstone is composed of subangular to subrounded detrital crystals and rock fragments that are mostly 0.1 to 0.2 mm across. The crystal fragments include quartz, plagioclase, K-feldspar, epidote, clinopyroxene, apatite and zircon, plus unidentified altered mafic minerals. The rock fragments are intensely altered, but at least some of these appear to have been volcanic. The detrital crystals are tightly packed, such that it is difficult to discern any matrix material between them. There is no obvious bedding or layering visible within this sample.

Alteration: Alteration of this sample is strong, with quartz, epidote, apatite, zircon, and some of the plagioclase and K-feldspar preserved. Most of the plagioclase has been replaced by albite and illite, while illite is also common within K-feldspar. Mafic minerals have been replaced by chlorite ± quartz and opaque minerals, and the rock fragments by various combinations of quartz, albite, illite, chlorite and opaque minerals.

Veining: Several generations of veins are visible within the thin section. The oldest of these, which consist of prehnite ± minor quartz, are up to 0.2 mm thick, and occur as fragmented vein sections. They are cut by younger veins up to 2 mm thick of quartz with minor chlorite and adularia, which in turn are cut and offset by chlorite-lined shear fractures. Cutting across all of those features are very thin (<0.2 mm) semi-planar calcite veins, some of which are lined by brown iron oxides.

Brecciation: This sample does not appear brecciated, though it is cut by a number of shear fractures that offset many of the veins within it.

Proportions (%): Quartz (44), illite (18), chlorite (12), prehnite (10), albite (6), K-feldspar (5), calcite (2), adularia (1), opaques (1), epidote (<1), plagioclase (<1), clinopyroxene (<1), apatite (<1), zircon (<1)

XRD:

Photo 15: ***Sample 2603 (BH2B_1144 40.50):*** Siltstone, cut by a thin continuous calcite vein (bottom) and fragmented quartz (top right) and prehnite (centre right) veins. Field of view = 3.0 mm, plane polarised light.

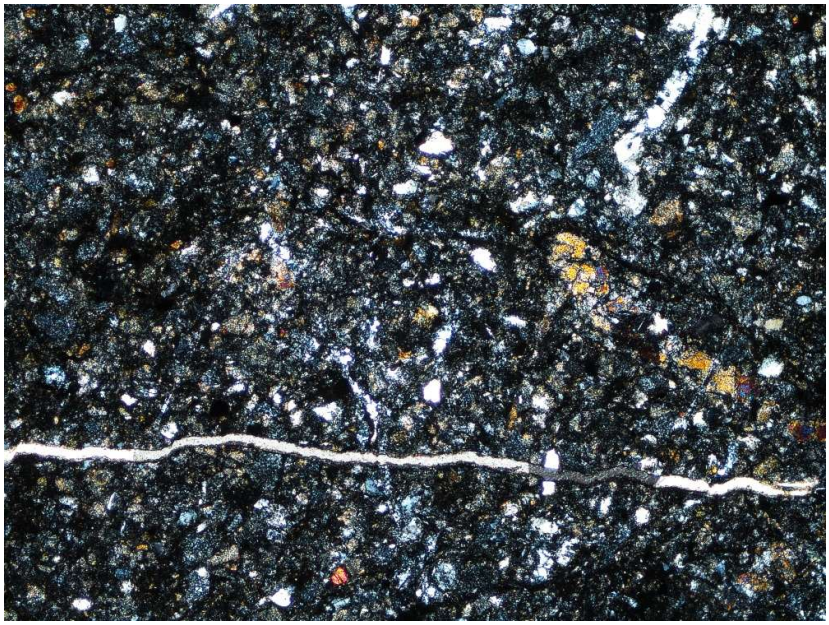

Photo 16: ***Sample 2603 (BH2B_1144 40.50):*** Same as above, crossed polarisers.

Sample Number:	**Panda:**	**2604**
	WSP:	**BH2B_1144 40.95**
Rock Name:	**Veined Siltstone**	

Petrographic Description

In hand specimen, this is an indurated grey siltstone that is cut by numerous veins and several shear fractures. The siltstone appears massive, with no visible bedding or sedimentary textures. It contains rare fine disseminated pyrite. The veins range from white to pale greenish, and are cut by the shear fractures. This sample is non-magnetic.

Lithology: In thin section, the siltstone contains subangular to subrounded detrital quartz, plagioclase, K-feldspar, clinopyroxene, epidote, opaque minerals, apatite and zircon crystals, altered rock fragments and unidentified altered mafic minerals. These detrital grains are mostly 0.1 to 0.2 mm long and subangular to subrounded. They are tightly packed together, with little or no matrix material between them.

Alteration: Alteration of this sample is strong. Most of the plagioclase has been replaced by albite, which in turn has been largely altered to illite. Detrital K-feldspars are also strongly altered to illite. Except for a few clinopyroxene crystals, the mafic minerals have been replaced by chlorite ± quartz, and rock fragments have been replaced by one or more of quartz, albite, chlorite, illite and opaque minerals.

Veining: Veins are common within this sample, and although most are thin, some are several millimetres thick in places. The oldest, fragmented veins consist of medium grained cloudy prehnite. Younger veins contain quartz with prehnite, including euhedral rectangular prehnite crystals in some veins. Other veins contain quartz with chlorite and rare adularia. Some calcite and chlorite fill interstitial spaces in one of the quartz-prehnite veins.

Brecciation: This sample does not appear brecciated, although it is cut by several semi-planar shear fractures that are filled with chlorite and/or quartz, and which offset all of the veins.

Proportions (%): Quartz (50), prehnite (20), chlorite (10), illite (8), K-feldspar (4), albite (5), plagioclase (2), calcite (<1), adularia (<1), epidote (<1), opaques (<1), clinopyroxene (<1), apatite (<1), zircon (<1)

XRD:

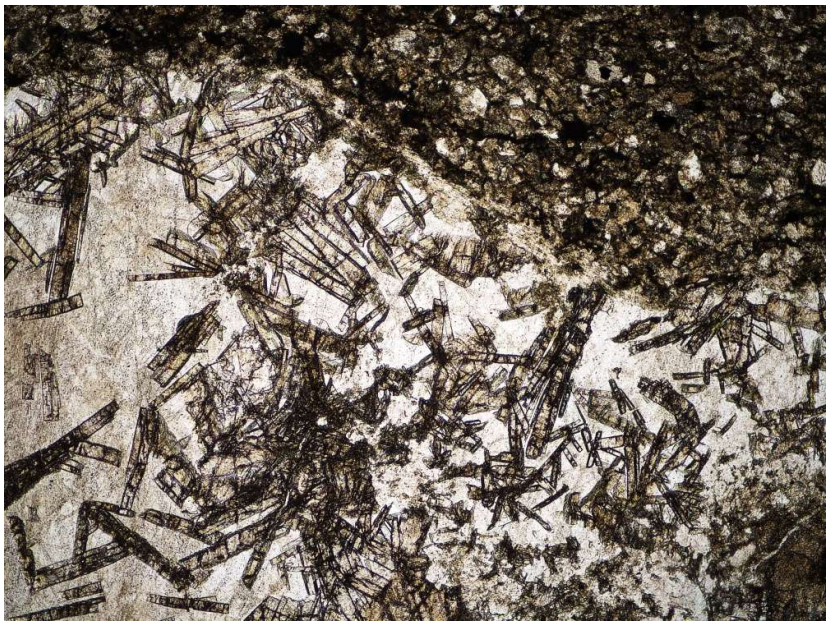

Photo 17: ***Sample 2604 (BH2B_1144 40.95):*** Vein containing quartz and prehnite cutting siltstone. Field of view = 3.0 mm, plane polarised light.

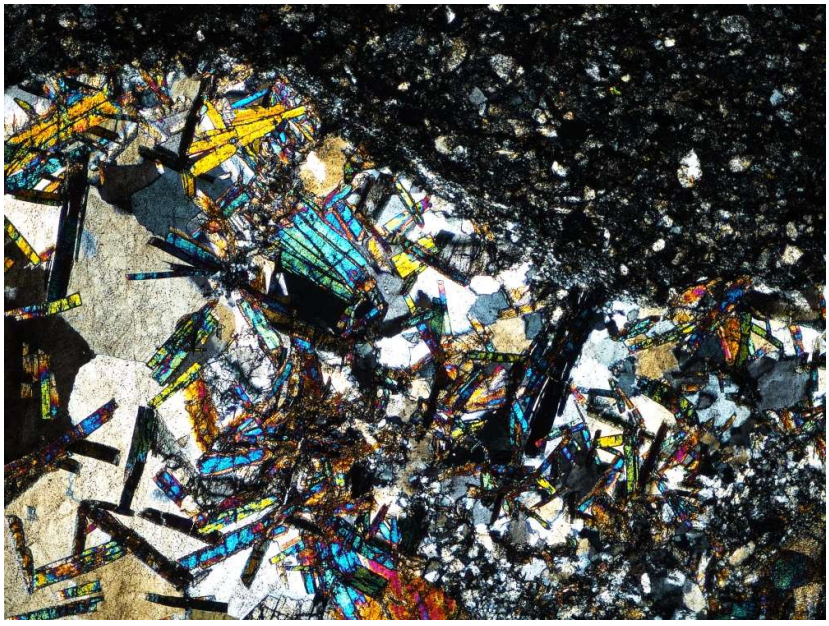

Photo 18: ***Sample 2604 (BH2B_1144 40.95):*** Same as above, crossed polarisers.

Sample Number:	**Panda:**	**2606**
	WSP:	**BH2B_1144 53.40**
Rock Name:	**Brecciated Veined Siltstone**	

Petrographic Description

In hand specimen, this is an indurated grey rock with a fine grained clastic texture. It is cut by thin white veins, many of which are discontinuous broken fragments, and some of them enclosing small open spaces. This sample is non-magnetic.

Lithology: In thin section, this is a siltstone, which contains subangular to subrounded detrital grains of quartz, plagioclase, K-feldspar, epidote, apatite, opaque minerals and completely altered mafic minerals and rock fragments. The detrital grains are up to 0.2 mm long, and are tightly packed together, with no interstitial matrix material readily discernible.

Alteration: Alteration of the detrital minerals is strong. Most of the plagioclase has been replaced by albite and illite, and K-feldspars have likewise been partly replaced by illite, whereas mafic minerals have been altered to quartz, chlorite and opaque minerals. In addition, the prehnite within veins has been partly replaced, as described below.

Veining: Several generations of veins are present within this sample. Prehnite-rich veins have been fragmented and altered, such that the prehnite that remains has irregular corroded margins. That prehnite is surrounded and largely replaced by masses of fine grained quartz, illite and chlorite. Very small prismatic prehnite crystals are preserved within one 0.8 mm quartz-rich vein however. Other veins are less than 0.5 mm wide, and include veins of quartz ± chlorite and/or adularia, and quartz with a band of prismatic zeolite(?) crystals at the margins.

Brecciation: This sample is cut by several shear fractures, and some of these offset all of the veins they intersect, including the quartz-zeolite veins. Some of the shear fractures are marked by thin zones that are filled with quartz and chlorite, while a few are up to 2 mm wide and comprise fine breccias that contain small angular siltstone and vein fragments in a largely clastic matrix. A number of shear fractures are subparallel, though others are at a high angle to those fractures. Many of the oldest veins have been brecciated, but brecciation textures are difficult to discern within the siltstone.

Proportions (%): Quartz (42), chlorite (16), illite (15), K-feldspar (12), albite (10), prehnite (2), plagioclase (1), adularia (1), zeolite (<1), opaques (1), apatite (<1)

XRD:

Photo 21: ***Sample 2606 (BH2B_1144 53.40):*** Brecciated shear zone (left side) cutting a quartz vein with small prismatic prehnite crystals and other thin quartz-rich veins. Thin (post-shear?) quartz-zeolite veins are present at left and right in siltstone. Field of view = 3.0 mm, plane polarised light.

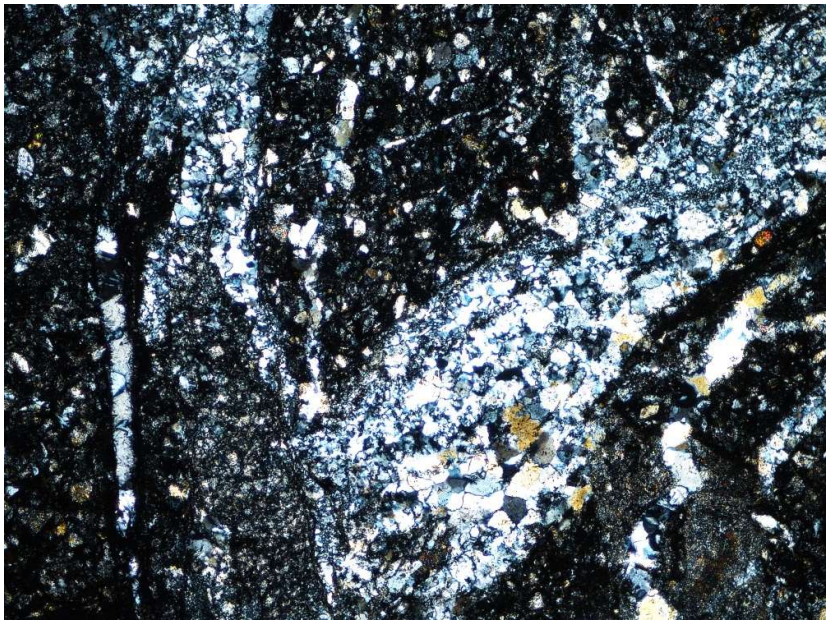

Photo 22: ***Sample 2606 (BH2B_1144 53.40):*** Same as above, crossed polarisers.

Sample Number:	**Panda:**	**2605**
	WSP:	**BH2B_1144 51.60**
Rock Name:	**Brecciated Veined Sandstone/Siltstone**	

Petrographic Description

The hand specimen is an indurated grey rock with a fine grained clastic texture. It is cut by several thin white veins, many of which are fragmented, and striated shear fractures are visible on some rock surfaces. Some of the veins have vuggy textures, with those vugs lined by colourless rectangular crystals. This sample is non-magnetic.

Lithology: In thin section, parts of the rock are sandstone, while other parts are siltstone, and there is also minor mudstone. However, contacts between these lithologies mostly correspond to shear fractures and veins, rather than sedimentary contacts. The areas of sandstone contain subangular to subrounded crystal and rock fragments up to 1 mm across. The crystal fragments are predominantly quartz, plagioclase and K-feldspar, with a few altered mafic minerals. Most of the rock fragments are volcanic (andesites?), though one may be granitic. The siltstones contain smaller (<0.2 mm) subangular grains of quartz, plagioclase, K-feldspar, altered mafic minerals, opaque minerals and rock fragments in a fine matrix. Apatite is visible as small inclusions within quartz and feldspar crystals. The mudstones contain fewer and smaller detrital grains, and a much greater volume of clay-sized material.

Alteration: Alteration of this sample is strong. Most of the plagioclase has been replaced by albite and illite, and K-feldspars are also dusted by illite. Mafic minerals are now unrecognisable, and have been replaced by chlorite, quartz and opaque minerals. In addition, prehnite is common in parts of the rock.

Veining: The oldest veins are represented by angular fragments of fine grained prehnite, which might enclose minor quartz. Other veins contain quartz with prehnite, and quartz with chlorite and/or adularia. The youngest veins are thin, semi-planar, and lined by pseudo-rectangular zeolite(?) crystals around central open spaces. These veins cut across all other veins, and also cut the shear fractures.

Brecciation: This sample has a chaotic brecciated texture, with disjointed sandstone, siltstone, mudstone, and vein fragments that are mostly separated by thin shear zones. Any spaces between the breccia clasts are filled with fine clastic material, and in places, chlorite and/or quartz.

Proportions (%): Quartz (40), prehnite (20), chlorite (15), illite (12), K-feldspar (5), albite (5), plagioclase (1), opaques (1), adularia (1), zeolite? (<1), apatite (<1)

XRD:

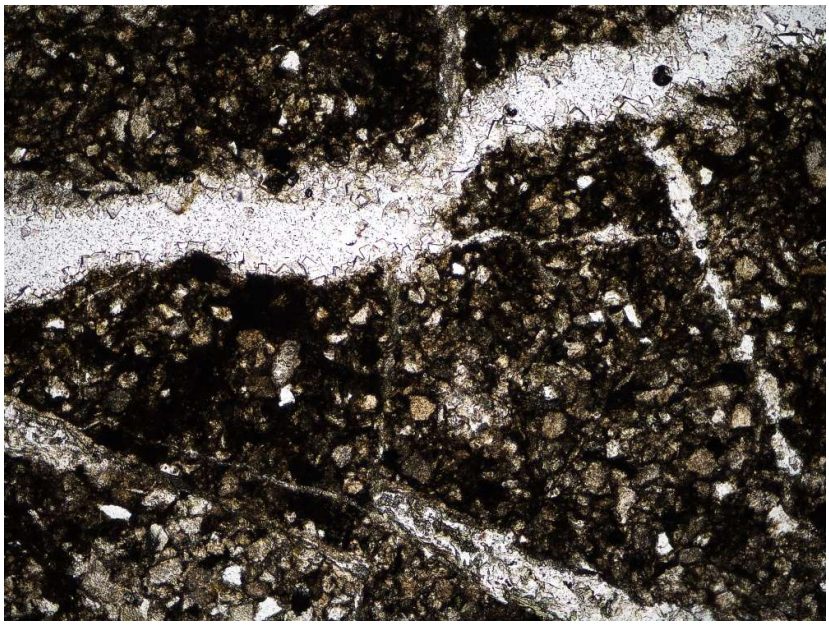

Photo 19: ***Sample 2605 (BH2B_1144 51.60):*** Vuggy zeolite(?) vein cutting siltstone, quartz-rich veins, and a thin shear zone (near centre) which offsets one of those veins. Field of view = 3.0 mm, plane polarised light.

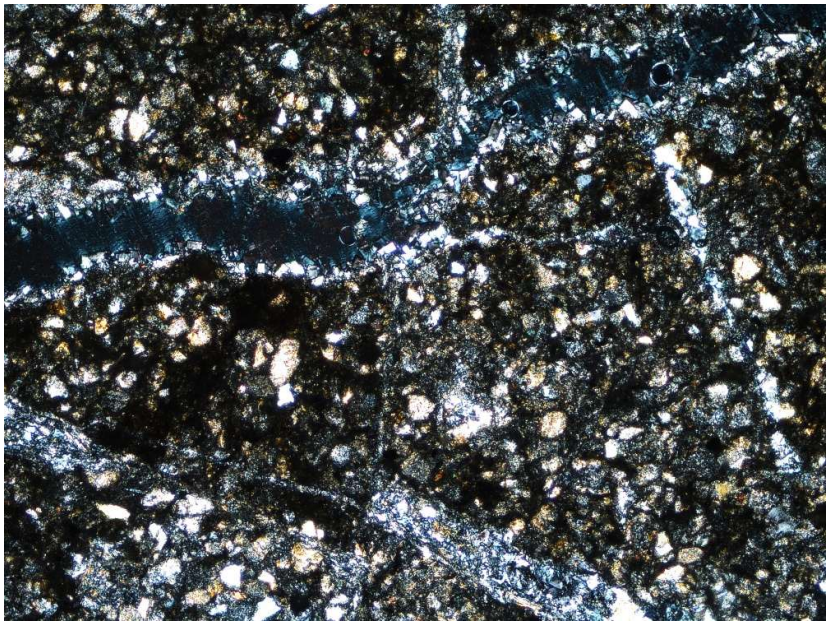

Photo 20: ***Sample 2605 (BH2B_1144 51.60):*** Same as above, crossed polarisers.

8. Petrographic Descriptions

Sample Number:	**Panda:**	**2716**
	WSP:	**BH2B_1157 25.10-25.25**
Rock Name:	**Dacite**	

Petrographic Description

In hand specimen, this is a massive light grey fine grained clay-rich rock. It is difficult to identify any primary minerals or textures within it. No veins are visible. This sample is weakly magnetic.

Lithology: In thin section, there is a distinctly igneous texture. Sparse small (<0.5 mm) phenocrysts of K-feldspar are surrounded by a fine (<0.2 mm) granular groundmass of plagioclase, K-feldspar and quartz crystals, with rare altered mafic minerals and small (<0.05 mm) opaque (magnetite) grains. The plagioclase crystals are euhedral and square or rectangular, and some are weakly zoned. They are enclosed by smaller subhedral quartz and K-feldspar. The mafic minerals are scarce, small and appear to be completely altered, though some of them may have been biotite. No vesicles, and no flow banding or alignment of the crystals were visible. What can be seen of the minerals and textures indicate that this is a dacite.

Alteration: Alteration of this sample is weak to moderate. The feldspars have been partly altered to clay, which was identified as halloysite by XRD analysis. The mafic minerals appear to have been completely replaced by iron-stained clay, but the presence of a small illite/mica peak on the XRD chart suggests that some biotite is preserved. Brown iron oxide staining is strong in parts of the rock.

Veining: No veins are visible in this sample.

Proportions (%): Primary: Quartz (35), plagioclase (25), K-feldspar (20), opaques (<1)
Secondary: Halloysite (20), iron oxides (<1)

XRD: Quartz, plagioclase, K-feldspar, halloysite, illite/mica

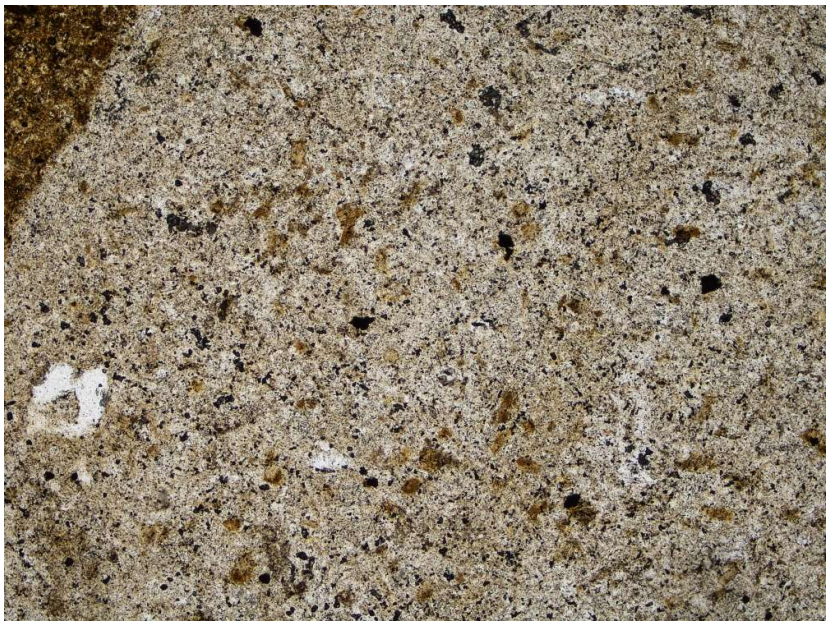

Photo 1: ***Sample 2716 (BH2B_1157 25.10-25.25):*** Dacite with one small K-feldspar phenocryst (left) in a groundmass of fine quartz, plagioclase, K-feldspar, brown iron-stained altered mafic minerals, and black opaque minerals (magnetite), with a dark brown oxidised zone (top left). Field of view = 3.0 mm, plane polarised light.

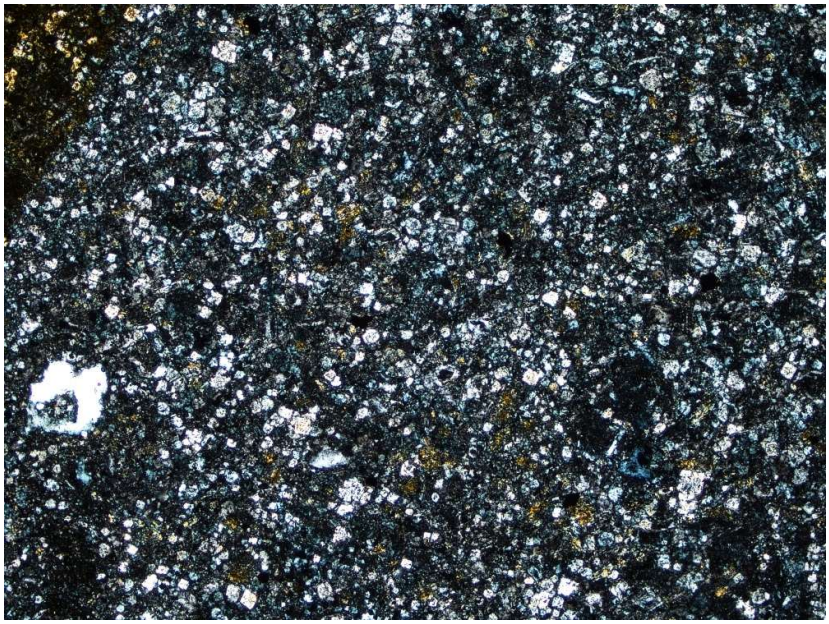

Photo 2: ***Sample 2716 (BH2B_1157 25.10-25.25):*** Same as above, crossed polarisers.

Sample Number:	**Panda:**	**2717**
	WSP:	**BH2B_1157 31.10-31.25**
Rock Name:	**Dacite**	

Petrographic Description

In hand specimen, this is a massive pale tan-grey rock that is fine grained but contains a few phenocrysts up to 1.5 mm long. No veining or brecciation are visible. This rock is weakly magnetic.

Lithology: In thin section, there are a few scattered phenocrysts of K-feldspar up to 1.5 mm long, and smaller (up to 0.5 mm) rectangular plagioclase phenocrysts. One of the K-feldspar phenocrysts contains two small pleochroic brown inclusions of biotite. Most of the plagioclase crystals are visibly zoned toward the rims. Surrounding those phenocrysts is a fine (<0.2 mm) crystalline groundmass of intergrown euhedral plagioclase and subhedral quartz, K-feldspar, altered mafic minerals and small (<0.1 mm) granular opaque minerals (magnetite). A broad alignment of elongate plagioclase crystals defines a distinct flow texture in this rock. The mafic minerals seem to be completely altered (except for the biotite inclusions in K-feldspar), but many of them could have been biotite. The minerals and textures indicate that this is a dacite.

Alteration: Alteration is weak, and has produced a brownish clay (confirmed as smectite by XRD analysis) within many of the feldspar crystals and throughout the groundmass. The mafic minerals have been replaced by brownish iron stained smectite, though a small amount of biotite may be preserved to account for the illite/mica XRD peak.

Veining: No veins were seen in this sample.

Proportions (%): Primary: Plagioclase (50), quartz (30), K-feldspar (15), opaques (<1), biotite (<1)
Secondary: Smectite (5), iron oxides (<1)

XRD: Quartz, plagioclase, K-feldspar, smectite, illite/mica

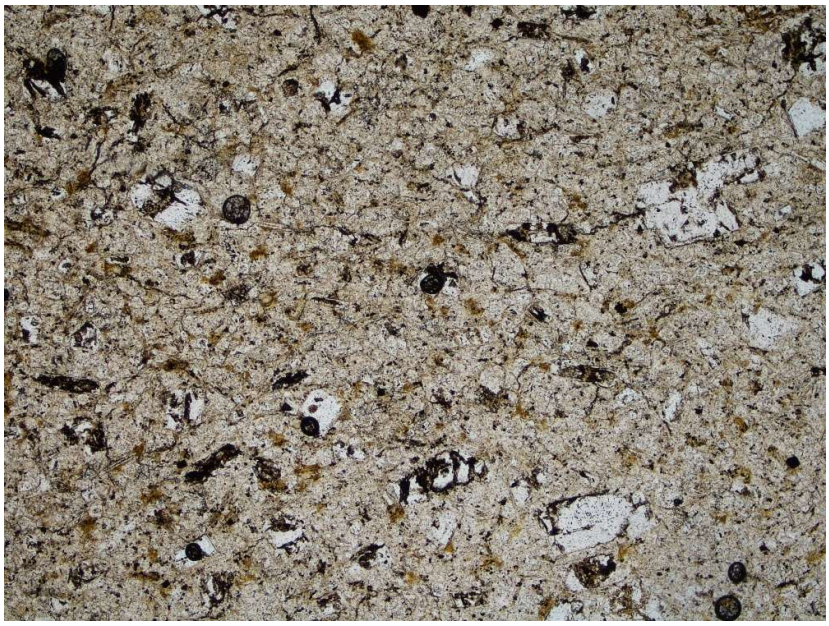

Photo 3: ***Sample 2717 (BH2B_1157 31.10-31.25):*** Small K-feldspar phenocrysts surrounded by fine quartz, plagioclase, K-feldspar, altered mafic minerals and granular opaque minerals. Field of view = 3.0 mm, plane polarised light.

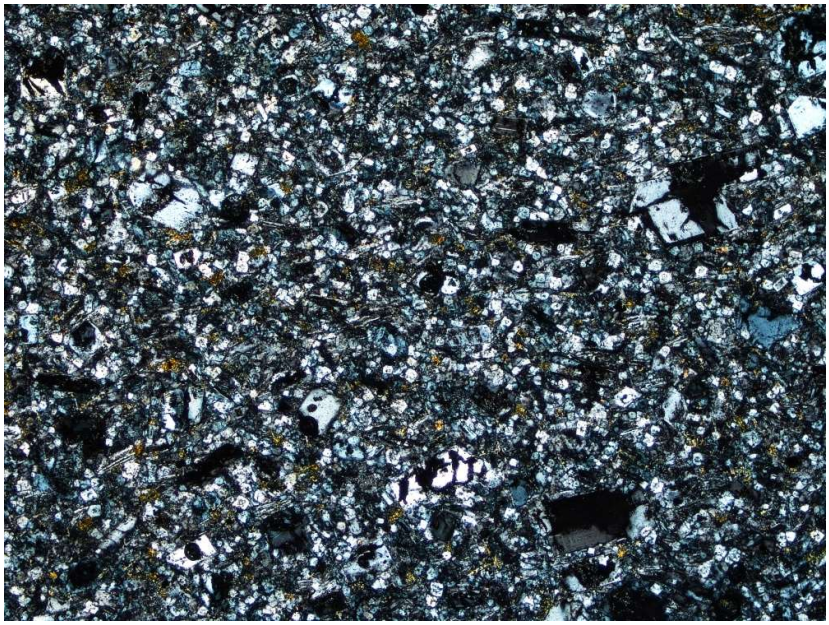

Photo 4: ***Sample 2717 (BH2B_1157 31.10-31.25):*** Same as above, crossed polarisers.

Sample Number:	**Panda:**	**2718**
	WSP:	**BH2B_1157 43.50-43.75**
Rock Name:	**Dacite**	

Petrographic Description

The hand specimen is a light grey massive fine grained rock that is cut by several planar fractures. A white clay and brown iron oxides are visible on fractures. No veins are visible. This sample is moderately magnetic.

Lithology: In thin section, there are sparse euhedral K-feldspar and elongate rectangular plagioclase (oligoclase) phenocrysts that are both up to 1 mm long. Complex oscillatory zoning and weak normal zoning are both visible within plagioclase and K-feldspar phenocrysts. Rare very small inclusions of apatite and biotite are present within K-feldspar. These scattered larger crystals are surrounded by a groundmass of small (<0.2 mm) intergrown plagioclase, quartz and K-feldspar, with a few altered mafic (biotite?) phenocrysts that are rarely up to 0.5 mm long, and fine granular opaque minerals (magnetite). A 0.7 mm patch of very fine opaque minerals and quartz could be a xenolith or perhaps an altered mafic mineral (hornblende?).

Alteration: This sample is weakly altered, with pale brownish smectite present within feldspars and in the groundmass. Iron stained smectite appears to be completely replacing the mafic minerals, although XRD analysis suggests that some biotite is preserved. In addition, stilbite was identified by XRD analysis, but was not seen in the thin section.

Veining: No veins are present in this sample.

Proportions (%): Primary: Plagioclase (40), quartz (30), K-feldspar (15), opaques (<1), apatite (<1), biotite (<1)
Secondary: Smectite (15), iron oxides (<1)

XRD: Quartz, plagioclase, K-feldspar, smectite, stilbite, illite/mica

Photo 5: ***Sample 2718 (BH2B_1157 43.50-43.75):*** Small K-feldspar and plagioclase phenocrysts in a groundmass of quartz, plagioclase, K-feldspar, altered mafic minerals and granular opaque minerals. Field of view = 3.0 mm, plane polarised light.

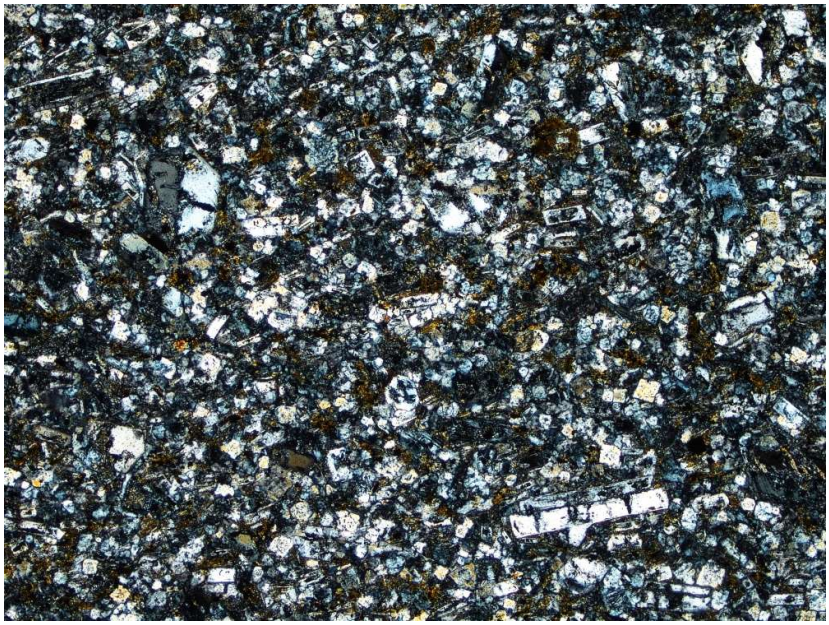

Photo 6: ***Sample 2718 (BH2B_1157 43.50-43.75):*** Same as above, crossed polarisers.

Sample Number:	**Panda:**	**2719**
	WSP:	**BH2B_1157 51.70-52.05**
Rock Name:	**Dacite**	

Petrographic Description

In hand specimen, this is a light to medium grey fine grained crystalline rock that is fractured and has a vague banding. No veins are visible. This sample is weakly magnetic.

Lithology: In thin section, there are scattered subhedral to euhedral phenocrysts of K-feldspar up to 1.5 mm long and plagioclase up to 1 mm. Complex oscillatory zoning is visible in both K-feldspar and plagioclase phenocrysts. The mafic minerals are completely altered, forming elongate crystals up to 0.6 mm long that may have been biotite. These minerals are set in a groundmass of fine granular quartz, plagioclase, K-feldspar, altered mafic minerals and fine granular opaques. In places there is a vague flow alignment of the elongate plagioclase and mafic minerals. Overall, the minerals and textures indicate that this sample is a dacite.

Alteration: This sample is weakly altered to a brown smectite clay. This is common in many of the plagioclase and K-feldspar crystals, and also within the mafic minerals. Possibly some biotite is preserved, to account for the illite/mica peak seen in the XRD analysis, but none was visible in the thin section. Likewise, stilbite was detected by XRD, but could not be discerned in thin section.

Veining: No veins were seen in this sample, but there are several thin fractures that are filled with smectite and dark brown iron oxides.

Proportions (%): Primary: Plagioclase (45), quartz (30), K-feldspar (15), opaques (<1)
Secondary: Smectite (10), iron oxides (<1)

XRD: Quartz, plagioclase, K-feldspar, smectite, stilbite, illite/mica

Photo 7: ***Sample 2719 (BH2B_1157 51.70-52.05):*** K-feldspar and plagioclase phenocrysts in fine grained quartz, plagioclase, K-feldspar, altered mafic minerals and granular opaque minerals. Field of view = 3.0 mm, plane polarised light.

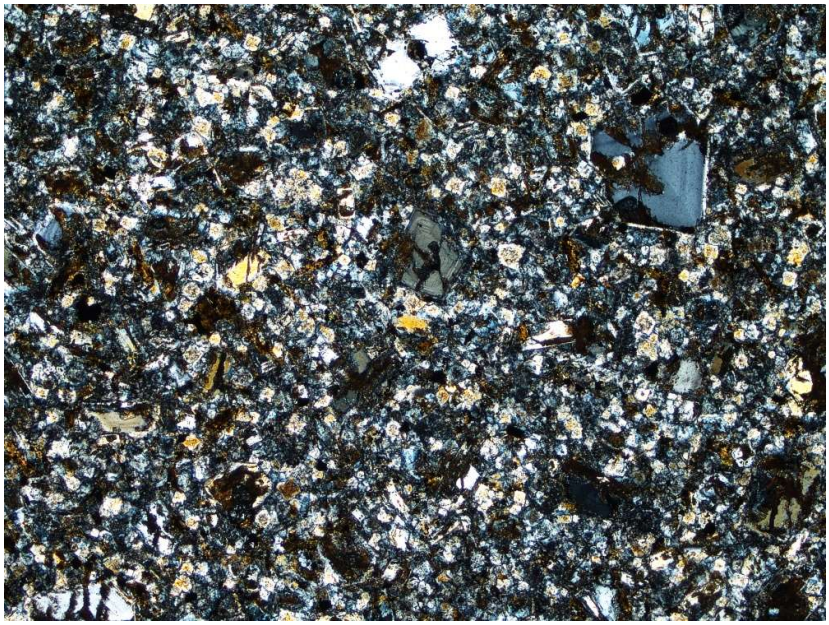

Photo 8: ***Sample 2719 (BH2B_1157 51.70-52.05):*** Same as above, crossed polarisers.

Sample Number:	**Panda:**	**2720**
	WSP:	**BH2B_1157 84.60-84.75**
Rock Name:	**Dacite**	

Petrographic Description

In hand specimen, this is a hard, medium grey fine grained rock that has a vague to distinct banding. It is cut by common subparallel planar fractures, and is strongly stained by brown iron oxides in parts. No veins are visible. It is moderately magnetic.

Lithology: In thin section, there are scattered small (up to 1.5 mm) euhedral K-feldspar phenocrysts with smaller (<1 mm) rectangular plagioclase and (<0.5 mm) elongate altered mafic minerals enclosed in a groundmass of finely intergrown plagioclase, quartz, K-feldspar, altered mafic (biotite?) and opaque minerals (magnetite). The elongate plagioclase and mafic minerals are weakly aligned. Based on these features, this is a dacite.

Alteration: This sample is weakly altered. Fine smectite clay is present within most of the plagioclase and K-feldspar crystals, and has completely or almost completely replaced the mafic minerals. Possibly a small amount biotite is preserved, hence explaining the 8.8° peak on the XRD chart. In addition, minor stilbite was identified by XRD analysis, though none was visible in thin section. Parts of the rock are strongly stained by brown iron oxides, with sharp contacts between brown and grey rock.

Veining: No veins were seen in this sample, and no minerals are visible on fractures.

Proportions (%): Primary: Plagioclase (40), quartz (30), K-feldspar (20), opaques (<1)
Secondary: Smectite (10), iron oxides (<1)

XRD: Quartz, plagioclase, K-feldspar, smectite, stilbite, illite/mica

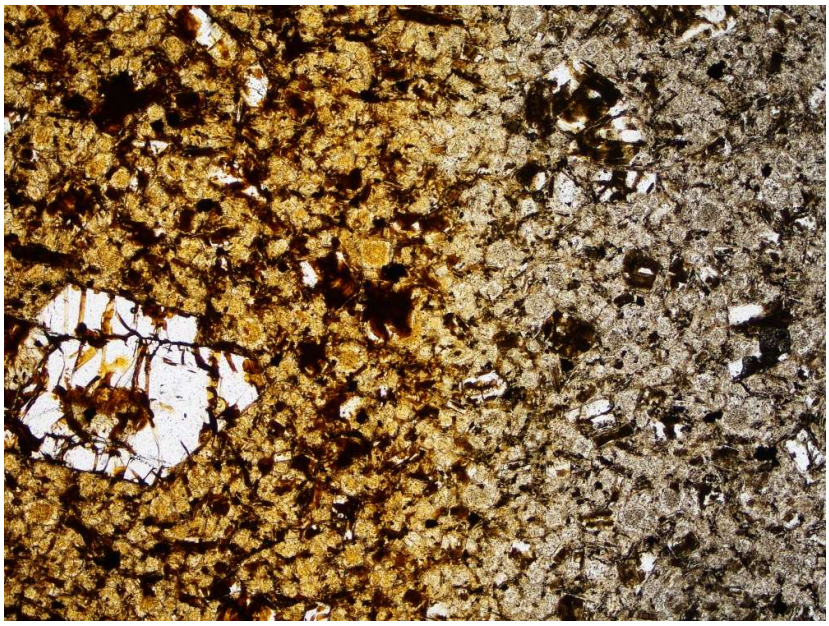

Photo 9: ***Sample 2720 (BH2B_1157 84.60-84.75):*** A K-feldspar phenocryst in a brown iron-stained part of the rock composed of plagioclase, quartz, K-feldspar, altered mafic minerals and granular opaque minerals. Field of view = 3.0 mm, plane polarised light.

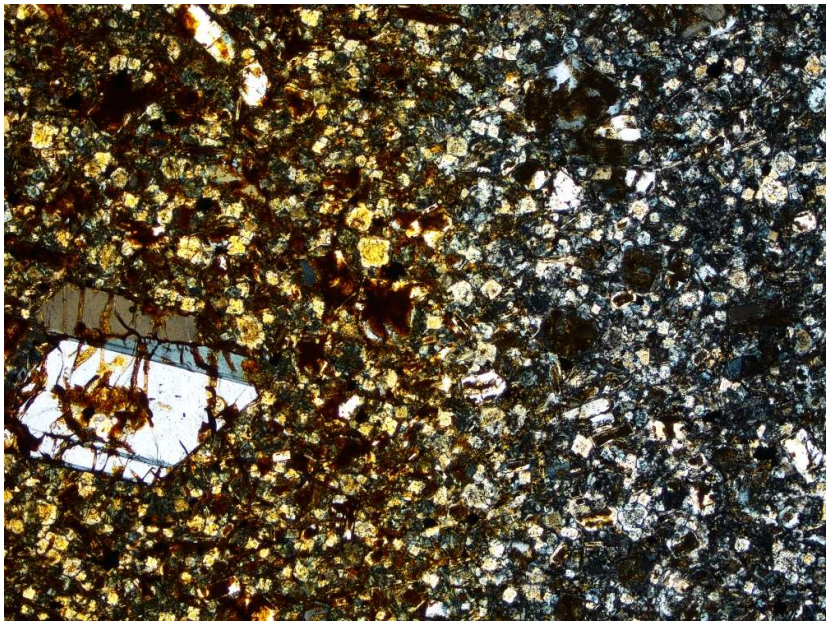

Photo 10: ***Sample 2720 (BH2B_1157 84.60-84.75):*** Same as above, crossed polarised light.

Sample Number:	**Panda:**	**2602**
	WSP:	**BH2B_1144 33.17**
Rock Name:	**Brecciated Veined Sandstone**	

Petrographic Description

In hand specimen, this is an indurated grey rock with a fine clastic texture, which is cut by closely spaced thin veins at various orientations, some of which enclose vuggy cavities. Some of the veins are semi-planar and continuous, but many are irregular and discontinuous, and appear fragmented. This sample is not magnetic, and contains small disseminated pyrite crystals.

Lithology: In thin section, this is a fine sandstone, in which there are subangular to subrounded detrital grains of quartz, K-feldspar, epidote, apatite, opaque minerals and zircon, and completely altered plagioclase, unidentified mafic minerals, and rock fragments. These detrital grains are mostly 0.1 to 0.3 mm across, and are tightly packed together, such that it is difficult to identify any matrix material between them. The sandstone appears massive, with no obvious bedding or alignment of the detrital grains.

Alteration: Alteration of this sample is strong to intense, although detrital minerals including quartz, K-feldspar, epidote, opaque minerals, apatite and zircon are preserved. Plagioclase has been completely replaced by albite, which in turn has been largely replaced by illite. Many of the K-feldspars have also been strongly altered to illite, while mafic minerals are altered to quartz, chlorite, titanite and opaque minerals, plus prehnite in parts of the rock. Rock fragments appear to contain all of these minerals.

Veining: A number of thin veins are present within the thin section. The oldest of these are composed of prehnite, some of which has been partly replaced by quartz and illite. The prehnite veins are cut by quartz-rich veins, most of which are very thin (<0.2 mm), though one semi-continuous planar vein is up to 2 mm thick. Minor chlorite and fine adularia crystals are present within some of these quartz-rich veins. A few of these veins contain open cavities at their centres, some of which are filled with calcite. In addition, one thin (0.05 mm) calcite vein cuts across the rock and post-dates all other veins.

Brecciation: This sample appears brecciated, although the textures are not as obvious as in other samples. Many of the veins are fragmented and discontinuous, and millimetre sized subangular prehnite-rich fragments are visible at one end of the

section, though it is difficult to identify any changes of lithology. It is also difficult to identify any breccia matrix. Some of the veins possibly follow shear fractures.

Proportions (%): Quartz (48), illite (24), chlorite (12), albite (6), prehnite (4), adularia (2), calcite (2), opaques (1), epidote (<1), titanite (<1), apatite (<1), zircon (<1)

XRD:

Photo 13: ***Sample 2602 (BH2B_1144 33.17):*** Sandstone, cut by quartz-rich veins, with minor calcite in some (centre left). Field of view = 3.0 mm, plane polarised light.

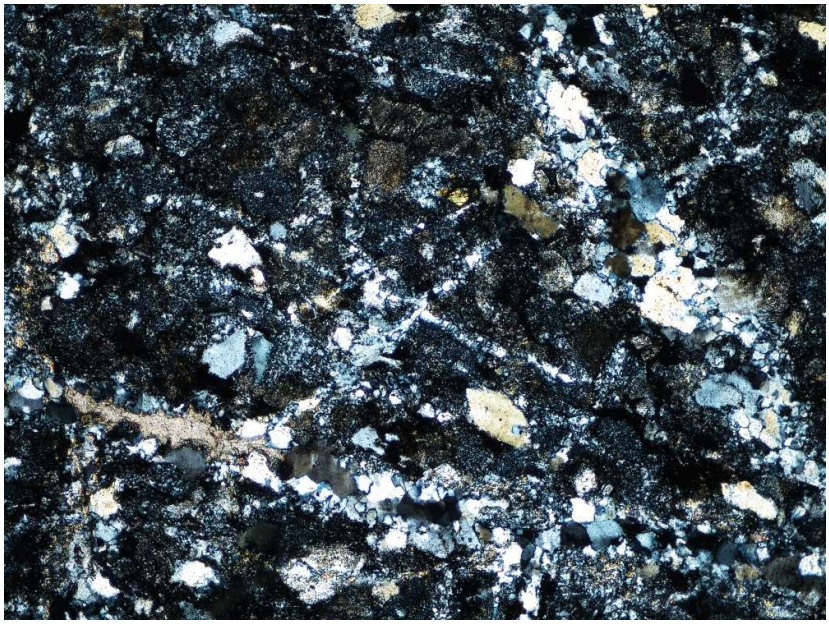

Photo 14: ***Sample 2602 (BH2B_1144 33.17):*** Same as above, crossed polarisers.