Appendix – Locations and Petrographic Descriptions of Tapeats Sandstone Samples

The thin sections of the fourteen (14) rock samples for this study were all mounted on standard 1.5 inch (~38 mm) long by 1.0 inch (~25 mm) wide glass microscope slides. Rock slices were cut perpendicular to the bedding so that the laminations could be viewed in cross-section. Any disruptions of the laminations due to ductile deformation would thus be evident without diminishing the ability to observe any dislocations of grains that might or might not have occurred. However, before the slices were cut from the rock samples using a diamond saw, the rock samples were impregnated under confining pressure with epoxy resin that contained a blue dye. This ensured that grains did not get dislocated or the rock fabrics get distorted during the sawing of the slices. However, this process left the thin sections with a blue dye staining as the surrounding background and in any holes or pores within the rock fabrics. Before cover slips were added, the thin sections were stained so as to make the K-feldspar and calcite in the rock fabrics more easily distinguished. Thus, the K-feldspar grains have a distinctive yellow color and the calcite is pinkish in plane polarized light.

The high resolution digital images of the whole thin sections (reproduced below) were obtained using a digital scanner that had been programmed accordingly. When the rock samples were collected in the field the right sides up (tops) were carefully marked, so that the thin sections were cut perpendicular to the bedding and stratigraphic upwards was marked on the thin sections. Consequently, all the images of the whole thin sections below are oriented with stratigraphic upwards always being to the top of the pages. Thus, most of the whole thin sections are reproduced lengthwise vertically, while some are oriented lengthwise horizontally, so that always stratigraphic upwards is at the top of each image (as annotated with an arrow). Carefully following this procedure allowed for observation of sedimentation features such as bedding planes, cross-laminations, and laminae, as well as the sorting and grading of grain sizes. Furthermore, because the images were cropped to remove extraneous details (such a labels) and then sized equally when placed with their respective petrographic descriptions below, a scale bar has been annotated to each image.

Regional Samples

TSS-01 N 36° 12.784' W 111° 48.411' (N 36.213° W 111.807°)

River Mile 60.1 – River left just below Sixtymile Rapid, at the upstream end of the beach, about 12 m (40 feet) down the stratigraphic section from the top of the cliff-forming unit.

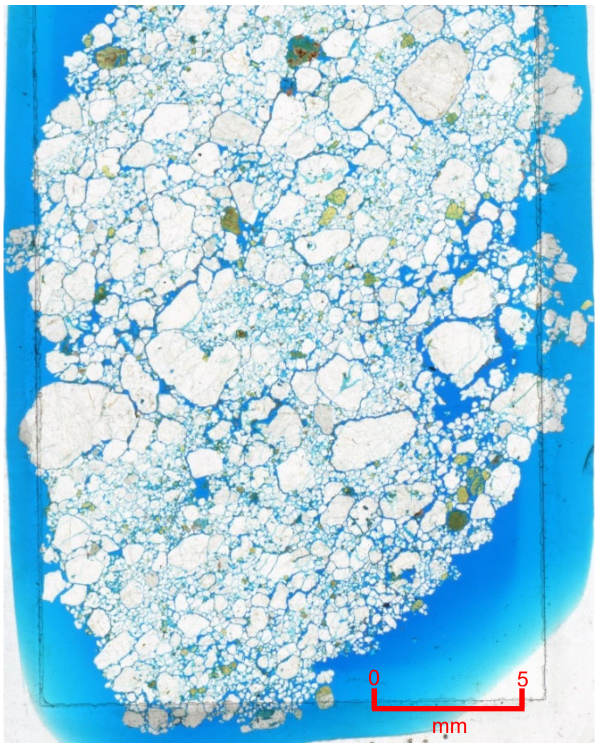
In hand specimen, a laminated sandstone with coarse-grained and finer-grained laminae. Poorly sorted, sub-angular to sub-rounded quartz grains.
At normal scale, the thin section confirms the poor sorting, although thin (1-2 cm) laminae of finer-grained and coarser-grained sand grains are visible, along with low-angle cross-bedding in the fine-grained layer and one of the two coarser-grained layers. Nevertheless, within the coarser-grained layers the quartz sand grains are poorly sorted because the full range of grain sizes are mixed, whereas the sorting is better in the finer-grained layer where only finer quartz sand grains are present. Occasional K-feldspar grains are scattered through this submature or arkosic quartz sandstone.

Under the microscope, a tightly-packed interlocking mosaic of scattered rounded and sub-rounded to sub-angular and sub-euhedral quartz grains of different sizes from very small to very large (0.05-2.0 mm, ϕ = +4.23 - -1.00, coarse silt to very coarse sand/granule size), sometimes euhedral, sometimes cracked, sometimes with domains or sub-grains of different crystallographic orientations as evidenced by different extinction angles, or even with undulose extinction, sometimes "ghost" rounded edges of original detrital grains with some euhedral overgrowths (cement) so that adjacent grains meet at triple points with roughly equal meeting angles. Some clusters of smaller quartz grains appear to be broken pieces. Occasional very large rounded to sub-rounded quartz grains are surrounded by very small to medium quartz grains tightly packed around them due to overgrowths (cement) on the latter, while in other places there are either lots of very small to small interlocking quartz grains or very small and medium to large irregularly-shaped sub-angular to sub-rounded quartz grains mixed or clustered together. Scattered among the mosaic of quartz grains are a lot of subordinate K-feldspar grains and broken fragments varying in size from very small to large (0.06-1.06 mm, ϕ = +4.05 - -0.08, coarse silt to very coarse sand size), often rounded but sometimes euhedral or sub-euhedral and usually fully altered or altered around edges and even cracked. One possible medium-sized plagioclase grain evidenced by its striped appearance due to telltale multiple twinning under crossed polars. Numerous thin edge-on very small to long (0.3-0.6 mm, ϕ = +1.75 - +0.74) muscovite flakes embedded within the mosaic, wedged primarily between, and sometimes bent or even broken around, the tightly-packed quartz grains, sometimes with frayed ends. One very small face-on muscovite flake is included within a very large sub-euhedral quartz grain. At least one very small, high relief, high birefringent, iron-oxide-stained sub-rounded tabular grain is zircon. The porosity appears variable from ~10% to almost 0%, (average overall ~6.5%) with some pore spaces being large with surrounding euhedral grains a jigsaw puzzle fit if "pushed" back together, but most are trivial, tiny or very small and very thin. Occasional iron-oxide stains around and/or coating grain edges, or staining K-feldspar grains, or even coating or in-filling pore spaces. The sample was forcefully impregnated before sectioning so there is a lot of blue dye between and coating many grains.

TSS-02 N 36° 14.419' W 112° 28.825' (N 36.240° W 112.480°)

River Mile 120.8 – River left, coarser-grained sandstone, with similar lithology to samples at Monument Fold (see below), cross-bedded, about halfway down the stratigraphic section from the top of the cliff-forming unit.

At normal scale, the thin section shows the rock fabric is certainly coarse-grained, but is also very poorly sorted, with scattered quartz grains or granules up to 6 mm wide and smaller quartz grains between them ranging down to very fine sand size, and occasional sand-sized K-feldspar grains wedged between them, which makes this a submature or arkosic quartz sandstone.



Under the microscope, the rock appears to have been friable in that the fabric of the rock looks like the grains were pushed apart likely during impregnation prior to the thin section being cut, because if pushed back together they would fit like a jigsaw puzzle. Otherwise, the rock consists of a tightly-fitting interlocking mosaic of quartz grains varying in size from very large to huge grains (up to 3-6 mm wide, ϕ = -1.63 - -2.33 granules to very small pebbles) with surrounding smaller grains (0.07 mm, ϕ = +3.77, very fine sand) to usually small, small-medium or medium-large grains, often rounded to sub-rounded or euhedral (likely due to overgrowths) or irregular with jagged edges, likely due to being fractured and forced apart. Thus, some aggregates of smaller quartz grains appear to be the broken-apart remains of much larger to huge quartz grains. Some huge quartz grains have a patchwork of sub-domains or sometimes sub-grains with different crystallographic orientations and thus extinction angles. Sometimes it is hard to discern whether such huge quartz grains are single grains with the internal patchwork or many smaller grains cemented together in a closely-knit mosaic. Where euhedral or jagged quartz grains meet or would have met if fitted back together triple point junctions are still evident. A few quartz grains have internal "ghost" outlines of the original sub-rounded detrital grains with overgrowths in optical continuity. The few subordinate K-feldspar grains and former laths are usually small (0.07 mm, ϕ = +3.77, very fine sand size) and often rounded, but some are medium to large or even very large (up to 1.00 mm, ϕ = 0.00, coarse sand size), are sometimes cracked, and are usually altered, sometimes to calcite, or are often even veined and/or lined with calcite, and often with some iron oxide staining or speckles. Some K-feldspar grains have ragged edges and one under crossed polars displays cross-hatched twinning. One K-feldspar grain is the rounded end of a former large lath, while several altered former K-feldspar grains or broken portions of them are included within large and huge quartz grains. Two rounded feldspar grains display multiple-twinning under crossed polars so may be plagioclase. One medium-sized, rounded grain looks like a fine-grained siltstone clast. A few small 0.05-0.25 mm, $\phi = +4.23 - +2.00$), thin edge-on muscovite flakes are sometimes frayed at their ends and are often wedged between quartz grains, or even included in medium-sized quartz grains. Calcite not only occurs as alteration after K-feldspar and as veining of K-feldspar grains, but as patches between and lining edges of, or cementing, quartz grains. The porosity varies and averages overall ~6%, indicating the original detrital grains were quartz-cemented into this tightly-fitted mosaic, with later trivial calcite penetrating as cement between a few quartz grains and altering some K-feldspar grains.

<u>TSS-03</u> N 36° 23.859' W 112° 31.896' (N 36.398° W 112.532°)

River Mile 138 – River right just below Doris Rapid. Cross-bedded, close to the Great Unconformity.

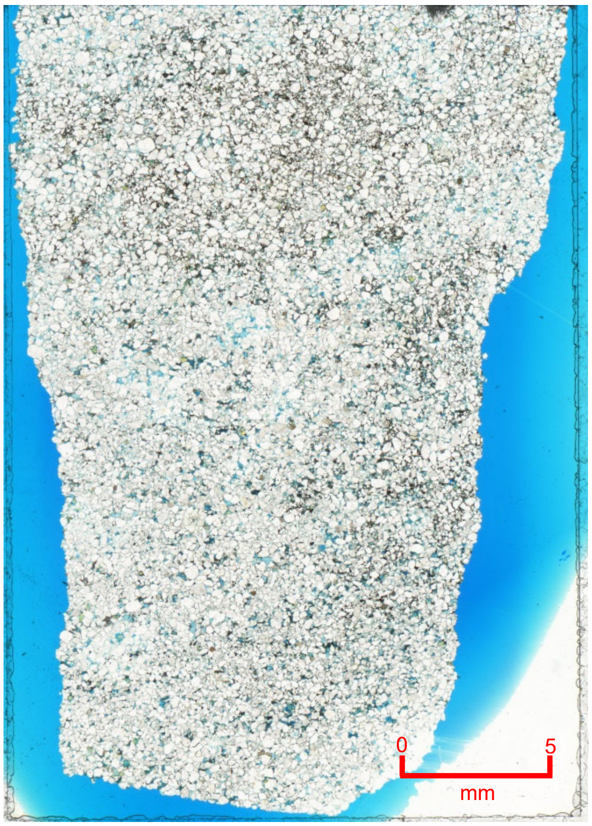
At normal scale, the thin section shows an even, finer-grained, massive sandstone with good sorting due to the quartz grains all being within a narrow size range of predominantly fine sand, with occasional similar-sized altered K-feldspar grains scattered evenly throughout this submature or arkosic quartz sandstone and no laminae evident.

Under the microscope, a tightly-fitting interlocking mosaic of quartz grains varying in size from small to medium to large (0.07-0.68 mm, ϕ = +3.77 - +0.56, very fine to coarse sand size), and sometimes elongated or odd shaped and/or some cracking. Most quartz grains are in the narrow size range of 0.17-0.26 mm (ϕ = +2.57 - +1.95, fine-medium sand). Some quartz grains are euhedral, but many are angular to sub-rounded with irregular edges that sometimes give the impression of being resorbed, and others have internal "ghost" outlines of the original detrital grains and overgrowths in optical continuity that often result in triple point junctions between some such grains. Some large quartz grains are surrounded by other small-medium angular quartz grains with irregular edges. Other large quartz grains contain sub-domains or sub-grains, sometimes with different crystallographic orientations and thus extinction angles. The abundant subordinate K-feldspar grains are usually small, small-medium or medium (0.07-0.75 mm, ϕ = +3.77 - +0.42, very fine to coarse sand size), and rounded, but there is also a very large (0.8 mm, ϕ = +0.33), rounded K-feldspar fragment and a huge (1.8 mm, ϕ = -0.85), corroded K-feldspar lath. Many K-feldspar grains are altered, often with calcite and iron-oxide, especially in cracks and coating the grains. More than a few edge-on muscovite flakes (0.3 mm, ϕ = +1.75, or more long by 0.09 mm thick) are scattered through the mosaic, usually wedged between and sometimes bent around the grains in it, and sometimes with frayed ends. Some are very large to huge and/or thick (up to 2.2 mm long, ϕ = -1.13, and 0.3 mm thick), often expanded between sheets with the ingress of alteration and having frayed ends. Others are broken and altered with accompanying calcite, quartz and iron oxide. One medium-sized quartz grain appears to have included in it a tiny fragment of a face-one biotite flake. There are what appear to be several small (0.15-0.20 mm diameter, ϕ = +2.75 - +2.33) rounded rock fragments accompanied by alteration and iron oxide staining. Calcite and iron oxide are often abundant between and on the edges of grains and sometimes coating K-feldspar grains, in cracks and fractures, and in patches that possibly are infilled pores, thus acting as a cement. The rock was well cemented, but the porosity is difficult to determine and varies, averaging overall ~5.5%. There is some cracking between grains (with blue dye staining now between and on grains due to the forced impregnation prior to the thin section being cut, and if pushed back together they would fit together again like a jigsaw puzzle.

TSS-04 N 36° 23.859’ W 112° 31.896’ (N 36.398° W 112.532°)

River Mile 138 – River right, opposite Doris Rapid. Cross-bedded, stratigraphically higher by 7.5 m (~25 feet).

At normal scale, the thin section shows an even-grained massive submature or arkosic quartz sandstone with a mixture of generally small and small-medium subangular to rounded quartz grains with occasional scattered small altered K-feldspar grains and no laminations, but with many very small quartz grains in between the larger grains the rock is not well-sorted.

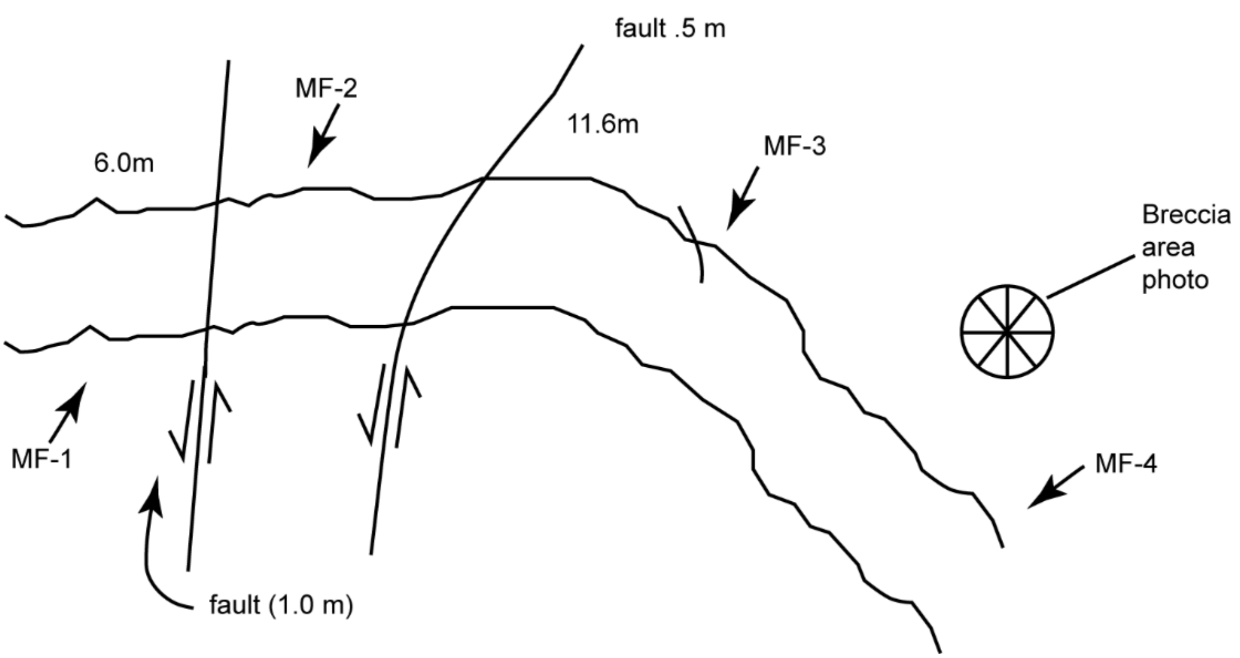


Under the microscope, an interlocking tightly-fitting mosaic of quartz grains that vary in size within the sample from very small to small-medium, medium-large and large (0.03-0.68 mm, ϕ = +5.01 - +0.56, medium silt to coarse sand sized), with most quartz grains in the 0.3-0.5 mm (ϕ = +1.75 - +1.00, medium sand size) range, and are euhedral or sub-angular to sub-rounded and generally rounded, except for some different and unusual shapes, sometimes elongated, sometimes cracked and some even have broken edges. Grain boundaries show clear outlines, or "ghost" outlines of sub-rounded original detrital grains with overgrowths in optical continuity with each grain, often meeting in triple point junctions. Occasional large irregular quartz grains have an internal patchwork of sub-domains that are various sizes and irregularly shaped, and at different crystallographic orientations and thus extinction angles, within the general mosaic of other small-large, rounded quartz grains. Some quartz grains exhibit undulose extinction. Otherwise generally there is a clear infilling quartz cement between the quartz grains. The edges of some quartz grains give the appearance of resorption, possibly representing solution of the quartz into the original pore water that then precipitated as the infilling overgrowths and quartz cement. Occasional quartz grains or overgrowths appear "dirty", perhaps from included iron oxide. The "dirty" quartz grains could be chert clasts. Some small and medium (0.06-0.33 mm, ϕ = +4.05 - +1.60, coarse silt to medium sand size), rounded K-feldspar grains are evident but are heavily altered. One elongated grain is altered with kaolinite (?) and calcite perhaps after K-feldspar. Another lath-like grain and a fragment are also clearly after K-feldspar. There are numerous small (0.06-0.20 mm, ϕ = +4.05 - +2.33) thin edge-on muscovite flakes, usually bent around and wedged between quartz grains in the mosaic. Other edge-on muscovite flakes are long (0.28-0.35

mm, ϕ = +1.85 - +1.50) or thick and degraded (expanded by alteration). Several small or medium (0.15-0.45 mm, ϕ = +2.75 - +1.15, fine to medium sand size), rounded and/or elongated grains appear to be rock (siltstone/schist?) fragments, often “dirty” from iron oxide. A small (0.10 mm, ϕ = +3.32) rounded oval, high relief, high birefringent, iron oxide stained grain tightly wedged between quartz grains is likely zircon. Small patches of calcite are scattered through the sample and there is a large totally-altered patch that is probably a kaolinite-infilled pore. There is scattered iron-oxide staining, probably with clay minerals (kaolinite and/or illite), between many quartz and other grains, and occasionally coating some quartz and other grains. There is virtually no remaining apparent pores, although since the grain size is very small, the porosity might be "hidden" by stacking of the silt grains which are tinier that the 30-micron slide thickness. Nevertheless, the rock was well cemented, so the porosity is difficult to determine as it varies, averaging overall ~0.5%. There is some cracking between grains.

Monument Fold (River Mile 116.4) Samples

Two beds within the reachable thickness of the Tapeats Sandstone cliff-forming unit within this fold were sampled (see the bed to the left in the marked image below). The first four samples were obtained from a bed not too far stratigraphically (~3-4 m, ~10-13 feet) above the Great Unconformity. Pebble and cobble-sized angular clasts in the bottom of the Tapeats Sandstone. Typical Tapeats Sandstone with small sets of cross-beds. Coarse plus granular sand in bed 3–4 m (10-13 feet) above the Great Unconformity. Some green muddy beds. Some blocks of small boulder-sized Tapeats clasts in vertical part of downriver side of fold. Some small faults within fold. Maybe 0.5 m (1.6 feet) displacement on most faults. Faults are not very numerous. Most of the faults are in muddy beds, but a few faults displace coarse sand beds. MF-4 was to the left of this area. This area: N 36° 11.824' W 112° 26.374' (N 36.197° W 112.440°).




MF-1

MF-01   N 36° 12.225'   W 112° 26.441'   (N 36.204°   W 112.441°)

Far left of down-river-most bend (see above).

About 20 cm (8 inches) thick, coarse arkosic sandstone bed with no gravel clasts at this point. 0.6 m (2 feet) thick, muddy beds above and below it. The muddy beds have some granular clasts in them, especially the one above. Sample taken from the bottom of the sandstone bed. This bed blends into about a 2 m (6.5 feet) thick bed above it.

At normal scale, the thin section shows a poorly sorted, very coarse-grained quartz sandstone with angular to subrounded quartz grains of all sizes from granules to fine sand size, the granules and very coarse grains often being elongated at an angle to the bedding and/or fractured, as is the rock fabric. Many altered K-feldspar grains and laths, from small to large are ubiquitous and are similarly fractured. Calcite and iron oxide infillings, veinlets and coatings are also scattered through the rock fabric. This is a submature or arkosic quartz sandstone.

Under the microscope, an often tightly-fitted mosaic of quartz grains, and perhaps broken fragments, of different sizes [small (0.12-0.24 mm, ϕ = +3.06 - +2.06, fine sand size) and medium (0.26-0.50 mm, ϕ = +1.95 - +1.00, medium sand size) to large (0.52-0.98 mm, ϕ = +0.95 - +0.02, coarse sand size), very large (1.03-1.50 mm, ϕ = -0.04 - -0.58, very coarse sand size) and huge (2.33-2.62 mm, ϕ = -1.22 - -1.38, granules)], sometimes elongated, and different irregular shapes (sub-angular to rounded), that are also often speckled with iron oxide streaks, cemented by quartz (as overgrowths and patches between detrital grains usually meeting at triple points), as well as calcite and iron oxide, both of which appear to be a later introduction to the rock fabric, particularly after fracturing of the rock fabric and of some grains had occurred. Iron oxide dustings form "ghost" outlines of the original rounded detrital quartz grains with surrounding overgrowths/cement in optical continuity. Some larger grains consist of sub-grains with different extinction angles. Some resorption of many quartz grain edges. Many grains are cracked, while many others have been fractured with some grains offset. Some grains exhibit undulose extinction. Very numerous altered and heavily altered K-feldspar laths, grains and fragments, sometimes small (0.10-0.24 mm, ϕ = +3.32 - +2.06) or medium (0.26-0.50 mm, ϕ = +1.95 - +1.00) and sub-rounded, but often large

(0.52-0.95 mm ϕ = +0.95 - +0.08) or very large (1.24-1.64 mm ϕ = -0.31 - -0.71), sometimes being partially sub-rounded and partially subangular at their corners, sometimes exhibiting cross-hatched twinning under crossed polars, isolated or in groups, sometimes also being broken or cracked in place and included in the overgrowths (cement) with huge (2.33-2.62 mm, ϕ = -1.22 - -1.38) quartz grains, the mosaic sometimes being molded around the K-feldspar grains. Two large altered K-feldspar laths are fractured and offset with calcite veins filling the main fractures. Several medium and large fragments of a very large altered, K-feldspar lath are surrounded by and included in a really huge (2.62 mm, ϕ = -1.38) quartz grain, while a very large (1.64 mm ϕ = -0.71), altered K-feldspar lath (exhibiting cross-hatched twinning in crossed polars) has small, rounded quartz inclusions. Two medium (0.36-0.43 mm, ϕ = +1.36 - +1.22) rounded and sub-angular or irregular grains are possibly plagioclase due to exhibiting multiple twinning under normal light and crossed polars. Many edge-on muscovite flakes, both small and large/long or very large/long (0.07-1.43 mm ϕ = +3.77 - -0.52), thin and thick (0.16 mm, ϕ = +2.66) or very thick (0.47 mm ϕ = +1.09), sometimes bent around quartz grains or even partly broken (often at their ends which may be frayed), sometimes altered/degraded and greatly expanded, wedged at various angles between quartz and sometimes K-feldspar grains. A small (0.09 mm, ϕ = +3.47) edge-on muscovite flake is included in a quartz grain, while a small (0.10 mm ϕ = +3.32) edge-on thick (0.04 mm ϕ = +4.64) muscovite flake is included in the edge of a very large altered and broken K-feldspar lath. Three large altered/degraded muscovite flakes with iron oxide along cleavages, and in part broken (likely from the forced impregnation), are embedded in huge (2.33-2.62 mm, ϕ = -1.22 - -1.38) quartz grains now fractured or surrounded by mosaic quartz grains, while another large (0.57 mm ϕ = +0.81) thick (0.10 mm, ϕ = +3.32) degraded edge-on muscovite flake is wedged between quartz grains and squeezed in-between two adjoining quartz grains. A narrow (0.20 mm ϕ = +2.35) but incredibly thick (0.16 mm, ϕ = +2.66) stacked "book" of edge-on muscovite wedged between two large quartz grains with adjacent vein calcite. Two small (0.14 mm ϕ = +2.84) rounded oval high relief, high birefringent crystals of zircon are wedged in the mosaic. Calcite occurs as between-grain veins of cement, sometimes as quite large areas, as veins cross-cutting quartz or K-feldspar grains or laths, often filling fractures, and as spotty coatings or even replacements of both quartz and K-feldspar grains, and on the edges of the grains, sometimes engulfing them, often also coated with iron oxide, the calcite clearly having been introduced to the rock fabric after its fracturing. Cracking of the rock fabric around grains and even across grains occurred due to the friability of the rock. The porosity varies but averages overall ~3%. There is some blue dye staining between and sometimes partially covering some grains due to the forced introduction of a bonding agent (epoxy) with blue dye before the thin section was cut.

MF-02 N 36° 12.107' W 112° 26.312' (N 36.202° W 112.439°)

Bed has coarse gravel in it, typical angular clasts for the bottom of the Tapeats Sandstone. Large sample collected. Rock held together well. Bed thickness 35.5 cm (14 inches) (approximately to thin mudstone bed). Mudstone bed above no longer visible. Bed thickness approximate. This bed appears to join into thicker 2 m (6.5 feet) thick bed 6 m (20 feet) from last bed.

At normal scale, the thin section shows a very coarse grained, poorly sorted and fractured quartz sandstone, with small fractured quartz pebbles (4.03-7.58 mm wide, ϕ = -2.01 - -2.56) and granules (2.10-3.38 mm wide, ϕ = -1.07 - -1.76) set in a matrix of primarily medium to very coarse cracked quartz grains with some very fine to fine quartz grains between them and many scattered altered and fractured K-feldspar grains ranging from very fine grains to granules, as well as an area of scattered calcite veinlets and vein-like patches between quartz and K-feldspar grains, all cross-cut by a fracture zone approximately perpendicular to the bedding. This is a submature or arkosic quartz sandstone.

Under the microscope, a tightly fitting and interlocking mosaic of quartz grains, and apparent fragments, of various sizes, sometimes in mixtures [a few small (0.10-0.24 mm, ϕ = +3.32 - +2.06, very fine to fine sand size), many medium (0.26-0.50 mm, ϕ = +1.95 - +1.00, medium sand size), mostly large (0.52-1.00 mm, ϕ = +0.95 - 0.00, coarse sand size), very large (1.03-1.98 mm, ϕ = -0.04 - -0.98, very coarse sand size) and huge (2.10-7.58 mm, ϕ = -1.07 - -2.56, granules and small pebbles)] and various shapes

(euhedral or sub-euhedral and angular to sub-rounded and rounded) with straight and irregular edges (the latter likely due to resorption), numerous cracks and iron oxide streaks (including along cracks) in a tight jigsaw fit due to infilling overgrowths/cement in optical continuity so that grains often meet at triple points, often making for an apparent solid mass of quartz. Many quartz grains have heavily iron oxide "ghost" outlines of the sub-angular to sub-rounded and rounded detrital grain shapes, which are sometimes internally quite "dirty" with iron oxide, for example, in wavy lines suggesting the clasts are metamorphic, with overgrowths usually in optical continuity and some being euhedral. Many larger grains also consist of various-sized, irregular-convoluted or straight edged, sub-grains (sometimes separated by cracks) or sub-domains with different extinction angles, some such grains having irregular and fuzzy edges marked by their sub-domains. One huge (2.62 mm, ϕ = -1.38) quartz grain impinges into an adjoining quartz grain and consists of an internal original sub-angular detrital grain (metamorphic) covered in wavy dirty lines and speckles of iron oxide as well as the iron oxide outline, with its overgrowths in optical continuity. Some quartz grains exhibit undulose extinction. Along the edges of two huge (4.69 and 6.14 mm, ϕ = -2.12 and -2.36) quartz grains is what appears to be a zone of crushed and/or sheared quartz like "mylonite" made up of tiny-small irregular quartz fragments with different extinction angles but "blend" into one another as a cemented mass, that on their other sides also cuts off the corners of former K-feldspar laths. The same wide crushed quartz "mylonite" zone elsewhere cuts between two very large K-feldspar laths, cuts the edges of other quartz grains, or even includes an altered elongated K-feldspar grain, and a sheared "island" medium quartz grain with stress twinning in crossed polars and with an included long, thick, altered edge-on muscovite flake with frayed ends. Many small (0.12-0.24 mm, ϕ = +3.06 - +2.06), medium (0.28-0.50, mm ϕ = +1.85 - +1.00), large (0.52-0.89 mm, ϕ = +0.95 - +0.17) and very large to huge (1.03-4.03 mm ϕ = -0.04 - -2.01), altered (with iron oxide staining and spots) and cracked, euhedral and angular or sub-angular to sub-rounded and rounded, sometimes irregular-edged, K-feldspar grains and former laths, wedged tightly in the mosaic, sometimes with fragments of them laterally adjoining them, and sometimes with euhedral partial quartz grains grown around them. Several huge (2.24-4.03 mm, ϕ = -1.16 - -2.01) euhedral K-feldspar laths with sub-angular to sub-rounded corners and many medium-large rounded K-feldspar grains (often former laths) are not only cracked but some display warped stress multiple and cross-hatched twinning extinction under crossed polars. Several large irregular and very large euhedral K-feldspar grain and laths respectively have small-medium rounded inclusions of quartz cement, the laths being fractured and bent between adjoining very large quartz grains. A few small to large (0.38-1.69 mm $\phi = +1.39 - -0.76$) thick, and sometimes long, altered (expanded and iron oxide stained) edge-on muscovite flakes with bent and frayed ends (one especially frayed) are wedged and bent between mosaic quartz grains and some K-feldspar laths. Wide vein-like patches and outright veins of calcite between overgrown very large and other quartz grains and altered K-feldspar ex-laths, in places appearing to replace quartz grain edges. Elsewhere calcite patches infill between adjoining grains or displace angular quartz fragments, sometimes accompanied by iron oxide patches. Calcite veining is within and on the edge of the crushed quartz "mylonite" zone and around quartz "remnants". Small iron oxide patches are scattered between some grains and in some cracks within a few grains, or in one case a large streaky swath of iron oxide is over part of a large, altered K-feldspar lath. Widespread iron oxide staining, including in the "mylonite" zone cutting through the sample. A lot of cracking, but few to no pores, the porosity being variable and averaging overall ~1.5%. There is some blue dye staining between and sometimes partially covering some grains due to the forced impregnation prior to the thin section being cut.

MF-03 N 36° 11.875' W 112° 26.218' (N 36.198° W 112.437°)

11.6 m (38 feet) to the right from last sample spot (MF-02). Bed dipping about 45° Bed structural measurement). Clasts in the bottom of the bed, thickness about 0.6 m (2 feet) to some mudstone layers with gravel in them. Bed thicknesses are quite variable and not easy to follow. This is part of a larger 2 m (6.5 feet) thick bed that can be followed from the other side of the river. Muddy bed, with mudstone plus gravel in it, below the sampled bed. Sampled bed has large angular gravel plus cobble clasts in it.

At normal scale, the thin section shows a very coarse grained, poorly sorted quartz sandstone, with fractured quartz small pebbles and granules (2.00-4.62 mm wide, ϕ = -1.00 - -2.10) set in a matrix of primarily medium to very coarse cracked quartz grains with some very fine to fine quartz grains between them and many scattered altered and fractured K-feldspar grains ranging from very fine grains to granules (2.12-3.85 mm wide, ϕ = -1.08 - -1.94), as well as many areas of scattered calcite veinlets and vein-like patches between quartz and K-feldspar grains. This is a submature or arkosic quartz sandstone.

Under the microscope, an often tightly-fitted mosaic of quartz grains of different sizes [a few small (0.10-0.24 mm, ϕ = +3.32 - +2.06, very fine to fine sand size), some medium (0.26-0.50 mm, ϕ = +1.95 - +1.00, medium sand size), and many large (0.52-1.00 mm, ϕ = +0.95 - 0.00, coarse sands size), very large (1.02-2.00 mm, ϕ = -0.03 - -1.00, very coarse sand size), and huge (2.50-4.62 mm, ϕ = -1.32 - -2.10, granules and small pebbles)], and various shapes (euhedral and sub-angular to sub-rounded and rounded), often meeting at triple points and sometimes so cemented together that grain boundaries are indistinct except for streaks of fine iron oxide staining so it looks like a solid mass of quartz until the different extinction angles are seen under crossed polars. Many grains have iron oxide streaks and dustings or even heavy coatings, sometimes in patches with clean areas between. Others consist of patchworks of irregular-shaped (ragged edged) sub-grains or sub-domains of various sizes (medium, small and very small) that are evident when there is faint or heavy iron oxide staining of the boundaries or when the different extinctions angles are seen under crossed polars. Some euhedral clean overgrowths are on iron oxide "ghost" outlines and rounded iron oxide dirty cores in optical continuity, but elsewhere the rounded detrital cores and overgrowths/cement are equally "dirty" from iron oxide speckling in patches and along cracks but also leaving clean areas. Curved and irregular, ragged edges are where resorption (?) may have occurred. Some grains and sub-grains exhibit undulose extinction. Some huge (2.50-4.62 mm, ϕ = -1.32 - -2.10) quartz grains are elongated with irregular edges and many grains are also cracked with iron oxide along cracks. Occasionally large quartz grains are resorbed significantly on one or more edges and iron oxide stained calcite has replaced much of the quartz, while some large quartz grains have their edges fractured into small fragments. Many medium (0.27-0.50, mm ϕ = +1.90 - +1.00), sub-angular to sub-rounded, altered (often heavily) K-feldspar grains and laths, in part cracked and with iron oxide staining in cracks and in patches, wedged in the mosaic, sometimes with small (0.23-0.25 mm, ϕ = +2.13 - +2.00) fragments of the same K-feldspar lath adjacent. Many large (0.52-1.00 mm, ϕ = +0.95 - 0.00) and very large (1.10-3.85 mm, ϕ = -0.13 - -1.94) altered K-feldspar laths with iron oxide filled cracks and irregular, sometimes rounded, ends, and sometimes with patches of calcite alteration on them, or even large portions totally replaced by calcite, and one rounded end has a thin calcite coating. A ragged remnant of a former large K-feldspar lath partially replaced by calcite and iron oxide but beyond its ragged edge and around its other perimeter is halite, all wedged between quartz grains. A large (1.09 mm, ϕ = -0.12) angular altered K-feldspar grain included in a large quartz grain with sub-domains, while a small (0.10 mm, ϕ = +3.32) sub-angular quartz grain is included in the side of a very large, altered K-feldspar lath. Two long (0.33-0.36 mm, ϕ = +1.60 - +1.46) thin edge-on muscovite flakes are wedged and bent between quartz grains (some of which have been partially replaced by iron oxide stained calcite), and a small (0.18 mm, ϕ = +2.48) thick possible edge-on muscovite flake replaced by calcite. A very small (0.05 mm, ϕ = +4.23) edge-on muscovite flake and a small (0.16 mm, ϕ = +2.66) face-on altered biotite flake (one end partly altered to calcite) are included in two quartz grains. Calcite infilling or veining, sometimes thick, between or across grains in the mosaic, sometimes between the edges of the overgrowths, sometimes accompanied by very small quartz (?) (or unstained calcite) grains and encroaching on (replacing and engulfing?) many quartz and some K-feldspar grain edges making them ragged accompanied by iron oxide staining, so the calcite veining and iron oxide staining occurred after the quartz overgrowths/cement and appear to be replacing the quartz grains. A thin vein of calcite ± quartz ± iron oxide cuts across earlier calcite between quartz grains. Many low relief (and isotropic) clear (cream) irregular, small and large, areas of halite sometimes with fuzzy edges or with fine "prominences" reaching out into adjoining quartz grains along fractures, or within/replacing huge (2.50-4.62 mm, ϕ = -1.32 - -2.10) quartz grains and large altered K-feldspar laths, and elsewhere veining across iron oxide stained calcite infilling between mosaic grains, indicating the halite was the latest alteration. An area of small (0.23-0.28 mm, ϕ = +2.13 - +1.85) polygonal clean grains (halite?) in association with calcite infilling between quartz and K-feldspar grains. A large area of alteration (fine-grained quartz or halite? plus illite? plus minor iron oxide staining) infilling between quartz and K-feldspar grains and encroaching into them (resorption?). Heavy iron oxide coatings around and between some quartz grains making their edges irregular and along some cracks in the grains. Some very small irregular patches of iron oxide between mosaic grains. Virtually no pores, with the variable porosity averaging overall only ~0.2%. There is also some cracking and some blue dye staining between and sometimes partially covering some grains due to the forced impregnation prior to the thin section being cut.

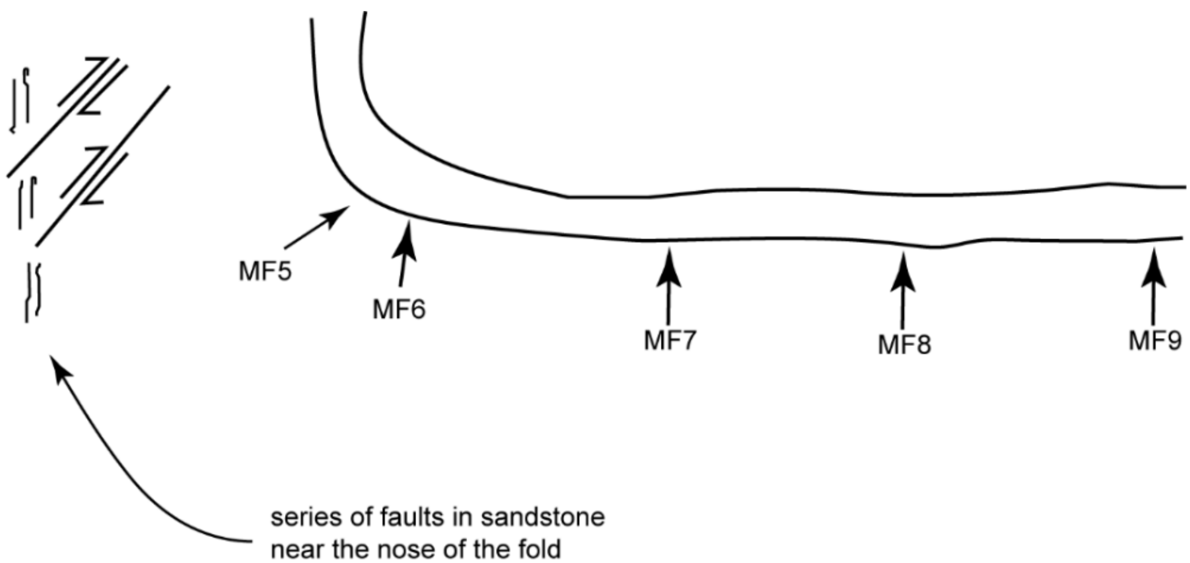
MF-04 N 36˚ 11.832’ W 112˚ 26.164’ (N 36.197° W 112.436°)

Dipping about 80° (bed structural measurement). Coarse gravel in the bottom of the bed about (approximately) 1 m (~3 feet) thick to thin claystone bed, but part of a larger bed. About 14 m (~46 feet) laterally along the bed from the last sample. Very thin sample. Hard to get a thicker one. This bed again sits above purplish mudstone bed with gravel in it.

At normal scale, the thin section shows a very coarse grained, poorly sorted quartz sandstone, with fractured quartz granules and small pebbles (2.50-5.18 mm wide, ϕ = -1.32 - -2.20) set in a matrix of primarily medium to very coarse cracked quartz grains with some very fine to fine quartz grains between them and many scattered altered and fractured K-feldspar grains ranging from very fine grains to granules (2.50-3.21 mm wide, ϕ = -1.32 - -1.68), as well as many areas of scattered calcite veinlets and vein-like patches between quartz and K-feldspar grains. There appears to be some incomplete graded bedding, and

there is a thin anhydrite vein filling a fracture parallel to the bedding, but this is the same submature or arkosic quartz sandstone.

Under the microscope, an often tightly-fitted mosaic of quartz grains of different sizes [very few small (0.12-17 mm, ϕ = +3.06 - +2.57, fine sand size), some medium (0.26-0.50 mm, ϕ = +1.95 - +1.00, medium sand size), and many large (0.52-0.98 mm, ϕ = +0.95 - +0.03, coarse sand size), very large (1.02-1.86 mm, ϕ = -0.03 - -0.89, very coarse sand size) and huge (2.50-3.39 mm, ϕ = -1.32 - -1.76, and 4.11-5.18 mm, ϕ = -2.02 - -2.20, granules and small pebbles respectively)] and various shapes (sub-euhedral to sub-rounded) often meeting at triple points, sometimes so cemented together that grain boundaries are indistinct except for streaks of fine or heavy iron oxide staining so it looks like a solid mass of quartz until the different extinction angles are seen under crossed polars. Many grains are "dirty" with iron oxide speckling and streaks along cracks as well as general staining, while many medium-large and huge (2.50-5.18 mm, ϕ = -1.32 - -2.20) grains contain the "ghost" iron oxide outlines of the rounded detrital grains with the overgrowth/cement in optical continuity and sometimes euhedral infilled to meet at triple points. Some medium and large quartz grains consist of patchworks of sub-grains or sub-domains of different sizes (tiny to small), usually irregularly-shaped but sometimes polygonal, usually exhibiting different extinction angles with irregular edges lined with iron oxide and often meeting at triple points. Sometimes overgrowths/cement are patchy or consist of patchworks of small somewhat-polygonal cement grains or sub-domains with different extinction angles that meet at triple points, sometimes very small quartz grains fill what are probably former pores, and some portions are sometimes altered to/replaced by calcite. Some grains and overgrowth sub-grains exhibit undulose extinction. Some grains also show some internal similar corrosion, and many have straight and curved edges and irregular shapes due to their ragged edges corroded by encroaching by iron oxide ± calcite alteration. Some huge (2.50-5.18 mm, ϕ = -1.32 - -2.20) quartz grains contain zones of disruption with subsequent recementing, or with sub-grains sometimes offset and which have been intruded along cracks by iron oxide stained calcite veins and patches. A few small (0.14-0.21 mm, ϕ = +2.84 - +2.25), many medium (0.26-0.50 mm, ϕ = +1.95 - +1.00) and large (0.52-0.97 mm, ϕ = +0.95 - +0.05), and some huge (1.05-3.21 mm, ϕ = -0.07 - -1.68) altered (often heavily) K-feldspar laths, grains and angular fragments, usually with rounded ends or ragged edges but sometimes euhedral, with heavy iron oxide along cracks and cleavages (some show cross-hatched twinning under crossed polars), one with a calcite vein through it and some edges with calcite alteration, always wedged tightly (encapsulated) within the mosaic. Several altered (one heavily) K-feldspar laths have remnants of small (0.08-0.10 mm, ϕ = +3.64 - +3.32) rounded included quartz grains, or they may represent silica produced by the alteration. The remnant of another former K-feldspar lath is totally altered to iron oxide stained calcite, its irregular outline with straight-edges generally matching the adjoining large quartz grains it is tightly wedged between, all edges often meeting at triple points. Thick broken pieces of a very long (0.69 mm ϕ = +0.54), two other long (0.50-0.53 mm ϕ = +1.00 - +0.92), and a small (0.29 mm ϕ = +1.80) altered (and expanded) edge-on muscovite flakes with some frayed ends, wedged tightly and bent in the mosaic between and around quartz and K-feldspar grains. A small (0.16 mm ϕ = +2.66) face-on muscovite flake included within a large, rounded quartz grain. Wide iron oxide stained calcite veining and large and small areas infill between quartz grains and K-feldspar laths and replacing/engulfing the quartz and K-feldspar grains to produce their ragged edges and entraining tiny quartz remnants, some perhaps filling former pores. Some veins of anhydrite (tiny, high birefringent grains and flakes) are along fractures in some quartz grains and between quartz grains, and some anhydrite patches replace the ends of K-feldspar laths and are between quartz grains. Small and large patches of partially iron oxide stained anhydrite alteration are between and draped around quartz grains some potentially being infilled former pores, one patch of small anhydrite grains infilling between broken pieces of overgrowths from adjacent quartz grains and abutting a patch of calcite against a K-feldspar grain, suggesting the anhydrite was the last alteration. One large patch of low relief, isotropic halite adjoins iron oxide stained anhydrite alteration between two large, rounded quartz grains next to a K-feldspar lath. One large patch of alteration, consisting of a fan of radiating iron stained bladed flakes of possibly illite/smectite, replaces or covers a large oval quartz grain with remnants showing around the periphery, all between other quartz grains. Iron oxide linings and patches are around and on edges between some grains. Virtually no pores, the minimal varying porosity averaging overall only ~0.1%. But there is also some cracking and some blue dye staining between and sometimes partially covering some grains due to the forced impregnation prior to the thin section being cut.



The remainder of the samples were collected from a second bed ~50 m (~164 feet) above the Great Unconformity (see the upper bed to the right in the marked image above). Sample MF-5 was 4 m (13 feet) to the right of the faults. The faults are smeared, which means the rock was semi-plastic when it moved. Sandstone beds about 20 cm (c. 8 inches) thick. Muddy beds with granules in them on either side of faulted sandstone. There is also a larger fault parallel to smaller faults that breaks all the strata for many meters; difficult to tell the displacement.

<u>MF-05</u> N 36° 11.650' W 112° 26.168' (N 36.194° W 112.436°)

At the hinge of the fold. Small folded section in the sample we are attempting to take. Mudstone beds just to left of this sample have faults in them. Reverse faults, same as in the area to the left. Laminated sandstone with granules in it. Mudstone (with granules) above and below. All of the mudstone beds here are purple with granules in them. Dip approximately 60° (bed structural measurement).

At normal scale, the thin section shows a very coarse grained, poorly sorted quartz sandstone, with granules and small pebbles (2.12-4.81 mm wide, ϕ = -1.08 - -2.14) of quartz set in a matrix of primarily medium to very coarse quartz grains with some very fine to fine quartz grains between them and many scattered altered K-feldspar grains ranging from very fine to medium grains. There appears to be vague incomplete graded bedding, but this is the same submature or arkosic quartz sandstone.

Under the microscope, an often tightly-fitted mosaic of quartz grains of different sizes [many small (0.09-0.25 mm, ϕ = +3.47 - =2.00, very fine to fine sand size), numerous medium (0.26-0.50 mm, ϕ = +1.95 - +1.00, medium sand size), numerous large (0.52-0.98 mm, ϕ = +0.95 - +0.03, coarse sand size), many very large (1.03-1.86 mm, ϕ = -0.04 - -0.89, very coarse sand size), and a few huge (2.12-4.81 mm, ϕ = -1.08 - -2.14, granules to small pebbles)] and various shapes (angular and euhedral to sub-rounded and rounded) often meeting at triple points, but sometimes so cemented together that grain boundaries are indistinct except for streaks of fine or occasionally heavy iron oxide staining so it looks like a solid mass of quartz until the different extinction angles are seen under crossed polars. Many "ghost" iron oxide outlines of many small and medium to huge (2.12-4.81 mm, ϕ = -1.08 - -2.14) original rounded and sub-angular detrital grains, their overgrowths of polygonal tiny to small sub-grains and sub-domains meeting at triple points Many very large-huge (1.03-4.81 mm, ϕ = -0.04 - -2.14) quartz grains are still rounded (sometimes two such grains almost "touch" one another) and set in a matrix mosaic of small-medium, polygonal-rounded quartz grains, but most boundaries meet at triple points so the interlocking fit is tightly "molded." Some mosaic grains have fuzzy irregular edges (possibly due to resorption) and roughly polygonal shapes suggestive of resorbing and cementation into solid masses of quartz, still with triple point junctions. Faint iron oxide staining and speckling, and some patchy coatings, make some grains quite "dirty." Often the uniform overgrowths between quartz grains form a common cement. Many large grains consist of sub-grains, with different extinction angles under crossed polars, that are often polygonal with straight edges meeting at triple points and sometimes these sub-grains become indistinguishable from, and blend with, the surrounding mosaic grains. Large to huge (0.52-4.81 mm, ϕ = +0.95 - -2.14) cracked or fractured quartz grains with iron oxide lining cracks and oblique fractures, the latter potentially offset, some with edges lined by iron oxide and often consisting of sub-grains with straight or curved edges with faint iron oxide staining and different extinction angles often meeting at triple points, and sometimes with linear zones (often along fracture zones) parallel to the top edges consisting of tiny grains suggestive of recrystallization after disruption, in a cementing interlocked mosaic of small to medium irregularly-shaped, sometimes polygonal quartz grains, some with overgrowths and cemented together often meeting at triple points. Sometimes these fractured grains have produced large, separated fragments set separately in the surrounding mosaic or within zones of disruption with tiny, crushed grains that are sometimes heavily iron oxide stained. In other places the fractured ends of elongated huge (2.12-4.81 mm, ϕ = -1.08 - -2.14) quartz grains were split into segments and the broken-off large fragments are set in a linear matrix zone of crushed tiny-very small angular fragments, sometimes set in a fine granular quartz matrix, adjacent to the regular matrix mosaic of small-medium, euhedral to sub-rounded grains with triple points. Patches and thin linear zones of tiny quartz grains are sometimes within and across the matrix mosaic which sometimes cut across mosaic grains, possibly representing healed zones of disruption. Numerous small (0.06-0.24 mm, ϕ = +4.05 - +2.06) and a few medium (0.26-0.46 mm, ϕ = +1.95 - =1.12) and several large (0.60-0.95 mm, ϕ = +0.74 - +0.08), one with included small quartz grains that may be due to original exsolution, altered (some heavily) K-feldspar laths and grains with rounded corners, or sometimes small to large broken angular fragments or broken edges, all with iron oxide staining, wedged tightly between small-medium mosaic quartz grains in a molded fit. Two medium (0.26-0.50 mm, ϕ = +1.95 - +1.00) rounded (but with irregular edges) possible plagioclase grains due to their strong display of multiple twinning in crossed polars. A few thin and thick, small (0.07-0.20 mm, ϕ = +3.77 - +2.33) edge-on muscovite flakes (some degraded) wedged and/or bent or contorted between mosaic quartz grains and sub-rounded K-feldspar grains. Two small (0.08-0.18 mm, ϕ = +3.64 - +2.48) thick tabular flakes totally covered with iron oxide may be altered edge-on muscovite flakes. Two small (0.07-0.10, mm ϕ = +3.77 - +3.32) rounded oval high relief, high birefringent crystal of zircons coated with some iron oxide are wedged in the mosaic. A medium (0.38 mm, ϕ = +1.39), rounded, altered rock fragment (iron-stained quartzite? consisting of small polygonal grains) set in the mosaic, and two small (0.15 mm, ϕ = +2.75) and a huge (2.24 mm, wide, ϕ = -1.16) rounded "dirty" rock fragments (iron-stained siltstone?) adjoining and cemented to very large rounded quartz grains. A linear patch of alteration between quartz grains consists of tiny and small illite (?) flakes with some iron oxides. Occasional patches within the mosaic of scattered very small quartz grains are set in a matrix of alteration (illite?) ± iron oxides. There are occasional small iron oxide patches, blotches and streaks between grains, and frequent cracking. The porosity varies but averages overall ~0.5%. There is also some blue dye staining between and sometimes partially covering some grains due to the forced impregnation prior to the thin section being cut.

<u>MF-06</u> N 36° 11.640' W 112° 26.151' (N 36.194° W 112.436°)

Sandstone with granules. Mudstone beds above and below as at MF-05 This sample was 1.8 m (6 feet) along bedding from MF-05. Bed is 30.5 cm (12 inches) thick. Sampled from the bottom of the bed. Bed dips at about 25° (bed structural measurement).

At normal scale, the thin section shows a coarse-grained, poorly sorted quartz sandstone with no apparent

sorting or layering, but significant brittle fracturing of some of the largest quartz grains and the rock fabric is evident (although there is no offsetting along the fractures). Quartz granules (2.03-2.81 mm wide, ϕ = -1.02 - -1.49) are set in a matrix of primarily medium-to-coarse and very coarse sand-sized quartz grains with some coarse silt and very fine to fine sand sized quartz grains between them and quite a few scattered altered K-feldspar grains ranging from very fine to medium sized. Some small to large patches of iron oxide cement are very evident in one area of the thin section. This is also a submature or arkosic quartz sandstone.

Under the microscope, a tightly-fitted mosaic of quartz grains of different sizes [very small (0.02-0.11 mm, ϕ = +5.71 - +3.19, medium silt to very fine sand sized), medium (0.27-0.48 mm, ϕ = +1.90 - +1.06, medium sand sized), large (0.52-0.92 mm, ϕ = +0.95 - +0.13, coarse sand sized) and very large (1.06-1.95 mm, ϕ = -0.08 - -0.96, very coarse sand sized) to huge (2.03-2.81 mm, ϕ = -1.2 - -1.49, granule sized), often in mixtures but dominated by the large to huge grains] and various shapes (euhedral, angular and sub-angular to sub-rounded, some irregular), with many iron oxide "ghost" outlines of the original, usually rounded, detrital grains and often euhedral overgrowths/cement usually in optical continuity making the grain boundaries meet at triple points, or just irregular-shaped quartz cement infilling between original quartz grains to make a molded fit of total quartz. Some fractures cross-cut the rock fabric marked by "healed" zones of "recrystallized" tiny-very small quartz fragments with irregular and resorbed fuzzy edges. Sometimes grain edges are irregular or fuzzy due to resorption, and in one area accompanied by encroaching calcite alteration. Many larger grains contain sub-grains with different extinction angles, and many grains have faint iron oxide streaks or are "dirty." In many places the tightly-fitting mosaic of irregular very small to small quartz grains meeting at triple points is between large to huge sub-rounded to rounded quartz grains, some with thin rind-like overgrowths, all forming a total mass of quartz. Some very large/huge (1.06-2.81 mm, ϕ = -0.08 - -1.49), rounded quartz clasts with irregular edges consist of patchworks of sub-domains of different shapes and sizes with faint iron oxide staining outlining them and different extinction angles. Many very large/huge (1.06-2.81 mm, ϕ = -0.08 - -1.49) sub-rounded and rounded quartz grains, some "dirty," some with sub-grains, some fractured, and some with "splintered" ends with offset fragments "healed" by overgrowths and by infilling quartz cement consisting of tiny grains with different extinction angles, in the one area some being encroached upon by iron oxide stained calcite alteration that has engulfed small-medium quartz grains infilling mosaic with fuzzy irregular edges. Three huge (2.03-2.81 mm, ϕ = -1.2 - -1.49), rounded quartz grains abutting one another, but one with one fractured edge set in the mosaic of medium angular to sub-rounded tightly interlocking quartz grains making a solid quartz mass with iron oxide outlines and streaks. Some huge (2.03-2.81 mm, ϕ = -1.2 - -1.49) quartz grains, and an area, consisting of a patchwork of irregularly-shaped very small-small and sometimes larger sub-domains meeting at triple points with different extinction angles giving a blotchy effect, and one cut by fractures. Some apparent remnants of fractured very large quartz grains with sub-grains set in a fracture zone matrix of "recrystallized" tiny-very small quartz fragments with irregular and resorbed fuzzy edges often meeting at triple points, in one instance with remnant medium grains in the matrix in an "island" between fractures. Some areas of tiny and very small angular to sub-rounded and irregular quartz grains often with fuzzy edges infilling between the mosaic of medium and larger original quartz grains and possibly representing "healed" recrystallized fracture zones, sometimes encroached on by calcite alteration between peripheral grains. An isolated area with medium and large angular quartz grains and fragments with "digested" edges due to resorption and re-precipitation of tiny quartz grains speckled with iron oxide that leaves skeletal original quartz grains. Many small (0.06-0.22, mm ϕ = +4.05 - +2.19) and medium (0.25-0.47 mm ϕ = +2.00 - +1.09), angular to sub-rounded and rounded grains, a medium angular cracked grain, and small-medium rounded laths of altered and very altered K-feldspar stained with iron oxide within tightly fitting mosaic. Several small and medium length (0.10-0.18 mm ϕ = +3.32 -+2.48) thick, and one thin, altered edge-on muscovite flakes, one with frayed ends, wedged between quartz and K-feldspar grains, and two irregularly-shaped, one larger (0.22 mm wide ϕ = +2.19), one small, partially face-on/edge-on muscovite flake included within very large quartz grains. In the one area there is calcite veining/alteration (with iron oxide staining) and patches of calcite grains infilling/cementing between quartz grains and encroaching between quartz grains and on their edges, sometimes also containing residual tiny quartz grains and sometimes appearing to have pushed apart euhedral large quartz grains. Several very thin quartz veins cross-cutting original quartz grains and the alteration/cement. One large granule-sized (2.66 mm wide ϕ = -1.41) angular rock (breccia) fragment. In that one area calcite also infills tiny residual pores between quartz grains. Otherwise, there are scattered tiny and small patches, and one very large patch, of iron oxide, but only minimal pores and variable porosity, which averages overall ~0.5%. There is also some cracking and some blue staining of some grains and their edges and along cracks due to the forced impregnation prior to the thin section being cut.

MF-07 N 36° 11.539' W 112° 25.941' (N 36.192° W 112.432°)

Sample taken from the bottom of the sandstone bed. Lots of granules. Sandstone bed is 17.8 cm (7 inches) thick. Layers are flat and not folded. Mudstone beds above and below. Same as last few samples. Sandstone has small, coarse, cross-bed sets half the thickness of the bed. 8 m (26 feet) from the last sample.

At normal scale, the thin section shows a coarse-grained, poorly-sorted quartz sandstone with no apparent sorting or layering. Quartz granules (2.03-2.83 mm wide, ϕ = -1.02 - -1.50, and sometimes cracked) are set in a matrix of primarily medium-to-coarse and very coarse (1.05-1.95 mm, ϕ = -0.07 - -0.96) sand-sized quartz grains with some coarse silt and very fine to fine sand sized quartz grains between them and quite a few scattered altered K-feldspar grains ranging from very fine to medium sized. There are several areas where scattered iron oxide cement is evident. This is also a submature or arkosic quartz sandstone.

Under the microscope, a tightly-fitted mosaic of quartz grains, often small-medium (0.05-0.49 mm, ϕ = +4.43 - +1.03, coarse silt to medium sand size) and occasionally large (0.51-0.94 mm, ϕ = +0.98- +0.09, coarse sand size), polygonal to sub-euhedral and sub-angular to sub-rounded grains, some with fuzzy and others with irregular edges, and some with iron oxide "ghost" outlines of original, often rounded, detrital grains surrounded by overgrowths in optical continuity meeting at triple points and forming the cement to tightly mold them together into a solid quartz mass, which is the matrix surrounding and sometimes impinging on many very large to huge (1.05-2.83 mm, ϕ = -0.07 - -1.50, very coarse sand to granule size), usually rounded or sub-rounded quartz grains whose own overgrowths have grown into the mosaic grains to fit/cement them together. Faint iron oxide speckling and streaks distinguish the grain boundaries when the quartz is a solid mass, and some "dirty" large original sub-rounded detrital quartz grains have clean overgrowths in optical continuity. Many very large and huge (1.05-2.83 mm, ϕ = -0.07 - -1.50) rounded quartz grains consist of patchworks of very small-medium and sometimes larger sub-domains in a tight jigsaw puzzle fit with irregular or polygonal shapes and edges, some even serrated, that meet at triple points and have different extinction angles under crossed polars. Sometimes the sub-domains/sub-grains at the edges of the huge (2.00-2.83 mm, ϕ = -1.00 - -1.50) quartz grains have euhedral outer edges that obviously have grown into/between the surrounding mosaic quartz grains because their respective edges meet at triple points. The edges of some huge and very large (1.05-2.83 mm, ϕ = -0.07 - -1.50) quartz grains meet each other at triple points due to the overgrowths/cement in optical continuity deposited between them. One medium sub-rounded squarish mosaic quartz grain exhibits undulose extinction. Numerous small (0.07-0.13 mm ϕ = +3.77 - +2.95) and small-medium (0.14-0.42 mm ϕ = +2.84 - +1.25), sub-rounded and sub-angular or even angular, altered (some heavily, some less altered) K-feldspar grains and laths, often stained with iron oxide especially along cleavage planes, some elongated and three have "half-moon" shapes, one displaying cross-hatched twinning under crossed polars, are wedged between quartz grains and sometimes with quartz overgrowths/cement molded around them. A small, altered K-feldspar grain and a small edge-on altered muscovite flake are included within a huge (2.33 mm, ϕ = -1.22)quartz grain that has minor cracks and iron oxide staining. Several small (0.12-0.14 mm ϕ = +3.06 - +2.84) edge-on altered muscovite flakes are included within sub-domains within huge (2.00-2.83 mm, ϕ = -1.00 - -1.50), rounded quartz grains, and two small (0.03-0.09 mm ϕ = +5.01 - +3.47) face-on muscovite flakes are wedged between sub-domains within the edges of two huge (2.24-2.66 mm, ϕ = -1.16 - -1.41), rounded quartz grains. Many small (0.05-0.12 mm ϕ = +4.23 - +3.06), fresh and altered edge-on muscovite flakes are also included within some mosaic small and medium quartz grains and their overgrowths, while several small edge-on muscovite flakes are wedged between mosaic quartz grains. Four small (0.10-0.23 mm ϕ = +3.32 - +2.13) and two medium-large (0.39-0.50 mm ϕ = +1.36 - +1.00) rounded altered rock fragments (?) that are iron oxide stained are wedged within the mosaic. A large patch of iron oxide stained alteration (tiny quartz grains and illite/smectite? flakes) is likely filling a former pore within the mosaic. In several areas of the sample the mosaic quartz grains are completely separated and iron oxide infills between them and encroaches on their edges, whereas in other areas iron oxide lines grain edges and spots are on many quartz grains. Small patches of iron oxides between some mosaic grains possibly fill former pores, but generally there are virtually no pores and just cracking, the porosity averaging overall ~1%. There is some blue staining of some grains and their edges and along cracks due to the forced impregnation prior to the thin section being cut.

MF-08 N 36° 11.591' W 112° 26.032' (N 36.193° W 112.434°)

Granular sandstone bed, with mudstone beds above and below. Beds are horizontal. Mudstone beds are the same as before, but less granules in them. 4m (13 feet) from last sample. Bed thickness is about 21.5 cm (8.5 inches). Sample from the bottom of the bed.

At normal scale, the thin section shows a coarse-grained, poorly-sorted quartz sandstone with no apparent layering, although there is some fracturing of the rock fabric. Rounded quartz granules (2.02-3.63 mm wide, ϕ = -1.01 - -1.86, and sometimes cracked) are set in a matrix of primarily medium-to-coarse and rounded very coarse (1.06-1.97 mm ϕ = -0.08 - -0.97) sand-sized quartz grains with some coarse silt and very fine to fine sand sized quartz grains between them and quite a few scattered altered K-feldspar grains ranging from very fine to medium sized, and one huge (2.22 mm wide, ϕ = -1.14) altered rounded grain (clearly visible near the top of the slide). This is also a submature or arkosic quartz sandstone.

Under the microscope, a tightly-fitted mosaic of quartz grains, small (0.05-0.23 mm, ϕ = +4.23 -

+2.13, coarse silt to fine sand size) to medium (0.25-0.48 mm, ϕ = +2.00 - +1.06, medium sand size) and large (0.52-0.98 mm, ϕ = +0.95 - +0.03, coarse sand size) to very large (1.06-1.97 mm, ϕ = -0.08 - -0.97, very coarse sand size) and some huge (2.02-3.63 mm, ϕ = -1.01 - -1.86, granule size), some larger grains occasionally with sub-grains, euhedral and angular to sub-rounded, with polygonal and irregular edges and shapes (occasionally with internal "ghost" outlines of the original detrital grains) often meeting at triple points in a tight jigsaw puzzle fit, is the matrix to large and very large rounded quartz grains (occasionally with internal "ghost" outlines of the original detrital grains) that often have overgrowths/cement in optical continuity protruding between the adjacent mosaic quartz grains, or overgrowths of the matrix mosaic quartz grains in optical continuity protruded into the edges of the large and very large quartz grains. Iron oxide streaks, speckling and botches are on many quartz grains, and when extensive make some grains look "dirty," in one instance one large rounded quartz grain being covered with clusters of tiny iron oxide grains, while some other matrix mosaic quartz grains have patchy coatings of faint iron oxide staining. Sometimes the matrix mosaic consists of a mixture of large and small quartz grains with irregular to polygonal shapes still meeting at triple points. Some generally rounded or sub-rounded large, very large (1.06-1.97 mm, ϕ = -0.08 - -0.97) and huge (2.02-3.63 mm, ϕ = -1.01 - -1.86) quartz grains (and one medium general matrix mosaic quartz grain) with occasional irregular edges consist of sub-grains with different extinction angles under crossed polars, or patchworks of sub-domains of all different sizes which have different extinction angles under crossed polars and have irregular shapes and edges that are often outlined by faint iron oxide staining and that often meet at triple points, sometimes almost forming a continuation into the surrounding similar-sized matrix mosaic quartz grains. At least one large quartz grain with an iron oxide dusted "ghost" outline and core of the detrital grain is elongated parallel to the bedding with a small sub-euhedral overgrowth in optical continuity impinging on the surrounding smaller mosaic grains and their overgrowths. Two small-medium squarish with rounded corners mosaic quartz grains consist of patchworks of tiny irregularly-shaped sub-grains with different extinction angles under crossed polars, which thus might represent rock (quartzite?) fragments. Some larger quartz grains appear to have been fractured. One medium sub-angular to sub-rounded mosaic quartz grain contains a 0.06 mm wide fluid inclusion (?). Numerous very small (0.04-0.12 mm, ϕ = +4.64 - +3.06) and small (0.13-0.25 mm, ϕ = +2.95 - +2.00), several medium (0.26-0.34 mm, ϕ = +1.95 - +1.55) and a massive (2.22 mm wide, ϕ = -1.14), angular-rounded altered (some heavily with iron oxide staining) K-feldspar grains, laths and fragments, one medium grain exhibiting cross-hatched twinning under crossed polars, wedged between mosaic quartz grains often "molded" around them, and one (0.09 mm wide, ϕ = +3.47) wedged between the sub-grains within a huge (3.21 mm, ϕ = -1.68) quartz grain. Two medium (0.26 mm, ϕ = +1.95) and one small (0.12 mm ϕ = +3.06) sub-rounded altered grains are possibly plagioclase due to exhibiting multiple twinning under crossed polars. Many small-medium (0.07-0.19 mm, ϕ = +3.77 - +2.40) or long, and thick altered edge-on muscovite flakes (several with frayed ends) are wedged between, and one bent around, mosaic quartz grains. Two small (0.06-0.10 mm, ϕ = +4.05 - +3.32) face-on muscovite flakes are included within a very large (1.97 mm, ϕ = -0.97), rounded quartz grain, and a medium (0.20 mm, ϕ = +2.33) face-on biotite or altered muscovite flake is included in a medium-large subangular mosaic quartz grain. Several small (0.11-0.13 mm, ϕ = +3.19 - +2.95) rounded altered rock fragments are iron oxide stained, while two small-medium (0.13-0.18 mm, ϕ = +2.95 - +2.48) and medium (0.26 mm, ϕ = +1.95) rounded-subangular unaltered rock fragments may be siltstone (?). Two other small rounded grains are possible rock fragments consisting of small bladed tabular grains or flakes with some relief and iron oxide between them (covering some other mineral?), these being primary grains because the overgrowths/cement has been deposited, and the mosaic quartz grains molded, around them. A large patch of iron oxide stained alteration (tiny quartz grains and illite/smectite? flakes) is likely filling a former pore within the mosaic. Occasionally iron oxide is on the edges of, and between, grains. There are usually no pore spaces, just some cracking and some very small pores, the porosity varying and averaging overall ~1%. There is some blue staining of some grains and their edges and along cracks due to the forced impregnation prior to the thin section being cut.

<u>MF-09</u> N 36° 12.925' W 112° 26.468' (N 36.215° W 112.441°)

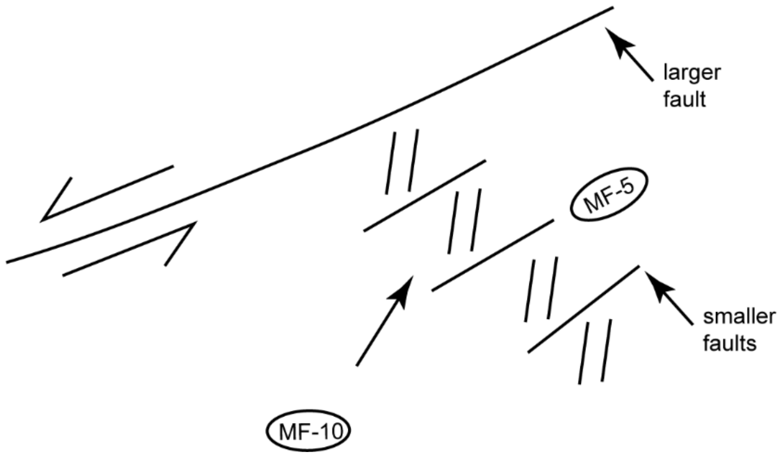
Far upriver end of the outcrop 4.8 m (16 feet) from last sample. Bed is 20 cm (8 inches) thick and a granular sandstone. Mudstone at the top while the bottom has granules in it.

At normal scale, the thin section shows a coarse-grained, partially-to-poorly sorted quartz sandstone with no apparent layering, except for the hint of some sorting into ill-defined bands. Rounded quartz granules (2.03-2.89 mm wide, ϕ = -1.02 - -1.53), very coarse (1.06-1.97 mm, ϕ = -0.08 - -.0.97) sand-sized quartz grains and a rounded large (1.13 mm wide, ϕ = -0.17) rock fragment are somewhat segregated into the ill-defined bands and set in a matrix which is uniform across all the rock fabric and consists of primarily medium-to-coarse sand sized quartz grains with some coarse silt and very fine to fine sand sized quartz grains between them and scattered altered K-feldspar grains ranging from very fine to medium sized. This is also a submature or arkosic quartz sandstone.

Under the microscope, a tightly-fitted mosaic of quartz grains, small (0.05-0.25 mm, ϕ = +4.23 - +2.00, coarse silt to fine sand size) to medium (0.26-0.47 mm, ϕ = +1.95 - +1.09, medium sand size) and large (0.52-0.93 mm, ϕ = +0.95 - +0.11, coarse sand sized), euhedral and angular to sub-angular and sub-rounded, some cracked, with polygonal and irregular (sometimes fuzzy) edges and shapes (occasionally with internal “ghost” iron oxide outlines of the original detrital grains), and overgrowths/cement often meeting at triple points in a tight molded jigsaw puzzle fit so cement and grains merge, is the matrix to large (0.52-0.93 mm, ϕ = +0.95 - +0.11, coarse sand sized), very large (1.05-1.95 mm, ϕ = +4.23 - -0.96, very coarse sand sized) and huge (2.03-2.89 mm, ϕ = -1.02 - -1.53, granule size) rounded quartz grains (occasionally with internal “ghost” outlines of the original rounded detrital grains) that often have overgrowths/cement in optical continuity protruding irregularly between the adjacent mosaic quartz grains. Some generally rounded very large (1.05-1.95 mm, ϕ = +4.23 - -0.96) and huge (2.03-2.89 mm, ϕ = -1.02 - -1.53) quartz grains consist of irregularly-shaped small to large sub-grains or sub-domains sometimes in patchworks (outlined by faint iron oxide staining) with different extinction angles under crossed polars, and occasional matrix mosaic quartz grains consist of patchworks of sub-domains or sub-grains of all different sizes and irregular shapes which have different extinction angles under crossed polars, so that sometimes the sub-grains/sub-domains in the large and huge (2.03-2.89 mm, ϕ = -1.02 - -1.53) quartz grains effectively merge with matrix mosaic quartz grains when they are approximately the same size. Iron oxide streaks and speckling are on many quartz grains, and when extensive make some grains look "dirty." Several small-medium matrix mosaic quartz grains consist of patchworks of tiny sub-domains with different extinction angles within sub-grains making them potentially look like rock fragments (quartzite?). Evidence of resorption of silica during diagenesis occurs where the edges of a large quartz grains are embayed thus interrupting its normal rounded profile, yet the grain has the matrix mosaic of smaller quartz grains molded around it. Sometimes some matrix mosaic quartz grains and their overgrowths/cement are in optical continuity with the very large (1.05-1.95 mm, ϕ = +4.23 - -0.96) and huge (2.03-2.89 mm, ϕ = -1.02 - -1.53) grains they surround. One large quartz grain has coalescing "stressed" linear zones as sub-domains and exhibits undulose extinction. Another medium sub-angular to sub-rounded matrix mosaic quartz grain has internal thin needles of rutile(?), while one medium sub-angular irregularly-shaped mosaic quartz grain contains a fluid inclusion (?). Numerous very small (0.05-0.12 mm, ϕ = +4.23 - +3.06), small (0.13-0.25 mm, ϕ = +2.95 - +2.00), and medium (0.26-0.34 mm, ϕ = +1.95 - +1.55), angular and sub-angular to sub-rounded and rounded altered (some heavily with iron oxide staining) K-feldspar grains and former laths, two a "half-moon" shape and one displaying cross-hatched twinning under crossed polars, are wedged between mosaic quartz grains. One very small (0.07 mm ϕ = +3.77) rounded altered K-feldspar grain is included within a very large quartz grain, and a small (0.13 mm ϕ = +2.95) sub-angular altered K-feldspar lath and a very small (0.06 mm ϕ = +4.05) edge-on muscovite flake are included in a very large quartz grain between and within its sub-domains, respectively. One small (0.10 mm ϕ = +3.32) sub-rounded altered grain is possibly plagioclase due to it exhibiting multiple twinning under crossed polars. Many small to medium (0.07-0.14 mm ϕ = +3.77 - +2.84), thin and thick altered (sometimes coated in iron oxide) edge-on muscovite flakes wedged in cement between matrix mosaic quartz grains, or in one instance between a K-feldspar lath and a mosaic quartz grain, and in another instance between a zircon and mosaic quartz grains. Also, remnants of a totally frayed and pulled apart thick altered edge-on muscovite flake are between matrix mosaic quartz grains. A small-medium (0.16 mm ϕ = +2.66) face-on muscovite flake is included within a very large subrounded "dirty" quartz grain, and a small thick altered edge-on muscovite flake is included within a small angular mosaic quartz grain. One small (0.08 mm ϕ = +3.64) face-on biotite flake is included in a very large, rounded quartz grain. One small-medium (0.12 mm ϕ = +3.06) and five small (0.05-0.10 mm, ϕ = +4.23 - +3.32) sub-rounded high relief, high birefringent zircon grains (some tabular), some coated with iron oxide, are wedged tightly between mosaic quartz grains. There are three small-medium (0.09-0.23 mm ϕ = +3.47 - +2.13) rounded iron oxide stained rock fragments, one consisting of many scattered iron oxide grains and blades between tiny quartz grains, and a very large (1.13 mm ϕ = -0.17) rounded altered (weathered) rock fragment with internal layering marked by iron oxide and tiny and very small quartz grains tightly wedged within the matrix mosaic of quartz grains “molded” around it. Occasionally iron oxide blotches (sometimes heavy/thick) and linings are on the edges of, and between, grains. Generally, there are no pores, but some small gaps/pores and cracking, the porosity varying and averaging overall only ~0.3%. There is some blue staining of some grains and their edges due to the forced impregnation prior to the thin section being cut.

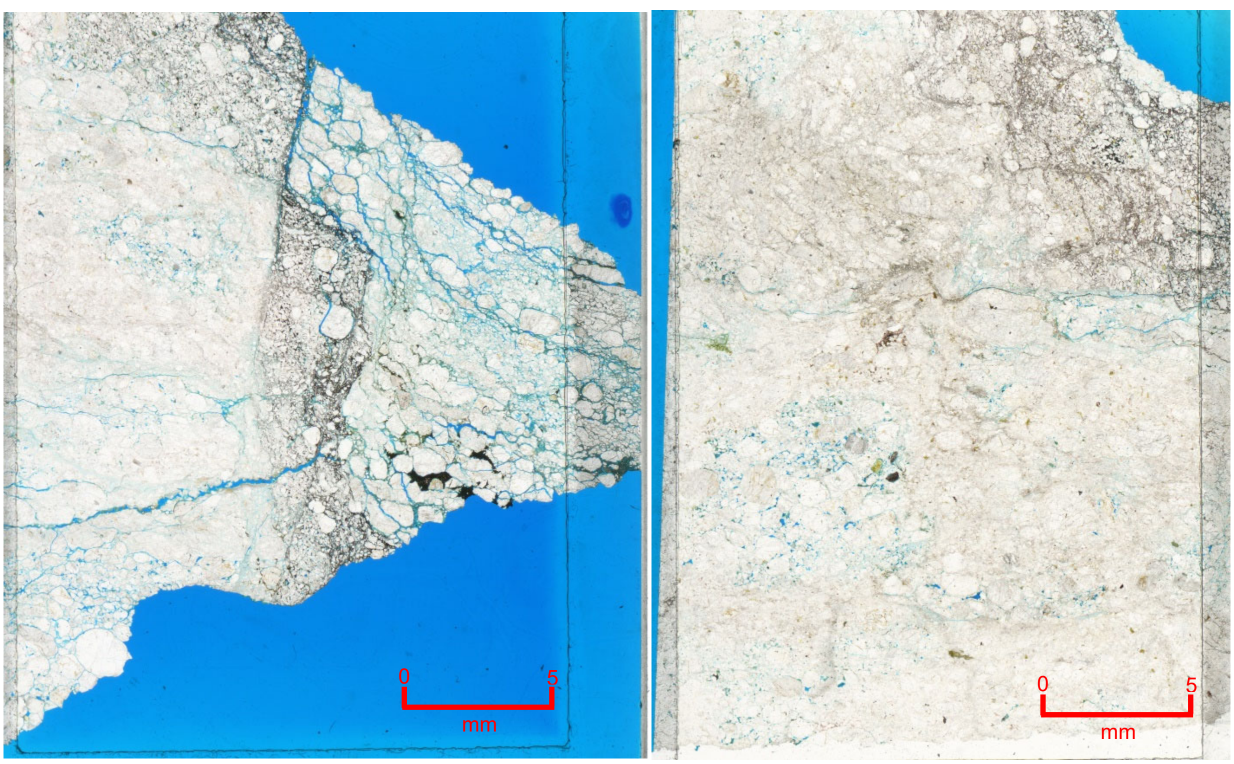
<u>MF-10</u> N 36° 11.865’ W 112° 26.150’ (N 36.198° W 112.436°)

Shearing along small faults described earlier.



Tops of the thin sections mark top of the bed.

At normal scale, the two thin sections of this sample show a very coarse-grained, poorly-sorted quartz sandstone with no apparent layering. Many scattered quartz granules (2.21-2.89 mm wide, ϕ = -1.14 - -1.53) and very coarse sand sized quartz grains (1.05-1.95 mm wide, ϕ = -0.07 - -0.96) are set in a matrix which is uniform across all the rock fabric and consists of primarily medium-to-coarse sand sized quartz grains with some coarse silt and very fine to fine sand sized quartz grains between them and scattered altered K-feldspar grains ranging from very fine to medium sized. This is also a submature or arkosic quartz sandstone.



Under the microscope, a once tightly-fitted mosaic of quartz grains, very small (0.06-0.12 mm, ϕ = +4.05 - +3.06, very fine sand size), small (0.13-0.25mm, ϕ = +2.95 - +2.00, fine sand size), medium (0.26-0.48

mm, ϕ = +1.95 - +1.06, medium sand size) and large (0.52-1.00 mm, ϕ = +0.95 - 0.00, coarse sand size), euhedral and angular to sub-rounded, with polygonal and irregular (sometimes fuzzy) edges and shapes (occasionally with internal “ghost” iron oxide outlines of the original detrital grains), and overgrowths/cement in optical continuity often meeting at triple points in a tight molded jigsaw puzzle fit so cement and grains merge, is the matrix and totally cemented to very large (1.05-1.95 mm, ϕ = -0.07 - -0.96, very coarse sand size) and huge (2.21-2.89 mm, ϕ = -1.14 - -1.53, granule size) rounded and sub-rounded quartz grains (sometimes with irregular edges and occasionally with internal “ghost” outlines of the original rounded detrital grains) that often have overgrowths/cement in optical continuity, sometimes protruding irregularly between the adjacent mosaic quartz grains. The rock has been fractured and crushed along linear zones usually between the larger quartz grains (which sometimes have also been fractured, sometimes with offsets that sometimes result in large sliver fragments) (annotated on the thin section above on the right) so that the matrix mosaic quartz grains have often been fractured and sometimes resorbed (as seen by fuzzy fractured or irregular edges), and then healed across and within the shattered matrix mosaic by small and very small quartz fragments and tiny quartz grains, all angular to sub-angular, or sometimes with areas of just clean quartz cement, often between the remnant portions of both mosaic and broken larger grains, or fragments of the matrix mosaic grains or from the large-huge (0.52-2.89 mm, ϕ = +0.95 - -1.53) quartz grains, and exhibiting different extinction angles under crossed polars but still sometimes meeting at triple points. In plane polarized light it can all look like a total solid quartz mass. Sometimes parts of the overgrowths/cement around the edges of very large (1.05-1.95 mm, ϕ = -0.07 - -0.96) and huge (2.21-2.89 mm, ϕ = -1.14 - -1.53) rounded quartz grains has been fractured off and included in the healed zone, and some of the small fragments and tiny grains in the healed zones exhibit undulose extinction (from stress?). Some generally rounded very large (1.05-1.95 mm, ϕ = -0.07 - -0.96) and huge (2.21-2.89 mm, ϕ = -1.14 - -1.53) quartz grains consist of irregularly-shaped small to large sub-grains, or small sub-domains sometimes in patchworks (outlined by faint iron oxide staining), with different extinction angles under crossed polars, and occasional matrix mosaic quartz grains also consist of patchworks of sub-domains or sub-grains of all different sizes and irregular shapes which have different extinction angles under crossed polars. Iron oxide streaks and speckling are on many quartz grains and sometimes irregular or thick linear blotches or pervasive heavy staining. Sometimes several huge (2.21-2.89 mm, ϕ = -1.14 - -1.53) and very large quartz (1.05-1.95 mm, ϕ = -0.07 - -0.96) grains with internal “ghost” outlines and “dirty” cores of the original detrital grains meet where the clean overgrowths around them in optical continuity converge at triple points, some euhedrally. A huge (2.24 mm, ϕ = -1.16) rounded and elongated quartz grain consisting of a patchwork of very small and tiny sub-domains at different extinction angles may be a rock fragment (quartzite?). Many very small (0.06-0.12 mm, ϕ = +4.05 - +3.06), small (0.13-0.22 mm ϕ = +2.95 - +2.19) and medium (0.26-0.50 mm ϕ = +1.95 -

+1.00) rounded altered (some heavily) grains and former laths (including a large [0.50 mm long ϕ = +1.00] lath with rounded corners) of K-feldspar are wedged between matrix mosaic quartz grains and even between some large quartz grains. Quite a few small (0.04-0.17 mm ϕ = +4.64 - +2.57) thin and thick edge-on muscovite flakes are wedged between matrix mosaic quartz grains, while a small thick altered edge-on muscovite flake is included within a sub-domain of a very large quartz grain, and another bent one is "floating" between small and medium quartz fragments in a "healed" fracture zone cemented by a matrix of tiny quartz grains. Very small (0.03-0.05 mm ϕ = +5.01 - +4.23) and small-medium (0.18 mm, ϕ = +2.48) face-on muscovite flakes are included within a small, fractured matrix mosaic quartz grain, a very large sub-rounded "dirty" quartz grain, and a very large tabular quartz grain respectively. Two small (0.08-0.11 mm ϕ = +3.64 - +3.19), face-on biotite flakes are included in a large sub-angular quartz grain, and two small (0.07-0.08 mm ϕ = +3.77 - +3.64) prismatic high relief, high birefringent zircon crystals are included within a very large rounded but broken quartz grain. Another very small (0.05 mm ϕ = +4.23) zircon grain is in the matrix of quartz grains. A very large (0.91 mm ϕ = +0.14), half-moon shaped, heavily iron oxide covered rock fragment (containing some tiny quartz grains) is wedged tightly between the matrix mosaic quartz grains, while a large (0.48 mm ϕ = +1.06) lightly iron oxide dusted and fractured rock fragment consisting of tiny quartz grains (siltstone?) is wedged between large-very large quartz grains and smaller matrix mosaic quartz grains. Minor calcite alteration occurs in two small areas around the edges of large and huge (2.21-2.89 mm, ϕ = -1.14 - -1.53) rounded quartz grains and in between the adjoining matrix mosaic quartz grains. Illite (?) appears to sometimes replace former K-feldspar grains and laths totally, and some minor illite (?) alteration is with the tiny quartz grains in parts of the healed fracture zones, or as small or large and thick linear patches between quartz grains in healed fracture zones. Some iron oxide stains the healed fracture zones, but in some areas heavy iron oxide patches, streaks and veining are between the quartz fragments and across the matrix of tiny quartz grains. There are virtually no pores but a few very small gaps and cracking, the porosity varying and averaging overall ~0.5%. There is some blue staining of some grains and their edges and along cracks due to the forced impregnation prior to the thin section being cut.