

THIN SECTION LABEL ID: **378-U1553A-16X-CC-W 0/2-TSB-TS 1**

Thin section no.: 1

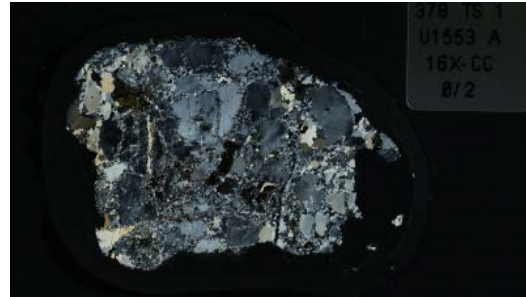
Observer: Simon George

Thin section summary: This section is an igneous or more likely metamorphic(?) mineralogy with quartz, plagioclase feldspar (incl microcline twinning), biotite, clinopyroxene? (green mineral with low birefringence), orthopyroxene (gray in XPL, low birefringence?) and opaque minerals. Possible exsolution lamellae of clinopyroxene. Quartz is much finer than plagioclase and pyroxene.

Plane-polarized: 56035791



Cross-polarized: 56035811



THIN SECTION LABEL ID: **378-U1553A-16X-CC-W 6/9-TSB-TS 2**

Thin section no.: 2

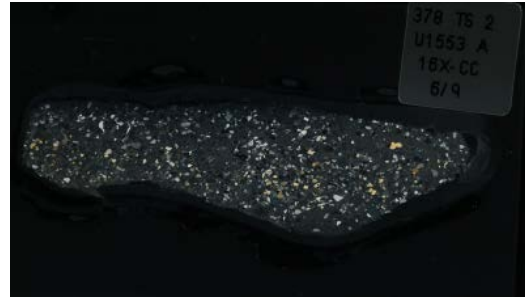
Observer: Simon George

Thin section summary: Angular biogenic carbonate debris, variety of sources, made of microcrystalline carbonate. Rounded to angular carbonate detritus/grains, appears to have been transported further than the organic detritus. Grain size ranges from 150µm to 1mm. Matrix appears to be a carbonate mud with yellowish clays?, possibly some organic matter. Matrix possibly recrystallised into a cement. Packstone.

Plane-polarized: 56109551



Cross-polarized: 56109571



THIN SECTION LABEL ID: **378-U1553A-16X-CC-W 22/26-TSB-TS 3**

Thin section no.: 3

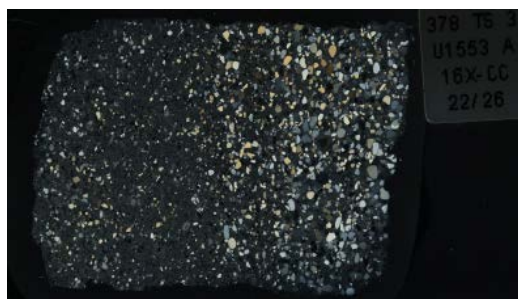
Observer: Kazutaka Yasukawa, Simon George

Thin section summary: This sample is mainly composed of foraminifers (~50%), sand-sized grains of quartz (~30%) and feldspar (~5%). Very fine sand-sized glauconite can also be seen. Lithic grains are sub-angular to rounded. Grain size shows pronounced grading, with larger grains of quartz associated with less matrix. These quartz grains show a wide range of rounding (subrounded to angular). The section grades into a higher proportion of foraminifera microfossils and matrix, which contains glauconite. The matrix appears to be micrite. Packstone.

Plane-polarized: 56035831



Cross-polarized: 56035851



THIN SECTION LABEL ID: **378-U1553A-26X-3-W 64/65-TSB-TS 4**

Thin section no.: 4

Observer: Kazutaka Yasukawa

Thin section summary: This sample is mainly composed of nannofossils (85-90%) and foraminifers (10-15%). Remains of radiolaria and diatoms can be identified, which are coated (or replaced) by pyrite. Silt to very fine sand-sized fragments of these are dispersed throughout the thin section (<1%). The matrix of this sample is likely microcrystalline quartz (chert).

Plane-polarized: 56035871



Cross-polarized: 56035891



THIN SECTION LABEL ID: **378-U1553B-2H-1-W 46/47-TSB-TS 5**

Thin section no.: 5

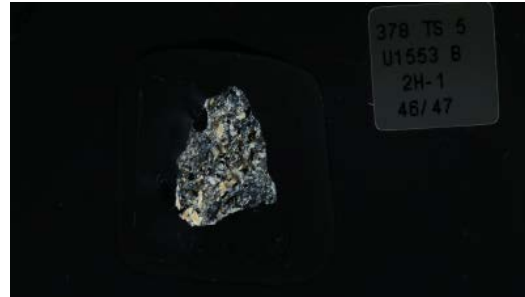
Observer: Simon George

Thin section summary: Predominantly composed of quartz of varying size. Brownish biotite, partly altered to brownish aggregates of fine grained clay, low birefringence, probably chlorite. Pale mica, probably muscovite, low abundance. Opaque minerals. Size of quartz varies from >2 mm to 50µm, cryptocrystalline in part.

Plane-polarized: 56035911



Cross-polarized: 56035931



THIN SECTION LABEL ID: **378-U1553B-15X-3-W 110/112-TSB-TS 6**

Thin section no.: 6

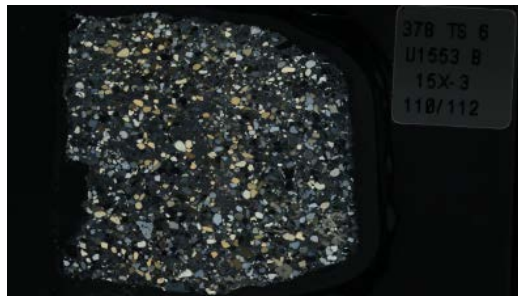
Observer: Erika Tanaka; Simon George

Thin section summary: This sample is composed of larger quartz grains (60%; 700 μm average) and feldspars (mainly microcline) superimposed on a fine matrix of foraminifer shells and unidentified calcareous fossils. Clay minerals (phyllosilicate in nature) are replacing primary minerals in situ. Muscovite in low abundance. Zeolites are observed in-filling some pore spaces. Radial extinction. Some chert areas partly replaced by carbonate. The quartz grains are about 800 μm across, well sorted, and rounded. Quartz grains are surrounded by pore rimming cement, yellowish, low birefringence, chert? Definition: lithic or calcareous sandstone.

Plane-polarized: 56035951



Cross-polarized: 56035971



THIN SECTION LABEL ID: **378-U1553B-26X-6-W 10/15-TSB-TS 7**

Thin section no.: 7

Observer: Simon George

Thin section summary: Large format thin section taken across 10-15 cm part, showing chalk with pale burrow, pale green layers, and pale purple diagenetic features. Thin section is rather poorly made, with lots of parts highly plucked during grinding to the right thickness. These appear bright black/white micro size in PPL. Also large domains of pale brown gunk, also something to do with thin section making, ignore as no geological information. No useful areas on this thin section.

Plane-polarized: 56265711



Cross-polarized: 56265731



THIN SECTION LABEL ID: **378-U1553B-29X-CC-W 31/34-TSB-TS 8**

Thin section no.: 8

Observer: Simon George and Laura Haynes

Thin section summary: Main framework grains are jagged and angular quartz, average grain size 200-250 μm = fine sand. Minor amounts of muscovite, plagioclase, chert. Significant amount of carbonate biogenic debris, about same size as quartz. Minor green glauconite grains. 60% of framework = quartz, 40% = rock fragments including carbonate bioclasts. Brownish matrix of micrite carbonate, possibly associated with some clays and/or organic matter. Matrix forms about 25% of rock. Massive fabric, no bedding. Poorly sorted, many grains finer than larger framework grains. Lithic graywacke. Sandstone. Entered as carbonate-rich wackestone.

Plane-polarized: 56109671



Cross-polarized: 56109691



THIN SECTION LABEL ID: **378-U1553C-3R-1-W 75/78-TSB-TS 9**

Thin section no.: 9

Observer: Simon George

Thin section summary: Slide is dyed with Alizarin red for carbonate identification, and impregnated with blue dye for porosity. Framework grains: quartz, plagioclase, chert, glauconite. Siliceous spicules. Carbonate debris: shells fragments; Many circular cross-sections through Si sponge spicules. Well formed rhombohedron of carbonate, no stain = dolomite. Some large quartz grains, 650 μm across. Matrix/cement: carbonate, stained red = calcite. Brownish-yellow, larger quartz is well rounded. Most of the finer material is very angular. Very poorly sorted. Average grain size = 100 μm , so very fine sand. There is more carbonate than quartz as a framework grain, so follows a limestone classification. Grain supported fabric. Packstone. Hardly any porosity.

Plane-polarized: 56134651



Cross-polarized: 56134671



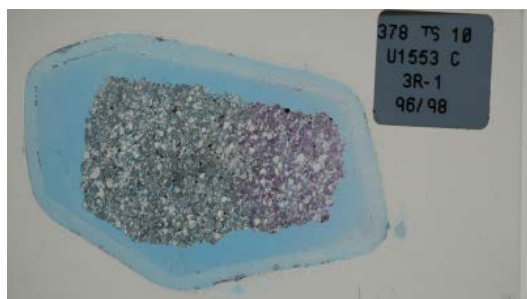
THIN SECTION LABEL ID: **378-U1553C-3R-1-W 96/98-TSB-TS 10**

Thin section no.: 10

Observer: Simon George

Thin section summary: Slide is dyed with Alizarin Red for carbonate identification, and impregnated with blue dye for porosity. Quartz grains, rounded, highly fractured and altered. Feldspar grains (plagioclase, microcline). Degraded chert grains. Carbonate grains, fibrous packets, from broken shell material? Average grain size 200-400 μm . Matrix is 1-3 μm size micrite. Composition: matrix 10% (arenite). Grains: quartz: 75%; feldspar: <5%, rock fragments, mainly carbonate = 20%. Porosity about 20%. Larger quartz is well rounded, as also shown in overlying packstone.

Plane-polarized: 56134691



Cross-polarized: 56134711



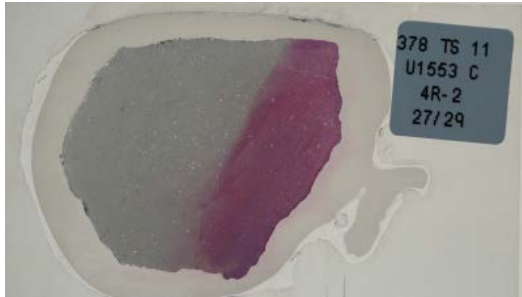
THIN SECTION LABEL ID: **378-U1553C-4R-2-W 27/29-TSB-TS 11**

Thin section no.: 11

Observer: Simon George

Thin section summary: Slide is dyed with Alizarin red for carbonate identification. Nannofossil chalk with foraminifers (based on smear slide). Chalk matrix is pervasively dyed red, so is calcite. Largest foraminifers are 150 μm across. Some smaller ones. Nannofossils are about 25 μm across. Are embedded in a micrite matrix.

Plane-polarized: 56134731



Cross-polarized: 56134751



THIN SECTION LABEL ID: **378-U1553C-7R-2-W 1/4-TSB-TS 12**

Thin section no.: 12

Observer: Simon George

Thin section summary: Slide is dyed with Alizarin red for carbonate identification. Chalk-chert contact. Much of the chalk is plucked away by the action of the slide making: hard chert, soft chalk. Chalk: some foraminifers, 100 μm across. Majority is sub 5 μm micrite. Chalk is stained red, so is composed of calcite. Chert: can see remains of the foraminifers, silicified, same approximate size as in chalk. Low birefringence, so silica. Matrix is also silicified: low birefringence, and not picked up any Alizarin Red stain. There are two areas of chalk in the thin section, separated by chert in the middle. The smaller part of the chalk, where dyed red, shows an interesting relationship between matrix and foraminifers in chalk. The matrix has red stain and high birefringence, so is calcite. The foraminifers have no stain, and low birefringence, so have been selectively silicified. Some foraminifers in the chalk are partially silicified.

Plane-polarized: 56134771



Cross-polarized: 56134791



THIN SECTION LABEL ID: **378-U1553C-9R-2-W 72/75-TSB-TS 13**

Thin section no.: 13

Observer: Laura Haynes, Simon George

Thin section summary: This sample is stained with Alizarin red. It records the chalk to chert transition and the chert-flint transition; carbonates are stained red, while chert and flint are not, and have low birefringence in PPL. Foraminifer from the chert section have initial structures preserved but show birefringence and so are replaced or partially replaced by silica. The transition is a linear surface. Both chalk and chert are matrix-supported (micrite?) with approximately 15% foraminifer clasts. The flint is a highly recrystallized form of the chert, and in thin section lacks the brownish color material that is in the chert.

Plane-polarized: 56134811



Cross-polarized: 56134831



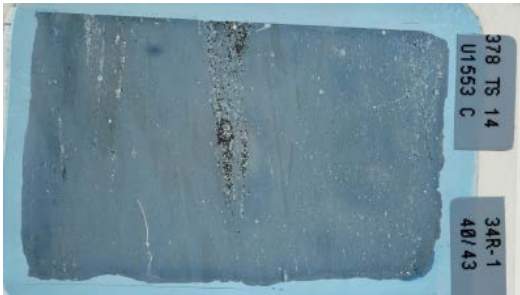
THIN SECTION LABEL ID: **378-U1553C-34R-1-W 40/43-TSB-TS 14**

Thin section no.: 14

Observer: Simon George

Thin section summary: Limestone with sand-sized minerals in burrows. Trace fossils. No Alizarin Red used initially. Blue epoxy used to stain pore space. Thin section: Very fine micritic matrix, with dark dendritic forms. $<1\ \mu\text{m}$ grain size. Within matrix, isolated larger microfossils, typically 50-200 μm size. Lenses of coarser material, sometimes associated with opaque pyrite. Grainsize is mostly 100-300 μm . Much carbonate debris, large crystals of pyrite, occasional quartz grains. Very low porosity, but occasional pale blue pore space visible, is isolated. Pore space is partially filled by clays, including yellowish low birefringence chlorite, and a colorless mid-order birefringent clay, possibly smectite-illite. Some lenses filled by clay minerals, probably the trace fossils seen macroscopically. Pyrite replaces a mineral. Mostly does not replace carbonate, but pale green fibrous very fine clay that forms clusters in the limestone. Has lower birefringence than carbonate. Could be chlorite. Pyrite sometimes associated with long fibrous minerals, low birefringence, could be quartz so sponge spicule, etc., or secondary later mineral? Possibly zeolite crystals. The thin section manifestation of some of the layering in the rock not very obvious in thin section. Brown stained layer in part (FeO?). Sometimes very small (30 μm) domains of pyrite in semi-layers. Alizarin Red stain applied on 31 January 2020, so as to characterize the carbonates. The matrix took the stain completely. Is a mauve color so is ferroan calcite. Most of the microfossils are not stained, so appear to be dolomitised. Parts contain non-ferroan calcite. Some microfossils are ferroan calcite: mauve. Some microfossils are ferroan calcite: mauve with some calcite areas (red), and dolomite (clear). Ferroan calcite matrix, zeolite?, pyrite, dolomitized microfossils. Some small (20-50 μm) dolomite rhombohedrons in matrix: mostly straight dolomite, but a little blue color indicates there is ferroan dolomite (ankerite) present. Calcite microfossil (red) surrounded by ferroan calcite micrite.

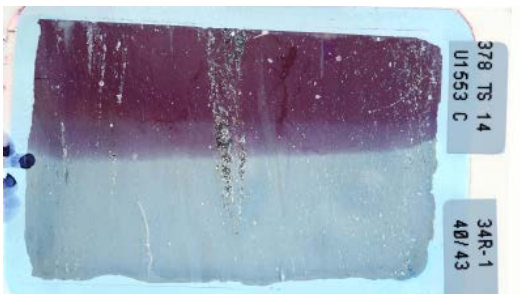
Plane-polarized: 56265631



Cross-polarized: 56265651

**Treated Thin Section Images**

Plane-polarized: 56294651



Cross-polarized: 56294671



THIN SECTION LABEL ID: **378-U1553C-39R-CC-W 18/21-TSB-TS 21**

Thin section no.: 21

Observer: Laura Haynes, Simon George

Thin section summary: Blue epoxy used to stain pore space. This is a matrix-supported rock with a finer, light matrix in PPL with subangular quartz grains (15%). The matrix is slightly birefringent and may be micrite. Glauconite is present as are the remains of siliceous fossils, which appear fairly well preserved. Muscovite is also abundant and identified as thin elongated minerals with high birefringence in XPL. Other unidentified biological grains are also observed, possibly fecal pellets or dinoflagellates. Grains are dominantly silt to clay sized (>50%). Small grains of opaque minerals (likely pyrite) are also observed (also silt-clay sized). Lineated iron staining is visible in PPL. A foraminifer with keeled morphology is also observed. Grains are very closely packed. Average grain size is about 25 μm , so is a fine siltstone. No grain size or mineralogy variations across pale burrows. Curved calcareous microfossil, 400 μm across. Lens of white mineral within dark layer: is 2mm long, 200 μm wide, contain low birefringent mineral, small (25-50 μm long). Could be zeolite, or quartz?. In hand specimen similar white mineral lenses are soft and inconsistent with quartz. Another pale lens 450 μm long, with white mineral (zeolite?) and clay mineral that is yellow with low birefringence (chlorite?), also some small opaque mineral, near thin section label. Minerals 15-20 μm across. A pale burrow in hand specimen is bottom left of thin section. The grain size is the same, as is the mineralogy. The difference is that the non-burrowed rock has a light brown-orange color, whereas this color is mostly missing from within the burrow. As well as a general yellow-brown color that is attributed to organic matter, there are very thin (2-3 μm) black stringers parallel to bedding. Some of these are 75 μm long. Circular feature, 150 μm diameter, filled with low birefringent mineral. Classification: Silt to mudstone (clay matrix) with siliceous and occasional carbonate- microfossils, and detrital organic matter. Alizarin Red stain applied on 31 January 2020, so as to characterize the carbonates. There is a faint pink tinge to the mudstone where stained, indicating a low amount of micrite amongst the clays. There are some layers that contain more micrite, especially around layer with more brown opaque, poorly focused material. The microfossils are not calcite or ferroan dolomite. Dolomite? Or replaced by silica? Certainly a few are pyritised. Mudstone, slightly calcareous in part.

Plane-polarized: 56274101



Cross-polarized: 56274121



Treated Thin Section Images

Plane-polarized: 56294771



Cross-polarized: 56294791



THIN SECTION LABEL ID: **378-U1553C-41R-1-W 111/114-TSB-TS 22**

Thin section no.: 22

Observer: Simon George

Thin section summary: From chert/carbonate mudstone facies. Grain size quite variable through section. Coarse layers: 100-400 microns so very fine sand to medium sand range, average = 200 μm , so fine sandstone. Fine layers: 10 μm to 25 μm , so is fine siltstone. Mineralogy: coarse layers; quartz: homogenous except for fluid inclusions, sub-rounded. Feldspar, blocky or cleavage, much altered to both clays and carbonates. Some long crystals of a pale, low birefringence mineral: looks like altered plagioclase, but more likely it is secondary zeolite. It also occurs as single crystals surrounded by pyrite in clumps. Carbonate debris. Circular "tyre" features with radial crystals are common. Estimated to be about 20-30%. Pink, so is calcite. Pyrite: about 10%. Clastic framework grains: about 50-60%. So an allochemical sandstone. Biotite: pale brown, elongate crystals. Muscovite: rare. Virtually no porosity (pale blue), except small fractures in rock: 2 photomicrographs. Green mineral (glauconite?, chlorite?) in lens surrounded by black and then orange diagenetic alteration zones. Green = low birefringence. Probably a glauconite pellet partially altered to FeO. Other glauconite minerals are partially brown around margin. Carbonate as cement, overgrowths grains include feldspar, is also associated with zeolite. This also stains pink so is calcite. Matrix composition: pale to yellow clays. Variable birefringence: some areas low (chlorite?), others with 2nd order colors so probably illite-smectite. Some brownish and poorly resolved material, organic matter? Fracture cuts through rock, filled with pale brown/opaque material that does not focus well, soft. Has a pale brown color in reflected, so may be migrated hydrocarbons. Rock description: Interbedded calcareous-rich fine grained sandstone and mudstone.

Plane-polarized: 56285221



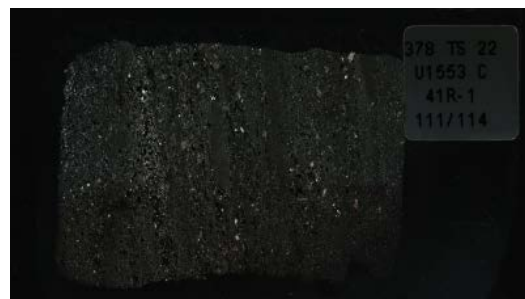
Cross-polarized: 56285241

**Treated Thin Section Images**

Plane-polarized: 56290401



Cross-polarized: 56290421



THIN SECTION LABEL ID: **378-U1553C-41R-4-W 35/37-TSB-TS 23**

Thin section no.: 23

Observer: Simon George

Thin section summary: This thin section was badly damaged during manufacture, with plucking and artificial stripes due to grinding. Only interpret un-damaged zones near the label end of the thin section. Matrix-supported texture. Largest grains are about 50 μm , majority <20 μm . Fine Siltstone. Larger very fine sand grains make up about 5%. Poorly sorted. Majority of the larger population of very fine sand grains are quartz containing fluid inclusions. These tend to be sub-rounded. Other low birefringent minerals include some feldspar (plagioclase seen with twinning) which are longer and more tabular, and muscovite, aligned to bedding. Glauconite. Chert mini-clasts. Spherical and tabular pyrite? opaques. Matrix: small muscovites, aligned to bedding. Clay minerals, <8 μm across. Probable quartz. Has a brownish-yellow appearance, suggest organic matter associated with clays. Dull brown laminations may be clays or organic matter. Some thinner stringers of black-dark brown opaques, probably organic matter. Sandy mudstone.

Plane-polarized: 56274141



Cross-polarized: 56274161



THIN SECTION LABEL ID: **378-U1553C-42R-3-W 103/105-TSB-TS 24**

Thin section no.: 24

Observer: Simon George

Thin section summary: Mudstone/very fine sandstone, highly bioturbated facies. Hand specimen: Matrix is dark and light bioturbated lenses, intersecting, with coarse lens that is pale in core photo. Blue epoxy used to stain pore space. Thin section: matrix is very fine grained, typically 30 μm so is a siltstone. Some of the largest grains in the main matrix are 150 μm , so fine sand. Poorly sorted, angular grains, smaller grains are about 25 μm . In PPL, matrix is greenish yellow to orange, with some color banding. Mineralogy: mainly low birefringent quartz and feldspar. Also probably clays. Darker poorly resolved material, no birefringence, may be organic matter. Glauconite, muscovite quite common, biotite. It is possible that some of the lath-like minerals with low birefringence are zeolites. Very low or zero porosity. Angular, low sphericity. Some larger grains: mix of quartz and feldspar (plagioclase). One large dolomite crystal seen. Coarse layer: similar mineralogy as matrix: plagioclase, quartz, biotite, opaque minerals, some porosity (pale blue). Some clumps of clay mineral: yellow-brown chlorite?. Average grain size is 200-300 μm . Mica in matrix usually aligned sub-parallel to bedding. Occasional wrapping of finer assemblages over larger grains. E.g. triangular quartz. Opaques are blurry, hand lens says not pyrite, so probably amorphous organic matter. Alizarin Red stain applied on 31 January 2020, so as to characterize the carbonates. Calcareous matrix, faint pink wash. There is a little more calcite in the coarser layers. One glauconite grains surrounded by a little calcite. Sandy mudstone, slightly calcareous in part.

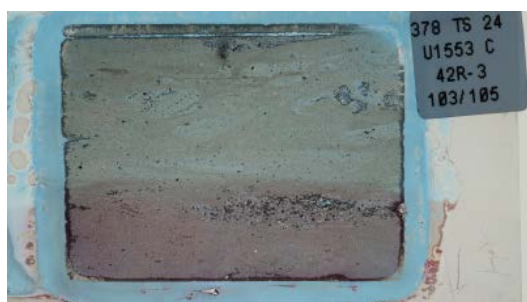
Plane-polarized: 56265671



Cross-polarized: 56265691

**Treated Thin Section Images**

Plane-polarized: 56294811



Cross-polarized: 56294831



THIN SECTION LABEL ID: **378-U1553C-42R-5-W 19/22-TSB-TS 25**

Thin section no.: 25

Observer: Simon George

Thin section summary: Core photo is from a darker layer of the core. Thin section appears thinner on long-side with label. Very fine grained, clay rich. Grain size: 10-25 μm , so fine siltstone. Glauconite: 25 μm . <0.5% Black organic matter stringers: oil in migration stringer?, or detrital? Probably latter. Has grey reflectance. Pyrite: reflected light confirms. About 1% large clear grains, yellow 1st order birefringence, thick section so quartz. 25-50 μm clays: mostly low birefringence, have pale yellow-brown color. Some have higher 2nd order birefringence. Mix of chlorite and smectite? Some clumps of browner material, in lenses parallel to bedding. 150 μm long, <25 μm wide. Birefringence masked by brown color, appears low. Red-brown (replacement mineral?) biogenic organic matter. No carbonate seen. Mudstone.

Plane-polarized: 56290201



Cross-polarized: 56290221



THIN SECTION LABEL ID: **378-U1553C-42R-6-W 79/82-TSB-TS 26**

Thin section no.: 26

Observer: Simon George

Thin section summary: Blue epoxy used to stain pore space. Medium grained sandstone based on hand specimen. Thin section has a fine matrix with large crystals scattered through the matrix. Large crystals are pale, white in PPL. Irregular shapes, generally blocky with straight edges. Two perpendicular cleavages, at 120 degrees, rhombohedral. Apparently low first order birefringence, like quartz. But some areas appear to have very high order birefringence. The thin section measures at 60µm, so this is dolomite. Birefringence masked and goes to virtually white, due to thick section. This is the same as in 378-U1553C-43R-2-W 38/40-TSB-TS 28. Grain size of dolomite: 50 to 400 µm, average 200 µm: (silt to medium sand; average fine sand). Matrix: 25 µm, so fine siltstone. Mudstone, dark organic matter stringers, brown and yellow clays. Some rounded grains, 40 µm so coarse silt grade. Opaques, reflected light shows is pyrite. Some areas appear to be micrite, need to stain to check. Occasional glauconite. Dolomite crystals have dark material around their margins. Diagenetic product from their formation? Alizarin Red stain applied on 31 January 2020 so as to characterize the carbonates. Dolomite rhombohedrons, no reaction with Alizarin Red stain so clear. No mauve/blue ankerite detected. Matrix does contain micrite, confirmed as purple ferroan calcite. Also clays that are not stained. Classification: Dolomite-bearing mudstone.

Plane-polarized: 56285261



Cross-polarized: 56285281

**Treated Thin Section Images**

Plane-polarized: 56294691



Cross-polarized: 56294711



THIN SECTION LABEL ID: **378-U1553C-42R-6-W 86/88-TSB-TS 16**

Thin section no.: 16

Observer: Simon George

Thin section summary: Blue epoxy used to stain pore space. Thin section in landscape mode parallel to bedding. Brown layers of fuzzy material cut through. These are the dark bands in hand specimen. Concentration of occasional coarser grains in upper part, this is the coarser unit at 378-U1553C-42R-6, 86 cm. Predominantly very fine grained through remainder. Bottom left corner of thin section has brown lumps that are trace fossils (possible Phycosiphon). Thin section: Main part of sample is mainly 20 μm to 50 μm , so is a fine to coarse siltstone, but with a significant finer (clay) fraction. The coarse part at top contains the same finer matrix, with additional coarser grains: mostly dolomite, blocky, rhombohedral, pale, high birefringence, 100 μm , so is a very fine muddy sand, or perhaps a sandy mudstone (need to quantify size fractions). Phycosiphon is similar, with brown fuzzy material covering shape of trace fossil. Brown clay mineral, perhaps with organic matter adsorbed? Mineralogy of fine siltstone: elongate, angular quartz. Muscovite, clays, brown fuzzy poorly focused material. Clays/organic matter mix? Coarser mineralogy: quartz, some opaques, muscovite, very fine quartz (like main part of sample). Alizarin Red stain applied on 31 January 2020, so as to characterize the carbonates. Shows that there is some pink stained calcite as a cement or micrite matrix in the slightly paler layers, especially not entering dark trace fossils. Alizarin Red stained calcite cement near trace fossil. Alizarin red not applied to coarser interval. Sandy mudstone with patchy calcite micrite, partly dolomitic.

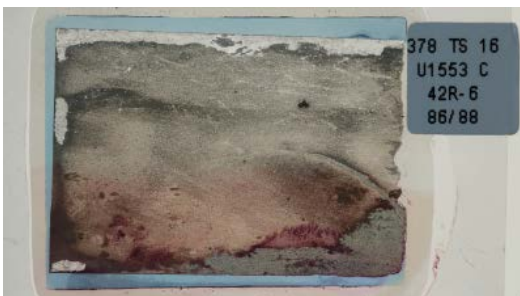
Plane-polarized: 56274021



Cross-polarized: 56274041

**Treated Thin Section Images**

Plane-polarized: 56294851



Cross-polarized: 56294871



THIN SECTION LABEL ID: **378-U1553C-43R-1-W 45/48-TSB-TS 27**

Thin section no.: 27

Observer: Simon George

Thin section summary: Macroscopic: very fine sand. Diagenetic halo near label. Lots of possible Phycosiphon type trace fossils at lower end away from label. Paler intervals higher, and lens of pyrite. Thin section: Generally fine matrix. Average about 30 μm . Pyrite lens is associated with a lens of coarser material. Sometimes isolated pyrite, straight edges and even cubic sometimes, other places different size blebs. Larger dolomite crystals, blocky, rhomboidal, pale, high birefringence (appears a bit white as slightly thick section). 20-150 micron size, fine sand size. Pyrite overgrows carbonate. Dolomite is mainly in the mudstone fabric, not in the coarser silt lenses. Dolomite occurs in both the dark and lighter parts of the mudstone: the diagenetic halo, and the dark/light parts due to trace fossils. Glauconite scattered, pale, coarser lens: 2.8 mm long, 800 μm wide. Composition is 20-50 μm , so coarser silt. Made of quartz, slightly thicker so some 1st order colors, high birefringent carbonate, muscovite (2%) some glauconite (2%), with yellow-brown clay matrix between silt grains. The dark "diagenetic halo" is the same mineralogical framework as the rest of the rocks, including the finer and coarser components, but the dark areas have an out-of-focus brown appearance. Is this a migrated hydrocarbons that has coated the sediment in small migration chimneys? The dark material overlaps onto secondary dolomite crystals. Alizarin Red stain applied on 31 January 2020, so as to characterize the carbonates. There is a marked pink tinge to the matrix, indicating there is calcite in there, presumably micritic. The large rhombohedrons of dolomites are clear, no stain, confirming dolomite, and no ankerite. In just a few places there is some calcite cement altering the dolomite, so later. The coarse layers have no or little background calcite. Patchy calcite micrite in thin coarser layers. Dolomitic, calcareous mudstone.

Plane-polarized: 56290241



Cross-polarized: 56290261

**Treated Thin Section Images**

Plane-polarized: 56294971



Cross-polarized: 56294991



THIN SECTION LABEL ID: **378-U1553C-43R-2-W 38/40-TSB-TS 28**

Thin section no.: 28

Observer: Laura Haynes, Simon George

Thin section summary: This is a matrix-supported rock with abundant large pale crystals, which are around 150-200 microns in size. They are blocky, and have low birefringence (1st order), with apparent partial alteration to high birefringence clays or carbonate along cleavage planes and fractures. Sometimes but not always the cleavage is rhombohedral. Sometimes euhedral. Main mineral: Dolomite? Feldspar? Zeolite? This thin section is thicker than normal, so this is dolomite. Birefringence masked and goes to virtually white, due to thick section. This is the same as in thin section 378-U1553C-42R-6-W 79/82-TSB-TS 26. The same mineral forming the large crystals is also present in the matrix as smaller grains, 25 microns. Matrix is comprised of clay to silt sized minerals and abundant muscovite. Glauconite is also present. The matrix is a light brownish color and pyrite framboids and euhedral crystals are abundant. Pyrite overgrows both the matrix and the large crystals. One large pyrite clump, 280 μ m long. Some siliceous microfossils are also visible. Grains are very closely packed. Dark, thin (5 micron) stringers in the matrix cut through the large crystals, suggesting that they grew later and over-grew the rock fabric. There is a little high birefringent carbonate, rhombodehral cleavage, near the dark/light transition in bottom of slide. There are dark and light patches, which relate to the trace fossils/burrows that cut across bedding. Darker areas are a dull brown. There is the same mineralogy in both areas, just color varies. This includes the large (diagenetic) crystals in both. Alizarin Red stain applied on 31 January 2020, so as to characterize the carbonates. Significant amount of micrite in the matrix, calcareous, faint pink dolomite rhombohedrons are sometimes partly altered to calcite. No sign of ankerite. Classification: Dolomite-bearing calcareous mudstone.

Plane-polarized: 56274181



Cross-polarized: 56274201

**Treated Thin Section Images**

Plane-polarized: 56294931



Cross-polarized: 56294951



THIN SECTION LABEL ID: **378-U1553C-43R-3-W 87/90-TSB-TS 17**

Thin section no.: 17

Observer: Simon George

Thin section summary: Blue epoxy used to stain pore space. From interval described as very fine sandstone by hand lens. Thin section: Moderately well sorted rock. About 100 μm -150 μm grains, very fine sand to fine sand. Angular to sub-angular grains, sphericity mostly quite high, except for occasional very laminar or tabular minerals. Composition: main mineral is brown color, goes into extinction progressively as rotate. Could be micro-domain quartz, but appears to have 2nd order birefringence. This is dolomite, can see rhombohedral cleavage. Birefringence altered to near whites because thin section is >30 μm thick. Glauconite, muscovite. Dark yellow and black, fuzzy material that does not focus well, probably organic matter. Detrital clay, yellow-brown, low birefringence, chlorite? Pyrite, opaque, some cubes, sometimes sphere and other shapes. One patch of coarser minerals, 650 μm x 400 μm . Filled with quartz. Alizarin Red stain applied on 31 January 2020, so as to characterize the carbonates. Shows that the carbonate in the sample is predominantly dolomite: no color from stain. Some areas are calcite, stain pink. But possibly these could be clays, stained pink as side-product of Alizarin Red reaction? Alizarin: Calcite cement fills gaps around some of the dolomite rhombohedrons. Is patchy, more of this style of cementation in the part of the thin section near the label. Calcite later than dolomite. Glauconite surrounded by calcite cement. Pyrite and dolomite are surrounded by later calcite cement. Some of pore space between dolomite is not filled with pink calcite, but a yellowish mineral with mostly low birefringence, although some bright 2nd order colors visible. Mix of smectite and/or chlorite? It is possible that a clay has been stained pink by Alizarin Red. At end away from label, dolomite is finer (30 μm), much less calcite cement (<1%). Near label, dolomite is 70-100 μm and there is about 15% calcite. Sample: dolomitic limestone. Grain size varies through thin section.

Plane-polarized: 56274061



Cross-polarized: 56274081



Treated Thin Section Images

Plane-polarized: 56294891



Cross-polarized: 56294911



THIN SECTION LABEL ID: **378-U1553C-43R-4-W 63/66-TSB-TS 29**

Thin section no.: 29

Observer: Simon George

Thin section summary: This is a matrix supported rock with a finer, dark brown matrix in PPL with abundant subangular quartz grains (approximately 30% in the average field of view). Some of the whiter/clearer areas in PPL are characterized by a greater abundance of quartz grains as visible in XPL. These areas are coarser grained (30-60 μm) so are a coarse silt. Quartz grains are sub-angular with moderate sphericity. In the lens at top left of section there is about 20% muscovite, a few opaques and rather limited clays, the rest is quartz. There is a 2-3mm translucent patch that is pale and near the label of the thin section. The middle part is clear in PPL and has very low birefringence and is very fine grained (<5 μm) so that almost appears opaque. It is probably chert. This zone is surrounded by concentric diagenetic haloes. These have the same mineralogy as outside the halo, but are paler, with paler streaks reaching into the main matrix. They are paler because they contain less of the dull brown material (clay and organic matter) that forms the matrix of the main lithology. It appears that a diagenetic reaction has led to Si precipitation and removal of the organic matter from the outer zone. Glauconite is also present throughout (~1%) and is more visible in clear/white domains. Opaque, square euhedral grains are visible, which is likely pyrite. Muscovite is abundant as observed by translucence in PPL and high birefringence in XPL. These grains often show horizontal lineation. Occasional rounded chert grains and a trace of biotite. The brown matrix varies in "brownness", related to the clays and/or organic matter present. Very dark stringers of organic matter (10 μm thick, 100-150 μm long) are sporadic and concentrated in the darker brown areas. Alizarin Red stain applied on 31 January 2020, so as to characterize the carbonates. Stain shows matrix is partly calcareous, appears pink. The micrite is mostly mixed with clays, but in places is by itself as a cement and appears paler pink. Classification: sandy calcareous mudstone.

Plane-polarized: 56274221



Cross-polarized: 56274241

**Treated Thin Section Images**

Plane-polarized: 56295011



Cross-polarized: 56295031



THIN SECTION LABEL ID: **378-U1553C-43R-8-W 44/47-TSB-TS 18**

Thin section no.: 18

Observer: Simon George

Thin section summary: Thin section quality is not ideal. Thin section is highly cracked and is about 100 μm . When the technician attempted to grind thinner, the thin section started plucking and peeling. Mostly very dark, nothing to be seen. One area near the middle is thin enough for light to transmit and be useful. Fine matrix, <5 μm size, fine silt/clay. Brown-yellow. Organic matter stringers. Large minerals, pale, 15-45 μm , go to extinction = quartz, so coarse silt. Glauconite mudstone.

Plane-polarized: 56285071



Cross-polarized: 56285091



THIN SECTION LABEL ID: **378-U1553C-44R-1-W 67/69-TSB-TS 19**

Thin section no.: 19

Observer: Simon George

Thin section summary: Thin section quality is not ideal. Thin section is highly cracked and is about 200 μm . When the technician attempted to grind thinner, the thin section started plucking and peeling. Mostly very dark, nothing to be seen. On upper side, far from label, there is an area that is a little thinner and transmits. Grain size is 30-50 μm . No mineralogy possible. Mudstone.

Plane-polarized: 56285111



Cross-polarized: 56285141



THIN SECTION LABEL ID: **378-U1553D-10R-1-W 33/36-TSB-TS 30**

Thin section no.: 30

Observer: Simon George

Thin section summary: Slide is dyed with Alizarin Red for carbonate identification (left side). Up is towards label. Macroscopic: Pale and dark areas in Lithologic Unit Va, lenses with fossils? Thin section: Predominantly fine grained, with some larger microfossils and grains. Mostly <60 μm , so is a mudstone. Matrix contains no carbonate/micrite. Occasional chert grain, 300 μm . Dolomite rhombohedrons, no blue/ankerite stain. 200 μm long. Scattered throughout at low density, about 5%. Some clumps of low birefringent fibrous mineral, diverging clusters of mineral laths, zeolite? 200 μm long. Pyrite sometimes cubic, sometimes clumpy, very small and larger clumps. Also in thin lenticular areas. About 1%. Circular features filled with quartz? 200 μm across. Dolomitic mudstone.

Plane-polarized: 56290281



Cross-polarized: 56290301

**Treated Thin Section Images**

Plane-polarized: 56295051



Cross-polarized: 56295071



THIN SECTION LABEL ID: **378-U1553D-17R-4-W 91/94-TSB-TS 31**

Thin section no.: 31

Observer: Simon George

Thin section summary: Slide is dyed with Alizarin Red for carbonate identification. Macroscopic: very fine coarse patches, trace fossils. Thin section: very fine grained matrix, varying in grain size. Part of the matrix has taken stain, appears to be calcite or ferroan calcite. The slightly coarser units contain micrite, ferroan calcite. Black organic matter stringers. Lens of coarser material, 600 μm long, 100 μm wide: calcite (red on stain, not purple) cementing angular grains, some lath like, could be feldspar or zeolite? Some of dark patches of some micrite, ferroan calcite. Ferroan calcite localized along fractures. Small patch (125 μm x 60 μm) within clay-micritic matrix filled by zeolite. Also in other places. Matrix formed by yellow-brown clays, with micritic carbonate.

Plane-polarized: 56290321



Cross-polarized: 56290341

**Treated Thin Section Images**

Plane-polarized: 56294731



Cross-polarized: 56294751



THIN SECTION LABEL ID: **378-U1553D-17R-6-W 117/120-TSB-TS 32**

Thin section no.: 32

Observer: Simon George

Thin section summary: Slide is dyed with Alizarin Red for carbonate identification. Macroscopic: Massive medium sandstone. Up is label end, portrait mode to bedding Thin section: the medium grained area at top of thin section (near label) is not due to sand, but to dolomite diagenesis. Thin section is a bit thick, so higher order birefringence is masked. Dolomite is pale, rhombohedral, took no stain, no Fe-dolomite (ankerite). Dolomite forms about 50% of the rock in this top zone. Within the medium grained part, a small clast (700 μm x 250 μm) of micro quartz (40 μm) cemented by calcite. The margin of the clast is brownish and rounded, suggesting transport as a cemented grain. Matrix of "medium" grained segment is dark brown, poorly focused, reflecting a non-flat surface to the thin section. Too dark for any birefringence. The matrix away from the intense dolomite crystals (the finer segment) has a better surface and seems to be made of the same minerals. It is pale brown to yellow, includes grey quartz, and probable clays. In a few places there is a little micrite in the matrix. Some partial and completely calcite filled areas in the matrix. One crystal of dolomite in the finer segment found to be ankerite at its center. Most are not. Glauconite low abundance (<1%). Pyrite ringed by calcite. Matrix; 25-50 μm , is a siltstone. In the main part of the sample, the percent dolomite is about 5%. Area of darker/lighter sections caused by trace fossils: mineralogy appears similar, as does grain size. The brown fluffy material seems to be the difference. Lithology: Mudstone, dolomitic in part.

Plane-polarized: 56290361



Cross-polarized: 56290381

**Treated Thin Section Images**

Plane-polarized: 56295091



Cross-polarized: 56295111

