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Diagenesis and Reservoir Quality of the Phacoides Sandstone of the Temblor Formation at the McKittrick Oil Field, California

By

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This thesis or project has been accepted on behalf of the Department of Geological Sciences by their supervisory committee:

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ABSTRACT

The McKittrick oil field is located near the western edge of the San Joaquin basin approximately 60 km west of Bakersfield and just north-east of the McKittrick thrust fault. The oil field is currently in production with over 480 producing wells. The oil field produces from the Tulare, San Joaquin, Reef Ridge, Monterey, Temblor, Tumey, and Kreyenhagen Formations. Within the Temblor Formation production is mainly from the Carneros and the Phacoides sands. The Phacoides reservoir is located in an anticlinal structure with approximately 300 m of closure. Reservoir temperature is 110°C and formation water contains 13,000 ppm total dissolved solids and 9,700 ppm dissolved NaCl. Samples for this study were obtained from the California Well Sample Repository taken from the Phacoides sands from depths between 2403 and 3045 meters. These were studied using transmitted and reflected-light petrography and scanning electron microscopy including energy dispersive x-ray spectrometry (SEM-EDS) and cathodoluminescence imaging (SEM-CL). The Phacoides sandstones consist of fine to very coarse, poorly to well sorted, arkosic arenites and wackes. The detrital framework grains include sub-angular quartz, K-feldspar (microcline and orthoclase), plagioclase, and rock fragments. Three chemically distinct types of K-feldspars have been identified: Ba-poor, Ba-rich, and perthite. Accessory minerals include glauconite, biotite, muscovite, magnetite, titanomagnetite, sphene, zircon, phosphate, corundum, and rutile. Diagenetic alteration includes compaction, dissolution of detrital minerals, albitization of feldspars, cementation by kaolinite, calcite and dolomite, precipitation of K-feldspar and quartz overgrowths, replacement of framework grains by calcite, alteration of volcanic rock fragments, and the alteration of biotite to pyrite and chlorite. Long, sutured, and interpenetrating grain-to-grain contacts, squashing of labiles to create pseudomatrix, and

fracturing of brittle grains (quartz and feldspar) indicate significant compaction. Fractures were healed by authigenic quartz, albite, and K-feldspar. The average composition of albitized plagioclase indicates a maximum burial temperature approximately 30°C higher than the current reservoir temperature, corresponding to 1 km deeper burial. Precipitation of carbonates and clays, rearranging of broken grains, and formation of pseudomatrix subsequently reduced porosity. Secondary porosity is common and formed initially by the dissolution of plagioclase (excluding albite) and volcanic fragments and later by dissolution of calcite, dolomite, and detrital K-feldspars. Oil emplacement was followed by precipitation of late pyrite framboids in pores containing both oil and clays. This suggests that continuing maturation of the hydrocarbons supplied sulfur that reacted with ferrous ions in pore fluids trapped within the clays' microporosity. Reservoir quality was controlled primarily by feldspar dissolution and precipitation of kaolinite. Secondary porosity accounts for at least half of the total porosity. Dissolution of plagioclase significantly altered the detrital composition of the sands as indicated by large shifts in QFRf, QFL, and QKP ratios. Mass-balance calculations suggest overall export of aluminum from the sands. Paragenetic relationships indicate that hydrocarbon emplacement was a very late event.

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INTRODUCTION

Carbon capture and sequestration (CCS) is becoming increasingly important as CO_2 emissions continue to rise globally. Locations for storing these emissions, however, must meet specific standards to ensure the longevity and security of leak prevention. Depleted and nearly depleted oil reservoirs are of particular interest to storing CO_2 as a supercritical fluid. Over the past century, the San Joaquin basin (Figure 1) has been one of the most productive hydrocarbon basins in the United States (Kuespert, 1990). Consequently, there are now numerous available reservoirs that are possible candidates for CCS. One location of interest is within the Oligocene to Miocene Temblor Formation sandstones at the McKittrick oil field (Gillespie, 2011).

The McKittrick oil field is located within the southern San Joaquin basin, California, about 64 kilometers west of Bakersfield (Figure 1) and just north-east of the McKittrick thrust fault. The 700km long, asymmetrical San Joaquin basin is a major petroleum province located between the Costal Ranges and the Sierra Nevada. It originated between a subduction zone to the west and a volcanic arc to the east (Scheirer and Magoon, 2007). The complex tectonics of the evolving convergent-to-transform margin, coupled with the dynamic depositional environment throughout the Cenozoic, have created some of the best oil and gas reservoirs in California.

The McKittrick oil field is currently in production with over 480 producing wells (California Division of Oil and Gas, 1998). The oil field produces from the Tulare, San Joaquin, Reef Ridge, Monterey, Temblor, Tumey, and Kreyenhagen Formations. Within the Temblor Formation production is mainly from the Carneros and the Phacoides sands. The deepest well in the area runs through the Temblor Formation at 3,353 meters and into the Point of Rocks Formation (California Division of Oil and Gas, 1998). The Phacoides reservoir is located in an anticlinal structure with approximately 300 m of closure. Reservoir temperature is 110°C and formation water contains 13,000 ppm total dissolved solids and 9,700 ppm dissolved NaCl. Because this reservoir meets the United States Geological Survey (USGS) depth, size, and salinity requirements for CO_2 sequestration (Gillespie, 2011), the Phacoides sandstone within the Temblor Formation was chosen as the focus of this study (Figure 2).

Traditionally, reservoir quality is of the utmost importance for economic interests such as petroleum exploitation and production. The effects of diagenetic processes on the overall reservoir quality are of particular interest (Ali, 1981). These changes are equally important for CO_2 storage. By obtaining and interpreting the effects of diagenesis on the porosity and permeability at this location, the quality of the reservoir can be determined for long term and safe CO_2 storage. The goal of this project is to interpret the diagenetic evolution of these sandstones and to provide baseline data on the mineralogy and reservoir quality for future geochemical evaluation of this reservoir for carbon capture and sequestration.

GEOLOGIC SETTING

The McKittrick oil field is located in the San Joaquin Valley. The valley is bounded by the Coast Ranges (Temblor Range) to the west, the Sierra Nevada to the east, and by the Transverse Ranges to the south (Figure 1). The basin is filled with upper Mesozoic and Cenozoic sediment up to 9 km thick (Bartow, 1991). The depositional sequence during the Oligocene and early Miocene produced the shales and sandstones that make up the eight members of the Temblor Formation. These were deposited during complex Tertiary tectonic and sedimentary events through four partial to complete depositional cycles (Carter, 1985). The Temblor Formation's depositional environments were principally influenced by tectonism (Bartow, 1991), but short-term fluctuations in global eustatic sea level may have played a role (Bartow, 1991; Johnson and Graham, 2007). The Temblor Formation sediments were deposited in environments ranging from shoreline to bathyal depths. They also encompass multiple unconformities (Graham and Williams, 1985; Pence, 1985) due to uplift produced by displacement along the San Andreas fault (Johnson and Graham, 2007).

During the early Tertiary, subduction of the Farallon plate beneath the North American plate changed from oblique to normal convergence beneath the North American plate. During the middle Oligocene the Pacific-Farallon spreading ridge's subduction resulted in the formation of the San Andreas transform system and the Mendicino triple junction (Bartow, 1991). Temblor Formation deposition was contemporaneous with the northwest migration of the Mendocino Triple Junction and the onset of motion along the San Andreas fault (Pence, 1985).

The McKittrick oil field is located in the west-side fold belt between Panoche Creek and Elk Hills (Bartow, 1991). This region is defined by a series of folds and faults slightly oblique to the San Andreas fault (Bartow, 1991). During the Paleogene, folding took place largely in the northern portion of the belt while during the Neogene folding intensity increased southwest, toward the San Andreas fault, and southeast along the Diablo and Temblor Ranges (Bartow, 1991).

The evolution of the basin includes three major tectonic shifts that can be identified by four regional petrofacies found within the Temblor Formation (Bent, 1985). Throughout the Oligocene, plutoniclastic sandstones derived from the dissected magmatic arc of the Sierra Nevada were widely deposited throughout the basin (Bent, 1985). Volcaniclastic and plutoniclastic sandstone deposition followed during the Early Miocene due to the uplift associated with the northward migration of the Mendocino triple junction (Bent, 1985). During the late-Early Miocene, arc-derived volcaniclastics were deposited in the northern end of the basin, while southern areas continued to receive plutoniclastic sediments from the dissected arc to the south (Bent, 1985). Finally, the change from a convergent margin to a transform margin occurred with the uplift of the southern Diablo Range during the Middle Miocene with sediments derived from the Coast Ranges as well as the Sierra Nevada (Bent, 1985). These changes are recorded in the Temblor Formation as granitic, transitional, lithic, and feldspathic petrofacies (Bent, 1985).

Stratigraphy and Sedimentology of the Phacoides Sandstone

The Carneros Sandstone and the Wygal Sandstone are the two producing sand bodies within the Temblor Formation. This study focuses on the Wygal Sandstone, informally known as the Phacoides sandstone (Carter, 1985), which lies between the Santos Shale and the Cymric Shale (Figure 2b) (California Division of Oil and Gas, 1998). The Phacoides sandstone includes three sandstone units separated by thin shales. Three lithofacies make up the Phacoides sandstone: a basal sandstone, a fossiliferous sandy siltstone, and an upper glauconitic and phosphatic sandstone (Carter, 1985). They collectively thicken eastward and are possibly a deep-marine turbidite package related to the Cymric Member (Johnson and Graham, 2007). Farther east, the Phacoides sandstone coincides with the Vedder Sandstone and the Bloamer sandstone, which are both shallow-marine deposits (Johnson and Graham, 2007).

The basal sandstone is composed of well cemented, fine-to coarse-grain sand. It has a sharp contact with the underlying Cymric Shale (Carter, 1985). Burrows, shark teeth, and phosphatized bone fragments suggest a shallow marine setting (Carter, 1985), but lack of sedimentary structures could be indicative of a massively bedded turbidite sequence. Sedimentological and faunal evidence indicate a high energy environment; this is also supported by the textural maturity of the sandstone. A local, possibly tectonically controlled, regression may have been related to a eustatic fall in the sea level before Wygal Member (Phacoides sandstones) deposition (Carter, 1985). Local uplift caused by the initiation of the Mendicino triple junction may have contributed to the fall in sea level recorded in the rock record.

The fossiliferous sandstone within the Wygal Member is a calcareous siltstone with interbeds of friable, fine-grain sands (Carter, 1985). The presence of bathyal foraminifera suggests a bathymetric range that is somewhat deeper than the underlying basal sandstone (Carter, 1985). This is consistent with the finer grain size and lack of wave-produced sedimentary structures of this unit (Carter, 1985).

Finally, the upper glauconitic and phosphatic sandstone of the Wygal Member contains bone fragments, shark teeth, fish scales, sponge spicules, and rare pebbles throughout the fine to medium glauconitic grain sandstone (Carter, 1985). Low diversity of marine assemblages and the presence of glauconite and phosphate indicate reducing marine conditions (Carter, 1985). These features are interpreted as a long depositional hiatus in a reducing outer shelf or upper bathyal environment (Carter, 1985).

METHODS

Samples were obtained from the California Well Sample Repository at California State University, Bakersfield. Two whole-cores, from wells McKittrick Fee 516-8, and Circle Oil SP 32X-21, were available for study (Figure 2). Depths range from 2403 to 2623 meters in the McKittrick Fee 516-8 well and from 3029 to 3045 meters in the Circle Oil SP 32X-21 well. Eighty-two samples were made into thin sections. Of these, fifteen thin sections were stained for potassium, fifteen thin sections were stained for calcium, and twenty-six thin sections were polished. All were impregnated with blue epoxy to highlight porosity. Sixty-four of the thin sections were point counted with at least 300 point counts each and 19 were analyzed using the Hitachi S-3400N scanning electron microscope (SEM) equipped with an Oxford Inca energy dispersive x-ray spectrometer (EDS) and a Gatan cathodoluminescence system (CL). The electron-interaction volume of the SEM beam is approximately 10μm in diameter.

Properties recorded during point counting included mineralogy, roundess, contact index (CI) and tight packing index (TPI), grain size, and diagenetic features. The contact and tight packing index were determined following the methodologies of Wilson and McBride (1988). Ternary diagrams following Dott (1964) as modified by Pettijohn et al., (1987), Dickinson (1970, 1985), and Harris (1989) are used to display data from point counting.

Analyses obtained from the SEM-EDS yielded the chemical compositions of individual grains and cements within the sandstones. These results are displayed through images and ternary diagrams. Cathodoluminescence imaging was used to determine various textural relationships between detrital grains, authigenic clays, and overgrowths. A separate EDS analyses of 30-50 plagioclase grains from each of 8 samples was completed to determine the degree of albitization (Boles and Ramseyer, 1988).

The mass transfer of aluminum was investigated by comparing point-counted volumes of dissolved K-feldspar and plagioclase to kaolinite for 64 thin-sections. These calculations allowed for the interpretation of the import or export of aluminum into or out of the system on the thin-section scale. The calculations assumed that all aluminum released through feldspar dissolution was precipitated as kaolinite. Kaolinite microporosity was estimated, using SEM-BSE images, to be 30%. The initial composition of plagioclase was assumed to be An_{30} ($Na_{0.7}Ca_{0.3}Al_{1.3}Si_{2.7}O_8$) based on this study as well as Boles and Ramseyer's (1988) study of albitization in the San Joaquin basin. The following reactions were used in the calculations:

For the dissolution of K-feldspar:

$$\underset{\text{(K-feldspar)}}{KAlSi_3O_8} + H^+ + 4.5H_20 \rightarrow \underset{\text{(Kaolinite)}}{0.5Al_2Si_2O_5(OH)_4} + 2H_4SiO_4 + K^+$$

For the dissolution of plagioclase:

$$\underset{\text{(Plagioclase)}}{Na_{0.7}Ca_{0.3}Al_{1.3}Si_{2.7}O_8} + H^+ + 3.75H_2O \rightarrow$$

$$\underset{\text{(Kaolinite)}}{0.65Al_2Si_2O_5(OH)_4^+} + 1.4H4SiO4 + 0.7Na^+ + 0.3Ca^{2+} + 0.3OH^-$$

Other sources of aluminum, such as plagioclase albitization have been ignored. Also, these calculations do not account for secondary porosity for which the dissolved phase is unknown.

Thus, these calculations are conservative with regard to expected kaolinite. A second set of calculations included secondary porosity for which the dissolved phase could not be identified by assuming that the dissolved phases were feldspars and in the same ratio as used in the first set of calculations. This approach ignored other minerals that contributed to secondary porosity. This is justified because their contribution is volumetrically minor and more than offset by secondary porosity that was destroyed by subsequent compaction (Horton et al., 2009).

RESULTS

Detrital Mineralogy

The Phacoides sandstones of the Temblor Formation at the McKittrick oil field are made up of arkosic arenites and arkosic wackes containing up to 33.54% dark brown matrix (Figure 3). Although grain size for all samples ranges from medium to very coarse, wackes tend to have smaller grain sizes than the arkosic arenites (Figure 3).

The detrital framework grains include quartz, K-feldspar, plagioclase, and rock fragments. Compositional data is plotted on two ternary diagrams following Pettijohn et al., (1987) and Dickinson (1985) (Figure 4). The mean value between quartz, feldspars, and rock fragments is $Q_{53}F_{32}Rf_{15}$ and $Q_{51}F_{27}Rf_{22}$ for wells McKittrick Fee 516-8 and Circle Oil SP 32X-21 respectively. Most points plot in the dissected arc and recycled origin provenances of Dickinson (1985) (Figure 4).

Quartz makes up 18-50% of the sands and is usually monocrystalline with lesser amounts of polycrystalline quartz or chert. Zircon inclusions are occasionally present in monocrystalline quartz. Detrital quartz usually luminesces dark blue.

K-feldspar makes up 5-19% of the sands. Orthoclase is most common followed by lesser amounts of microcline. Detrital K-feldspar typically contain small amounts of Na (Figure 5). Three chemically distinct types of potassium feldspar are present: barium-poor, barium-rich, and perthite (Figure 6). Barium-rich K-feldspar usually luminesces light blue and barium-poor luminesces light pink (Figure 7).

Plagioclase makes up 3-15% of all analyzed samples and ranges compositionally from An_{40} to An_{0} (Figure 5). Albite is found within detrital perthitic plagioclase. Detrital plagioclase, including plagioclase in perthite, luminesces bright red (Figure 8). Whole plagioclase grains from eight samples were measured and found to have an average composition of An_{18} to An_{8}.

Rock fragments include volcanics, microphanerites, chert, carbonate clasts, and shale clasts. Detrital accessory minerals make up less than 5% of sands and include biotite, muscovite, chlorite, apatite, rutile, sphene, zircon, hornblende, magnetite, and titanomagnetite. Fossils are occasionally present. Of the accessory minerals, muscovite and biotite are the most common. Apatite and zircon inclusions are usually present within monocrystalline quartz or igneous rock fragments. Zircon also occasionally occurs as larger individual grains.

Texture

The Phacoides sandstone ranges from poorly to well sorted arkosic arenites and arkosic wackes. Overall, the Phacoides sandstone contains angular to sub-round grains with the exception that glauconite, phosphate, and volcanic rock fragments are generally round. Fractures are ubiquitous through all samples and all stages of burial (Figure 9). The sandstones are tightly compacted with an abundance of point, long, concave, and sutured contacts between grains (Figure 10). Poikilotopic calcite cement affected tight packing in some shallower samples leaving an abundance of floating grains (Figure 11).

Labile grains, such as volcanics, glauconite, micas, and rock fragments, have been squashed between detrital framework grains creating pseudomatrix (Figures 12, 13, 14, and 15). This makes up 4.0% of rock volume on average. Samples from Circle Oil SP 32X-21 contain slightly higher amounts of volcanics than McKittrick Fee 516-8 and subsequently the pseudomatrix makes up 4.9% of the rock volume. The average pseudomatrix for all wackes is 6.4%.

Authigenic Mineralogy

Albite

Authigenic albite is present in K-feldspar and plagioclase. It occurs along fractures, micropores, and grain-edges (Figures 16 and 17). Authigenic albite is non-luminescent regardless of the host mineralogy (Figure 18).

K-feldspar

Authigenic K-feldspar occurs as overgrowths on (Figures 7, 8, 19, 20, and 21) and along fractures (Figures 7, 20, 21, and 22) within detrital K-feldspar. No K-feldspar overgrowths were found on plagioclase. Authigenic K-feldspar is typically very pure (Figure 5), with little or no Na, Ca, Ba, or Sr. Authigenic K-feldspar is non-luminescent.

Quartz

Non-luminescent, authigenic quartz formed as overgrowths and healed fractures on and within detrital quartz grains (Figures 7, 8, and 22). Some authigenic quartz exhibits euhedral grain edges. Authigenic quartz also healed fractures within authigenic K-Feldspar (Figure 8 and 21).

Glauconite

Glauconite typically occurs as rounded peloidal grains, and less commonly as pseudomatrix. It occasionally replaces quartz (Figure 23). It occurs in small quantities in most samples and is most abundant in Circle Oil SP 32X-21.

Phosphate

Calcic phosphate occurs as rounded peloids usually surrounding a detrital-grain (Figure 24). Both bone fragments and quartz served as nuclei for phosphate growth.

Chlorite

Authigenic chlorite is present only in a few samples. Glauconite and biotite were sometimes altered to chlorite with partial to complete replacement of biotite by chlorite.

Pyrite

Authigenic pyrite is abundant and generally occurs as micron-sized euhedral crystals that are sometimes surrounded by calcite (Figures 11a and 11b), as framboidal clusters surrounded by kaolinite cement (Figure 25), amidst hydrocarbons or matrix as framboidal clusters (Figures 26a, 26b, and 27), within micropores of phosphate (Figure 26c) and as individual euhedral inclusions in secondary pore spaces (Figure 26d). Pyrite is also present along cleavage planes in biotite (Figure 12) and in biotite that has been altered to chlorite.

Calcite

Poikilotopic calcite is present in most samples. Its most common habit is pore-filling cement (Figures 11, 19, and 20) but it also fills fractures and commonly replaces framework grains including quartz, feldspar, and glauconite (Figures 11c, 11d, and 28). In some cases grain replacement is so extensive that the unreplaced framework grains appear to be floating in the cement (Figure 11).

Dolomite/Ankerite

Zoned dolomite/ankerite crystals (Figures 25 and 29) occur as isolated subhedral to euhedral rhombs (Figures 30, 31c, 31d, and 32), clusters of rhombs filling pore space (Figures 31c and 31d) and as isolated rhombs within matrix and pseudomatrix (Figure 33). Much of the dolomite/ankerite contains iron-rich zones (Figure 29). As these zones are thinner (typically 1-2μm thick) than the 10μm electron-interaction region diameter of our SEM, quantitative analyses of these zones was not possible. Dolomite/ankerite is sometimes associated with pyrite as well (Figures 31a and 31b).

Clays

Clay cements, clay coatings, and remnant clay rims are abundant. Pore-filling kaolinite is most abundant (Figures 25, 34, 35, and 36). It occurs as, vermicular 'booklets' (Figure 34c) that collectively fill pore spaces (Figure 34a). Kaolinite filled intergranular and intragranular pore spaces (Figures 34 and 35), left coatings on detrital grains (Figure 34b), and sometimes precipitated between individual sheets of biotite separating them over time (Figure 36). Thin, dark, clay coatings (and remnant coatings) are also common on framework grains. Their mineralogy could not be determined, but in samples stained for potassium feldspars, clays were also stained yellow, suggesting illitic or mixed illite/smectite compositions.

Hydrocarbons

During thin section fabrication most hydrocarbons were removed. However, some hydrocarbon is present within all samples. It occurs within intergranular and intragranular pore spaces, (Figures 26a, 26b, and 37), including those interpreted to be secondary in origin.

Compaction

Contact indices (CI) and tight-packing indices (TPI) are plotted versus depth in Figure 38. Average values for the CI and TPI for the Phacoides sands are 3.1 and 2.5 respectively (Figure 38). The deeper samples (Circle Oil SP 32X-21) have a higher contact index average (3.4) and tight-packing index average (2.7) than the shallower samples (contact index average 3.0, tight-packing index average 2.5).

Porosity

Thin-section porosity ranges from 0 – 30.1%, and averages at 15.7% (Figure 39). This does not include microporosity. Types of porosity include intergranular pores, intragranular pores, fractures, and micropores. Secondary porosity (Schmidt and McDonald, 1979; Shanmugam, 1985) averages 51% of total thin-section porosity. Arkosic wackes generally have lower porosities than arenites due to the abundance of labile grains forming pore-filling pseudomatrix. Porosity is also lower in sands containing significant amount of calcite cement.

Dissolution of grains and cements is common in these samples (Figures 10, 11a, 11b, 14, 16, 20, 24, 27, 35, 40, and 41). Dissolution textures include oversize and elongate pores, skeletal grain fragments, grain-edge dissolution, and enlarged fractures (Figures 40 and 41). Dissolution is most common among the feldspars, particularly plagioclase. However, significant dissolution of quartz is also common. Preferential dissolution of feldspars resulted in a shift in the detrital grain composition towards quartz on the ternary diagram (Figure 42).

Mass Balance Calculations

The mass transfer of aluminum was investigated by comparing the present volumes of kaolinite to the predicted volumes of kaolinite assuming all aluminum released during dissolution of feldspars precipitated as kaolinite. Assumptions made about these calculations were based on previous work (Hanson, 1988; Taylor, 2007; Nguyen, 2015; R.A. Horton, personal communication). Figure 43 shows two graphs of mass-balance calculation results. Figure 43a only considers secondary porosity for which the dissolved grain could be positively identified and suggests that Al^{3+} was imported into the system. However, in most cases the dissolved grain could not be positively identified. Figure 43b shows the hypothetical amount of expected kaolinite if it is assumed that all secondary porosity determined through point-count analysis was the result of plagioclase and K-feldspar dissolution (using the same ratios of plagioclase: K-feldspar-included in the calculation for Figure 43a). This suggests Al^{3+} export from approximately three-fifths of the samples. As these calculations do not consider secondary porosity destroyed by subsequent compaction (Horton et al., 2009), they are still conservative.

DISCUSSION

Paragenesis (Diagenetic History)

Diagenesis includes the chemical and physical changes that sediments undergo after deposition until metamorphism begins (Ali, 1981). Diagenetic processes commonly take place at temperatures below 300°C and pressures below 1-2 kb (Boggs, 1992). The

Phacoides sandstone has undergone significant diagenetic changes including compaction, deformation, mechanical rearrangement of grains, dissolution, precipitation of cements, various types of alteration, and subsequent changes in compositional texture. These changes were controlled by temperature, pressure, pore-water chemistry, and lithology. Diagenetic processes may selectively remove feldspars, heavy minerals, or rock fragments by intrastratal dissolution or replacement thereby altering the composition of the sandstones (McBride, 1987; Milliken, 1988; Harris, 1992). This may limit the usefulness of compositional data for provenance interpretations.

At the McKittrick oil field, diagenesis began penecontemporaneously with deposition beginning with glauconite and phosphate formation. Within the Phacoides sandstone, glauconite is of minor occurrence (3% to 10%). The glauconitic minerals occur mainly as structureless peloids (Figures 13, 23, and 28) or occasionally as pseudomatrix (Figure 13). Glauconite typically develops in the reducing regions of open marine environments (Odin, 1980; Stonecipher, 2000) on siliciclastic shelves to about 200m (Boggs, 1992).

Like glauconite, phosphate typically occurs as peloids in the Phacoides sandstone. Phosphate is found as peloids throughout several samples. Some peloids occur surrounding detrital quartz fragments suggesting nucleation sometimes began on quartz (Figure 24). Most phosphate deposition occurs in marine sedimentary sequences on the ocean floor (Odin, 1980; Boggs, 1992). They form due to upwelling of phosphate-rich waters into relatively shallow marine settings, usually above 400m (Boggs, 1992; Thiry et al., 2006). Warm temperatures in marine environments largely influence phosphate deposition, which may occur before, after, or synchronously with glauconite formation (Odin, 1980). Timing between phosphate and glauconite formation could not be determined in these samples.

Early pyrite precipitated into secondary micropores in the peloids (Figures 23a, 23b, and 26c) suggesting diagenetic processes continued acting on glauconite and phosphate shortly after deposition, at least through the sulfidic diagenetic zone (Berner, 1981). In some instances, glauconite and phosphate peloids are present in early-calcite-cemented sandstones, also suggesting early formation (Figure 28).

Early authigenic pyrite formation is also associated with biotite alteration to chlorite (Figure 12). Early pyrite precipitated between sheets of biotite separating them before the sands became tightly compacted. This is evident by the secondary pore space still present within deformed biotite grains surrounding the authigenic pyrite (Figure 12). This early stage of pyrite precipitation was likely caused by a shift in diagenetic environments from post-oxic to sulfidic (Berner, 1981). Iron liberated during biotite alteration likely reacted with sulfur in the pore water to form pyrite.

Carbonate cement occurs as poikilotopic calcite (Figures 11, 19, 20, 30, and 35) and as euhedral dolomite rhombs (Figures 25, 30, 31, 32, and 33). Two phases of calcite cementation were identified. Early poikilotopic calcite cement is most common, especially in the shallower samples from well McKittrick Fee 516-8. In these calcite-cemented sandstones calcite replacement of quartz, feldspars and glauconite is typical (Figures 11c, 11d, 28, and 35). The presence of abundant, un-altered, floating grains (Figure 11) indicates that this was an early stage of calcite precipitation before significant compaction occurred. The extent of carbonate cementation has been interpreted to be related to the amounts of extrabasinal and intrabasinal carbonate grains, which provided cations and sources for the precipitation and growth of carbonate cements (Mansurbeg et al., 2009).

Dolomite/ankerite cement occurs as individual rhombs that formed shortly after calcite cementation (Figures 30 and 32). This is evident in Figure 32 where the calcite cement has become fractured around a euhedral dolomite grain. Occasionally, clusters of dolomite/ankerite rhombs occur with pyrite and hydrocarbon (Figures 31, 33c, and 33d). Typically iron-rich bands are present within dolomite/ankerite crystals (Figures 25, 30, 31, and 32) suggesting multiple stages of precipitation. This also suggests a prolonged precipitation event under conditions with changing pore-water chemistry.

Authigenic quartz and feldspar formed as overgrowths and coatings on, and healed fractures within, detrital framework grains (Figures 7, 8, 19, 20, 21, and 22). Figure 8 shows a fractured detrital quartz grain with an authigenic K-feldspar coating that was later fractured and healed by authigenic quartz during mid-diagenesis. This suggests authigenic K-feldspar precipitation occurred before authigenic quartz precipitation.

This was followed by a late stage of calcite precipitation that replaced framework grains (Figures 11 and 44). Late calcite also surrounds K-feldspar grains with K-feldspar overgrowths (Figures 19, 20, and 30) and quartz with euhedral (authigenic) terminations (Figure 44d). The euhedral grain-edges surrounded by calcite cement suggests late calcite precipitation followed quartz precipitation (Figure 44d). Figure 44c shows calcite cement surrounding a partially albitized plagioclase grain that is also partially replaced by late calcite. Remnants of albite within the replacive calcite suggests albitization occurred before replacement by calcite.

Extensive dissolution is evident through the presence of oversize and elongate pores, skeletal grain fragments, grain-edge dissolution, and fracture-induced dissolution (Figures 10, 11a, 11b, 14, 16, 20, 24, 27, 35, 40, and 41). Dissolution began during early diagenesis and continued through all stages of burial. It is most common among the feldspars, particularly plagioclase. This resulted in a shift in the detrital grain composition away from plagioclase and towards quartz on the ternary diagram (Figure 42) that ultimately could affect provenance interpretation (Figure 45).

Kaolinite cement is abundant in nearly every sample. It occurs as clay coatings on detrital grains (Figure 34b), within dissolution pores (Figure 35), adjacent to partially dissolved K-feldspar grains (Figure 34a), and between sheets of biotite (Figure 36). Authigenic kaolinite is largely associated with feldspar dissolution (Figures 34 and 35). These textural relationships suggest kaolinite precipitation occurred during late diagenesis.

Following significant dissolution, hydrocarbon migration into secondary and primary pore space occurred during late diagenesis (Figures 26a, 26b, and 37). After migration, continued hydrocarbon maturation resulted in pyrite precipitation (Figures 26a and 26b). This suggests that hydrocarbon continued to mature or evolve following emplacement, thereby releasing sulfur into the pore-fluid system (R. Horton, personal communication). Euhedral pyrite also formed within dissolution pores of detrital framework grains (Figure 26d) and framboidal pyrite also formed within secondary pore spaces (Figure 27). This suggests a late stage of pyrite formation not necessarily associated with hydrocarbon migration. Less commonly, late pyrite also replaced rutile (Figures 46 and 47).

Authigenic albite replaced plagioclase and K-feldspars in all samples. Two distinct types of albitization occurred. Nearly pure albite (Figure 5) healed fractures within and replaced grains along fractures, cleavage planes, and micropores where pore water could make contact with the grains’ interiors (Figures 16, 17, and 18). Notably, no albite overgrowths are present. This type of authigenic albite is most abundant in plagioclase

(Figures 16a, 16b, 17a, 17b and 18) but is also common in detrital K-feldspars (Figures 16c, 16d, 17c, 17d, and 20) as well. It formed during mid-diagenesis, before significant dissolution took place. Albitization is primarily temperature controlled and typically occurs from 100-150°C (Milliken et al., 1981; Boles, 1982; Surdam et al., 1989), although other studies have suggested temperatures as low as 70°C (Aagaard et al., 1990; Morad et al., 1990). The reservoir temperature within the Phacoides sandstone in the McKittrick Fee 516-8 well ranges from 88°C to 97°C at depths between 2403 and 2623 meters. This is consistent with albitization at lower temperatures (Aagaard et al., 1990; Morad et al., 1990) that would have been present during mid-diagensis. This type of albitization was followed by precipitation of poikilotopic calcite cement (Figures 16a, 17d, and 20). Lee and Boles (1996) studied oxygen isotope ratios (18O) in late-calcite cements in San Joaquin basin sandstones and determined that these cements precipitated at temperatures between 70-120°C, again consistent with the formation of this type of albite during mid-diagenesis.

Albitization also occurs in plagioclase by the gradual replacement, throughout an entire grain, of Ca^{2+} and Al^{3+} by Na^{+} and Si^{4+} (Boles, 1982, 1984). Boles and Ramseyer (1988) presented data showing this type of albitization progressively occurs between 120-160°C in the San Joaquin basin, and Boles and Perez (2005) developed a kinetic model that predicted those data. These authors suggested that the average albite content of detrital plagioclase grains could be used to determine the maximum burial temperature to which the plagioclase had been exposed. Average whole-grain plagioclase compositions from eight Phacoides sandstone samples range from An_{18}-An_{8}. These compositions correspond to burial temperatures between 130°C and 150°C (Boles and Ramseyer, 1988; Perez and Boles, 2005). The maximum temperature in the Phacoides reservoir at McKittrick does not exceed 110°C

(California Division of Oil and Gas, 1998). Using the temperature/depth data for the McKittrick Fee 516-8 well (88°C at 2403m, 97°C at 2623m), the geothermal gradient at McKittrick is 37°C km^{-1}, consistent with typical values of ~35°C km^{-1} reported by Lee and Boles (1996). This suggests uplift of between one-half and one kilometer subsequent to maximum burial.

Texture and Dissolution

Various factors control reservoir quality including mechanical compaction (mechanical rearrangement of grains and fracturing), chemical compaction (dissolution and alteration), and cementation (Schmidt and McDonald, 1979; Wilson and McBride, 1988; Fisher et al., 1999; Sheldon et al., 2003; Taylor, 2007). Compaction changed the texture and composition of the Phacoides sandstone significantly. Compaction resulted in deformation of both labile and brittle detrital grains. Labile grains, such as biotite, glauconite, and volcanic lithics, were squashed into surrounding pore spaces creating pseudomatrix (Figures 3b, 12, 13, 14, and 15) while brittle framework grains, such as quartz and feldspars, underwent significant fracturing and mechanical rearrangement (Figures 9, 14, 20, 48c, and 48d) that caused changes in texture (increased angularity, decreased sorting). Along with continued compaction, this caused a reduction in porosity and permeability. Mechanical grain rearrangement also allowed for the formation of tangential contacts between grains.

Packing parameters document the changes in fabric that result from compaction (Wilson and McBride, 1988). Changes in contact index (CI) and tight-packing index (TPI) are shown in Figure 38. Both the CI and TPI increase with depth, similar to results obtained elsewhere within the San Joaquin and Ventura basins (Wilson and McBride, 1988; Taylor, 2007; Horton et al., 2009). When compared closely to the aforementioned studies, however, the CI and TPI for the current burial depth of the Phacoides at McKittrick oil field is slightly higher than for sediments at similar depths elsewhere in the basin (Horton et al., 2009). This supports the idea that the sediments in this location area were likely buried deeper than at present.

Significant fracturing increased the grains' surface areas that were exposed to pore fluids (Taylor, 2007; Horton et al., 2009; Nguyen, 2015). This facilitated processes such as albitization, healing of fractures, and dissolution to occur. Dissolution preferentially occurred along fractures resulting in the formation of intragranular secondary porosity.

Dissolution began during early diagenesis and continued through to late diagenesis. Preferential dissolution of partially albitized plagioclase resulted in remnant skeletal fragments of albite within secondary pore spaces (Figures 16a, 16b, 17a, and 17b). This suggests albitization occurred before dissolution. Figure 41d shows intergranular porosity, whereas Figures 40a, 41a, and 41b show the transformation from primary porosity to secondary intragranular porosity. Figure 41c shows a secondary pore formed by the complete dissolution of a clay-coated grain with only the grain-coating remaining. Figure 41d shows a partially dissolved feldspar along with oversized and elongate intergranular pores, including some that contain remnants of dissolved grains. As entire grains dissolved to form elongate and oversized intergranular secondary pores (Figure 20, 40a, 40b and 41c), continuing compaction altered the shapes to resemble primary porosity (Schmidt and McDonald, 1979; Horton et al., 2009).

The dissolution and albitization of feldspars resulted in the liberation of aluminum into pore fluids, resulting in precipitation of kaolinite (Figures 34a, 48a, and 48b). Figure 43 shows results of mass-balance calculations between feldspar dissolution and kaolinite precipitation. In Figure 43a, mass-balance calculations were made using 30% kaolinite microporosity. This suggests an import of Al^{3+} into the system. In Figure 43b, still using 30% kaolinite microporosity, secondary porosity for which the dissolved grain is unknown was also taken into account by assuming the ratio of dissolved phases in these pores was the same as in the pores where the dissolved grain could be identified. This suggests an export of Al^{3+} from the system. These calculations do not account for Al^{3+} released by the albitization of plagioclase. However, the shift in average plagioclase composition from an initial value of An_{30} (Hayes and Boles, 1992) to about An_{11} found in this study suggests that this source of dissolved Al^{3+} could be important. These calculations also do not account for secondary porosity that has been destroyed by subsequent compaction. Studies in the San Joaquin basin (Horton et al., 2009) and elsewhere (McBride, 1988; Harris, 1992) suggest that this could also be important. The shifts in quartz : feldspar ratios (Figures 42, 45, and 49) observed during this study indicate significant dissolution of framework grains has occurred, but thin-section-porosity values are not abnormally high for the sandstones current or inferred burial depths (Horton et al., 2009), so loss of secondary porosity due to compaction at McKittrick is likely.

Provenance

The mineralogy of the Phacoides sandstones indicates they are sourced from felsic plutonic rock. Various types of rock fragments and K-feldspars with varying chemical compositions suggest multiple source rocks. Furthermore, shale clasts (which are likely local) suggest nearby uplift and erosion of the underlying sediment. All of this affects provenance interpretation.

Feldspar dissolution was extensive in the Phacoides sandstone at McKittrick. Although quartz underwent some dissolution, primarily along grain edges, it is the most stable of the framework grains. As a result, there has been a significant shift in the sediment composition due to dissolution of feldspars (Figures 45 and 49), primarily plagioclase (Figure 42). As there are many oversized and elongate pores of secondary origin for which the dissolved mineral cannot be determined the actual shifts are probably much larger.

As grain dissolution is a large control on sandstone composition, provenance interpretation can be severely affected by diagenetic processes that selectively removed feldspars, heavy minerals, or rock fragments by intrastratal solution (Dickinson and Suczek, 1979; Shanmugam, 1985; Milliken, 1988; Boggs, 1992). Entire grain replacement by calcite at the McKittrick oil field also contributed to difficulties determining provenance accurately. Figure 49 shows the compositions of the sandstones after correction for dissolved constituents. The data show a significant shift in composition towards the quartz corner of the ternary diagrams due to preferential dissolution of feldspars. Similar compositional shifts have been documented elsewhere (McBride, 1987; Harris, 1989). Figure 45 shows the data plotted following the methodology of Dickinson (1970, 1985). As noted above, actual shifts in composition are likely to be larger. The present composition of most samples plot in the recycled orogenic and transitional continental regions rather than in the dissected arc and basement uplift regions as might be expected from sand sourced from the Sierra Nevada. However, when the loss of feldspar is taken into account, the samples shift toward the basement uplift and dissected arc regions of the ternary diagram (Figure 45).

SUMMARY AND CONCLUSIONS

The Oligocene to Miocene Phacoides sandstone of the Temblor Formation was deposited in a shallow marine environment. The reservoir sandstones include arkosic arenites and wackes that are poorly to well sorted and range from angular to sub-round. The detrital mineralogy suggests multiple source rocks and rapid uplift of nearby source areas. The complicated diagenetic history (Figure 50) of these sandstones produced significant changes in the mineralogy and overall texture at the McKittrick oil field. Diagenesis began shortly after deposition with glauconite and phosphate formation. Fracturing and dissolution began shortly after the formation of phosphate and glauconite where it continued through later diagenesis and into present-day conditions. Compaction resulted in the formation of pseudomatrix from labile grains and a reduction in porosity and permeability. An early stage of pyrite precipitation occurred followed by an early stage of calcite precipitation. Overgrowths on K-feldspar and quartz occurred next. Two stages of albitization occurred: one during mid-diagenesis and one during late diagenesis. Early albitization occurred along fractures in K-feldspar and plagioclase grains as pure albite. Late albitization consisted of the gradual replacement of Ca^{2+} in plagioclase by Na^{+} in plagioclase grains. Dissolution of feldspars followed and was accompanied by kaolinite precipitation. Dolomite precipitation was followed by a late stage of calcite precipitation. Finally, hydrocarbon migration was followed by pyrite precipitation as sulfur was liberated by continued thermal evolution of hydrocarbons that reacted with iron in the pore fluids.

Selective dissolution of feldspars resulted in improved reservoir quality. However, it also caused shifts in the detrital grain ratios, diminishing their use for determining provenance accurately. Dissolution is the main contributing factor to the formation of secondary porosity (Schmidt and McDonald, 1979) and continued dissolution increased the overall thin-section porosity to as much as 30%, of which at least half is secondary. As a result, the arkosic arenites that make up the Phacoides are highly porous and, due to abundance of oversized and elongate pores, likely permeable as well.

Secondary porosity is the dominant type of porosity in major sandstone reservoirs worldwide (Schmidt and McDonald, 1979; Shanmugam, 1985) including the Phacoides sandstone. Due to the prevalence of dissolution and subsequent formation of secondary porosity, this reservoir would be an ideal candidate for carbon capture and sequestration. The average overall thin-section porosity of the Phacoides is 15.7% ranging up to 30.0%. Typically, in the San Joaquin Basin thin-section porosity is 80% of the porosity that would be obtained through core analysis (Horton et al., 2009). This suggests there is sufficient space to store CO_2. Of this porosity, up to 86.0% is secondary (average 51.0% secondary porosity). However, secondary porosity can often resemble primary porosity and can therefore be difficult to distinguish (Schmidt and McDonald 1979; Horton et al., 2009; Nguyen, 2015).

The information obtained in this study will be useful for any future geochemical and reservoir modeling that will be conducted in the Phacoides sands. These results will not only help to identify whether or not the McKittrick oil field is an ideal location for carbon capture and sequestration, but they will also shed more insight on the implications of diagenesis and its impact with regards to storing CO_2.

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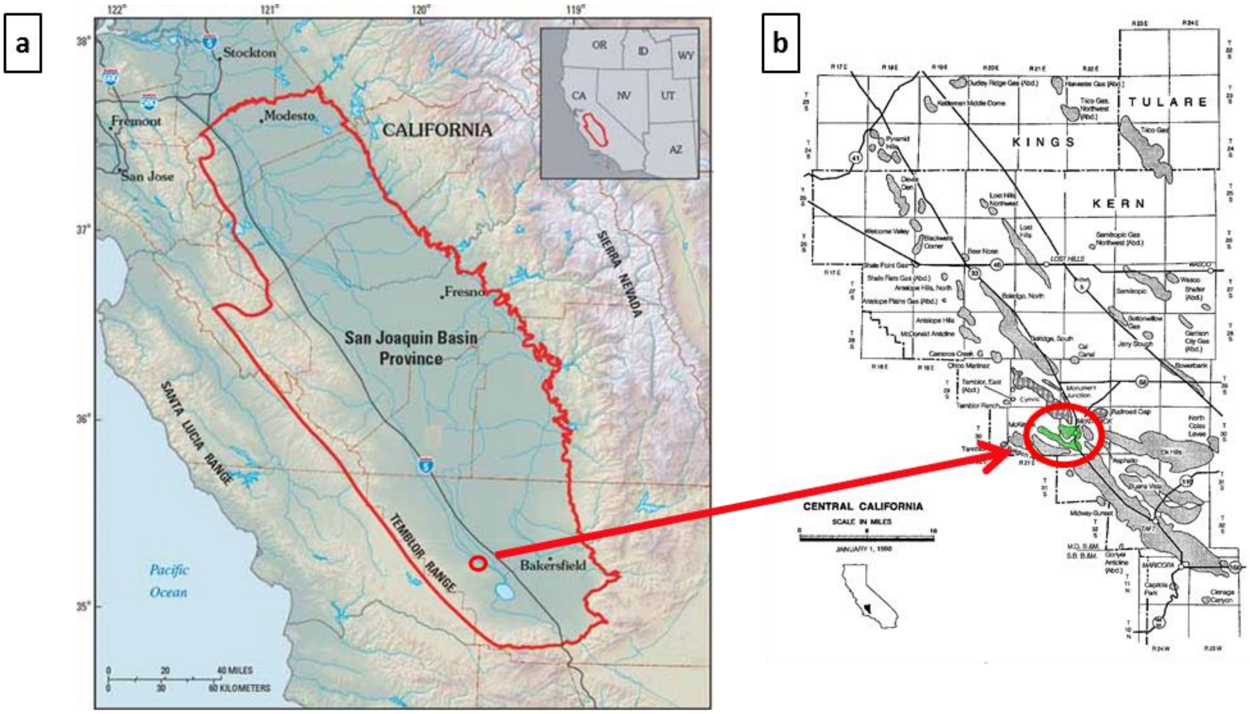


Figure 1. a) San Joaquin basin. McKittrick is indicated with the red circle. Modified from Scheirer and Magoon (2007). b) Map of Central California oil fields showing McKittrick oil field in green. Modified from California Department of Conservation (1998).

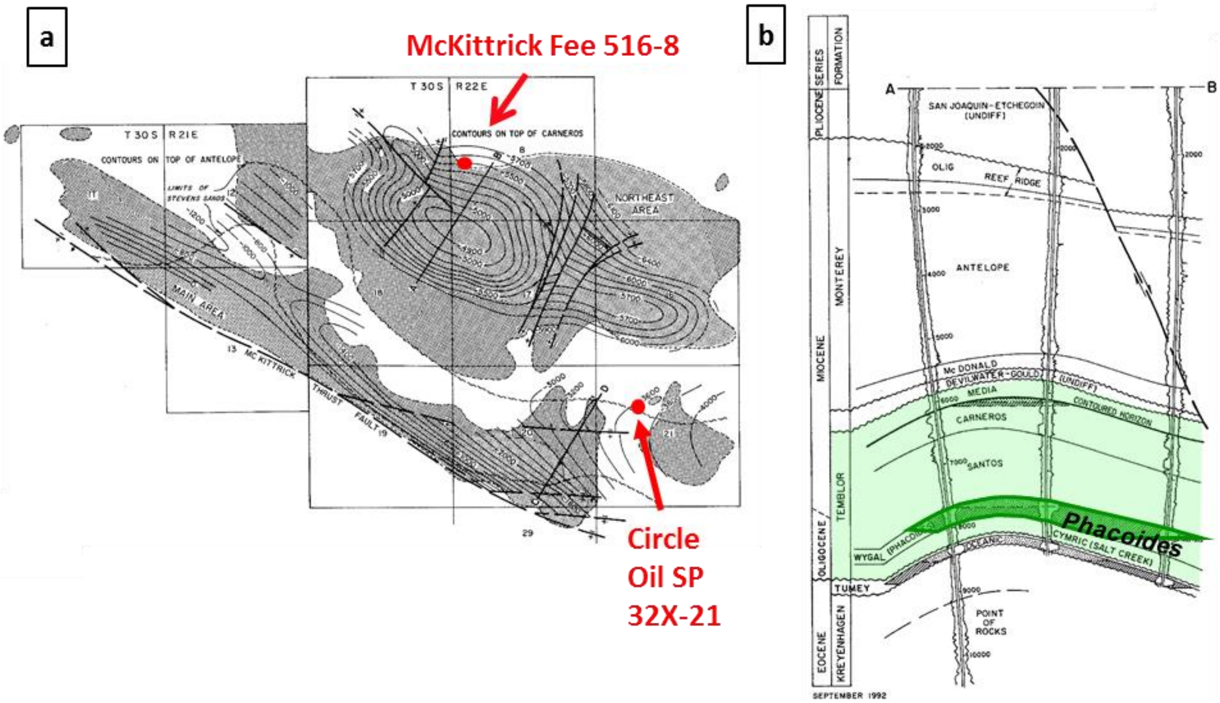


Figure 2. a) Structure map showing the McKittrick Fee 516-8 and SP 32X-21 wells. b) Stratigraphic cross section of the McKittrick Oil Field with Temblor Formation highlighted in light green and the Phacoides sandstone highlighted in dark green (right). Modified from California Department of Conservation (1998).

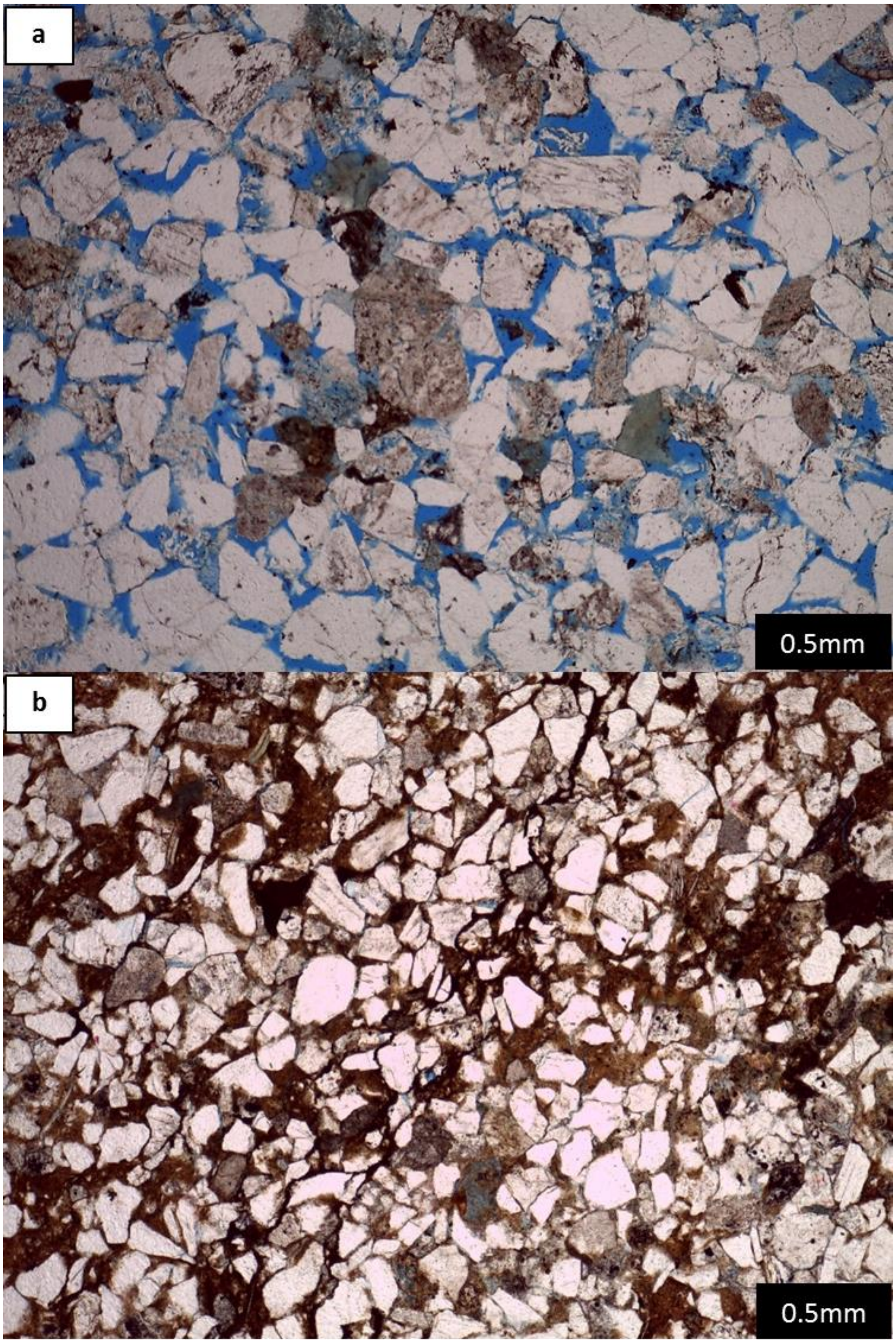


Figure 3. Photomicrographs of typical Phacoides sandstones. a) Arkosic arenite (plane-polarized light, 2468m). b) Arkosic wacke (plane-polarized light, 3038m).

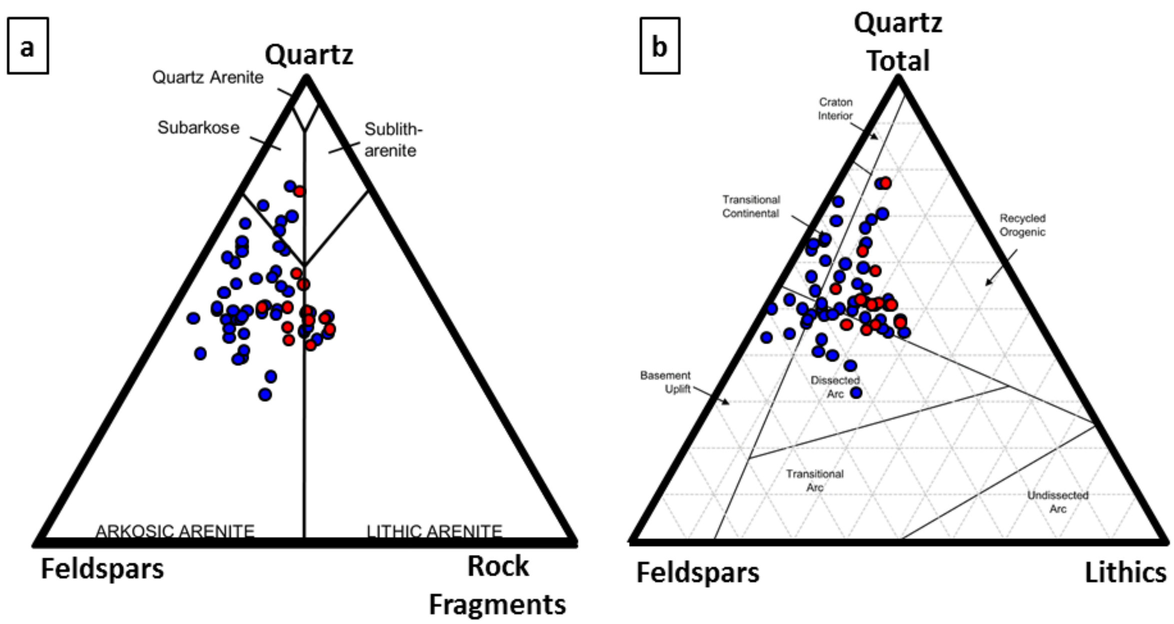


Figure 4. Ternary diagrams showing the composition of the sands. a) Detrital components (quartz, feldspars, and rock fragments) plotted following Pettijohn et al. (1987). b) Detrital components plotted following Dickinson (1985). The blue points represent shallower samples (well McKittrick Fee 516-8). The red dots represent deeper samples (well Circle Oil SP 32X-21).

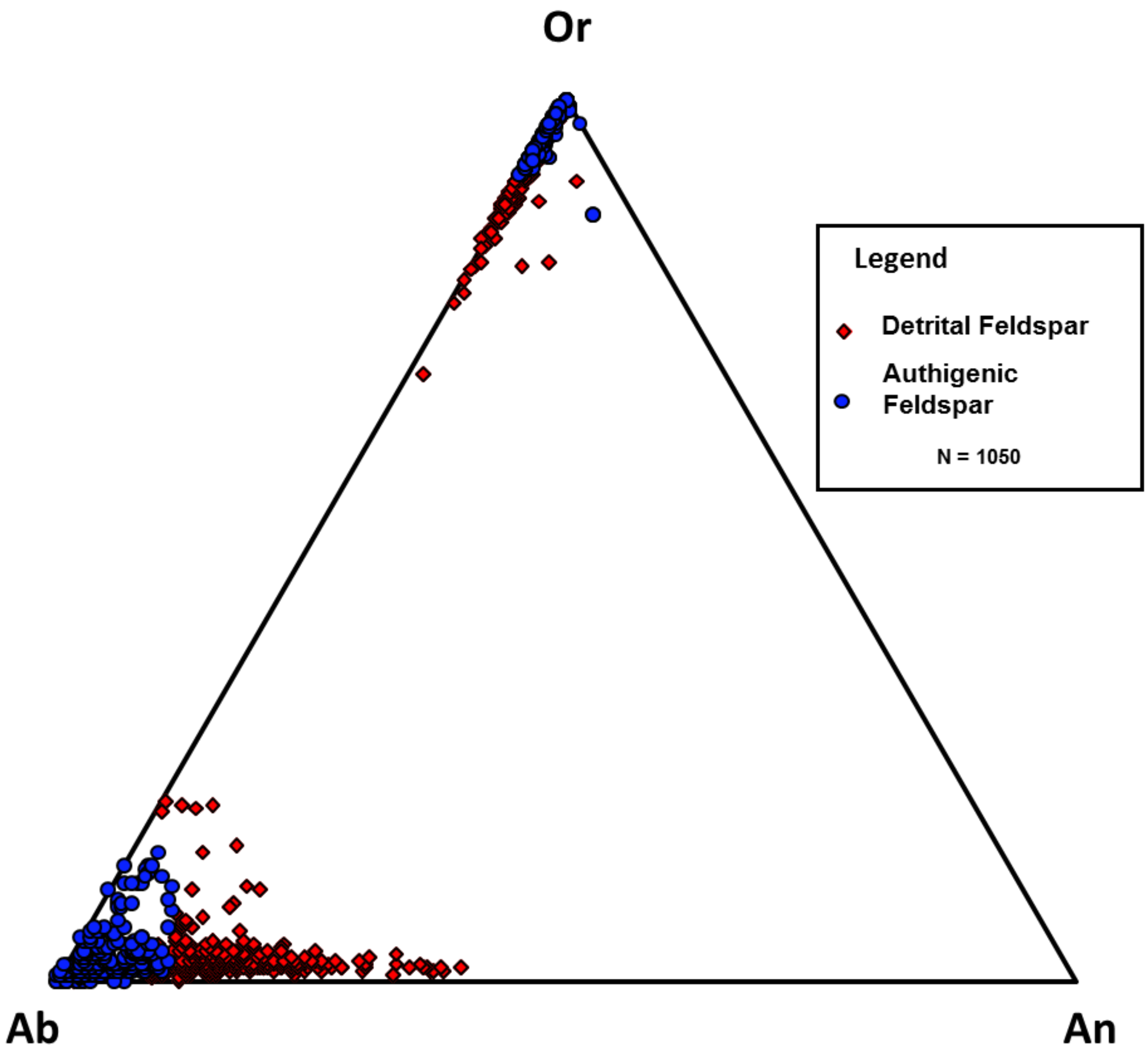


Figure 5. Ternary diagram showing feldspar compositions. End member compositions are $KAlSi_3O_8$ (Or), $NaAlSi_3O_8$ (Ab), and $CaAl_2Si_2O_8$ (An). Red dots represent detrital feldspars and blue dots represent authigenic feldspars.

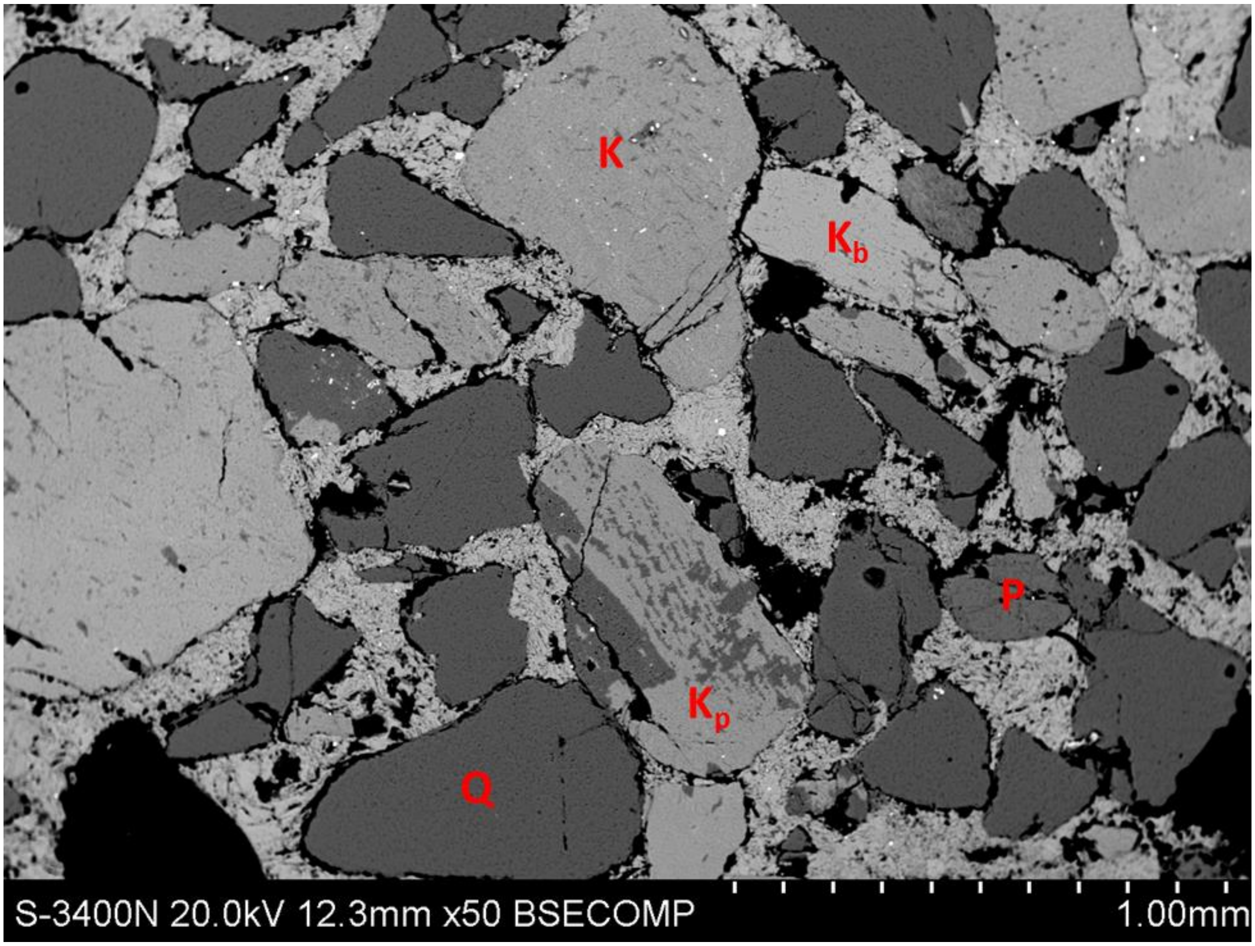


Figure 6. SEM-BSE image showing barium-poor K-feldspar (K), barium-rich K-feldspar (K_b), perthite (K_p), plagioclase (P), and quartz (Q) (2418m).

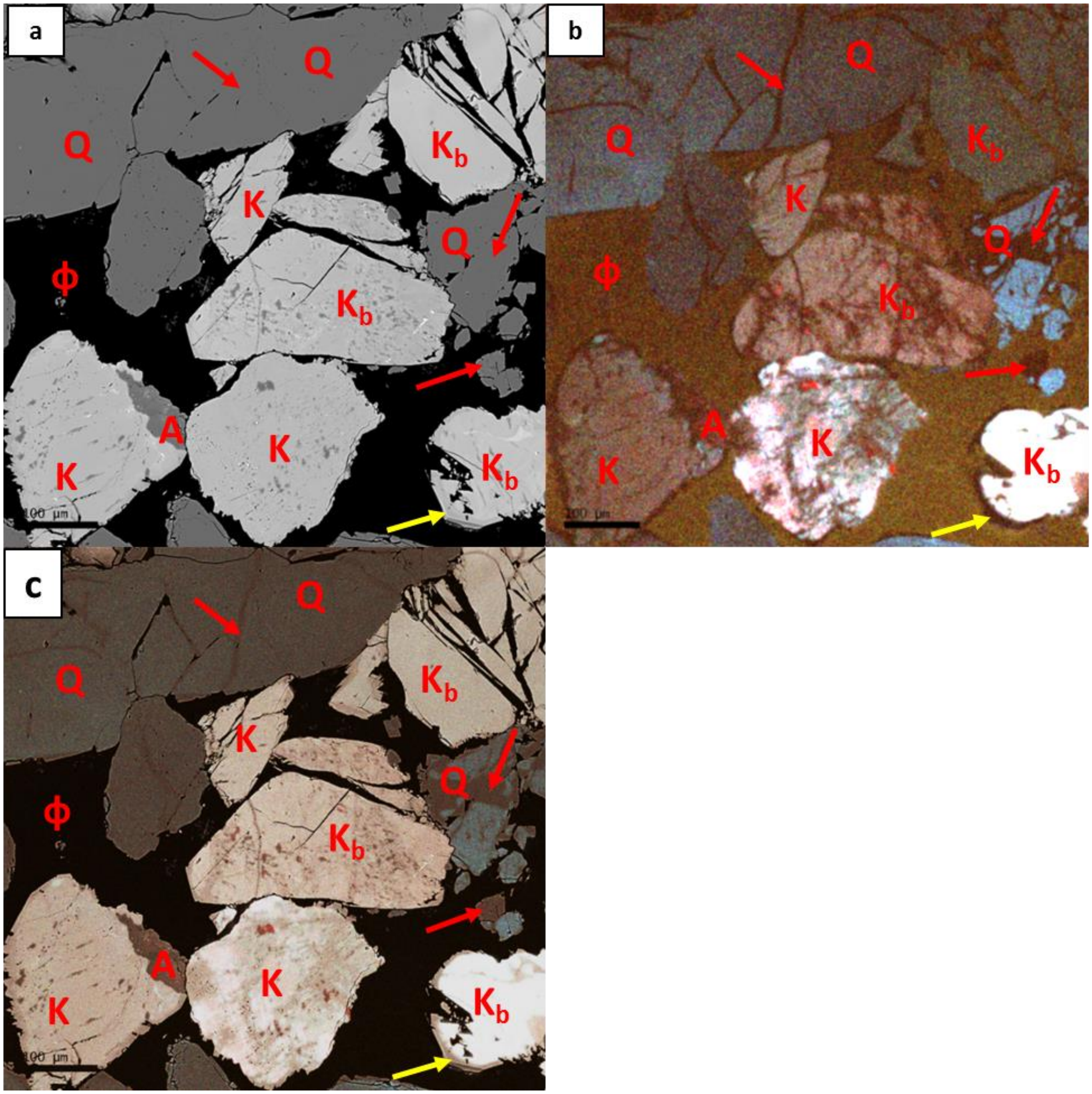


Figure 7. a) SEM-BSE image, b) CL image, and c) composite image of SEM-BSE and CL of the same sample showing authigenic and detrital components. Quartz (Q), barium-poor K-feldspar (K), barium-rich K-feldspar (K_b), albite (A), porosity (ϕ), authigenic quartz (red arrows), authigenic K-feldspar (yellow arrows) (2423m).

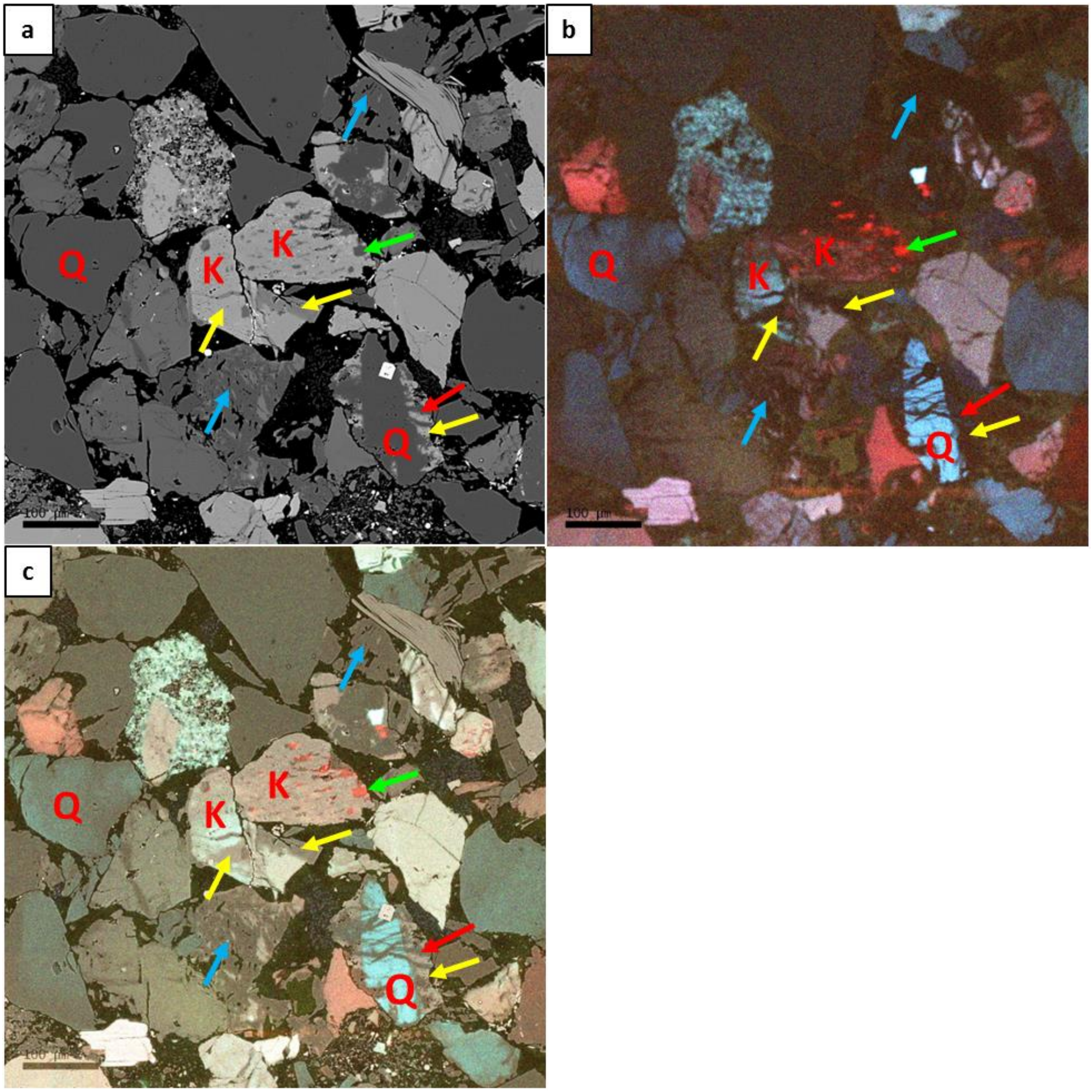


Figure 8. a) SEM-BSE image, b) CL image, and c) composite image of SEM-BSE and CL of the same sample showing various detrital framework grains with authigenic overgrowths, healed fractures, and coatings. Quartz (Q), K-feldspar (K), igneous albite (green arrows), albite (blue arrows), authigenic quartz (red arrows), authigenic K-feldspar (yellow arrows) (2510m).

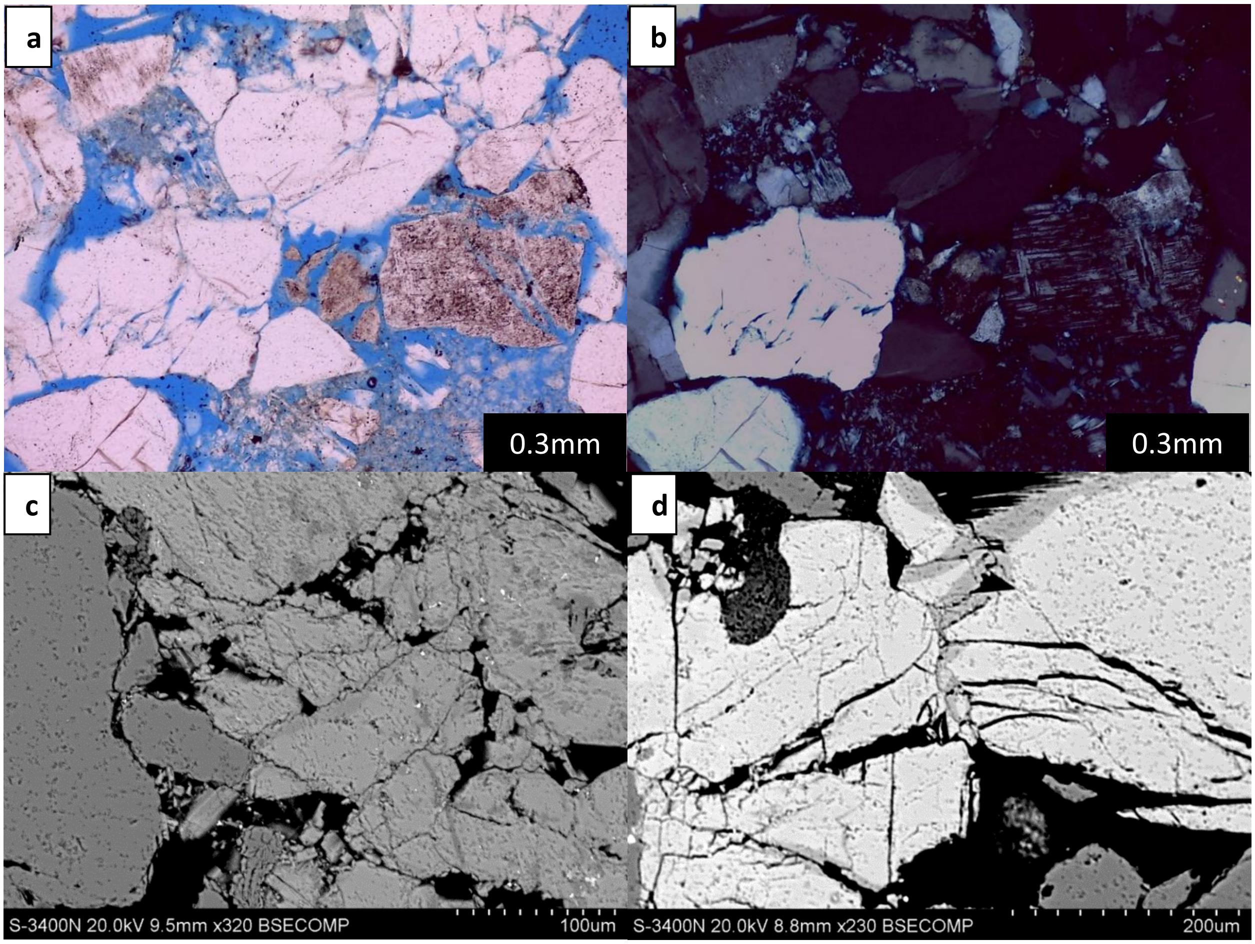


Figure 9. a) Plane-polarized and b) crossed-polarized light photomicrographs of significant fracturing within detrital framework grains (2422m). c and d) SEM-BSE images of various fractured detrital framework grains (2461m).

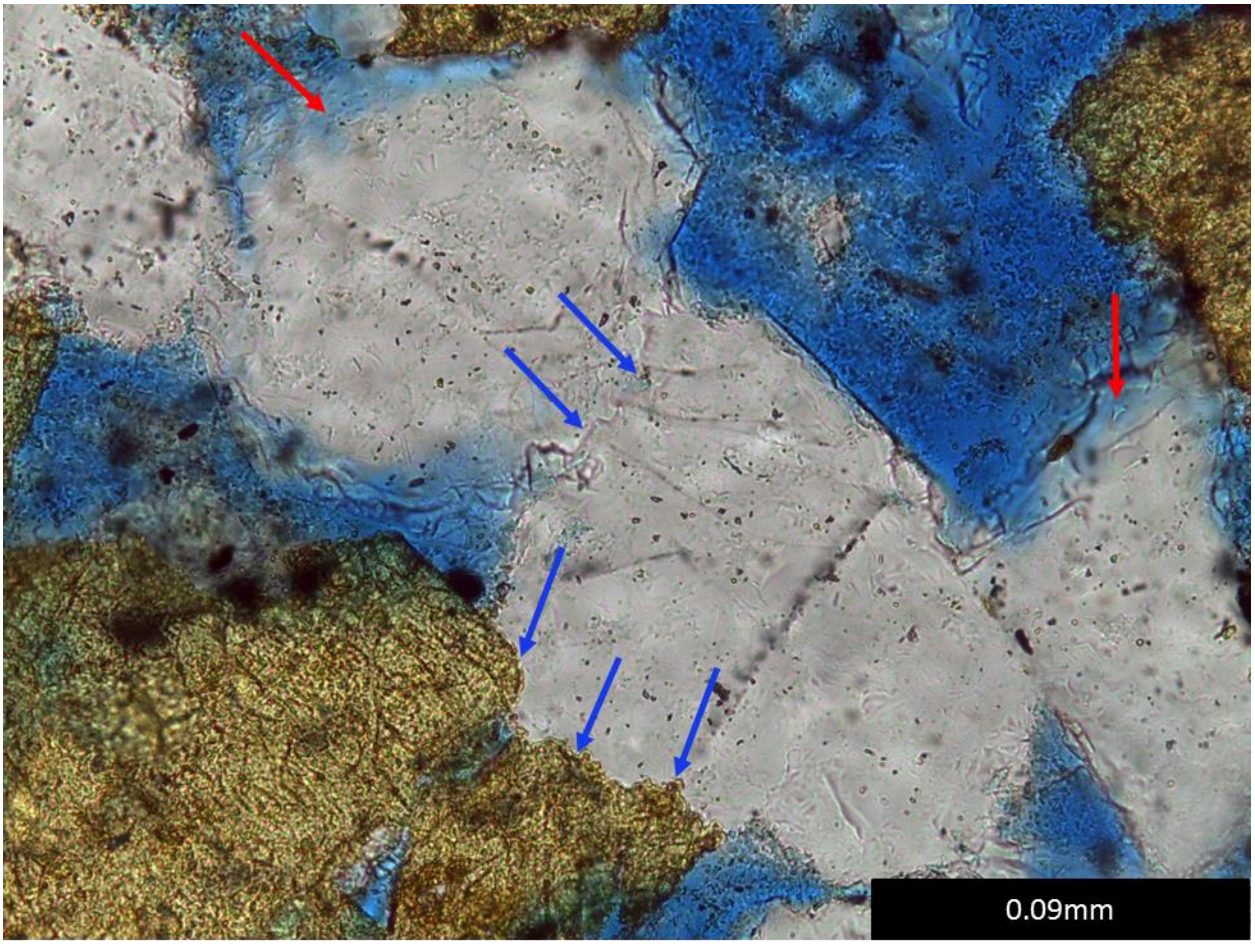


Figure 10. Plane-polarized light photomicrograph showing sutured contacts between quartz-quartz and K-feldspar-quartz (blue arrows) and dissolved grain-edges on quartz (red arrows). K-feldspar are stained yellow (2464m).

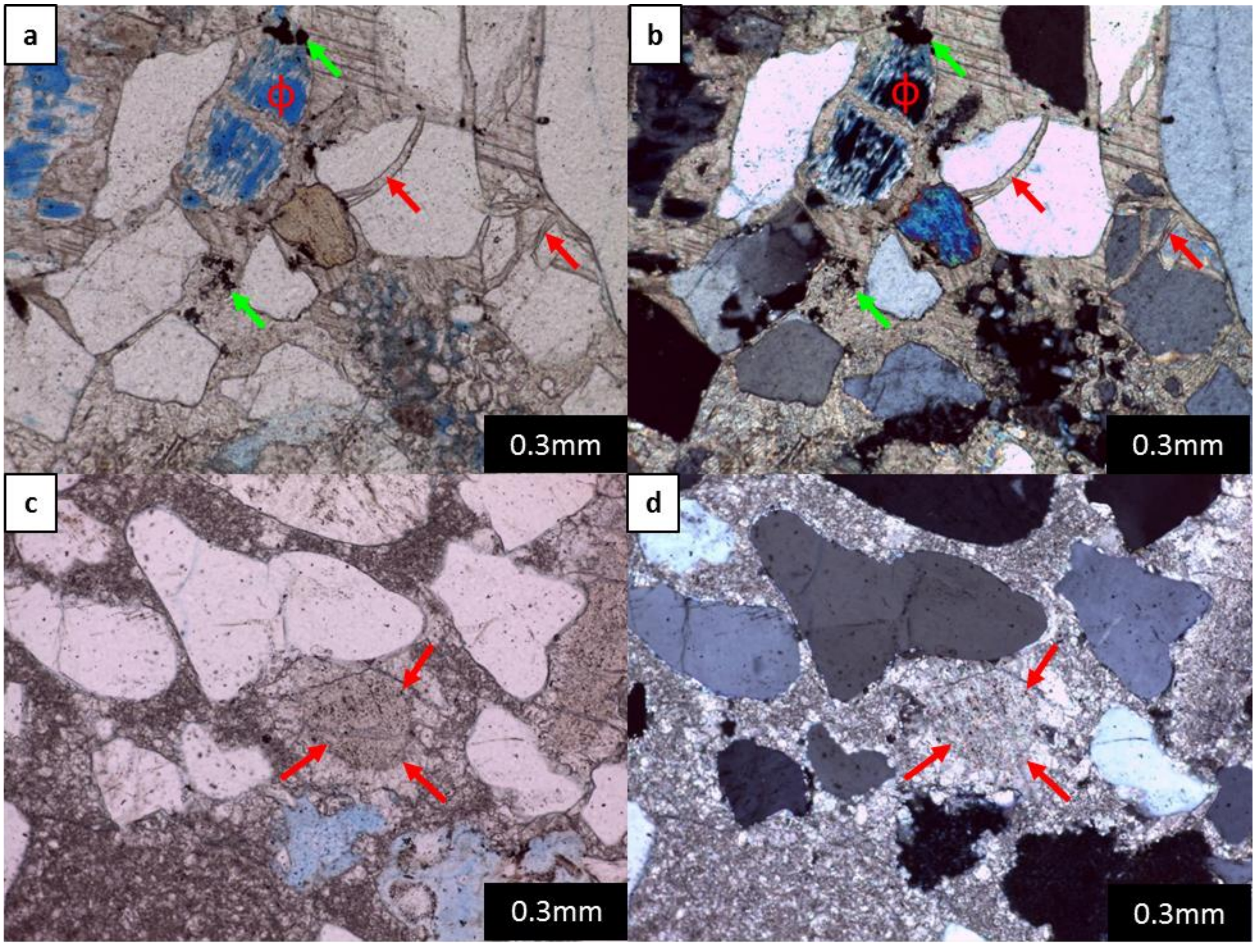


Figure 11. a) Plane-polarized and b) cross-polarized light photomicrographs of poikilotopic calcite cement surrounding pyrite (green arrows) and filling fractures in detrital grains (red arrows) (2403m). c) Plane-polarized and d) cross-polarized light photomicrographs showing poikilotopic calcite cement that has replaced framework grains (red arrows) (2413m).

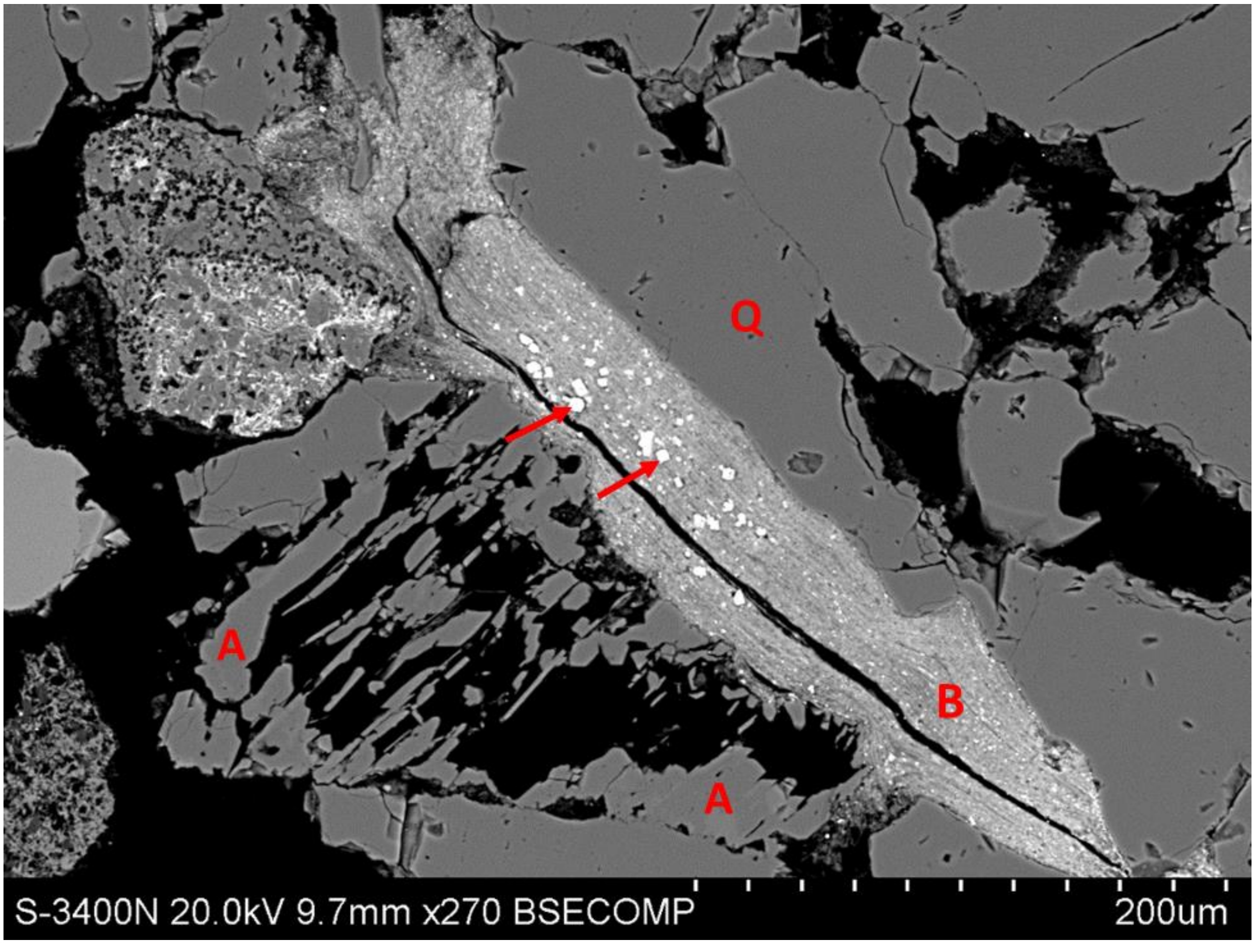


Figure 12. SEM-EDS image of quartz (Q), albite (A), and deformed biotite (B) containing authigenic pyrite (red arrows) (2429m).

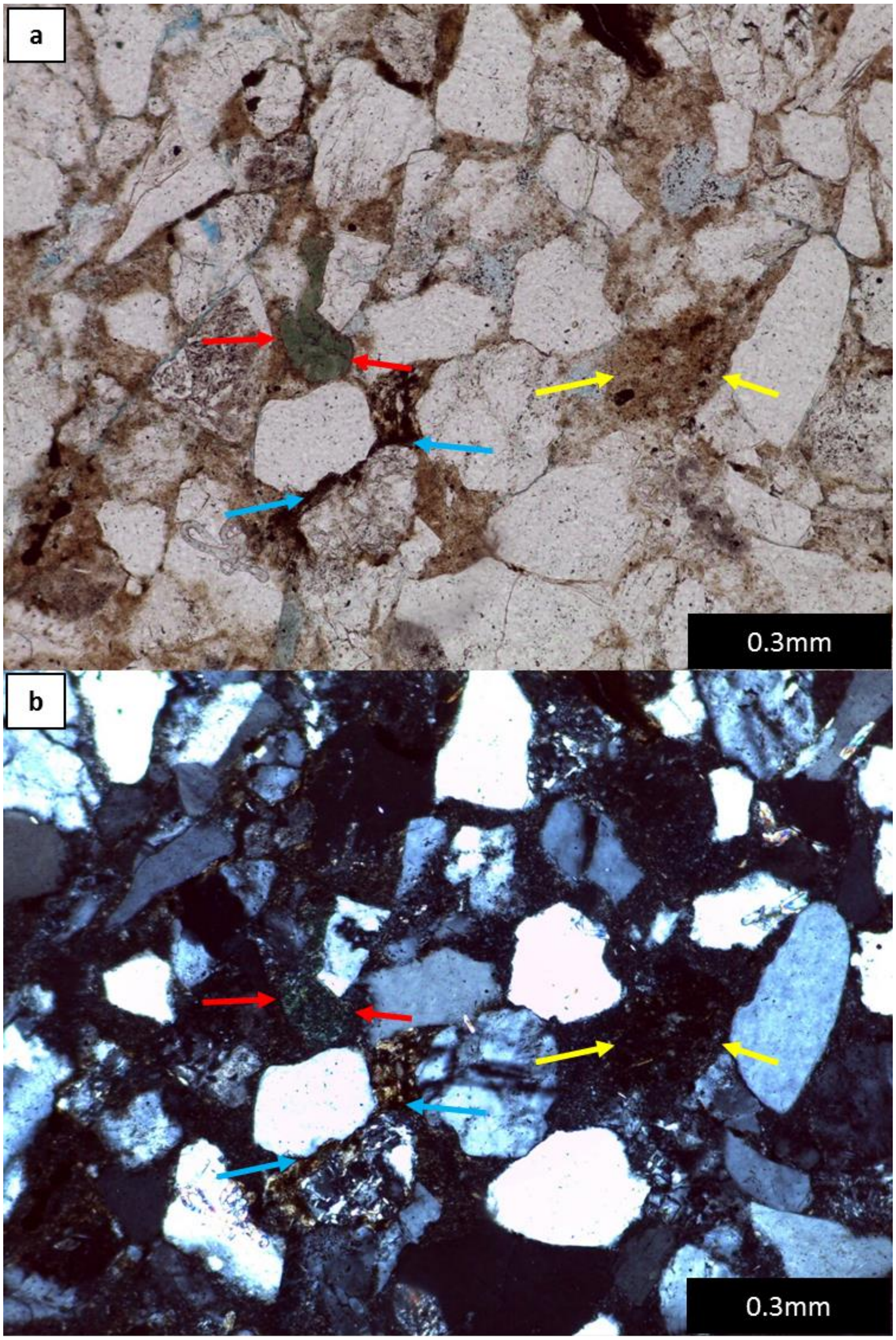


Figure 13. a) Plane-polarized and b) crossed-polarized light photomicrographs of pseudomatrix containing deformed glauconite (red arrows), biotite (blue arrows), and altered volcanics (yellow arrows) (3030m).

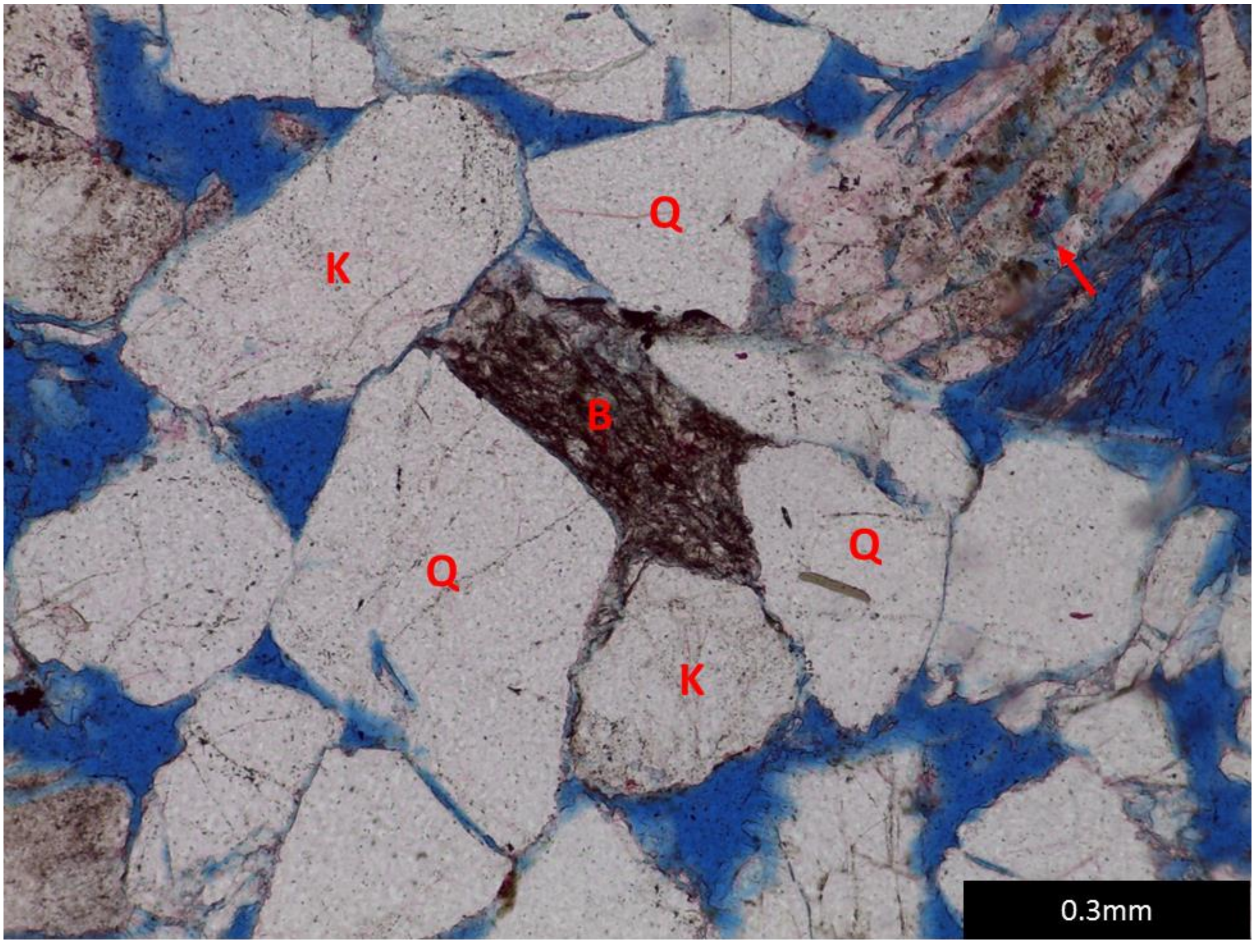


Figure 14. Photomicrograph of deformed biotite (B) between detrital quartz (Q) and K-feldspar (K). Fractured and partially dissolved plagioclase is stained pink from Ca (red arrow) (2405m).

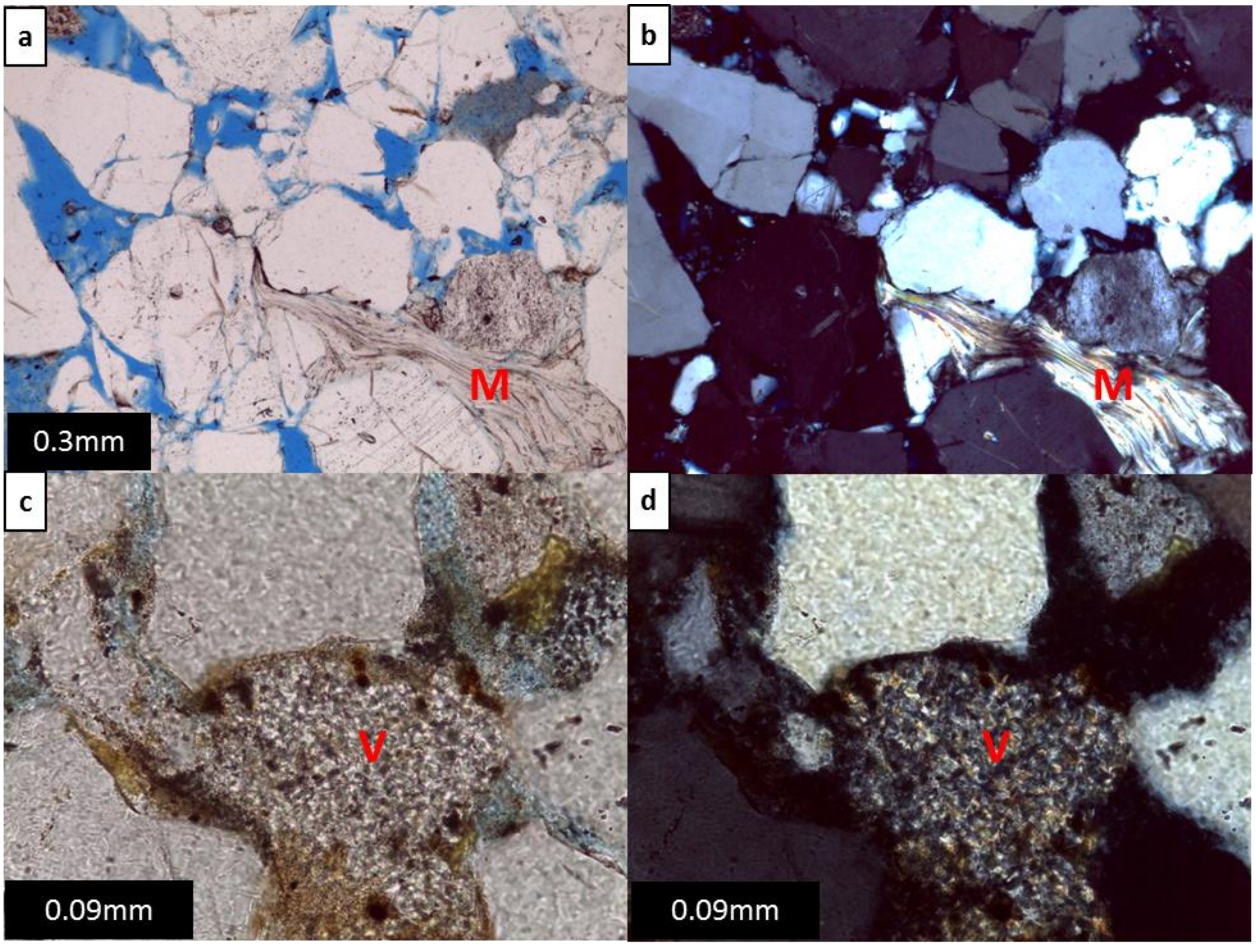


Figure 15. a) Plane-polarized and b) cross-polarized light photomicrographs of muscovite (M) squashed between detrital grains (2422m). c) Plane-polarized and d) cross-polarized light photomicrographs of a deformed volcanic fragment (V) that has been altered to a mixture of clay and zeolite (3033m).

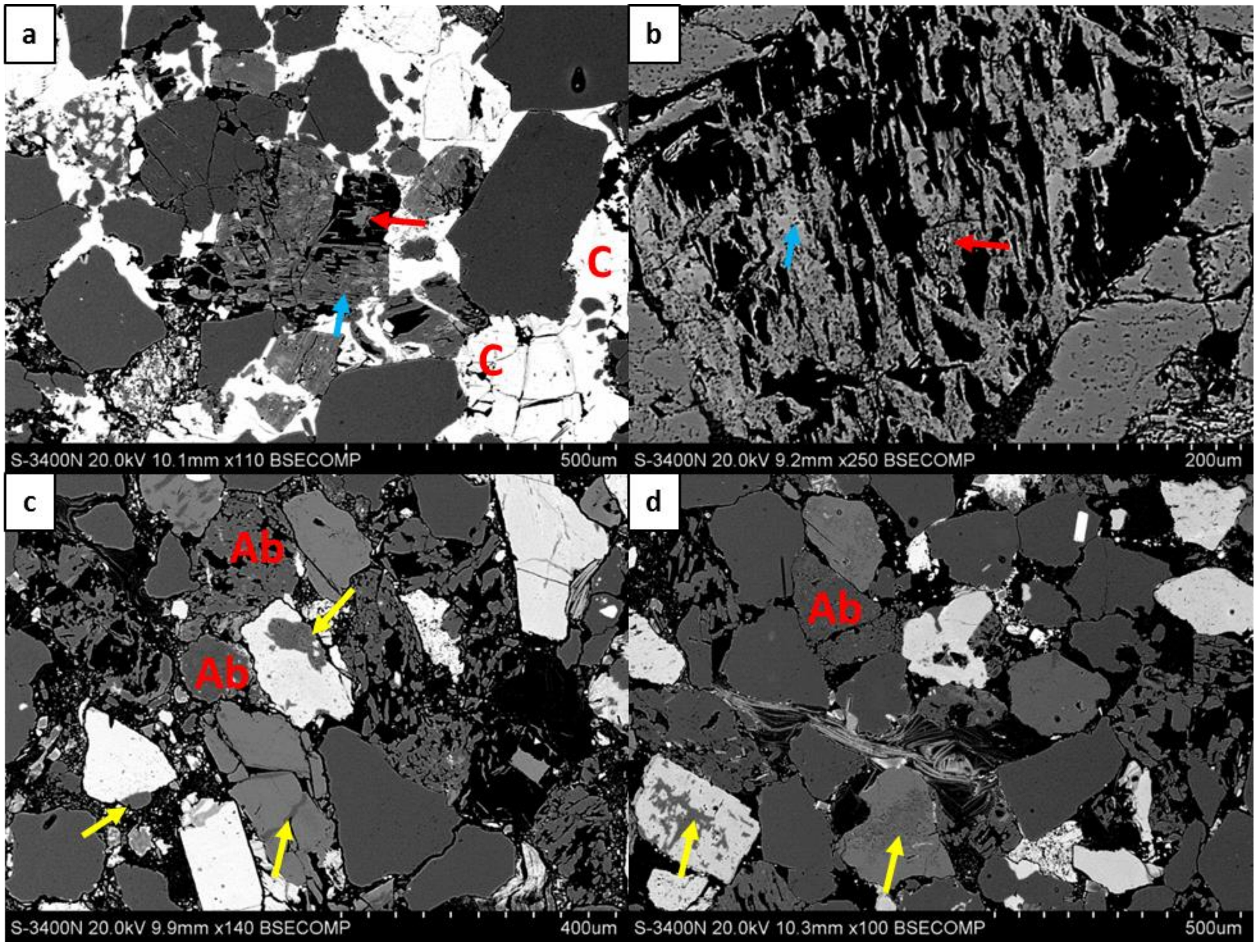


Figure 16. a and b) SEM-BSE images of detrital plagioclase (red arrow), albitized plagioclase (blue arrow), and calcite (C) (2422m and 2461m). c and d) SEM-BSE images of entirely albitized feldspars (Ab), authigenic albite along fractures, micropores, and grain-edges (yellow arrows) (2447m).

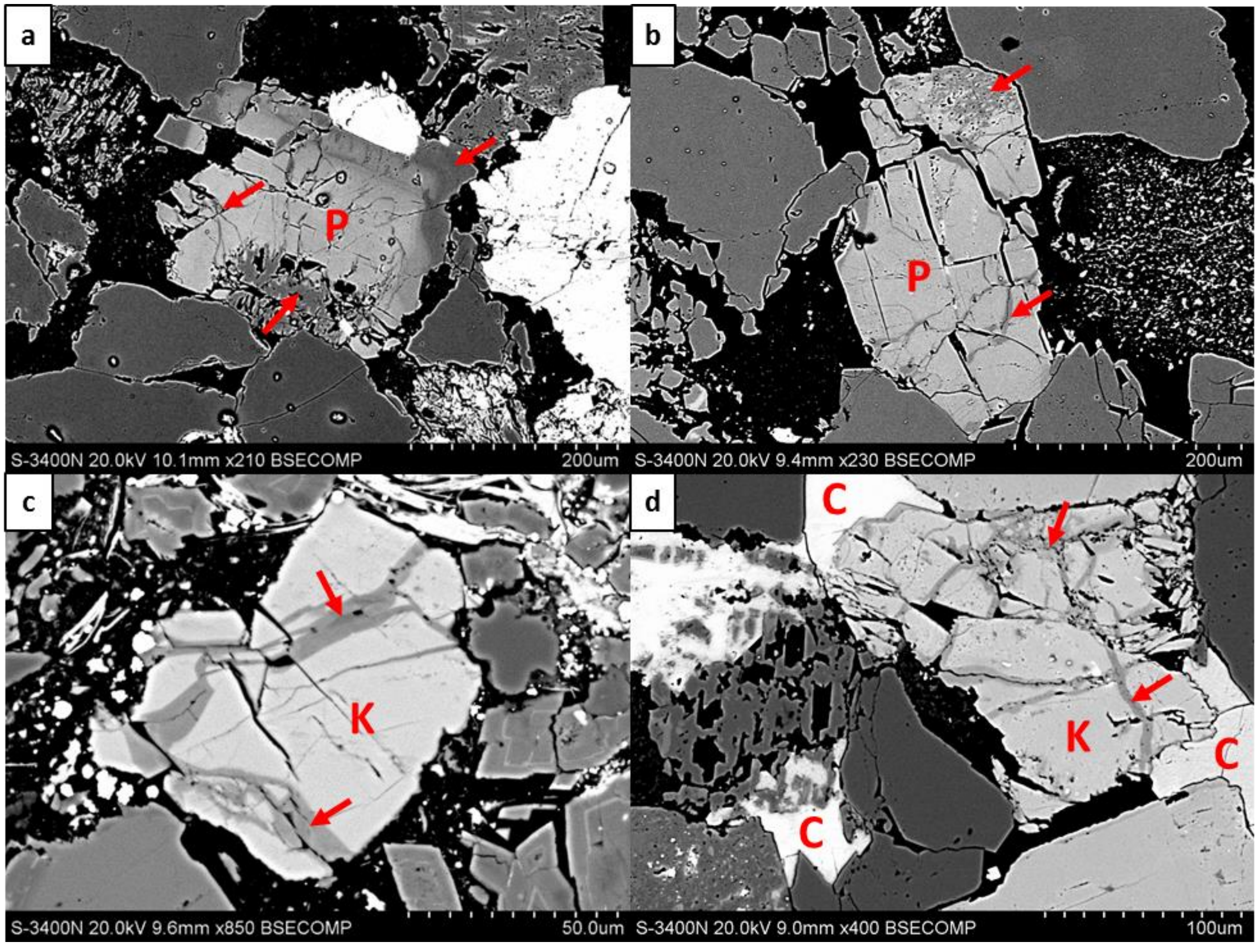


Figure 17. a) SEM-BSE image of plagioclase (P) that has been partially albitized (red arrows) along the grain-edge, in areas where dissolution occurred, and along fractures (2472m). b) SEM-BSE image of fractured and albitized (red arrows) plagioclase (P) grain (2621m). c) SEM-BSE image of albite (red arrows) that has replaced and healed fractures within K-feldspar (K) (2494m). d) SEM-BSE image of significantly fractured and albitized (red arrows) K-feldspar (K) surrounded by calcite (C).

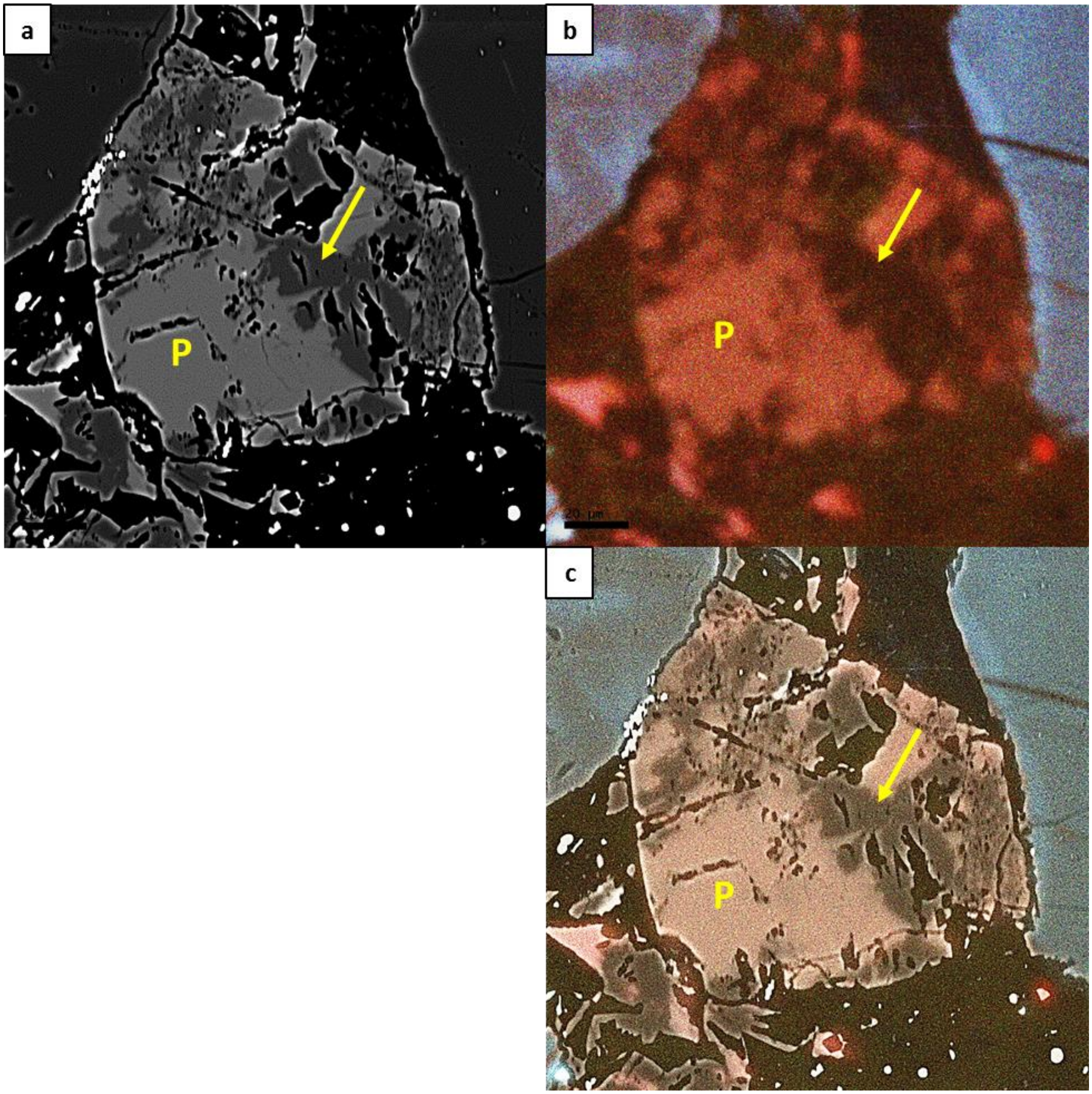


Figure 18. a) SEM-BSE image of partially albitized (yellow arrows) plagioclase (P). b) CL image of image ‘a’ c) SEM-BSE-CL composite image of image ‘a and b’ (2487m).

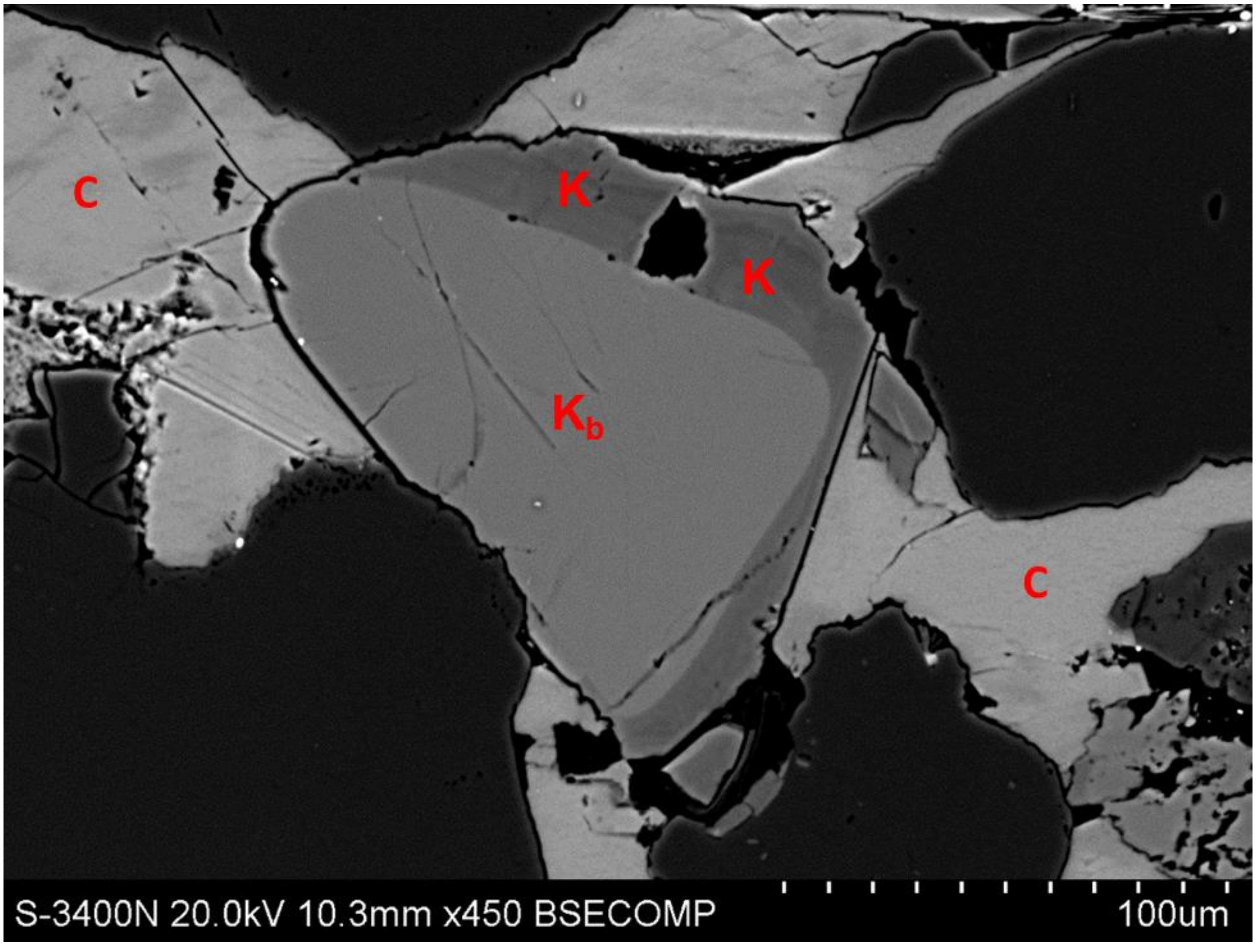


Figure 19. SEM-BSE images of detrital barium-rich K-feldspar (K_b) with barium-poor K-feldspar overgrowths (K) in a calcite cemented sandstone (2439m).

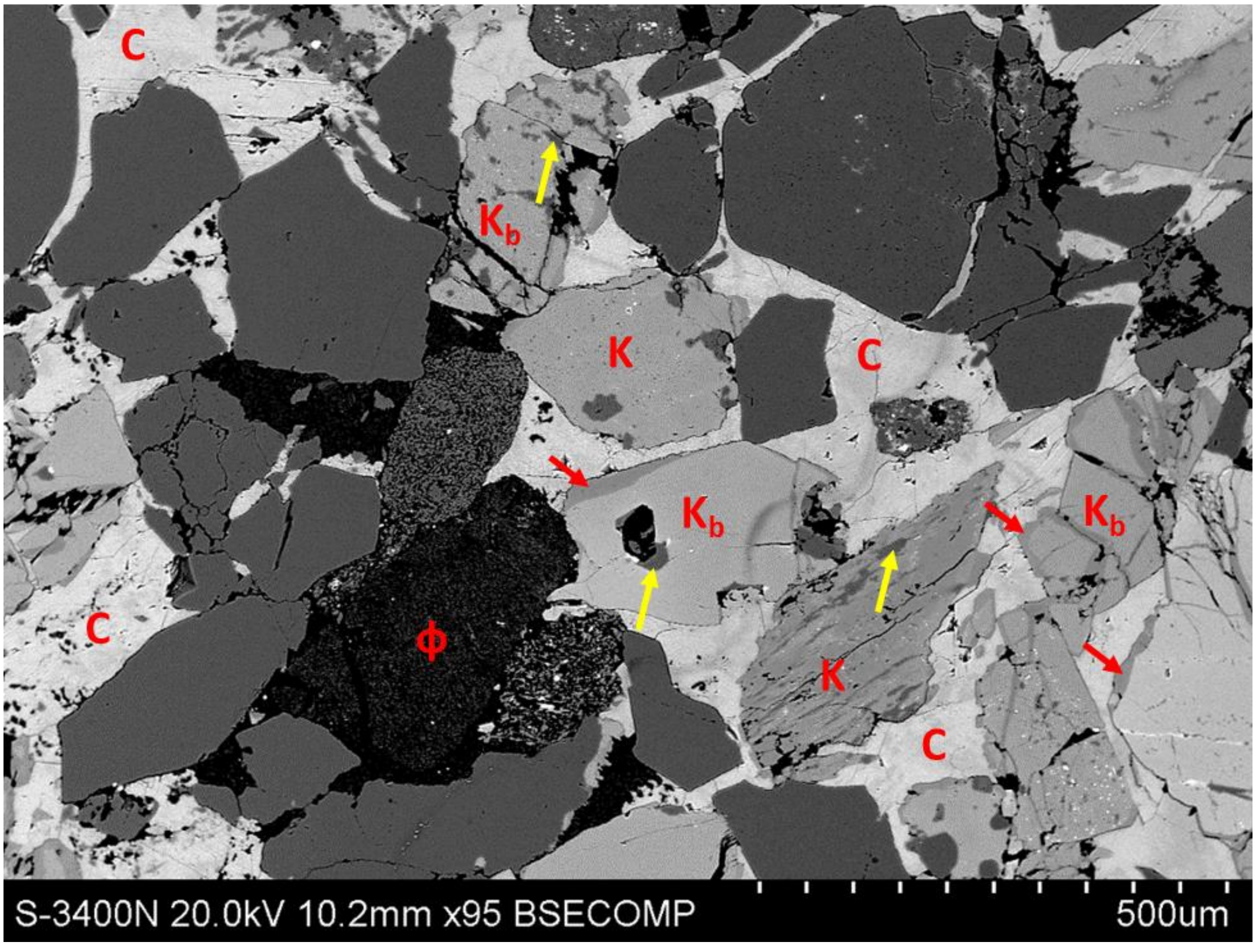


Figure 20. SEM-BSE image K-feldspar (K) and barium-rich K-feldspar (K_b) grains with authigenic K-feldspar (red arrows) and authigenic albite (yellow arrows) surrounded by calcite (C) (2439m).

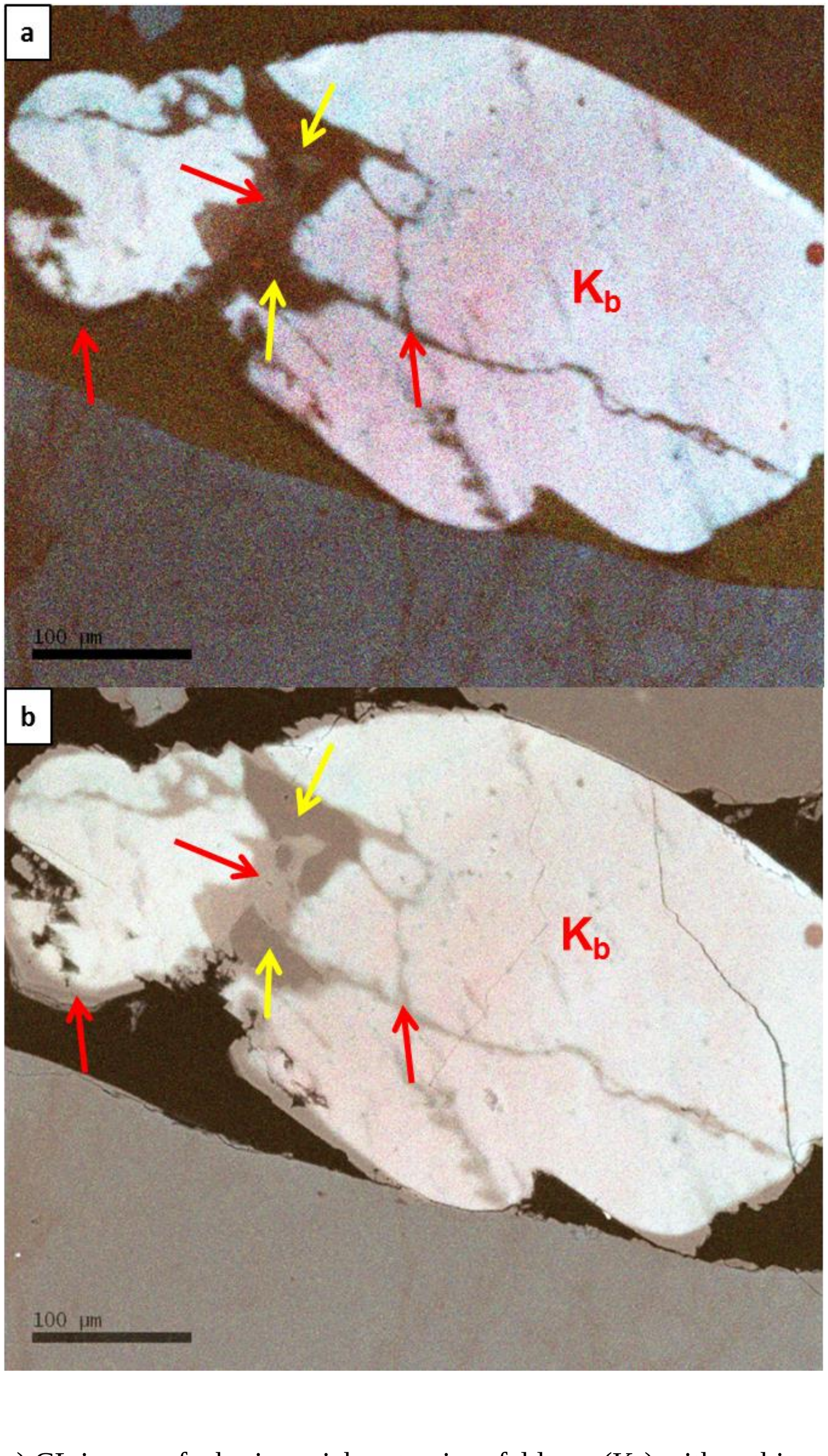


Figure 21. a) CL image of a barium-rich potassium feldspar (K_b) with authigenic K-feldspar overgrowths and healed fractures (red arrows), and authigenic quartz (yellow arrows). b) CL-SEM-BSE composite image of figure 'a' (2422m).

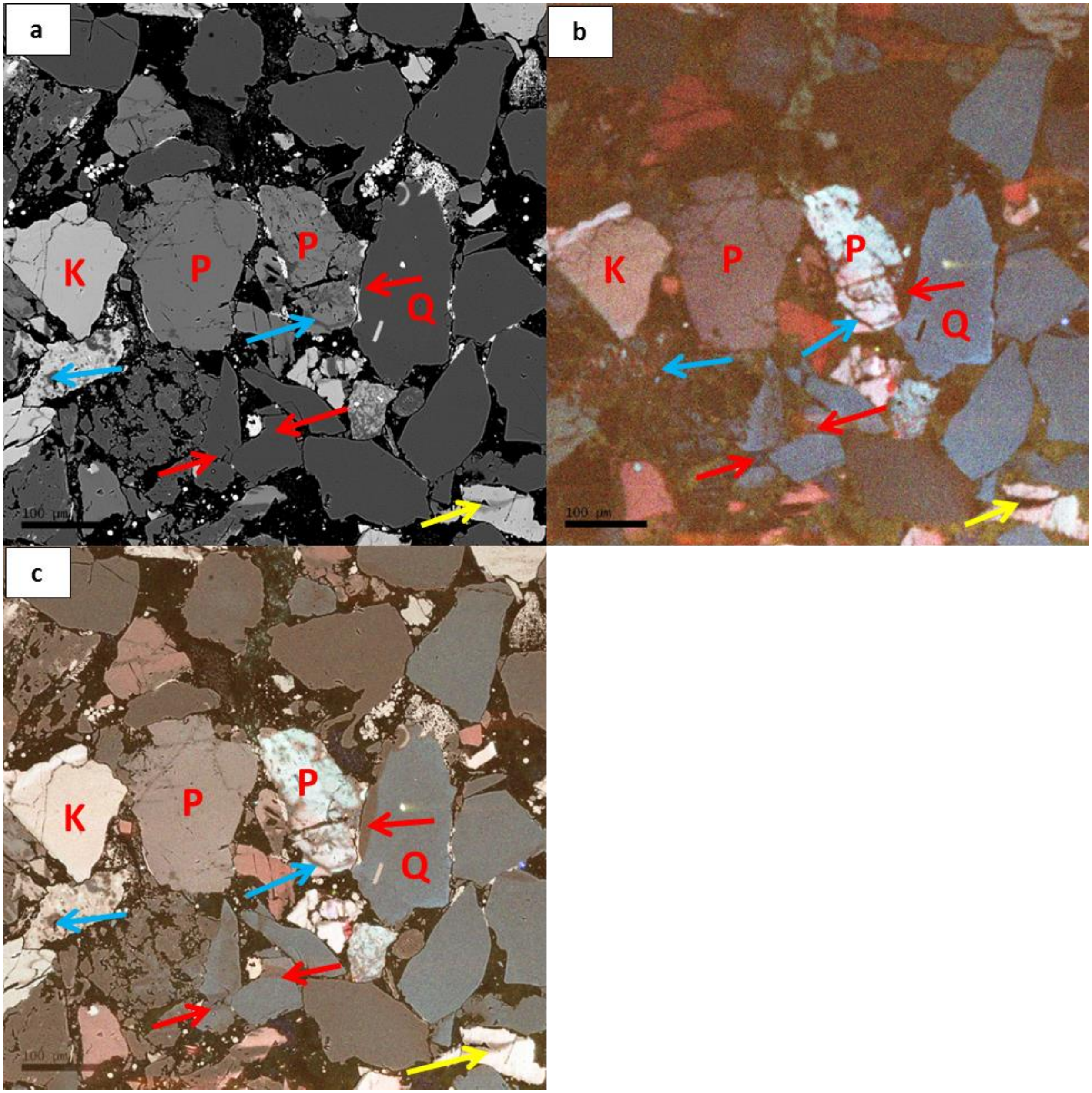


Figure 22. a) SEM-BSE image, b) CL image, and c) SEM-BSE and CL composite image of the same sample of various detrital grains with authigenic overgrowths and healed fractures. K-Feldspar (K), plagioclase (P), and quartz (Q), authigenic quartz (red arrows), authigenic K-feldspar (yellow arrows), and authigenic albite (blue arrows) (2510m).

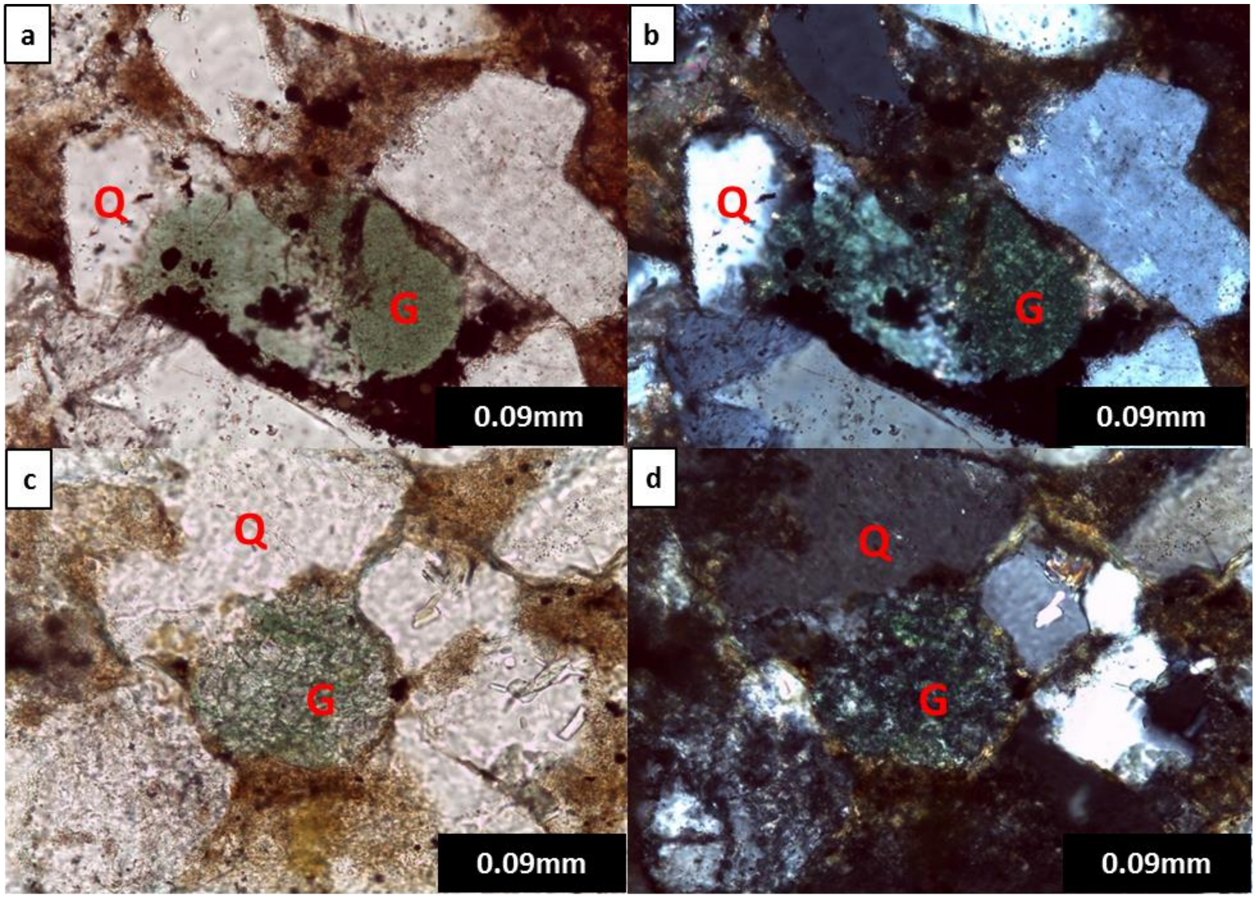


Figure 23. a and c) Plane-polarized and b and d) cross-polarized light photomicrographs of quartz (Q) replaced by glauconite (G) (3030m and 3033m).

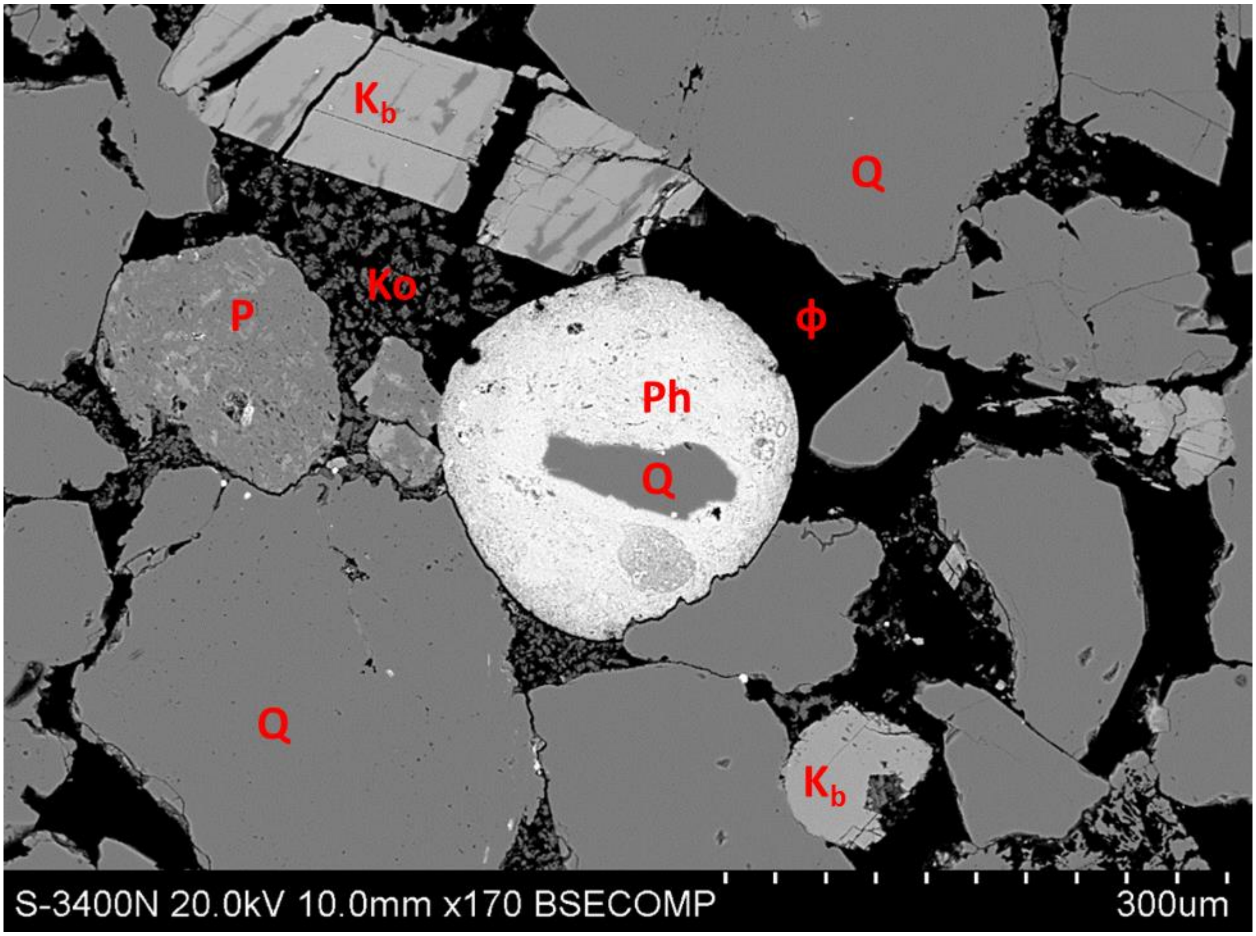


Figure 24. SEM-BSE image of phosphate peloid (Ph) that nucleated on detrital quartz (Q). Kaolinite (Ko) filled some pore-space (ϕ). Plagioclase (P), and barium-rich K-feldspar (K_b) also present (2438').

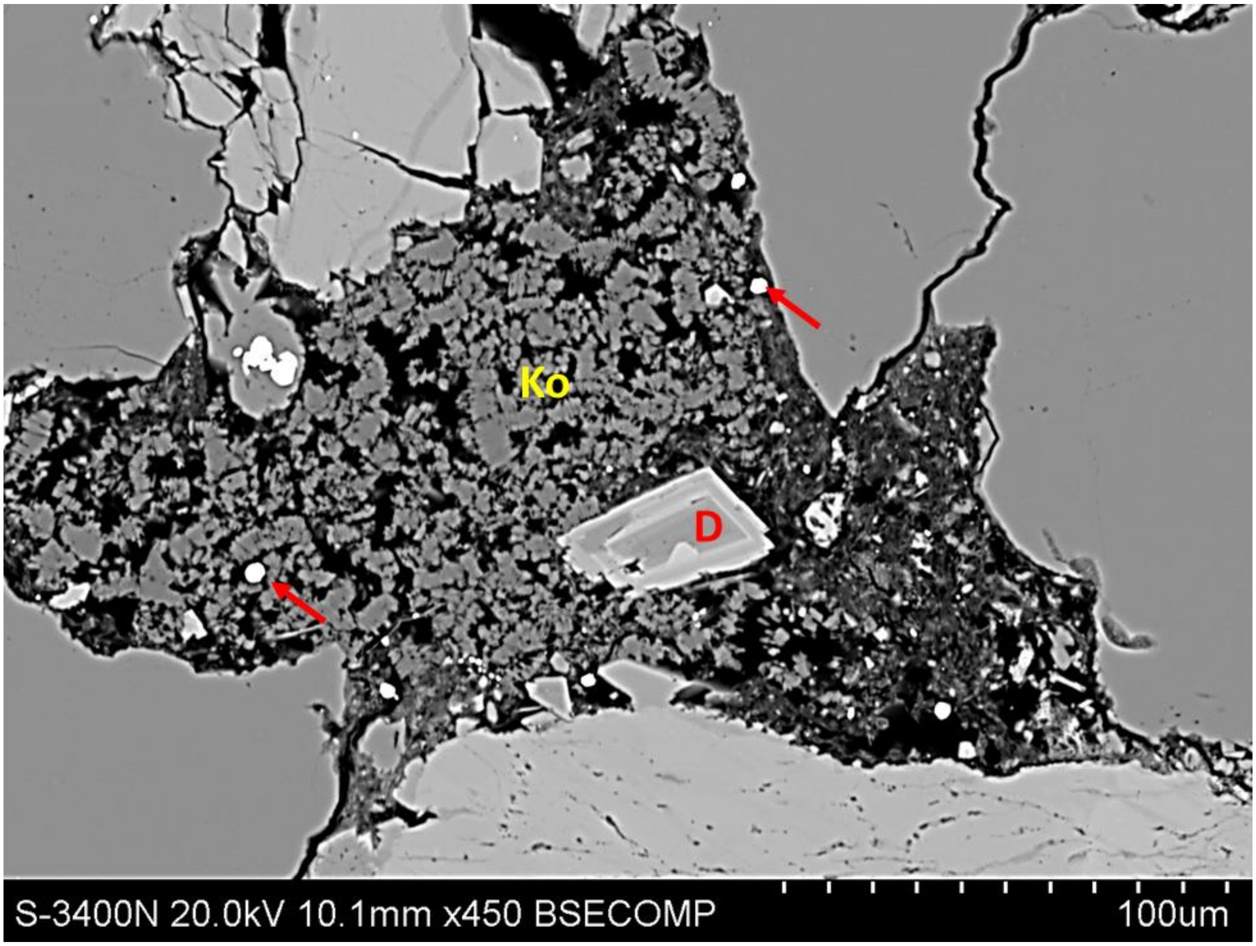


Figure 25. SEM-BSE image of dolomite/ankerite (D) surrounded by kaolinite (Ko) cement. Authigenic framboidal pyrite is also present (red arrows) (2439m).

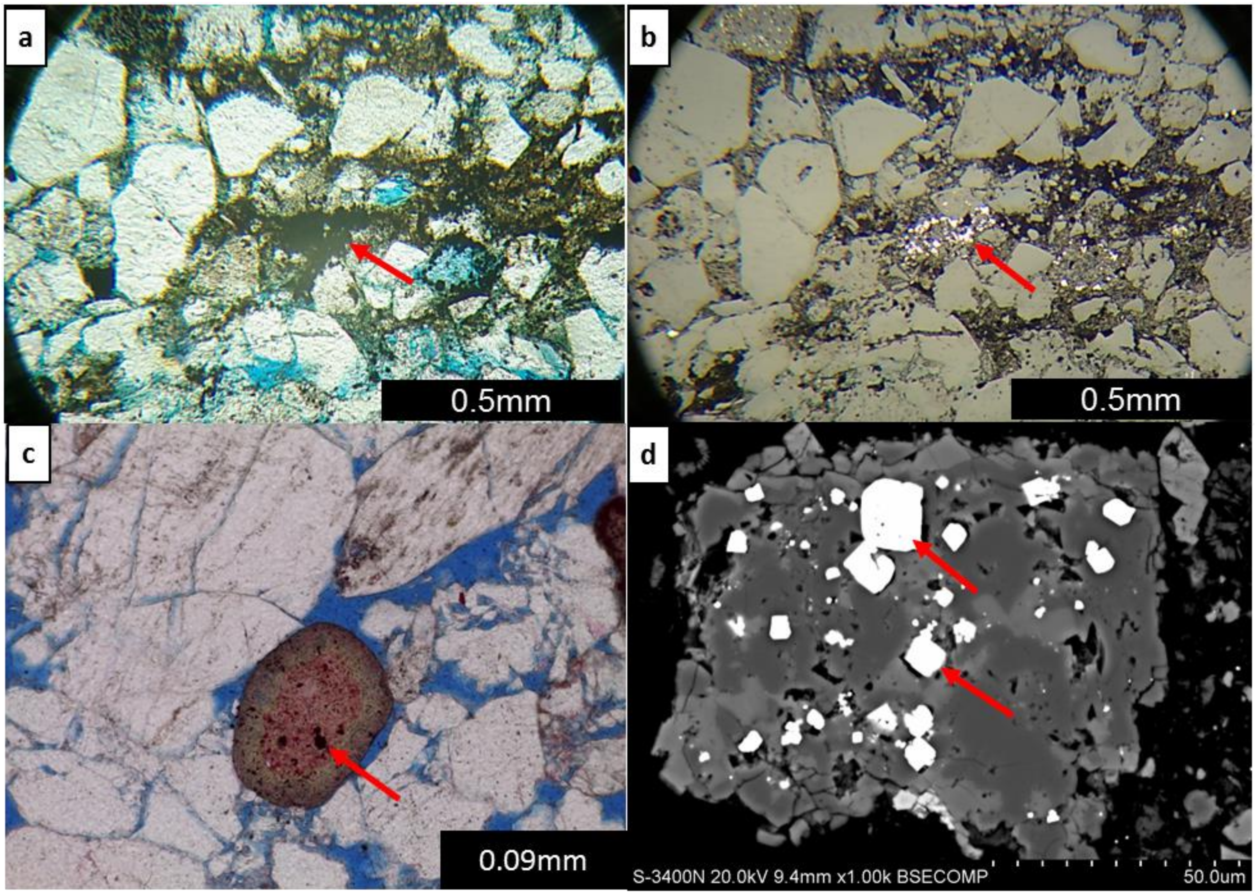


Figure 26. a) plane-light and b) reflected-light photomicrographs of hydrocarbon (red arrows) and pyrite within a secondary pore-space (3035m). c) Plane-light photomicrograph of pyrite (red arrow) in a secondary pore-space within phosphate (2405m) d) SEM-BSE image of pyrite (red arrows) within a secondary dissolution pore-space in a detrital microphanerite grain (2429m).

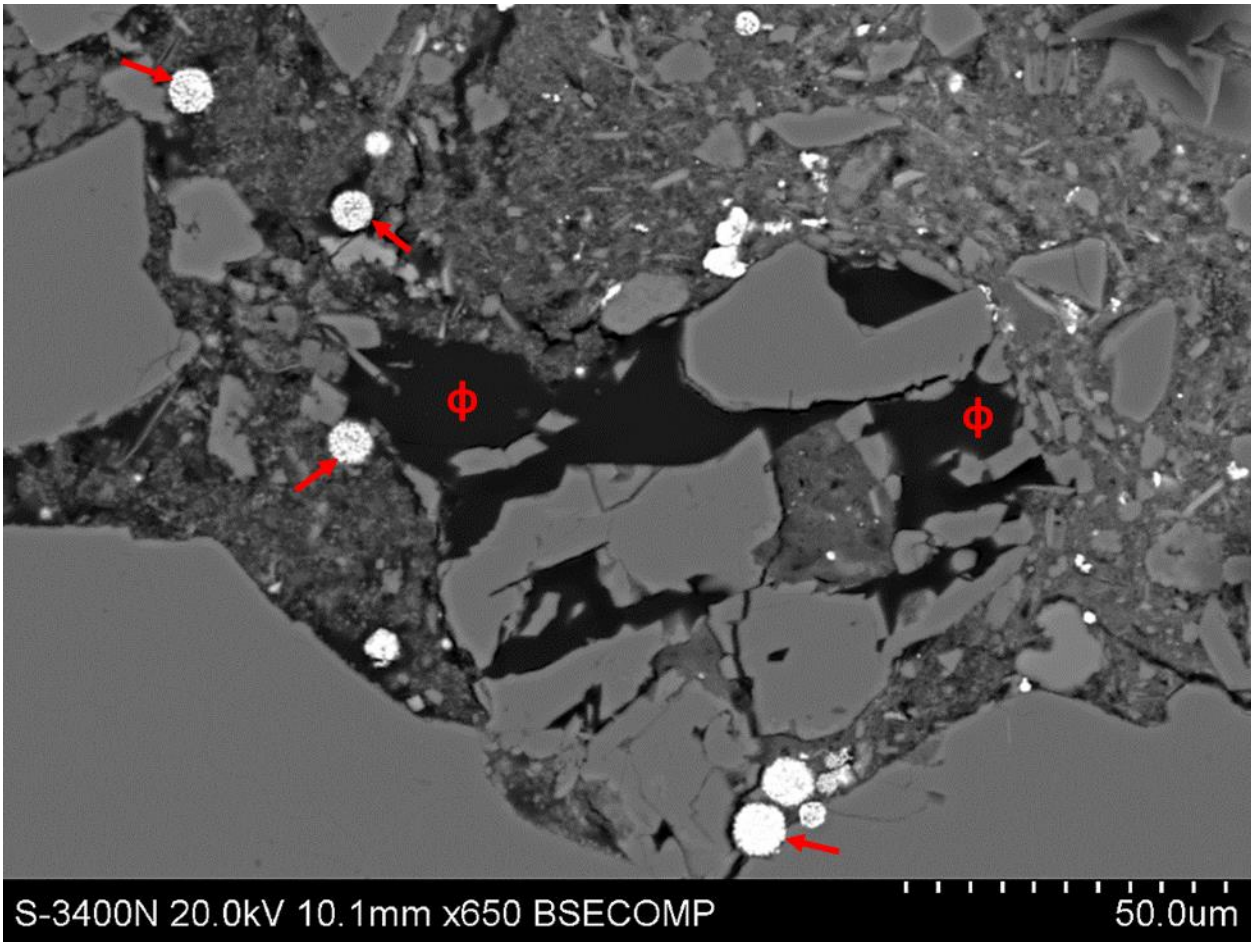


Figure 27. SEM-BSE image of framboidal pyrite (red arrows) within pseudomatrix and porosity (ϕ) (2510m).

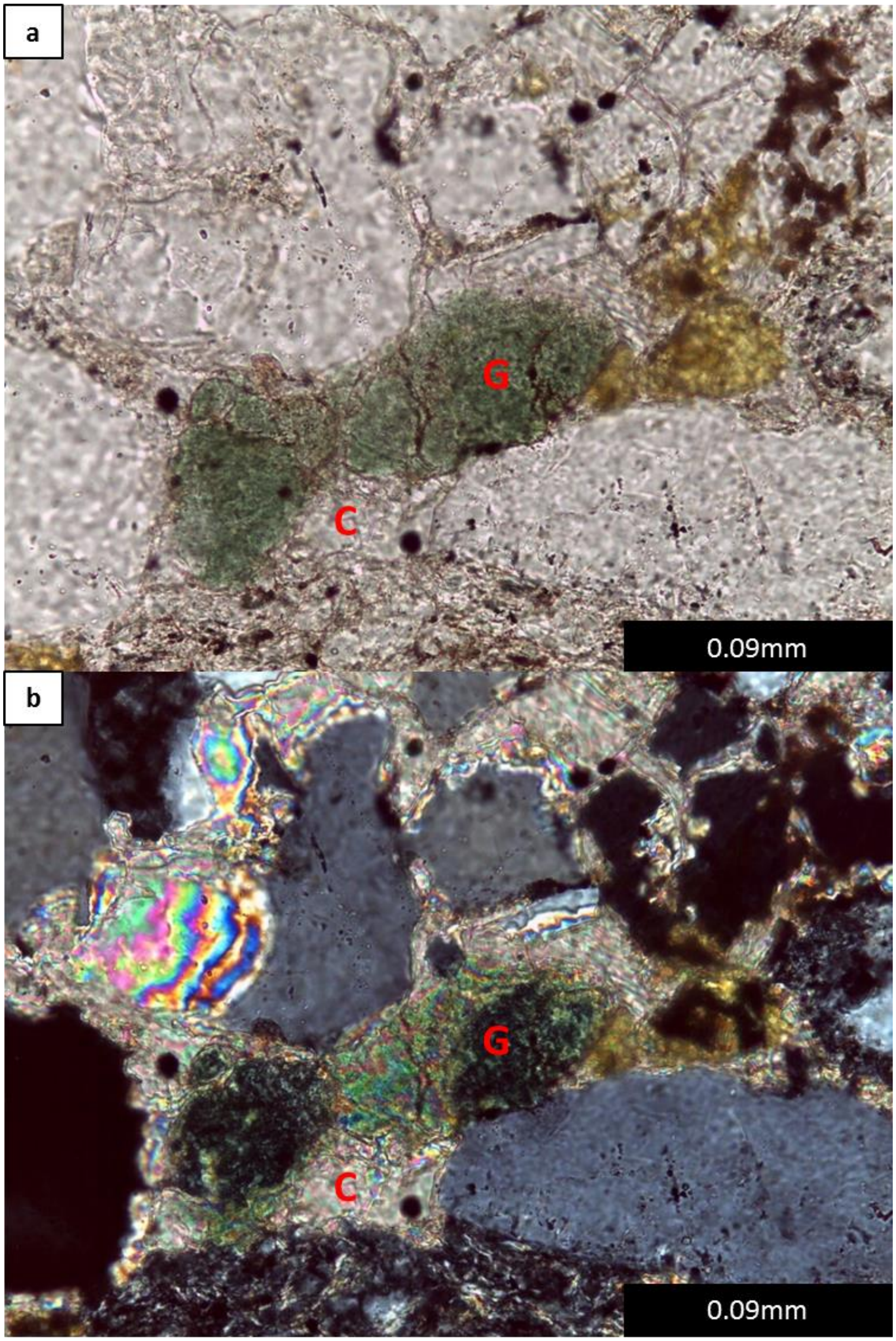


Figure 28. a) Plane-polarized and b) cross-polarized light photomicrographs of glauconite (G) that's been partially replaced by calcite (C) (3030m).

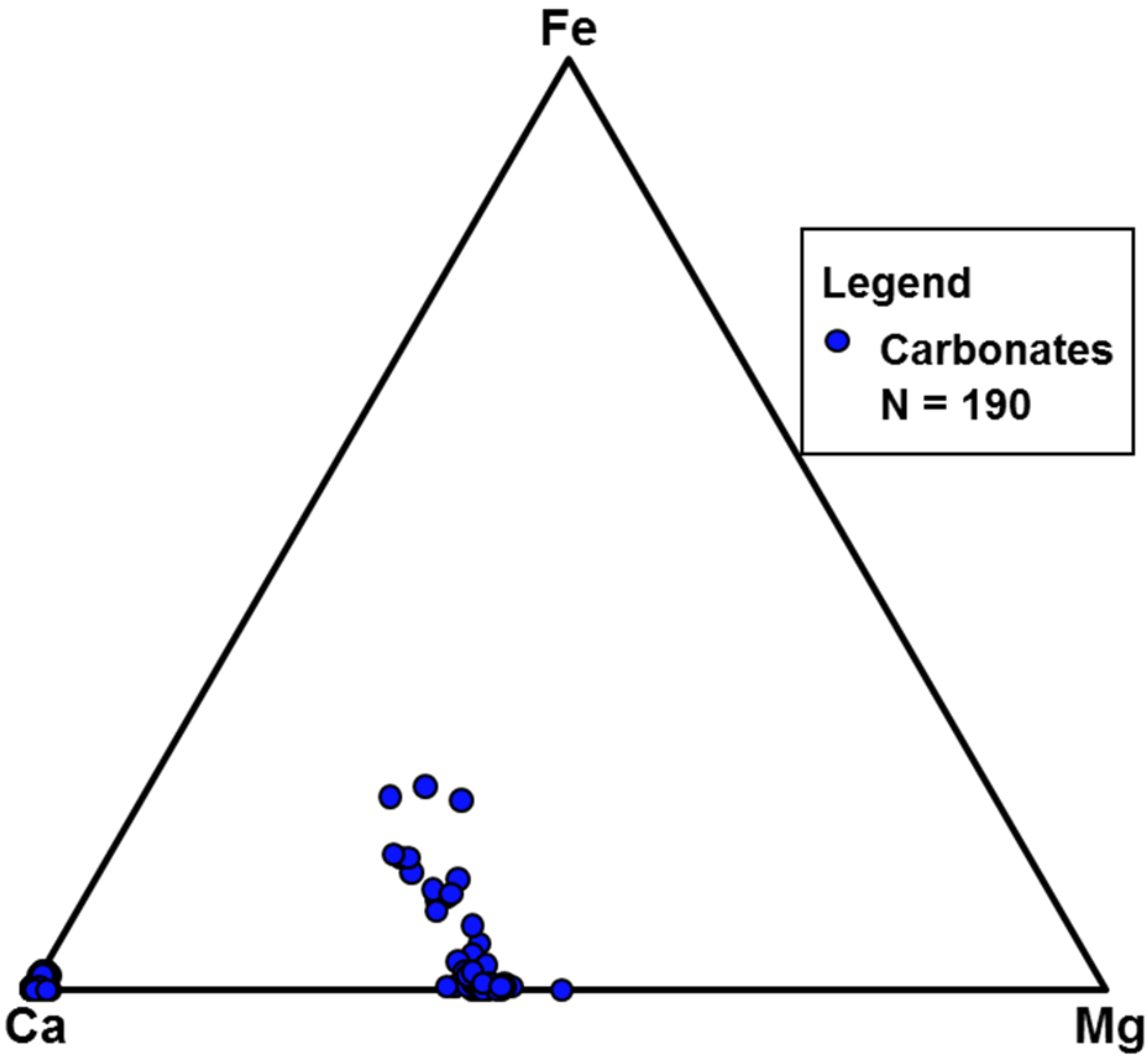


Figure 29. Ternary diagram showing carbonate compositions. End member compositions $CaCO_3$, $CaMg(CO_3)_2$, and $FeCO_3$ are shown as Mg, Ca, and Fe respectively.

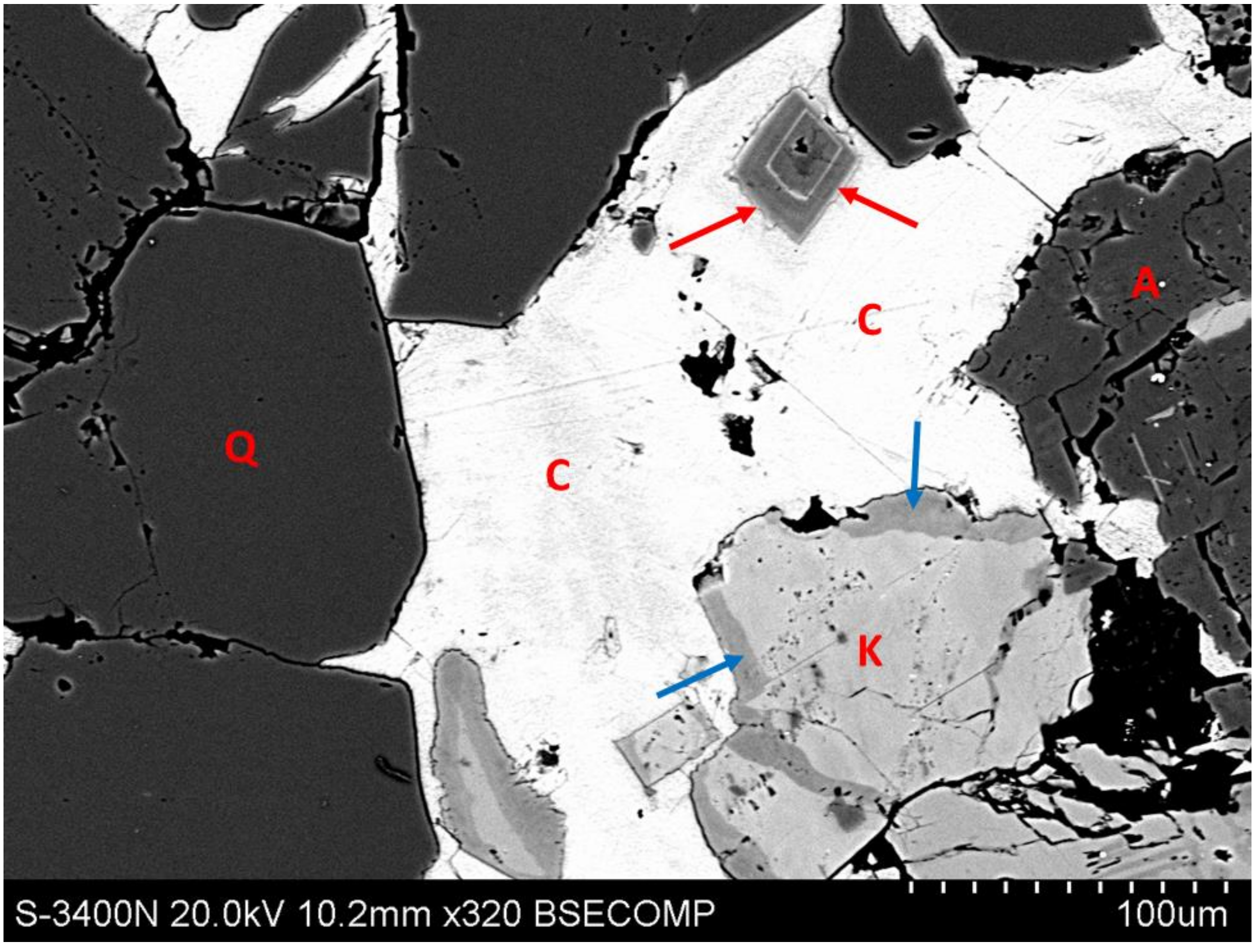


Figure 30. SEM-BSE image of dolomite (red arrows) surrounded by calcite (C). Calcite surrounds K-feldspar overgrowths (blue arrows) on K-feldspar (K). Quartz (Q) and albite (A) are also present (2439m).

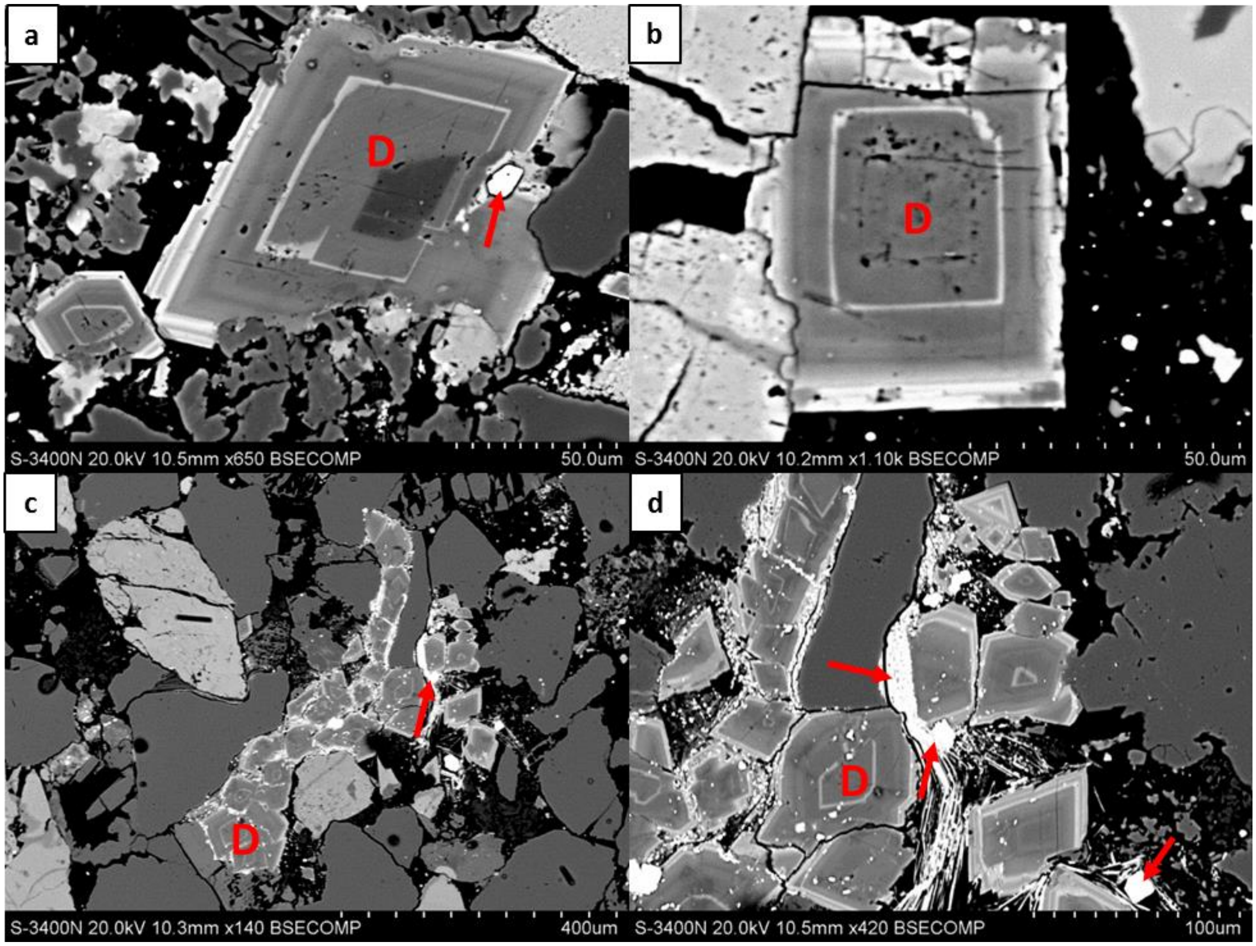


Figure 31. a and b) SEM-BSE images showing euhedral dolomite/ankerite (D) with iron-rich zoning (2447m) and (2439m). c and d) SEM-BSE images showing clusters of dolomite/ankerite (D) next to biotite that has been partially altered to pyrite (red arrows) (2447m).

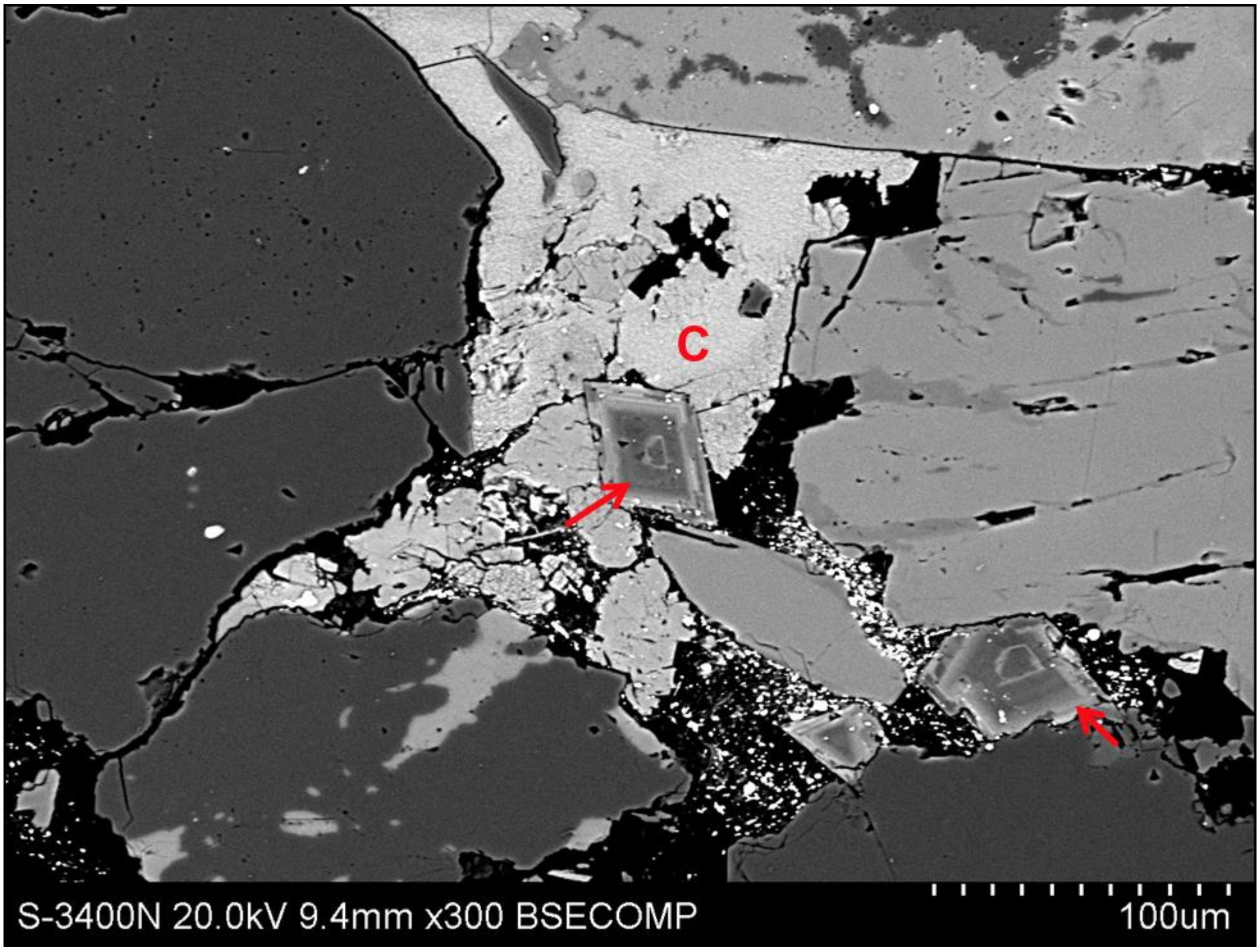


Figure 32. SEM-BSE image showing zoned dolomite/ankerite (red arrows) and calcite (C).

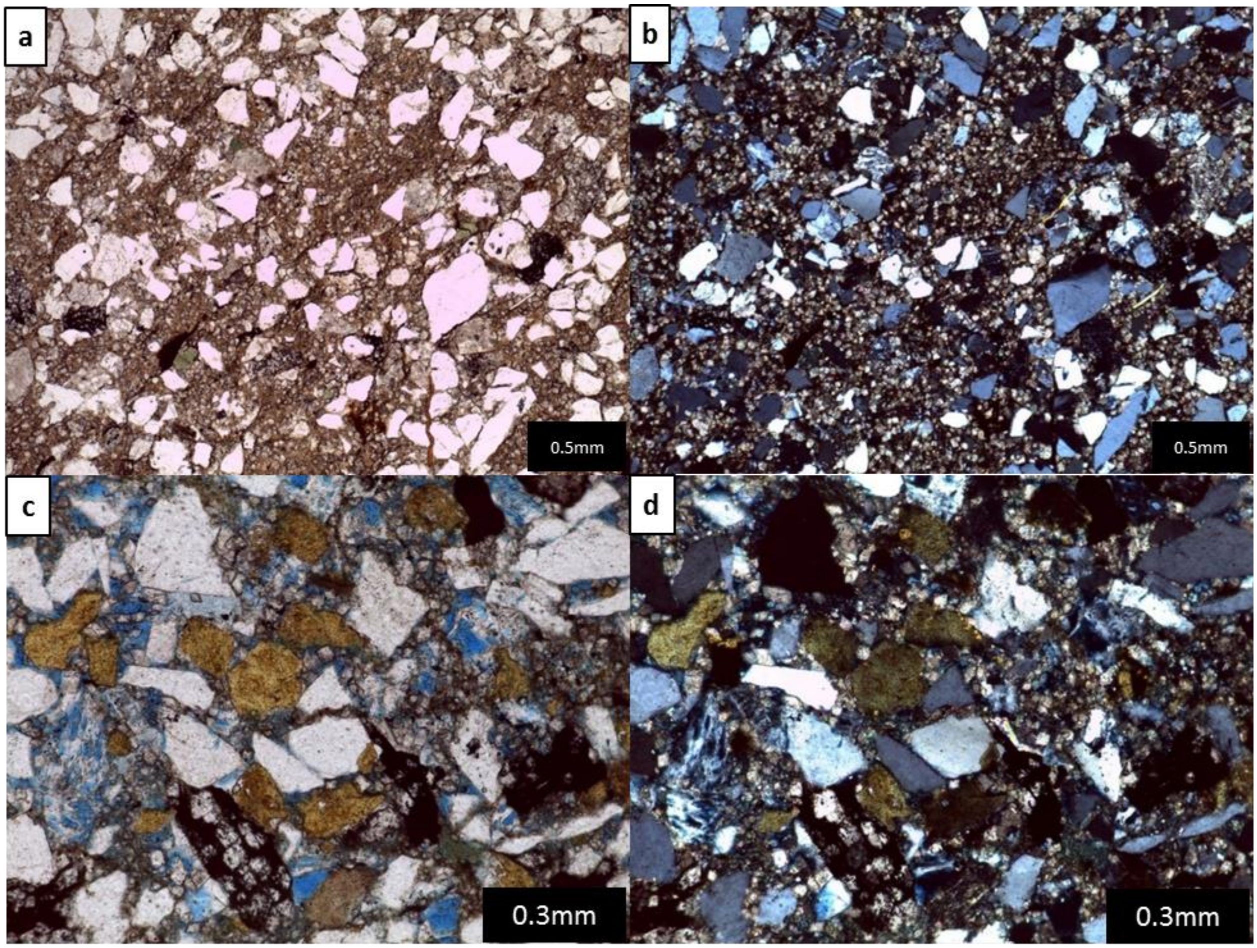


Figure 33. a) Plane-polarized and b) cross-polarized light photomicrographs of an arkosic wacke with significant amounts of dolomite cement (3029m). c) Plane-polarized and d) cross-polarized light photomicrographs of dolomite within pseudomatrix (2471m).

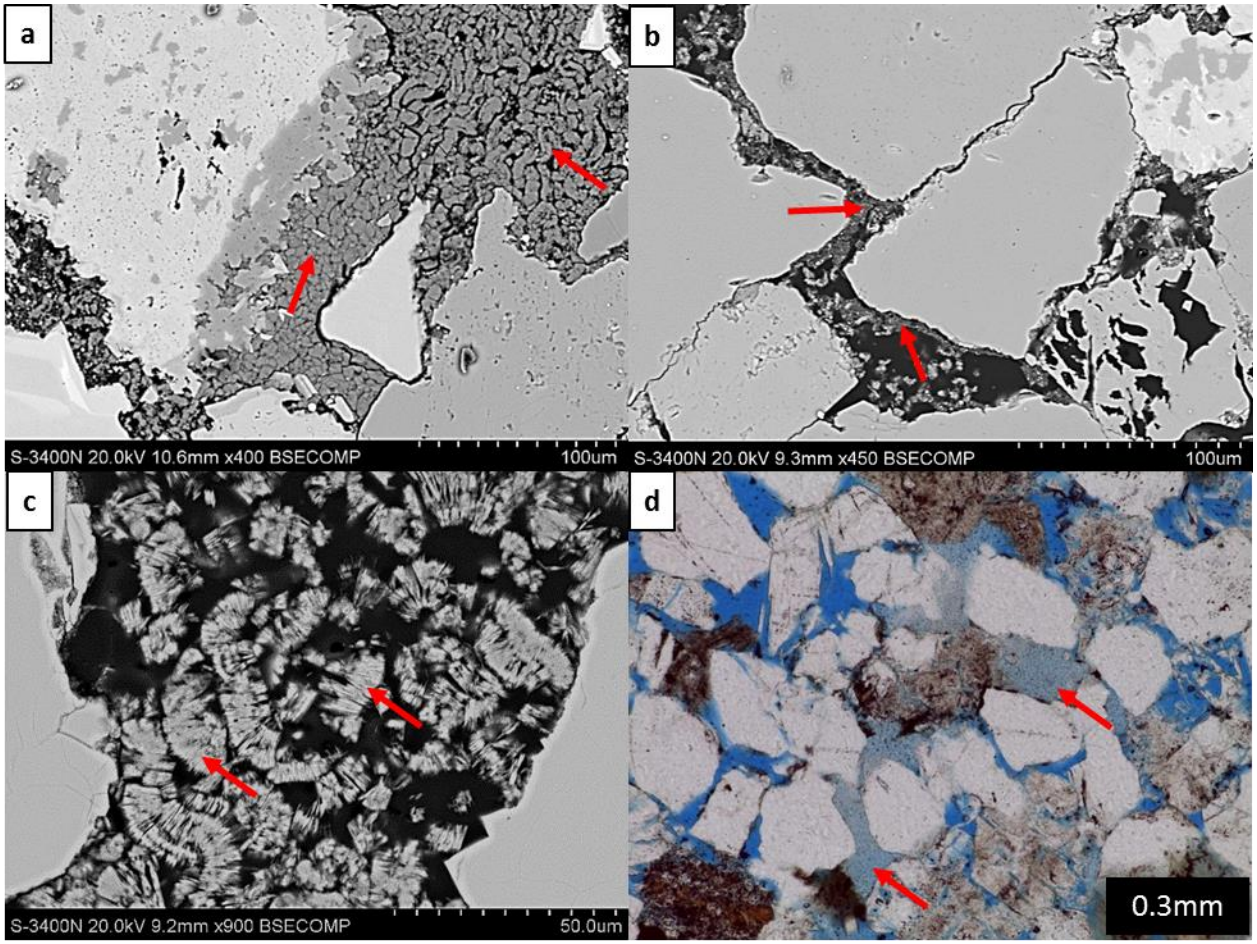


Figure 34. a) SEM- BSE image of pore-filling kaolinite cement (red arrows) associated with partially dissolved K-feldspar (2447m). b) SEM-BSE image of pore-filling kaolinite cement and coatings (red arrows) between detrital framework grains (2431m). c) SEM-BSE image of pore-filling vermicular kaolinite booklets (red arrows) (2422m). d) Plane-polarized light photomicrograph of pore-filling kaolinite cement (red arrows) filling over-sized pore spaces (2468m).

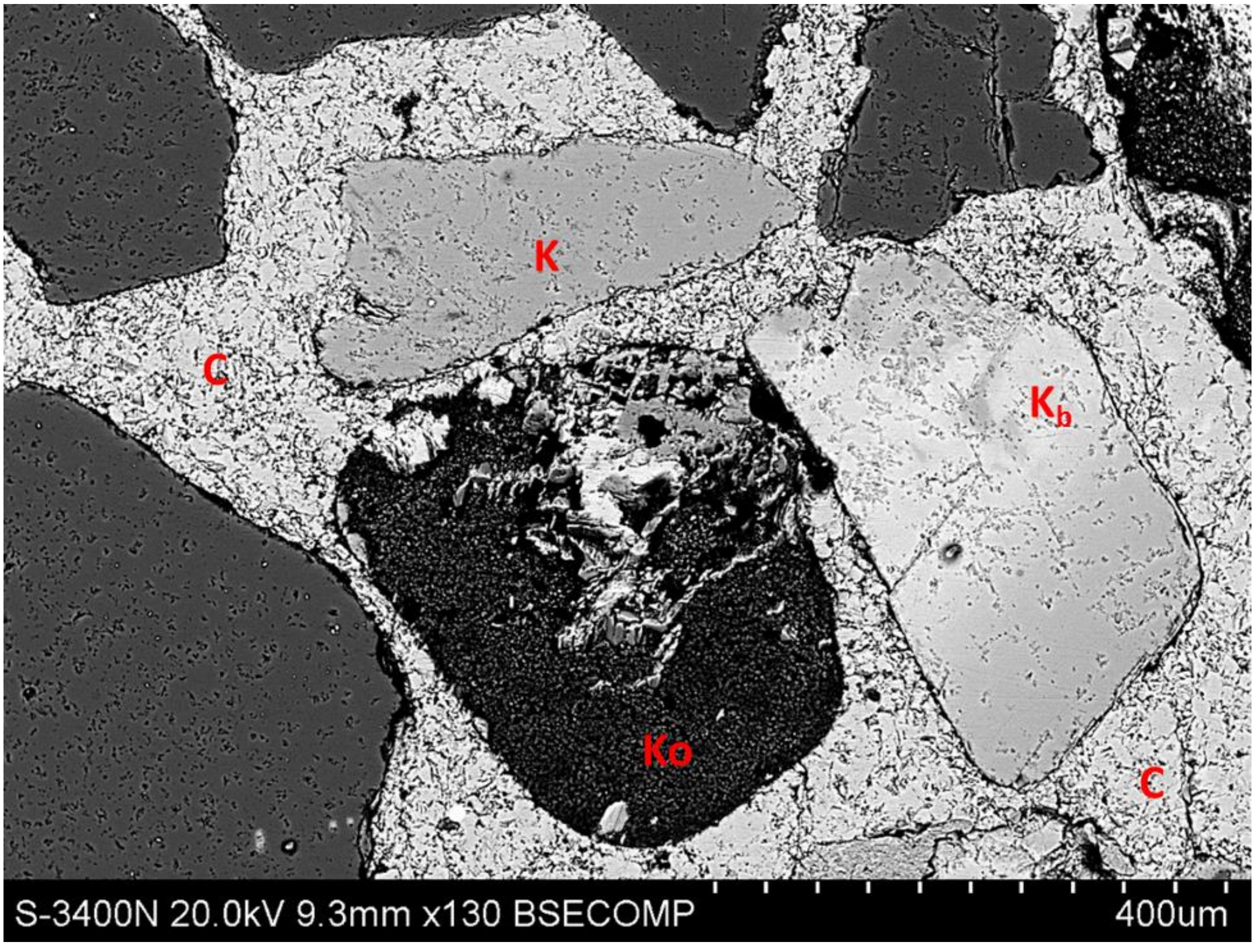


Figure 35. SEM-BSE image of poikilotopic-calcite-cemented (C) sandstone surrounding a dissolution pore-space filled with kaolinite (Ko). K-feldspar (K) and barium-rich K-feldspar (K_b) occur as floating grains.

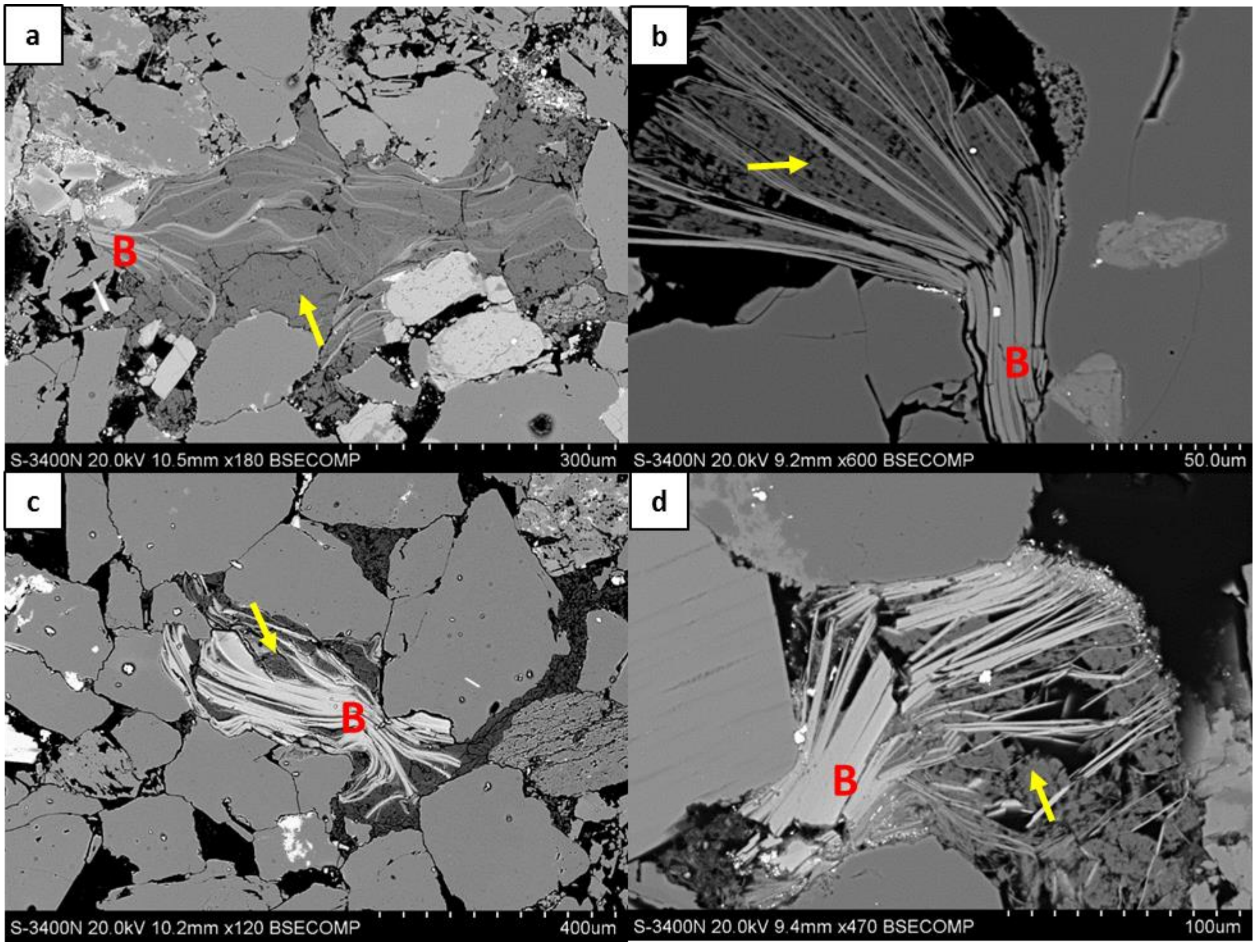


Figure 36. SEM-BSE images of pore-filling kaolinite cement (yellow arrow) between altered sheets of biotite (B). a) 2447m, b) 2422m, c) 2472m, d) 2429m.

Figure 37. Plane-light photomicrograph of hydrocarbon (red arrows) within several secondary pore-spaces in sandstone containing abundant pseudomatrix (3043m).

Figure 38. a) Contact indices and b) tight-packing indices plotted versus depth of all point-counted samples. Following the methodologies of Wilson and McBride (1988).

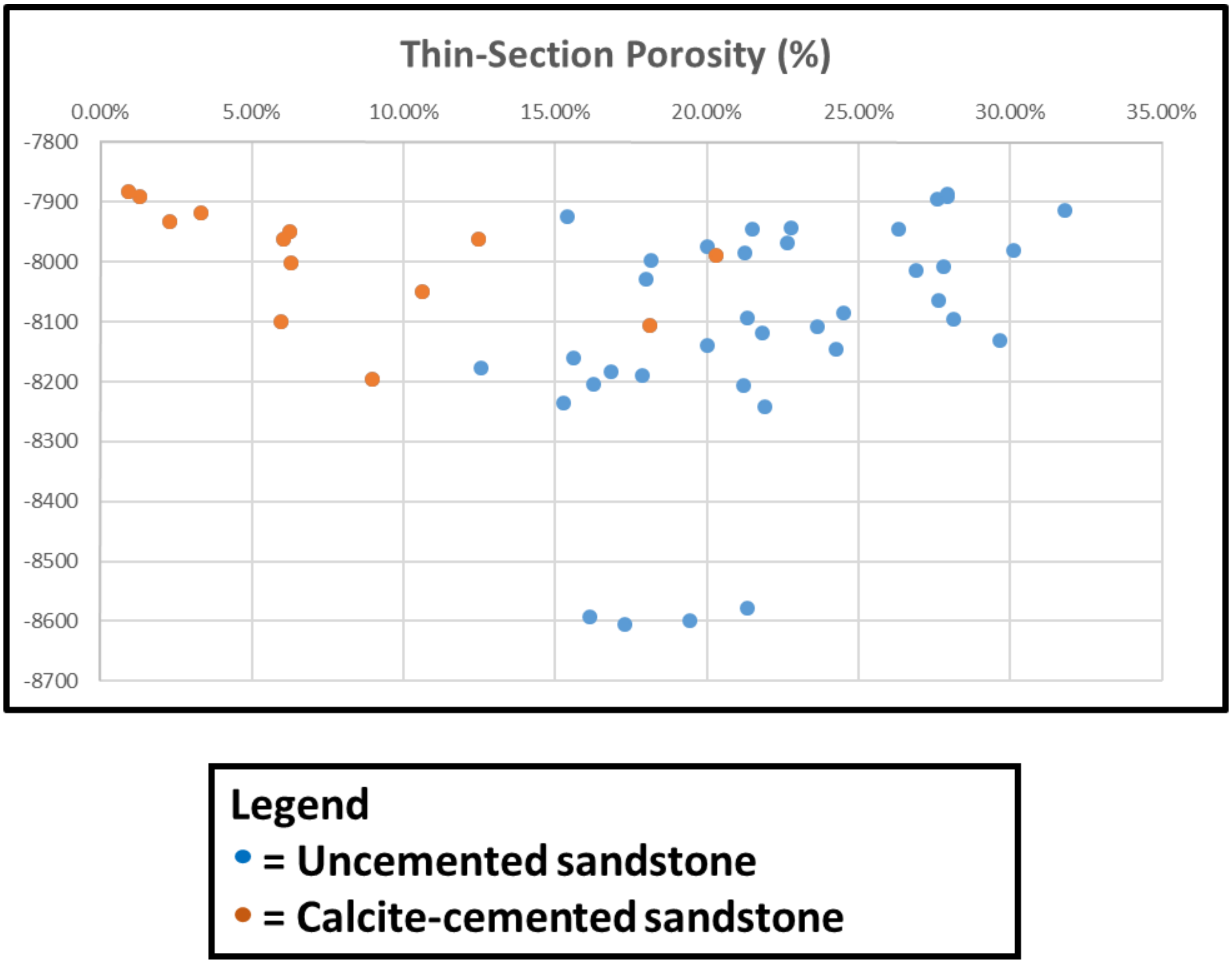


Figure 39. Porosity of all samples from McKittrick Fee 516-8 plotted with depth. Blue dots represent uncemented sandstone and red dots represent calcite-cemented sandstones.

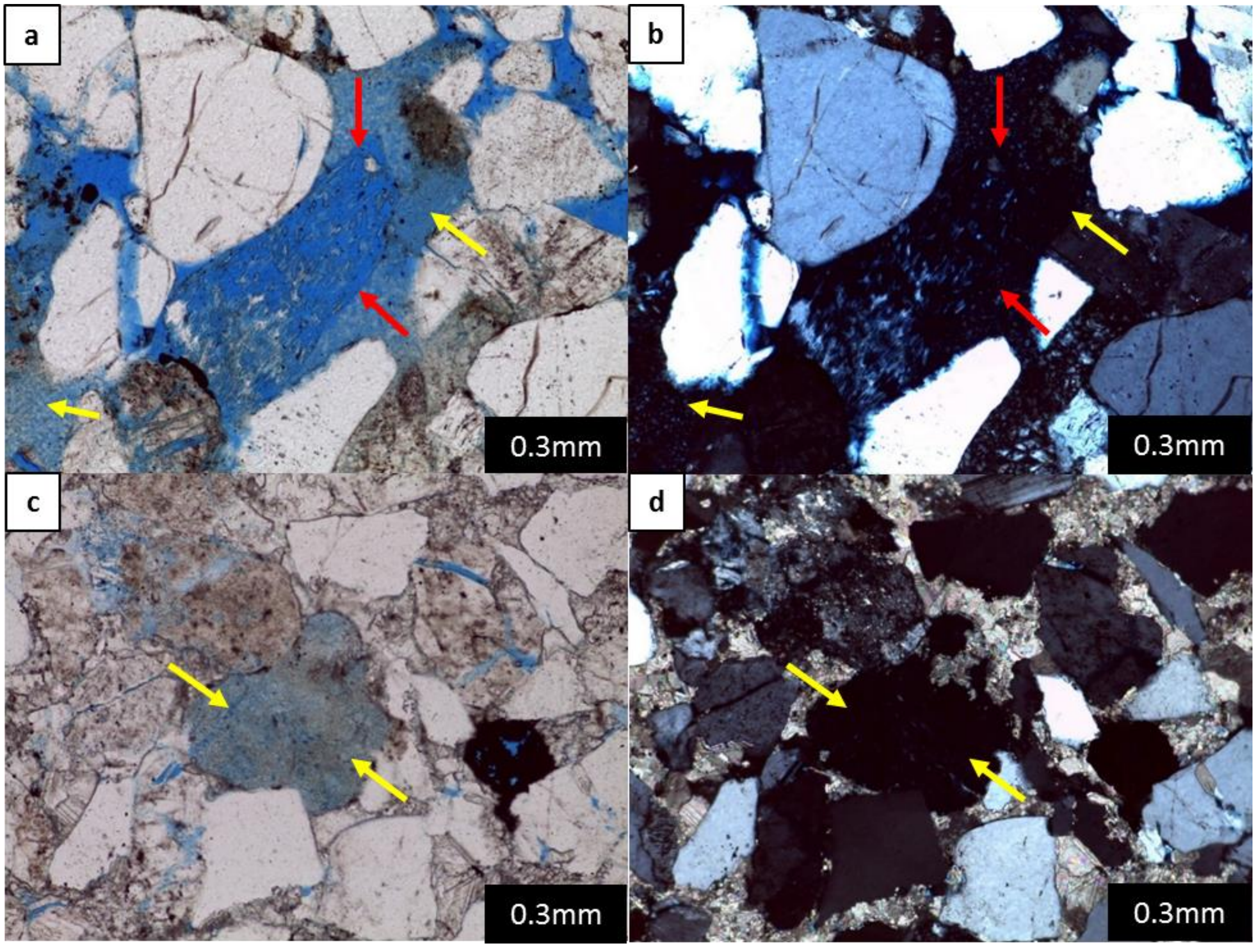


Figure 40. a) Plane-polarized and b) cross-polarized light photomicrographs of skeletal feldspar fragments (red arrows) surrounded by kaolinite cement (yellow arrows) (2621m). c) Plane-polarized d) and cross-polarized light photomicrographs of a secondary pore-space filled with kaolinite cement (yellow arrows) (2418m).

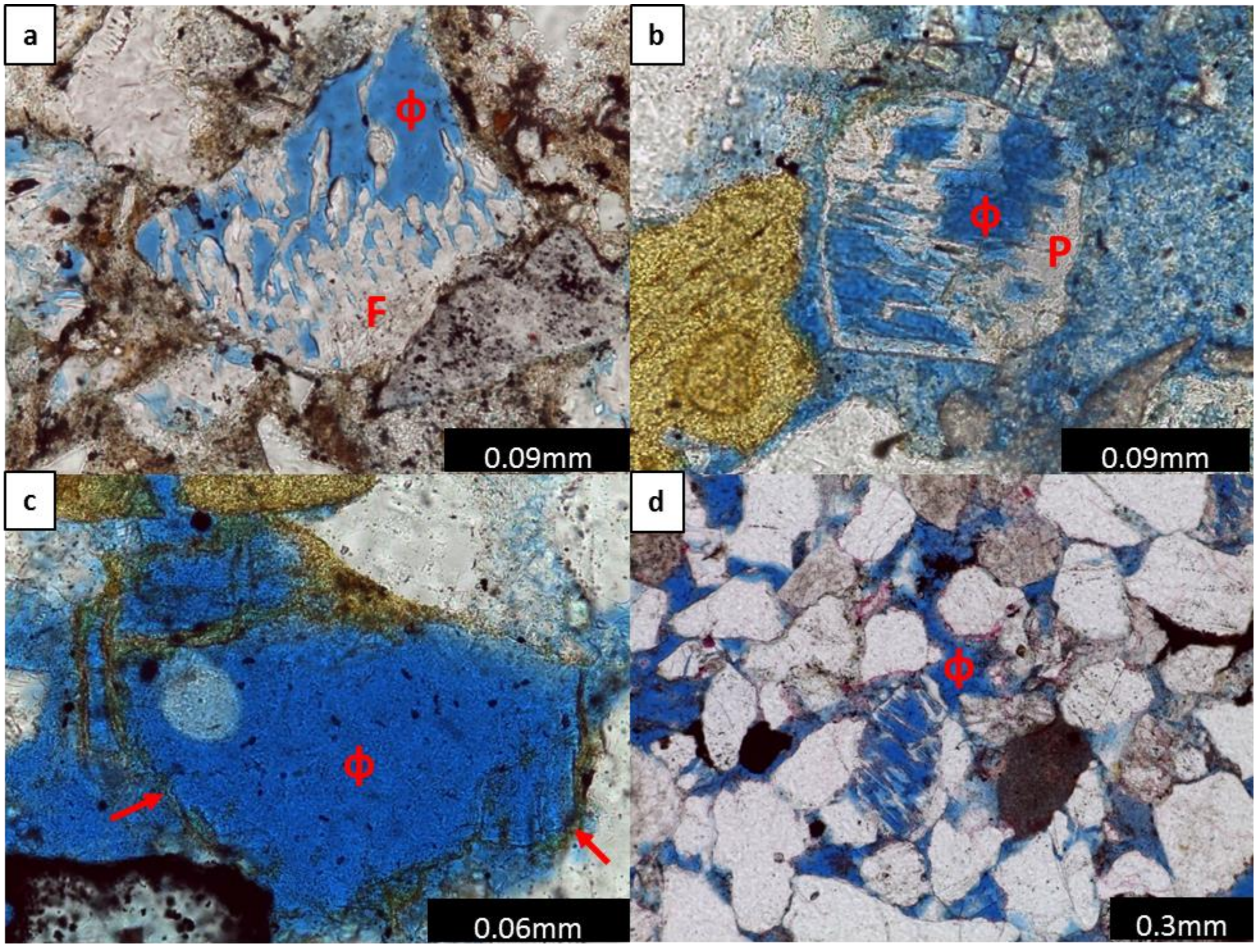


Figure 41. a) Plane-polarized light photomicrograph of dissolution of a feldspar (F) along cleavage planes after clay cementation (2501m). b) Plane-polarized light photomicrograph of intragranular pore-space (ϕ) due to plagioclase (P) dissolution (2441m). c) Plane-polarized light photomicrograph of remnant clay rims (red arrows) in an oversized pore-space (ϕ) (2464m). d) Plane-polarized light photomicrograph of feldspar fragments within an oversized pore-space (ϕ) (2434m).

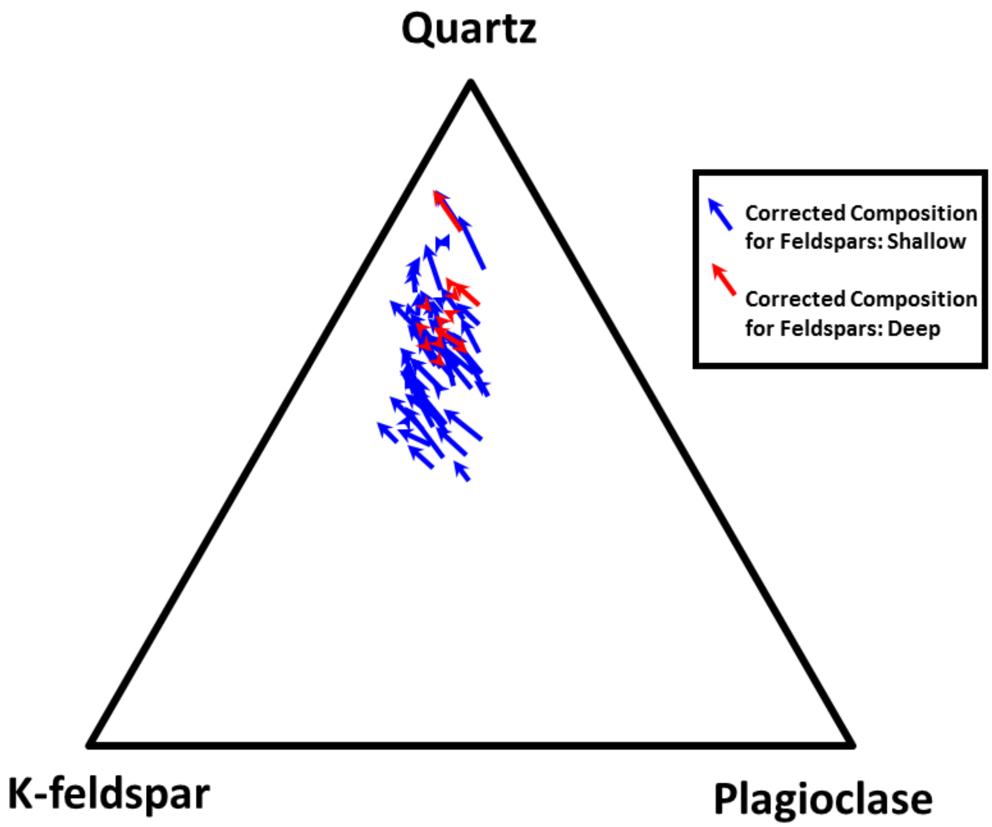
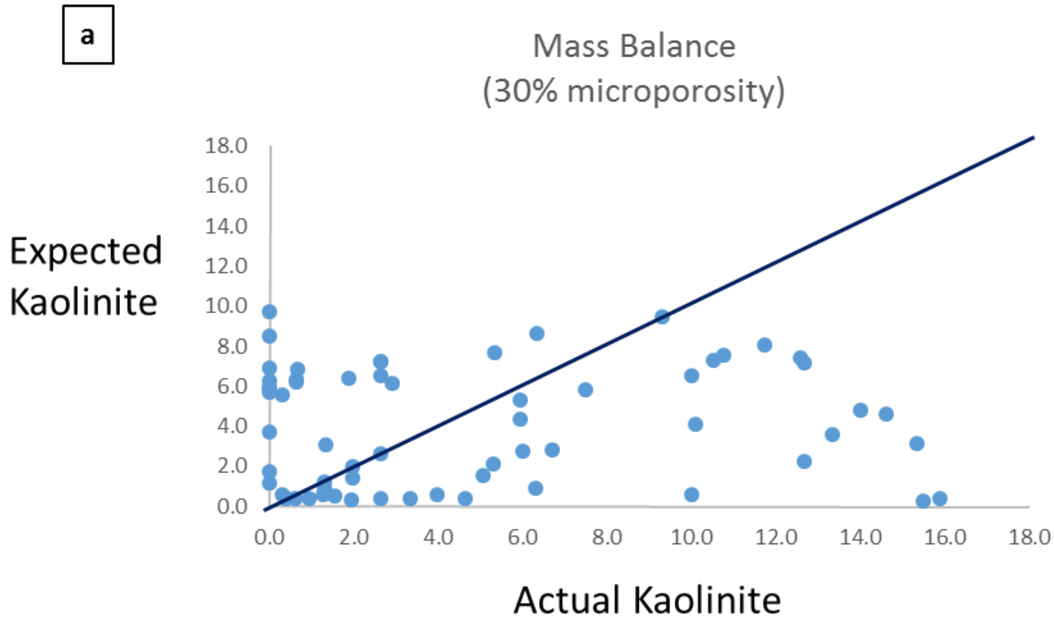


Figure 42. Ternary diagram of quartz, K-feldspar, and plagioclase adjusted for grain dissolution. The arrowhead is the current composition and the arrow tail is the composition corrected for dissolution where the minerals could be identified. Blue arrows represent samples from well McKittrick Fee 516-8 and red arrows represent more deeply buried samples from well Circle Oil SP 32X-21.



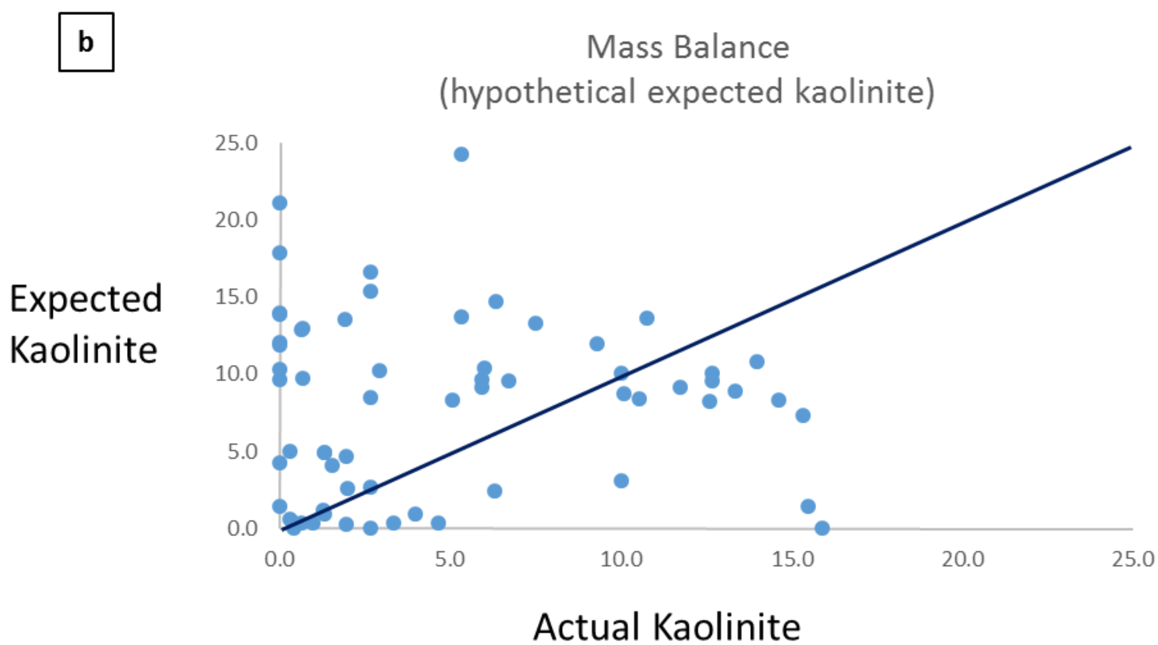


Figure 43. Expected kaolinite plotted versus actual kaolinite. Points plotted above the line indicate Al^{3+} export, those plotted below the line Al^{3+} import. a) Calculated using only secondary porosity for which the dissolved mineral could be identified. b) Calculated using all secondary porosity (see text for details).

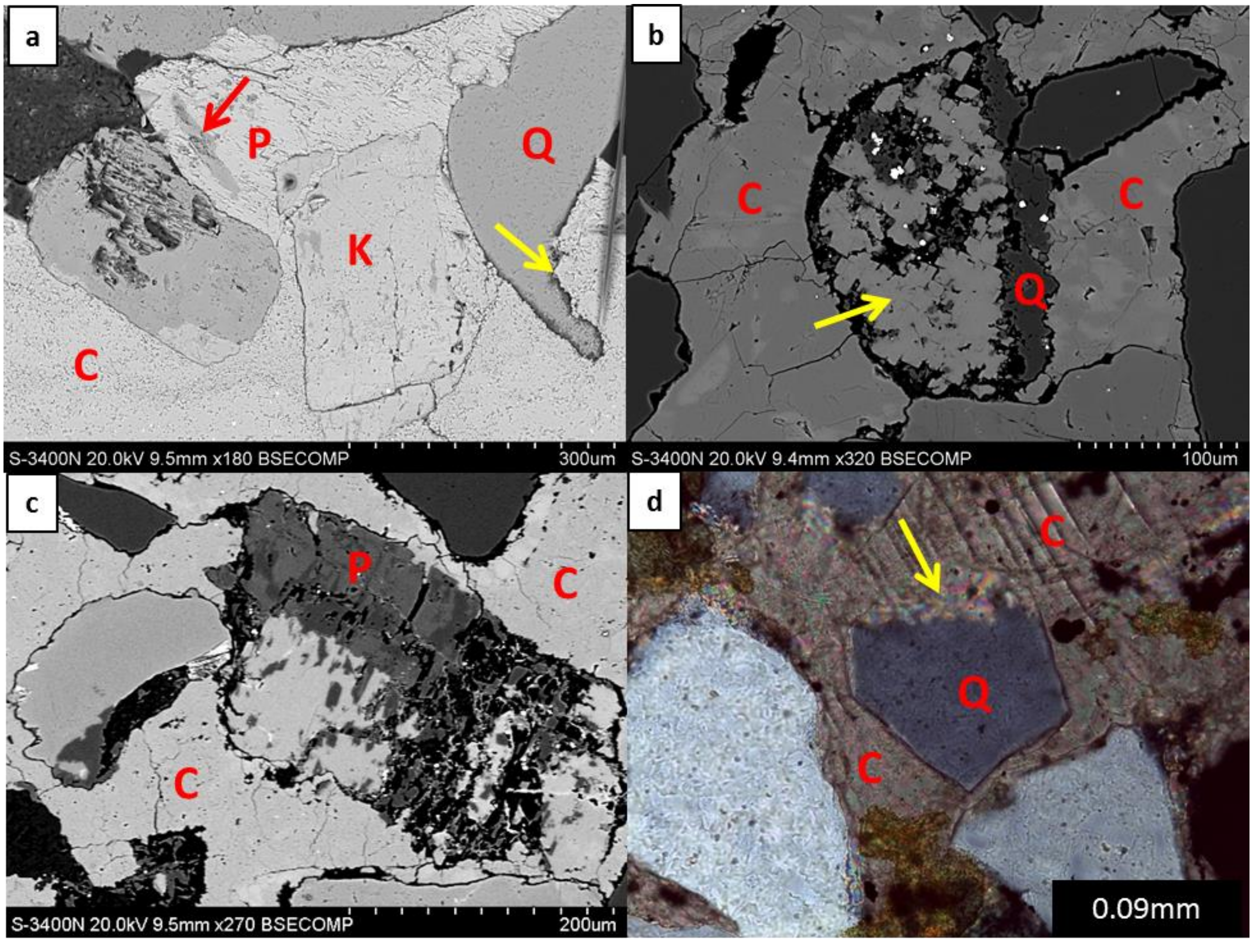


Figure 44. a) SEM-EDS image of calcite-cemented (C) sandstone with an albite remnant (red arrow), after calcite, nearly entirely replaced plagioclase (P). K-feldspar (K), and quartz (Q) have also been replaced by calcite (yellow arrow). b) SEM-EDS image of quartz (Q) partially replaced (yellow arrows) by calcite (C) (2418m). c) SEM-EDS image of calcite that replaced a partially albitized plagioclase grain and secondary porosity within plagioclase grains (2413m). d) Cross-polarized light photomicrograph of quartz (Q) partly replaced (yellow arrows) by calcite (C) (2459m).

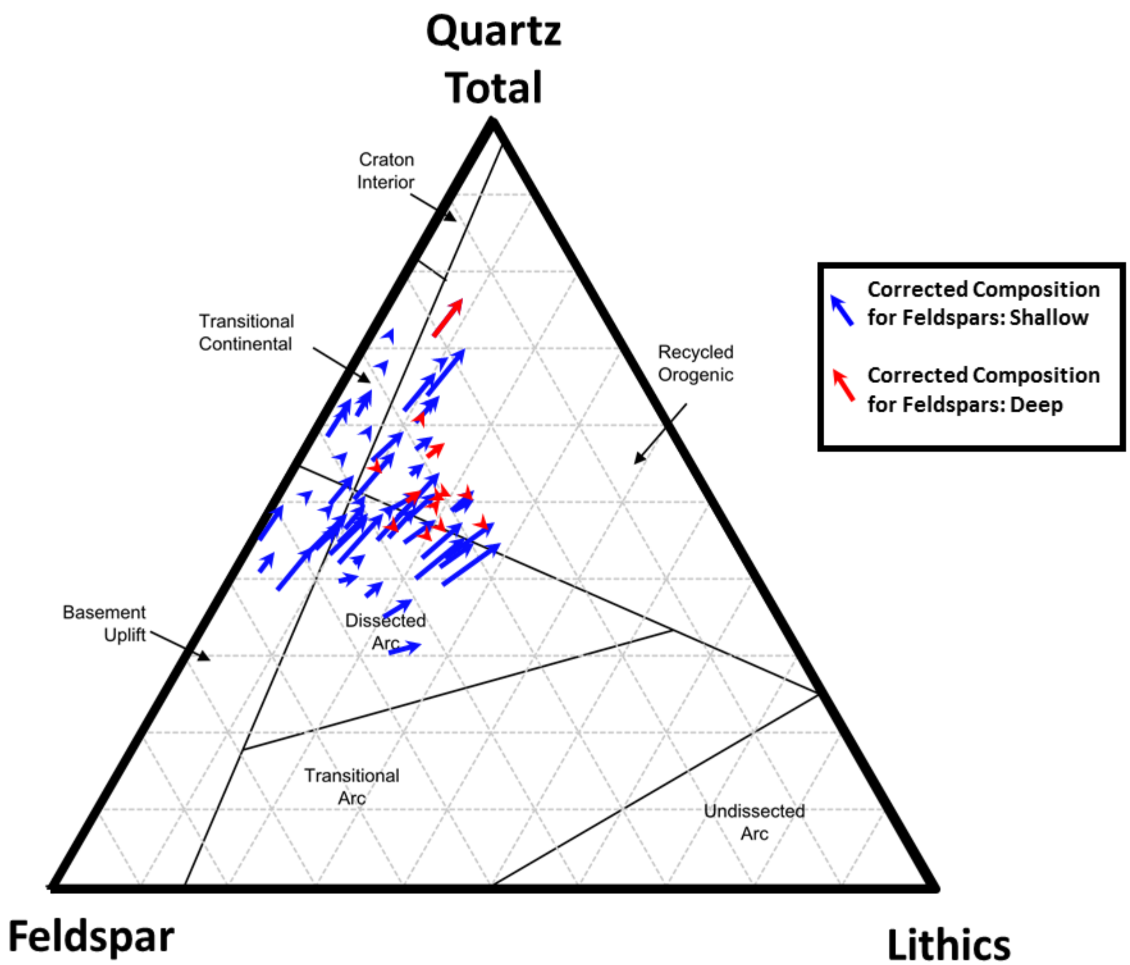


Figure 45. Ternary diagram plotted following the methodologies of Dickinson (1985) and Harris (1989). The arrowheads show the present composition and the arrow tails show the reconstructed composition.

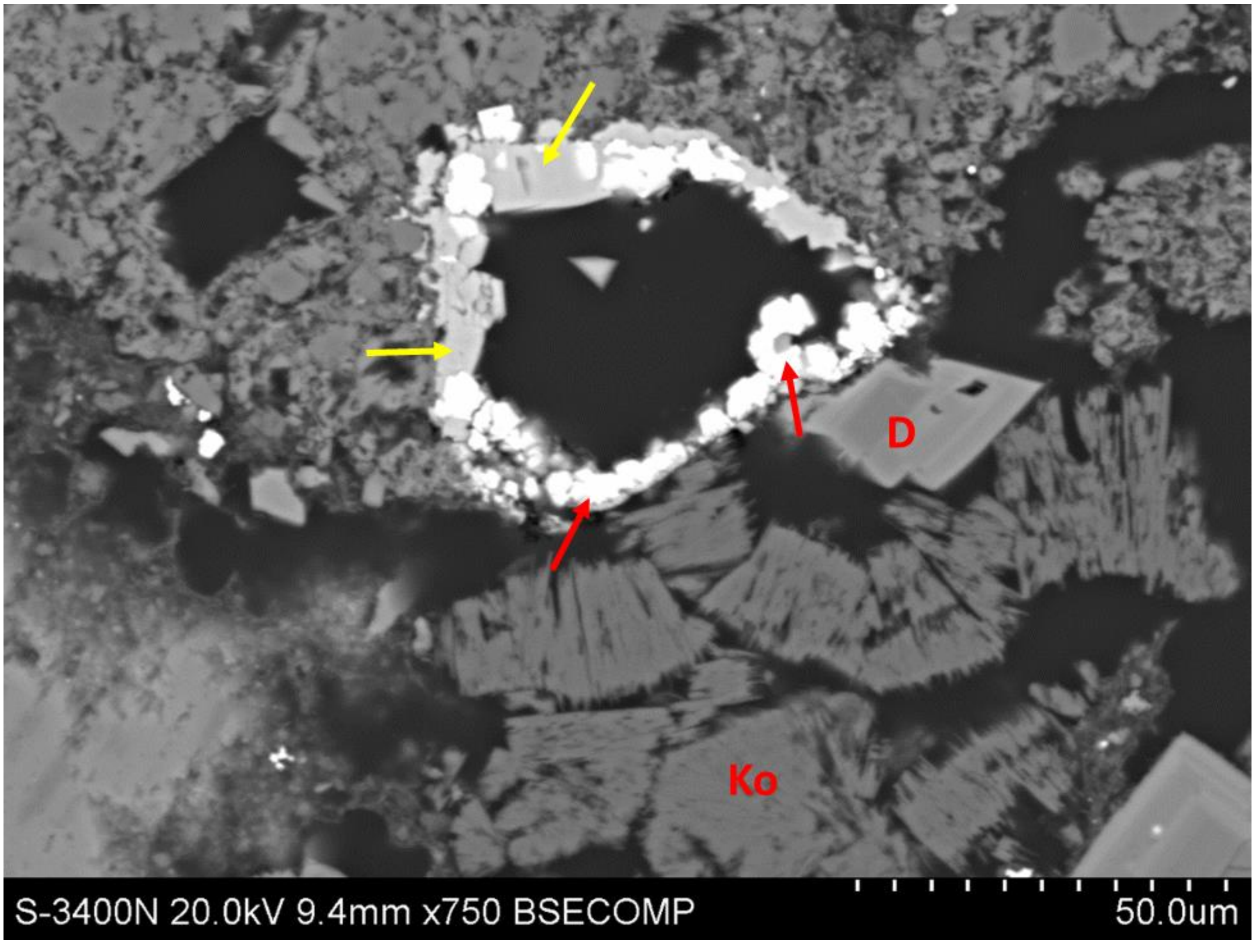


Figure 46. SEM-BSE image of partially dissolved rutile (yellow arrows) replaced by pyrite (red arrows) surrounded by large kaolinite booklets (Ko) and dolomite (D).

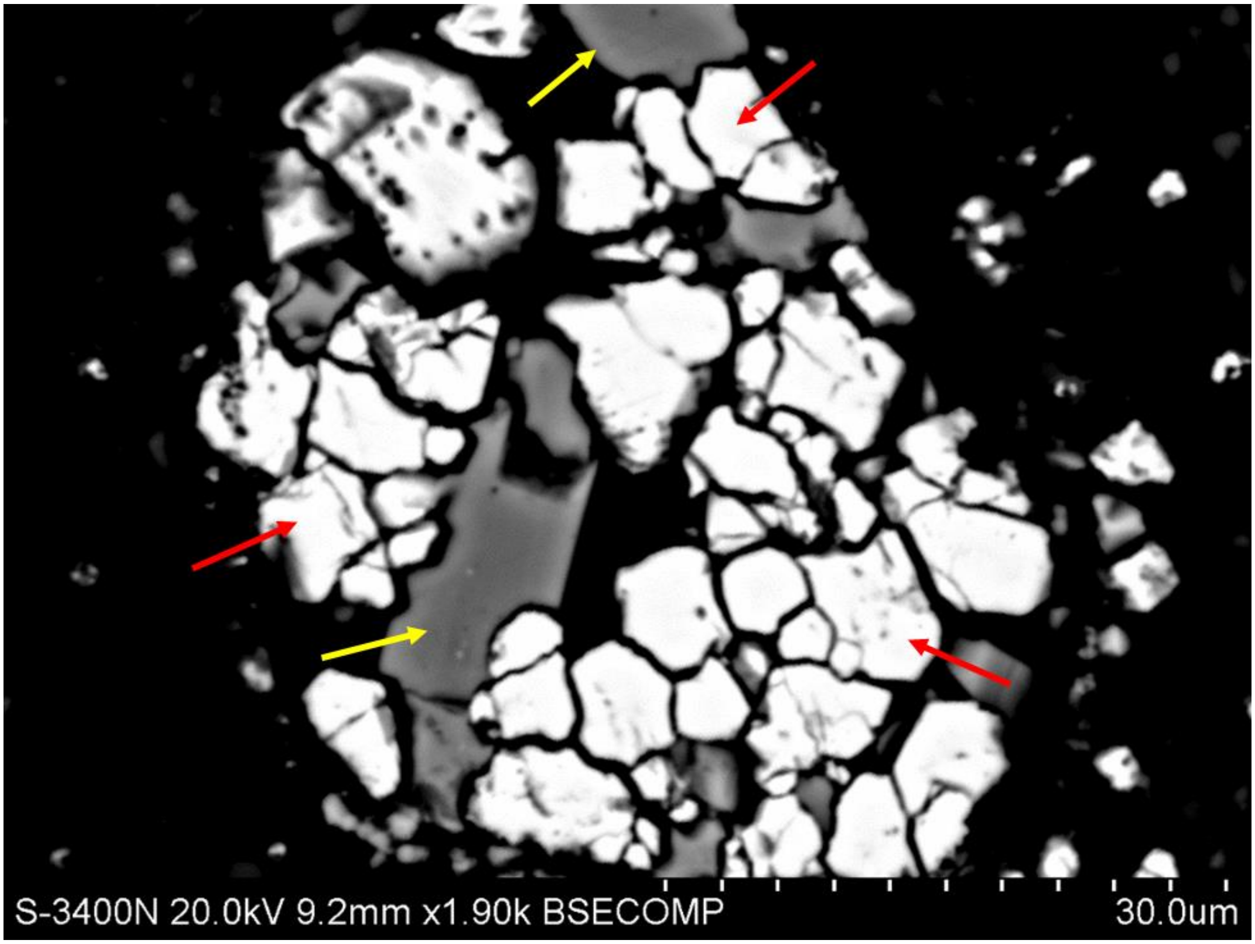


Figure 47. SEM-BSE image of rutile (yellow arrows) that has been replaced by pyrite (red arrows) (2422m).

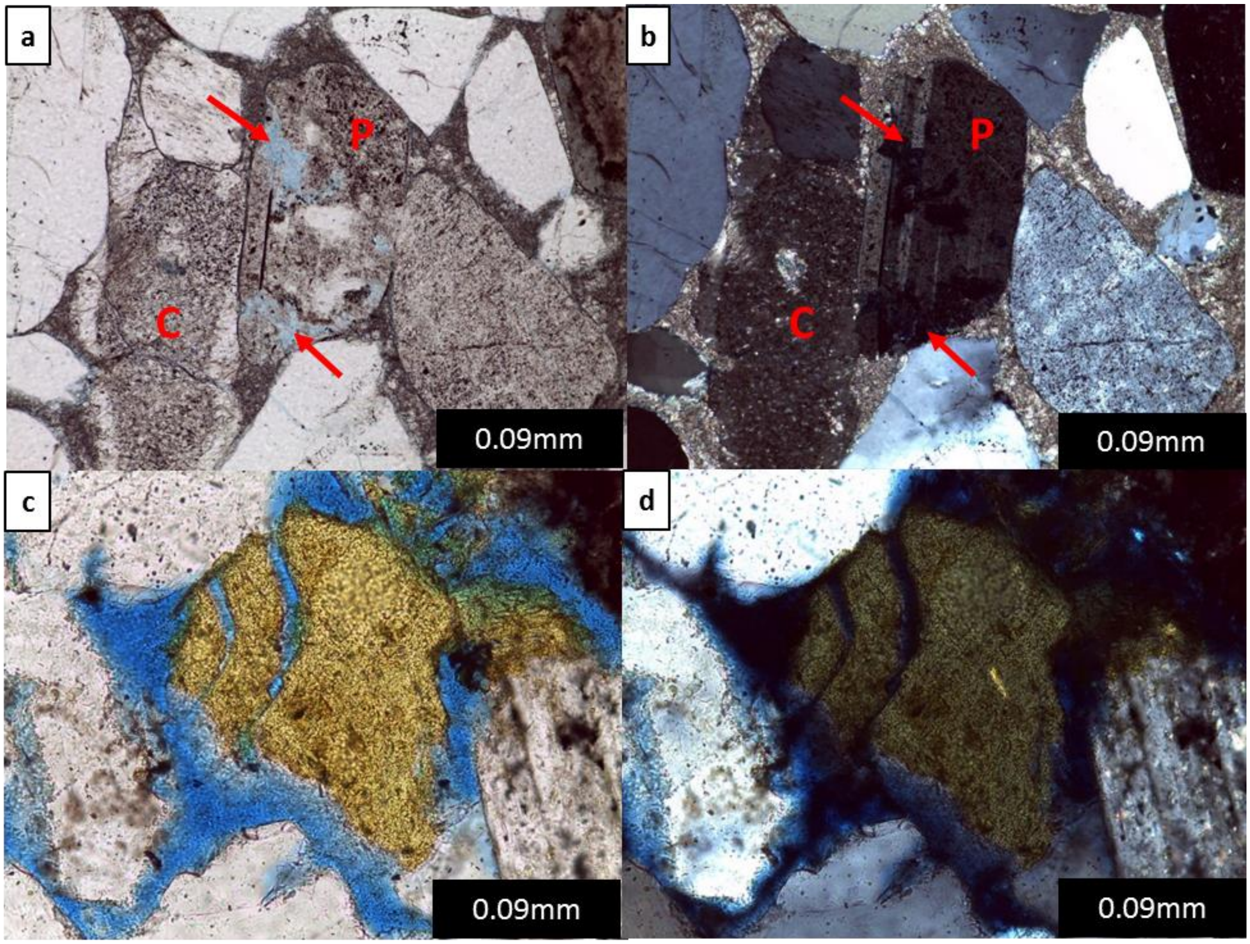


Figure 48. a) Plane-polarized and b) cross-polarized light photomicrographs of kaolinite (red arrows) within secondary pore-space along cleavage planes in plagioclase (P) surrounded by calcite cement (C) (2413m). c) Plane-polarized and b) crossed-polarized light photomicrograph of fractured K-feldspar (stained yellow for potassium) (2413m).

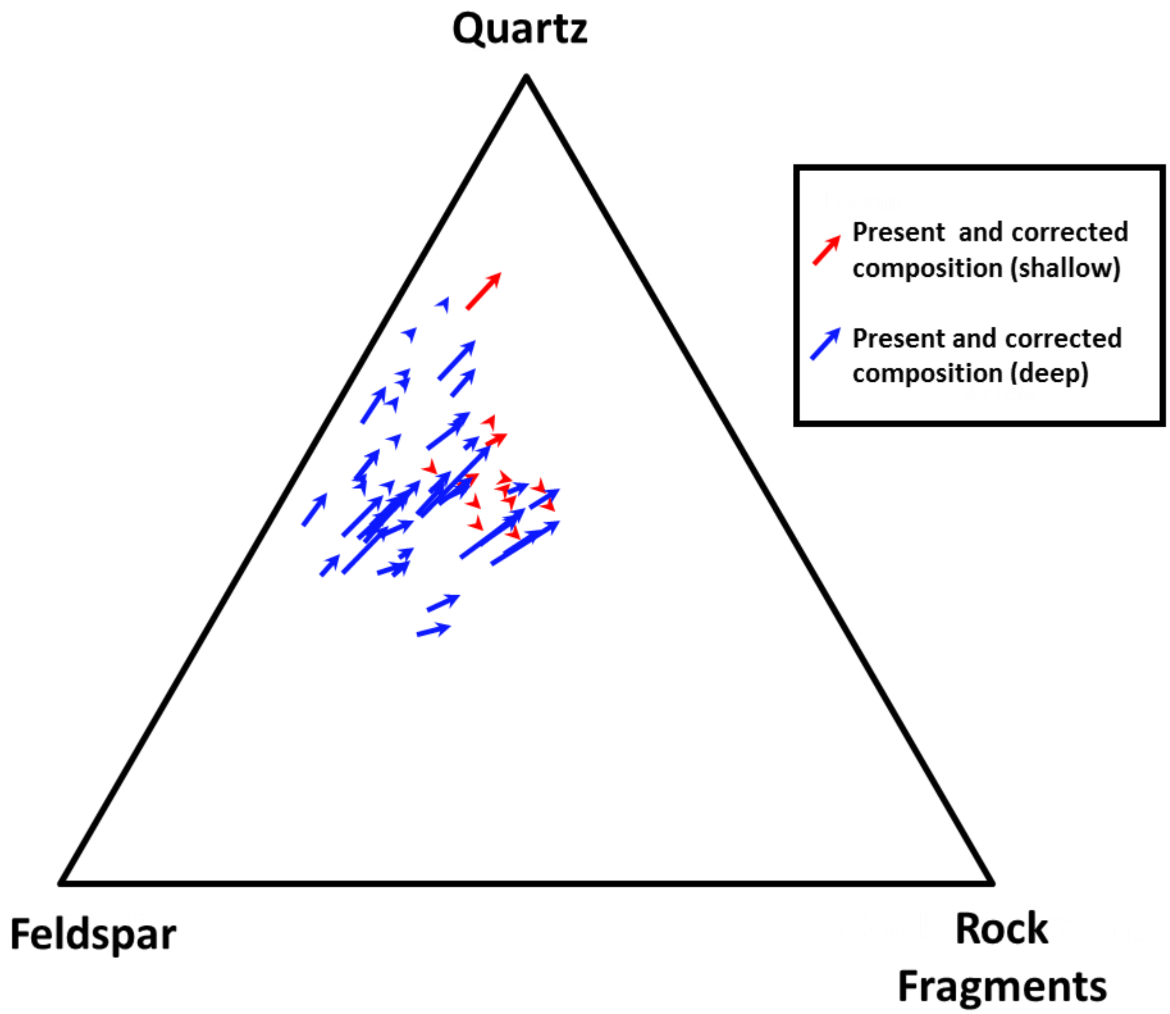


Figure 49. Ternary diagram of the detrital composition (Pettijohn et al., 1987) of the Phacoides sandstones adjusted for grain dissolution (Harris, 1989). The arrow heads show the present compositions presented earlier. The arrow-tails show the composition corrected for secondary porosity.

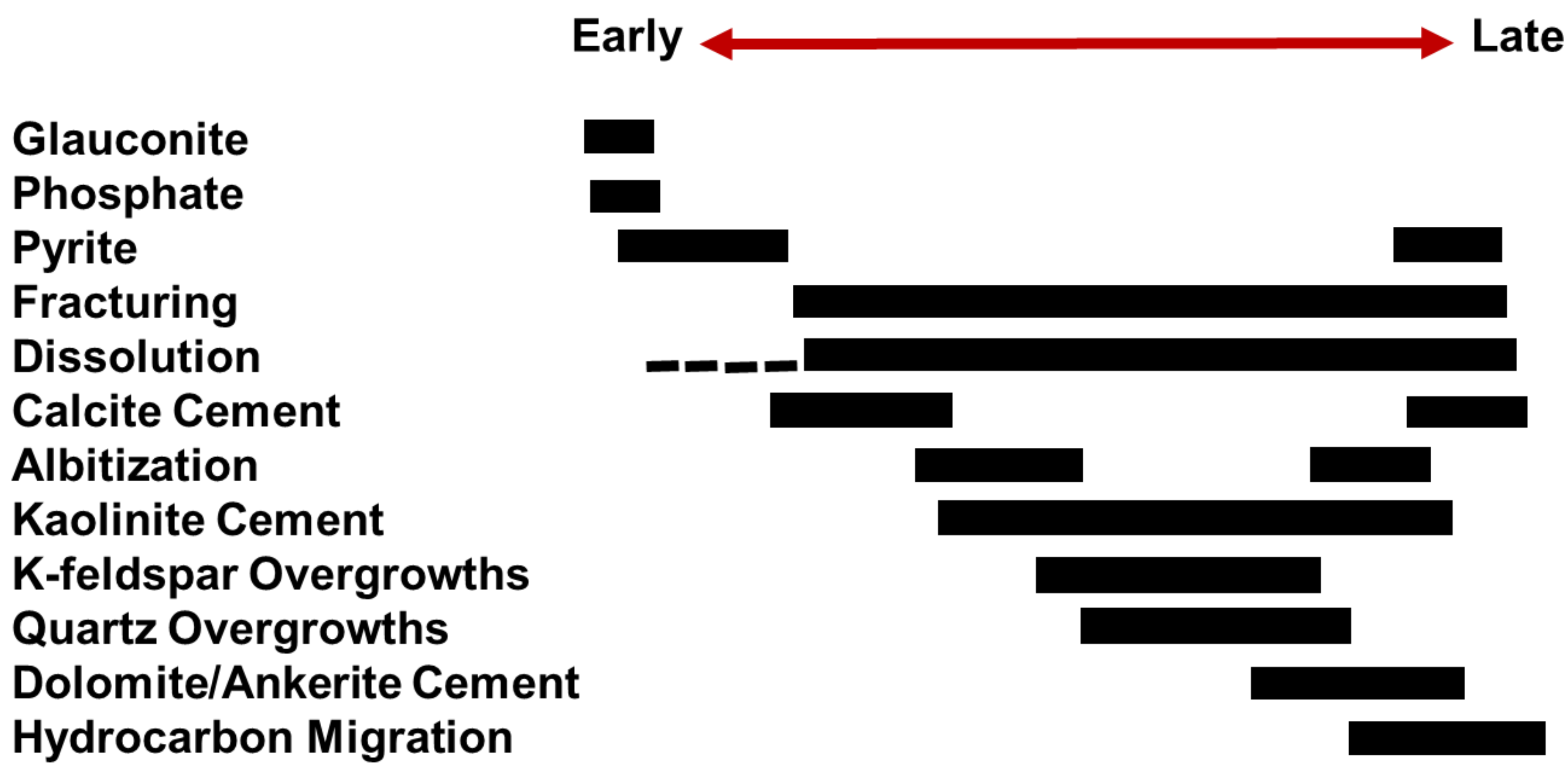


Figure 50. Paragenetic sequence of the timing of diagenetic processes that occurred in the Phacoides sandstones.

APPENDICES

I. Petrographic Data

Depth (meters)	Quartz	K-feldspar	Plagioclase	Volcanics	Microphanerites	Accessory Minerals
2403	31.8%	16.1%	10.6%	4.2%	0.0%	0.3%
2404	34.1%	18.9%	10.1%	4.7%	0.6%	1.6%
2405	35.8%	17.7%	7.9%	1.3%	0.0%	0.9%
2406	36.1%	11.3%	6.0%	3.0%	0.3%	1.0%
2406	32.7%	17.5%	9.2%	4.4%	0.0%	0.3%
2413	26.5%	9.3%	6.6%	11.9%	0.0%	1.3%
2413	39.2%	8.3%	3.7%	1.7%	0.0%	0.3%
2416	49.2%	13.1%	4.6%	7.2%	0.7%	0.7%
2418	34.9%	13.8%	8.2%	2.3%	1.0%	0.7%
2421	34.9%	14.0%	14.7%	5.5%	0.0%	0.0%
2422	49.1%	14.9%	4.4%	0.3%	0.0%	0.3%
2422	41.7%	15.3%	5.3%	3.0%	0.3%	0.7%
2423	49.5%	9.2%	5.5%	1.2%	0.0%	1.8%
2427	42.0%	14.8%	8.5%	2.6%	0.0%	0.0%
2427	21.1%	16.6%	8.9%	3.8%	1.3%	1.9%
2429	32.0%	10.3%	4.3%	3.3%	0.7%	5.3%
2431	24.0%	18.7%	6.7%	5.3%	0.0%	5.3%
2432	28.5%	17.2%	7.9%	4.0%	2.6%	1.3%
2434	31.3%	12.5%	6.9%	9.4%	1.3%	0.0%
2435	26.0%	16.8%	8.3%	6.0%	1.9%	2.9%
2438	32.3%	13.9%	6.6%	4.0%	0.0%	4.0%
2439	25.6%	12.6%	4.7%	7.0%	0.0%	1.0%
2441	26.5%	17.2%	6.6%	4.0%	0.3%	0.3%
2443	27.2%	9.3%	7.3%	10.6%	0.0%	2.0%
2447	22.7%	8.7%	3.3%	6.7%	0.0%	3.3%
2454	31.2%	11.3%	6.0%	5.3%	0.0%	1.3%
2458	46.7%	11.2%	3.9%	5.3%	0.0%	0.0%
2464	24.5%	18.3%	8.7%	2.5%	1.2%	2.2%
2467	31.3%	15.3%	6.0%	6.0%	0.0%	2.0%
2468	32.8%	16.6%	7.3%	4.6%	0.0%	2.0%
2469	40.2%	13.3%	5.3%	3.3%	0.0%	1.3%
2471	22.0%	12.3%	8.7%	1.0%	1.3%	4.2%
2472	29.7%	16.3%	7.7%	3.8%	0.3%	1.6%
2474	28.8%	15.6%	7.0%	3.3%	0.0%	2.3%
2478	31.3%	10.0%	5.3%	6.7%	0.0%	1.7%
2481	40.0%	13.0%	6.7%	8.7%	0.0%	0.0%

2483	39.3%	15.7%	3.5%	5.4%	2.6%	1.6%
2487	30.2%	12.3%	6.0%	5.3%	0.0%	3.7%
2493	31.1%	11.3%	4.0%	10.6%	0.0%	4.0%
2494	27.4%	7.6%	4.6%	7.9%	1.0%	4.6%
2496	21.1%	13.5%	9.5%	3.3%	1.3%	2.6%
2498	17.9%	5.3%	4.7%	0.7%	0.0%	2.0%
2501	24.8%	10.4%	3.9%	5.2%	0.7%	4.2%
2502	35.1%	14.6%	7.9%	3.5%	1.3%	3.2%
2505	33.3%	9.3%	7.3%	4.7%	2.0%	2.7%
2510	25.2%	16.6%	8.6%	5.3%	1.3%	1.0%
2512	22.3%	15.9%	13.6%	5.0%	0.0%	1.0%
2615	48.0%	7.3%	2.0%	4.0%	0.0%	1.3%
2619	45.8%	13.1%	3.7%	2.7%	0.0%	1.3%
2621	35.6%	19.5%	8.1%	4.0%	0.0%	0.7%
2623	49.8%	7.3%	5.3%	4.0%	0.7%	0.0%
3029	30.6%	11.3%	6.6%	8.0%	2.7%	2.7%
3030	33.0%	8.1%	6.1%	8.8%	1.3%	2.4%
3032	36.9%	12.6%	7.4%	3.6%	1.0%	3.6%
3032	37.7%	11.9%	7.9%	7.9%	3.3%	0.7%
3033	33.1%	14.2%	8.4%	5.1%	0.3%	1.0%
3034	34.4%	13.6%	5.8%	8.4%	5.2%	3.2%
3035	36.7%	9.3%	6.0%	6.0%	3.3%	2.7%
3036	29.1%	9.9%	5.3%	6.6%	3.3%	0.7%
3036	47.3%	7.3%	2.0%	4.7%	0.0%	1.3%
3038	29.8%	10.6%	9.9%	7.9%	6.6%	0.0%
3043	28.7%	11.3%	8.0%	5.3%	2.7%	4.7%
3044	28.2%	7.5%	6.3%	10.7%	3.1%	1.3%
3045	27.4%	11.9%	8.7%	5.2%	1.0%	3.5%

Depth (meters)	Carbonate	Clay Cement	Matrix	Pseudomatrix	Clay Altered Grains	Intragranular Porosity
2403	34.7%	0.3%	0.0%	0.3%	0.0%	0.6%
2404	0.0%	0.0%	0.0%	3.2%	0.0%	6.0%
2405	3.8%	0.6%	0.0%	1.6%	0.0%	4.1%
2406	37.1%	4.0%	0.0%	0.0%	0.0%	0.7%
2406	1.6%	1.9%	0.0%	2.9%	0.3%	3.8%
2413	0.3%	5.3%	0.0%	6.0%	0.0%	6.0%
2413	42.2%	0.0%	0.0%	0.0%	0.0%	0.3%
2416	3.3%	2.0%	0.0%	3.3%	0.0%	0.0%
2418	32.2%	1.3%	0.0%	1.0%	0.3%	1.0%
2421	6.8%	0.0%	1.0%	0.0%	0.3%	1.0%
2422	1.6%	5.1%	0.3%	0.6%	0.0%	1.3%
2422	0.0%	6.0%	0.0%	0.0%	0.0%	0.3%
2423	18.3%	1.5%	0.0%	6.1%	0.0%	0.0%
2427	15.1%	1.3%	0.0%	2.0%	0.0%	0.7%
2427	38.3%	0.0%	1.0%	0.0%	1.0%	3.5%
2429	0.7%	12.7%	0.0%	3.3%	3.7%	1.3%
2431	0.7%	13.3%	0.0%	4.7%	0.7%	3.3%
2432	0.3%	0.0%	1.3%	3.3%	3.3%	3.3%
2434	1.9%	7.5%	0.0%	8.1%	0.0%	3.1%
2435	16.5%	0.0%	0.6%	0.0%	0.6%	7.6%
2438	3.6%	6.3%	1.0%	5.0%	3.0%	3.6%
2439	32.9%	6.3%	0.3%	1.7%	0.0%	1.0%
2441	13.9%	0.0%	0.0%	3.0%	0.3%	6.3%
2443	6.6%	4.7%	0.0%	4.0%	0.0%	9.3%
2447	4.7%	12.7%	7.3%	7.3%	0.7%	7.3%
2454	29.9%	2.7%	0.0%	1.3%	0.0%	6.0%
2458	0.0%	0.0%	0.0%	2.6%	0.7%	2.0%
2464	7.8%	0.0%	3.1%	7.1%	0.0%	6.8%
2467	10.7%	0.7%	0.0%	4.7%	0.0%	5.3%
2468	0.0%	2.6%	0.0%	3.3%	0.0%	5.0%
2469	27.9%	2.7%	0.0%	0.0%	0.0%	2.0%
2471	27.8%	0.3%	1.9%	0.0%	0.0%	5.8%
2472	1.6%	10.9%	0.0%	4.2%	0.3%	6.7%
2474	4.6%	10.6%	0.7%	4.0%	0.7%	6.6%
2478	0.7%	9.3%	0.0%	4.0%	0.7%	6.7%
2481	1.3%	6.0%	0.0%	3.3%	0.3%	3.0%

2483	1.3%	2.6%	0.3%	1.0%	1.3%	6.1%
2487	0.7%	14.6%	0.3%	5.0%	5.0%	4.3%
2493	4.0%	12.6%	0.0%	9.9%	0.0%	6.6%
2494	0.0%	5.9%	14.9%	5.6%	1.7%	4.3%
2496	0.0%	0.0%	16.8%	10.2%	3.3%	6.3%
2498	57.8%	2.0%	0.0%	0.0%	0.0%	1.7%
2501	3.3%	11.7%	10.4%	8.5%	0.7%	5.9%
2502	0.0%	2.8%	0.0%	8.5%	0.9%	6.6%
2505	9.3%	8.7%	0.0%	10.7%	3.3%	2.0%
2510	1.3%	15.3%	4.0%	4.0%	2.0%	3.3%
2512	2.7%	0.0%	1.3%	11.6%	2.7%	8.0%
2615	0.7%	14.0%	0.0%	1.3%	0.0%	0.0%
2619	0.3%	10.1%	0.0%	6.4%	0.0%	2.7%
2621	0.7%	6.7%	0.0%	4.0%	0.0%	1.3%
2623	0.0%	10.0%	0.7%	4.0%	0.7%	0.0%
3029	25.9%	5.3%	3.3%	1.3%	0.3%	0.0%
3030	0.7%	15.5%	3.4%	2.0%	12.8%	0.0%
3032	1.9%	1.9%	9.7%	12.6%	2.3%	0.0%
3032	2.6%	9.9%	2.0%	6.6%	2.0%	0.0%
3033	0.0%	3.4%	16.2%	9.1%	2.7%	0.0%
3034	2.6%	1.3%	13.0%	4.5%	3.9%	0.6%
3035	0.0%	9.3%	13.3%	1.3%	7.3%	0.7%
3036	0.0%	2.6%	22.5%	7.9%	7.3%	0.0%
3036	0.7%	14.0%	0.0%	1.3%	0.0%	0.0%
3038	2.6%	4.6%	17.9%	5.3%	4.0%	0.0%
3043	7.3%	13.3%	4.0%	0.7%	8.7%	0.0%
3044	2.5%	0.6%	33.5%	2.5%	0.6%	0.0%
3045	17.1%	1.0%	13.2%	8.7%	1.6%	0.0%

Depth (meters)	Intergranular Porosity	Secondary Porosity	Hydro-Carbon	Other	Porosity	Sorting
2403	0.3%	66.7%	0.0%	0.6%	1.0%	moderate
2404	20.5%	85.7%	1.3%	0.6%	27.8%	NA
2405	23.7%	51.1%	0.0%	2.5%	27.8%	poor
2406	0.3%	75.0%	0.3%	0.0%	1.3%	moderate
2406	23.5%	58.6%	0.3%	1.6%	27.6%	poor
2413	25.8%	85.4%	0.0%	1.0%	31.8%	poor
2413	3.0%	50.0%	0.0%	1.3%	3.3%	poor
2416	15.4%	42.6%	0.0%	0.7%	15.4%	poor
2418	0.3%	42.9%	1.0%	2.0%	2.3%	poor
2421	21.8%	68.6%	0.0%	0.0%	22.8%	poor
2422	18.7%	47.1%	1.6%	1.9%	21.5%	poor
2422	26.0%	65.8%	0.0%	1.3%	26.3%	poor
2423	6.1%	76.2%	0.3%	0.3%	6.4%	poor
2427	11.8%	42.1%	0.0%	1.3%	12.5%	poor
2427	1.6%	78.9%	1.0%	0.0%	6.1%	well
2429	21.3%	50.0%	0.0%	1.0%	22.7%	moderate
2431	16.7%	50.0%	0.0%	0.7%	20.0%	moderate/well
2432	24.5%	68.1%	2.3%	0.0%	30.1%	NA
2434	18.1%	67.6%	0.0%	0.0%	21.3%	poor
2435	11.4%	68.8%	1.3%	0.0%	20.3%	well
2438	14.5%	57.9%	0.7%	1.7%	18.8%	moderate
2439	4.0%	42.1%	1.3%	1.7%	6.3%	moderate
2441	20.5%	58.3%	1.0%	0.0%	27.8%	well
2443	17.3%	63.0%	0.3%	1.3%	26.9%	moderate
2447	7.3%	63.0%	3.3%	4.7%	18.0%	well
2454	4.7%	87.5%	0.0%	0.3%	10.6%	moderate/well
2458	25.7%	54.8%	0.0%	2.0%	27.6%	moderate/well
2464	14.9%	54.4%	2.8%	0.0%	24.5%	moderate/well
2467	16.0%	53.1%	0.0%	2.0%	21.3%	poor
2468	22.5%	71.8%	0.7%	2.6%	28.1%	moderate
2469	2.0%	55.6%	2.0%	0.0%	6.0%	moderate
2471	12.3%	27.0%	2.3%	0.0%	20.4%	well
2472	16.6%	66.2%	0.3%	0.0%	23.6%	well
2474	12.6%	45.5%	2.6%	0.7%	21.9%	well
2478	21.7%	48.3%	1.3%	0.7%	29.7%	well
2481	17.0%	63.3%	0.0%	0.7%	20.0%	poor/moderate

2483	17.9%	69.7%	0.3%	1.3%	24.3%	well
2487	10.3%	61.7%	1.0%	1.3%	15.6%	well
2493	5.3%	73.7%	0.7%	0.0%	12.6%	well
2494	10.9%	60.8%	1.7%	2.0%	16.8%	well
2496	10.2%	66.7%	1.3%	0.7%	17.8%	moderate/well
2498	7.3%	33.3%	0.0%	0.7%	9.0%	well
2501	7.2%	64.0%	3.3%	0.0%	16.3%	moderate
2502	13.9%	52.2%	0.6%	0.9%	21.2%	well
2505	6.0%	61.5%	0.7%	0.0%	8.7%	well
2510	9.3%	60.9%	2.7%	0.0%	15.3%	well
2512	11.6%	51.5%	2.3%	2.0%	21.9%	well
2615	20.7%	56.3%	0.7%	0.0%	21.3%	moderate
2619	13.5%	66.7%	0.0%	0.3%	16.2%	poor/moderate
2621	17.4%	58.6%	0.7%	1.3%	19.5%	poor/moderate
2623	17.3%	65.4%	0.0%	0.3%	17.3%	poor
3029	0.0%	0.0%	2.0%	0.0%	2.0%	well
3030	3.4%	33.3%	2.7%	0.0%	6.1%	well
3032	2.3%	5.6%	3.6%	0.6%	5.8%	moderate
3032	6.0%	45.5%	1.3%	0.0%	7.3%	moderate
3033	4.4%	0.0%	1.0%	1.0%	5.4%	well
3034	1.9%	40.0%	0.6%	0.6%	3.2%	moderate
3035	0.0%	16.7%	3.3%	0.7%	4.0%	well sorted
3036	0.7%	20.0%	2.6%	1.3%	3.3%	moderate
3036	20.7%	56.3%	0.7%	0.0%	21.3%	well sorted
3038	0.0%	0.0%	0.7%	0.0%	0.7%	moderate
3043	0.0%	0.0%	5.3%	0.0%	5.3%	moderate
3044	0.0%	0.0%	3.1%	0.0%	3.1%	poor
3045	0.3%	0.0%	0.3%	0.0%	0.6%	poor/moderate

Depth (meters)	Angularity	Size	Contact Index	Tight Packing Index	Point Counts
2403	sub-round	very coarse	1.47	0.86	311
2404	sub-angular	NA			317
2405	sub-round	coarse	2.90	2.11	316
2406	NA	coarse	2.11	1.38	302
2406	sub-angular/sub-round	coarse	3.06	2.20	315
2413	sub-round/sub-angular	coarse	3.20	2.39	302
2413	sub-round	very coarse	1.32	1.04	301
2416	sub-round	coarse			305
2418	sub-angular	very coarse	2.45	1.50	304
2421	sub-round	very coarse	3.45	2.85	307
2422	NA	NA			316
2422	angular	very coarse	3.51	3.02	300
2423	sub-round	very coarse	2.65	2.29	327
2427	sub-round	very coarse	3.04	2.44	305
2427	sub-angular	coarse	2.19	1.70	313
2429	sub-angular	medium	2.99	2.40	300
2431	sub-angular	coarse	3.29	2.94	300
2432	Angular	coarse	4.12	3.66	302
2434	sub-round	coarse	2.66	2.24	320
2435	sub-angular	coarse	3.35	2.90	315
2438	sub-angular	coarse	3.81	3.35	303
2439	sub-angular	coarse	2.67	1.99	301
2441	sub-angular	coarse	2.93	2.24	302
2443	sub-round	coarse	3.04	2.16	301
2447	sub-angular	medium/coarse	3.17	2.41	300
2454	sub-angular	coarse	2.55	2.00	301
2458	sub-round	very coarse	3.70	3.68	304
2464	angular	NA	2.80	2.15	322
2467	sub-round	coarse	3.28	2.88	300
2468	sub-round	coarse	3.87	3.20	302
2469	sub-round	very coarse	2.77	2.18	301
2471	sub-angular	coarse	1.57	1.14	309
2472	sub-angular	coarse	3.81	3.05	313
2474	sub-angular	coarse	3.99	3.32	302

2478	sub-angular	coarse	3.36	2.97	300
2481	sub-angular	very coarse	4.04	3.61	300
2483	sub-angular	coarse	3.92	3.03	313
2487	sub-angular	coarse	3.23	2.61	301
2493	sub-angular	coarse	2.77	2.36	302
2494	angular	medium	2.27	1.85	303
2496	angular/sub-angular	medium	3.43	2.70	304
2498	sub-round	medium	0.55	0.52	301
2501	sub-angular	coarse			307
2502	angular/sub-angular	medium	3.18	2.46	316
2505	sub-angular	medium	3.00	2.36	300
2510	sub-angular	medium			301
2512	sub-angular	medium	4.19	3.43	301
2615	sub-round/round	very coarse	2.97	2.47	300
2619	angular	coarse	3.48	2.76	297
2621	angular	coarse	3.77	3.23	298
2623	sub-angular	very coarse	3.49	2.88	301
3029	sub-angular	coarse	2.19	1.76	301
3030	sub-angular	coarse	3.22	2.54	297
3032	sub-angular/sub-round	medium			309
3032	sub-angular	medium	3.45	2.72	302
3033	sub-angular/sub-round	medium			296
3034	sub-angular	coarse	3.67	2.90	308
3035	sub-angular	medium			300
3036	sub-angular	medium	3.90	3.08	302
3036	sub-angular	medium			300
3038	sub-angular	NA			302
3043	sub-angular	medium			302
3044	sub-angular	coarse	4.12	3.27	319
3045	sub-angular	medium			310

II. Point-Count Data

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 2
PROJECT: McKittrick
FORMATION (AGE): Oligocene - Miocene
LOCATION: Temblor Formation.
ROCK NAME:
DEPTH: 7883'
POINT COUNTS: ~~[illegible]~~ 311

SORTING: Poorly / Moderately Sorted
COMPACTION:

SIZE: Very Coarse Sand. 1.45mm
ANGULARITY: Sub-Round

COMMENTS

1. Quartz
   - Moncrystalline 𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸 |||
   - Polycrystalline |||
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline 𝍸 |||
   - Orthoclase 𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸 ||
   - Sanadine
   - Microphanerite M / O
   - Volcanic Rock Fragment |
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment |
   - Sedimentary 𝍸𝍸𝍸𝍸𝍸𝍸𝍸 |||
   - Metamorphic

4. Volcanics
   𝍸𝍸 |

5. Microphanerites

6. Accessory Minerals
   - Zircon |
   - MUSCOVITE
   - HORNEBLEND

7. Carbonate Cement
   - Calcite 𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸 |||

   · can see 'chunks' of calcite going extinct differently → different cementation rates.

8. Matrix / Pseudomatrix |

   · pseudomatrix is being replaced b[y] calcite → in some cases it is completely replaces.

   Clay-Altered Grains

9. Clay Cement
   - kaolinite |

10. Intragranular Porosity
    - Quartz
    - K-Feldspar
    - Plagioclase ||
    - VRF Q / K / P
    - PRF Q / K / P

11. Intergranular Porosity |
    - Fractures
    - Fracture-induced dissolution
    - Oversize/elongate pores
    - Grain-edge dissolution
    - Other

12. Other
    - SHALE CLAST ||
    - Calcite Fossil || (Not D.C.)

COMMEMTS

* Looks like most squashed VRFs and pseudomatrix has been replaced by calcite, which is why there are so many Floating grains.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

· pseudomatrix → calcite replacement → dissolution of grains.

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 3
PROJECT: McKittrick
FORMATION (AGE): Oligocene - Miocene
LOCATION: Temblor
ROCK NAME:
DEPTH: 7895 516-8
POINT COUNTS: 315

SORTING: Poorly Sorted
COMPACTION:

SIZE: ,8mm Coarse Sand
ANGULARITY: Sub - Angular - subs Round

COMMENTS

1. Quartz
   - Moncrystalline
   - Polycrystalline |
   - Microphanerite ________
   - Volcanic Rock Fragment ||
   - Quartz Arenite
   - Other Sedimentary ________
   - Metaquartzite
   - Other Metamorphic ________

   · some Fractured and crushed and being dissolved.

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanadine
   - Microphanerite ________ M O
   - Volcanic Rock Fragment
   - Sedimentary ________
   - Metamorphic ________

3. Plagioclase
   - Microphanerite ________
   - Volcanic Rock Fragment |
   - Sedimentary
   - Metamorphic ________

4. Volcanics

   · also as pseudomatrix

5. Microphanerites ________

6. Accessory Minerals
   - ZIRCON
   - MUSCOVITE |
   - Pyrite

7. Carbonate Cement
   - kaolinite

8. Matrix / Pseudomatrix

   ....Clay-Altered Grains. 1

   · one good squashed grain (shale clast) filled with hydro carbon.
   · shale clast

9. Clay Cement
   - ~~calcite~~
   - calcite

10. Intragranular Porosity
    - Quartz |
    - K-Feldspar
    - Plagioclase

VRF	PRF
Q	Q
K	K
P	P

11. Intergranular Porosity
    - Fractures |||
    - Fracture-induced dissolution
    - Oversize/elongate pores
    - Grain-edge dissolution
    - Other ________

12. Other
    - Carbonate Clast ||
    - Hydro Carbon |
    - Shale Clast |||

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q |	vrfQ	prfQ
K ||||	vrfK	prfK
P ||	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q||	vrfQ	prfQ
K |||	vrfK |	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P ||||	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K.

THIN SECTION: 4
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
ROCK NAME:
DEPTH: 7897 T-8 7925'
POINT COUNTS: 305
SORTING: Poorly Sorted
COMPACTION: arkosic arenite (very close to subarkose)
SIZE: 1mm Very Coarse -> Coarse Grained
ANGULARITY: Sub-Round

COMMENTS

1. Quartz
- 148 Moncrystalline
- 2 Polycrystalline ||
- Microphanerite
- 2 Volcanic Rock Fragment ||
- Quartz Arenite
- Other Sedimentary
- Metaquartzite
- Other Metamorphic

2. K-Feldspar
- 14 Microcline
- 29 Orthoclase
- Sanadine
- Microphanerite — M / O
- 2 Volcanic Rock Fragment ||
- Sedimentary
- Metamorphic

3. Plagioclase
- 2 Microphanerite Volcanic ||
- Volcanic Rock Fragment
- 14 Sedimentary
- Metamorphic

4. Volcanics 18

5. Microphanerites

6. Accessory Minerals
- 2 Muscovite ||
- Pyrite

7. Carbonate Cement 10 Calcite

8. Matrix / Pseudomatrix 10

Clay-Altered Grains

9. Clay Cement
- 6 Unidentified ||||
- Kaolinite ||

·unidentified as clay rims.

10. Intragranular Porosity
- Quartz
- K-Feldspar
- Plagioclase

VRF Q K P — PRF Q K P

11. Intergranular Porosity 27
- Fractures
- Fracture-induced dissolution 9
- Oversize/elongate pores 12
- Grain-edge dissolution
- Other

12. Other
- Phosphate ||
- Organic matter

COMMEMTS

*Tons of small fractured grains, and calcite seems to be random clasts.
*clay rims sometimes.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q ||	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K.

THIN SECTION: 7
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
DEPTH: 7943 -7961 T-S
SORTING: Poorly Sorted
SIZE: 1.43mm

PROJECT: McKittrick
ROCK NAME: Quartz Arenite
POINT COUNTS: 323
COMPACTION:
ANGULARITY: Sub-Round

COMMENTS

1. Quartz
Moncrystalline — Replacement by Calcite
Polycrystalline
Microphanerite ________
Volcanic Rock Fragment
Quartz Arenite
Other Sedimentary ________
Metaquartzite
Other Metamorphic ________

2. K-Feldspar
Microcline
Orthoclase
Sanadine
Microphanerite ________ M / O
Volcanic Rock Fragment
Sedimentary ________
Metamorphic ________

3. Plagioclase
Microphanerite ________
Volcanic Rock Fragment
Sedimentary
Metamorphic ________

4. Volcanics

5. Microphanerites ________

6. Accessory Minerals
hornblende
Zircon
Pyrite
Muscovite
Biotite

7. Carbonate Cement
Calcite
Dolomite

8. Matrix / Pseudomatrix — oftentimes tiny grain fragments too small to I.D. but not every time
Clay-Altered Grains

9. Clay Cement
illite/smectite

10. Intragranular Porosity
Quartz — VRF Q — PRF Q
K-Feldspar — K — K
Plagioclase — P — P

11. Intergranular Porosity
Fractures
Fracture-induced dissolution
Oversize/elongate pores
Grain-edge dissolution
Other ________

12. Other
OM/Pyrite
Shale Clast
Fossils

COMMEMTS

* Calcite → some precipitation, many large clasts/Fossils.
* Biotite looks like it might be transitioning to chlorite, and there are usually pyrite grains within it.

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION
Q — vrfQ — prfQ
K — vrfK — prfK
P — vrfP — prfP

GRAIN-EDGE DISSOLUTION
Q — vrfQ — prfQ
K — vrfK — prfK
P — vrfP — prfP

OVERSIZE/ELONGATE PORES
Q — vrfQ — prfQ
K — vrfK — prfK
P — vrfP — prfP

OTHER
____
____

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 10
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
ROCK NAME:
DEPTH: 8050'
POINT COUNTS: 301

SORTING: Moderately/Well Sorted
COMPACTION:

SIZE: 0.9mm
ANGULARITY: Sub-Angular

COMMENTS

1. Quartz
   - Moncrystalline
   - Polycrystalline
   - Microphanerite ________
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary ________
   - Metaquartzite
   - Other Metamorphic ________

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanadine
   - Microphanerite ________ M / O
   - Volcanic Rock Fragment
   - Sedimentary ________
   - Metamorphic ________

3. Plagioclase
   - Microphanerite ________
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic ________

4. Volcanics

5. Microphanerites ________

6. Accessory Minerals
   - Muscovite
   - Glauconite
   - Pyrite
   - Biotite
   - Zircon

7. Carbonate Cement
   - Calcite
   - Dolomite

8. Matrix / Pseudomatrix

Clay-Altered Grains

9. Clay Cement
   - Illite/Smectite
   - Kaolinite

10. Intragranular Porosity
   - Quartz
   - K-Feldspar
   - Plagioclase
   - VRF Q / K / P
   - PRF Q / K / P

11. Intergranular Porosity
   - Fractures
   - Fracture-induced dissolution
   - Oversize/elongate pores
   - Grain-edge dissolution
   - Other ________

12. Other
   - Shale Clast
   - organic matter
   - Phosphate

COMMEMTS

*calcite cemented

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 16
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor Formation
DEPTH: 8099' (8088-8139 T-4)

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: 301

SORTING: Moderately Sorted
COMPACTION:

SIZE: 1.15mm
Very coarse
ANGULARITY: Sub-Round

COMMENTS

1. Quartz 115
   - Monocrystalline
   - Polycrystalline 6
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline 6
   - Orthoclase 34
   - Sanadine
   - Microphanerite ≤ M / O
   - Volcanic Rock Fragment 2
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary 16
   - Metamorphic

4. Volcanics 8

5. Microphanerites

6. Accessory Minerals
   - Muscovite
   - Purite 4
   - Glauconite
   - Biotite
   - Hornblende

7. Carbonate Cement 84
   - Calcite

8. Matrix / Pseudomatrix

Clay-Altered Grains

9. Clay Cement 8
   - Kaolinite

10. Intragranular Porosity
   - Quartz
   - K-Feldspar 4
   - Plagioclase 2

   VRF Q K P — PRF Q K P

11. Intergranular Porosity 2
   - Fractures
   - Fracture-induced dissolution 4
   - Oversize/elongate pores
   - Grain-edge dissolution
   - Other

12. Other
   - Shale Clast
   - Phosphate
   - organic matter 6

COMMEMTS

* calcite cemented

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K 2	vrfK	prfK
P 2	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K.

THIN SECTION: 18
FORMATION (AGE): Oligocene - Miocene
LOCATION: Temblor
DEPTH: 8218 (8204 T-5)

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: 300

SORTING: Well Sorted
COMPACTION:

SIZE: .50 Medium/Coarse
ANGULARITY: Sub-Angular

COMMENTS

1. Quartz 100 Moncrystalline
Polycrystalline
2 Microphanerite granitic ||
Volcanic Rock Fragment
Quartz Arenite
Other Sedimentary ________
Metaquartzite
Other Metamorphic ________

2. K-Feldspar 2 Microcline ||
26 Orthoclase
Sanadine
2 Microphanerite granitic M O ||
Volcanic Rock Fragment
Sedimentary ________
Metamorphic ________

3. Plagioclase 2 Microphanerite granitic ||
Volcanic Rock Fragment
22 Sedimentary
Metamorphic ________

4. Volcanics 14

5. Microphanerites ________

6. Accessory Minerals 8
glauconite ||
pyrite ||||
biotite
horneblend
muscovite
Zircon ||

7. Carbonate Cement
6 calcite
22 dolomite
* many calcite clasts, not necessarily pore filling.

8. Matrix /
32 Pseudomatrix
10 Clay-Altered Grains

9. Clay Cement 26
~~calcite~~
~~dolomite~~
kaolinite ||||
unidentified

10. Intragranular Porosity
Quartz
K-Feldspar
6 Plagioclase
VRF Q K P
PRF Q K P

11. Intergranular Porosity
Fractures ||
Fracture-induced dissolution ||||
Oversize/elongate pores
Grain-edge dissolution ||||
Other ________

12. Other
HC/OM ||
Phosphate
* Phosphate dissolution common.

COMMEMTS

* glauconite → chlorite
* Biotite alteration, to chlorite. isn't as severe as in well SP-32x.
* Dolomite in clusters w/pyrite

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P ||||	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q ||||	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 21
FORMATION (AGE): Oligocene-Miocene
LOCATION: McKittrick
DEPTH: ~~90~~ 9942
SORTING: Well sorted
SIZE: 0.55mm Coarse

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: ~~304~~ 297
COMPACTION:
ANGULARITY: Sub-Angular

COMMENTS

1. Quartz
- 58 Moncrystalline
- 10 Polycrystalline
- 4 Microphanerite
- Volcanic Rock Fragment
- Quartz Arenite
- Other Sedimentary
- Metaquartzite
- Other Metamorphic

2. K-Feldspar
- Microcline
- 24 Orthoclase
- Sanadine
- Microphanerite — M / Ol
- 2 Volcanic Rock Fragment
- Sedimentary
- Metamorphic

3. Plagioclase
- 2 Microphanerite
- Volcanic Rock Fragment
- 18 Sedimentary
- Metamorphic

4. Volcanics 22

5. Microphanerites

6. Accessory Minerals 7
- Glauconite 1
- Muscovite 4
- Pyrite 1
- Biotite
- Zircon
- Hornblende 1
- Chlorite
- Appatite

7. Carbonate Cement 2
- Calcite
- Dolomite 2

8. Matrix / 10
- Pseudomatrix 6
- 45 Clay-Altered Grains

9. Clay Cement 46 unidentified

10. Intragranular Porosity
- Quartz
- K-Feldspar
- Plagioclase
- VRF Q, K, P
- PRF Q, K, P

11. Intergranular Porosity 10
- Fractures
- Fracture-induced dissolution
- Oversize/elongate pores
- Grain-edge dissolution
- Other

12. Other 8
- OM
- Phosphate

COMMEMTS

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K 1	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q 1	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 22
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
DEPTH: 9949'

PROJECT: McKittrick CCS

ROCK NAME:
POINT COUNTS: 300

SORTING: Moderately

COMPACTION:

SIZE: 0.45mm Medium

ANGULARITY: Sub-Angular

COMMENTS

1. Quartz
   - 112 Moncrystalline
   - 2 Polycrystalline ||
   - 2 Microphanerite granitic ||
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary ________
   - Metaquartzite
   - Other Metamorphic ________

2. K-Feldspar
   - Microcline
   - 36 Orthoclase
   - Sanadine
   - 2 Microphanerite granitic ≤ M O ||
   - Volcanic Rock Fragment
   - Sedimentary ________
   - Metamorphic ________

3. Plagioclase
   - 4 Microphanerite granitic ||||
   - Volcanic Rock Fragment
   - 24 Sedimentary
   - Metamorphic ________

4. Volcanics 24

5. Microphanerites pyrite/granitic || 2

6. Accessory Minerals 2
   - Muscovite ||
   - Glauconite
   - Pyrite
   - Chlorite

7. Carbonate Cement 8
   - calcite ||||| |
   - dolomite ||

4 8. Matrix / ||||| |
20 Pseudomatrix
16 Clay-Altered Grains

9. Clay Cement 30
   - unidentified
   - Kaolinite

10. Intragranular Porosity
    - Quartz
    - K-Feldspar
    - Plagioclase

    VRF Q K P — PRF Q K P

11. Intergranular Porosity ||||| |||
    - Fractures ||
    - Fracture-induced dissolution ||
    - Oversize/elongate pores ||
    - Grain-edge dissolution ||||
    - Other ________

12. Other OM/HC ||||

COMMEMTS

*volcanic glass → zeolite
*OM sometimes found in clumps w/carbonates.
*chlorite present is from alteration from glauconite.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q ||	vrfQ	prfQ
K	vrfK	prfK
P ||	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 23
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
DEPTH: 9954

PROJECT: McKittrick CCS
ROCK NAME:
POINT COUNTS: 308

SORTING: Moderately

COMPACTION:

SIZE: .55 mm Coarse (mostly medium)

ANGULARITY: Sub-Angular

COMMENTS

1. Quartz
 - 102 Moncrystalline
 - 4 Polycrystalline
 - 6 Microphanerite granitic
 - Volcanic Rock Fragment
 - Quartz Arenite
 - Other Sedimentary ________
 - Metaquartzite
 - Other Metamorphic ________

2. K-Feldspar
 - 4 Microcline
 - 38 Orthoclase
 - Sanadine
 - 2 Microphanerite granitic < M / O
 - Volcanic Rock Fragment
 - Sedimentary ________
 - Metamorphic ________

3. Plagioclase
 - 6 Microphanerite granitic
 - Volcanic Rock Fragment
 - 19 Sedimentary
 - Metamorphic ________

4. Volcanics
 - 26

5. Microphanerites Biotite/granitic
 - 2

6. Accessory Minerals 10
 - Muscovite
 - Pyrite
 - Glauconite
 - Biotite
 - Chlorite

7. Carbonate Cement 8
 - Calcite

40 8. Matrix /
14 Pseudomatrix
12 Clay-Altered Grains

9. Clay Cement 4
 - ~~unknown~~
 - ~~greenish~~ greenish/chlorite
 - Kaolinite

* unknown → might be illite/smectite

10. Intragranular Porosity
 - Quartz
 - K-Feldspar
 - 2 Plagioclase

VRF Q K P

PRF Q K P

11. Intergranular Porosity
 - Fractures
 - Fracture-induced dissolution
 - Oversize/elongate pores
 - Grain-edge dissolution

Other ________

12. Other
 - Fossils
 - OM/HC
 - Phosphate

* Phosphate is mostly dissol[ved] and looks green.

COMMEMTS

*large green streak looks like chlorite along fracture, but it's isotropic???

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 24
PROJECT: McKittrick ccs
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
ROCK NAME:
DEPTH: 9959
POINT COUNTS: 302
SORTING: Moderate
COMPACTION:
SIZE: 0.35mm Medium
ANGULARITY: Sub-Angular

COMMENTS

1. Quartz
- 88 Moncrystalline
- Polycrystalline
- 2 Microphanerite granitic ll
- Volcanic Rock Fragment
- Quartz Arenite
- Other Sedimentary ________
- Metaquartzite
- Other Metamorphic ________

2. K-Feldspar
- 2 Microcline ll
- 28 Orthoclase
- Sanadine
- 6 Microphanerite granitic M / O
- Volcanic Rock Fragment
- Sedimentary ________
- Metamorphic ________

3. Plagioclase
- Microphanerite ________
- Volcanic Rock Fragment
- 16 Sedimentary
- Metamorphic ________

4. Volcanics 20

5. Microphanerites Pyrite ll
2

6. Accessory Minerals
- Glauconite
- Muscovite ll
- Chlorite
- tourmaline
- Pyrite

2

* tourmaline is imbedded in quartz

7. Carbonate Cement

68 8. Matrix /
24 Pseudomatrix
22 Clay-Altered Grains

9. Clay unidentified
8 Cement

10. Intragranular Porosity: Quartz, K-Feldspar, Plagioclase — VRF Q, K, P — PRF Q, K, P

11. Intergranular Porosity: Fractures; Fracture-induced dissolution ll; Oversize/elongate pores; Grain-edge dissolution; Other ________

12. Other
- HCOM
- Shale clast llll

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

____
____

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K.!

THIN SECTION: 26
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor @ McKittrick
DEPTH: 9987'

PROJECT: McKittrick CCS
ROCK NAME:
POINT COUNTS: 319

SORTING: Poorly Sorted
COMPACTION:

SIZE: .55mm Coarse (mostly medium)
ANGULARITY: Sub-Angular

COMMENTS

1. Quartz
   - 78 Moncrystalline
   - 12 Polycrystalline
   - 4 Microphanerite granitic IIII
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary ________
   - Metaquartzite
   - Other Metamorphic ________

2. K-Feldspar
   - Microcline
   - 24 Orthoclase
   - Sanadine
   - 4 Microphanerite granitic — M O IIII
   - Volcanic Rock Fragment
   - Sedimentary ________
   - Metamorphic ________

3. Plagioclase
   - 2 Microphanerite granitic II
   - Volcanic Rock Fragment
   - 20 Sedimentary
   - Metamorphic ________

34 4. Volcanics — * some is chert. *Many form pseudomatrix

5. Microphanerites ________

6. Accessory Minerals (4)
   - Muscovite II
   - Glauconite
   - Zircon
   - Biotite II
   - Pyrite

7. Carbonate (8)
   - Calcite
   - Cement

107 8. Matrix /
   - 8 Pseudomatrix
   - 2 Clay-Altered Grains II

9. Clay
   - unidentified II
   - 2 Cement

10. Intragranular Porosity
   - Quartz
   - K-Feldspar
   - Plagioclase

VRF Q K P — PRF Q K P

11. Intergranular Porosity
   - Fractures
   - Fracture-induced dissolution
   - Oversize/elongate pores
   - Grain-edge dissolution

Other ________

12. Other 10
   - OM|HC
   - ~~Car~~ Fossils
   - Phosphate

COMMEMTS

*Clay matrix is detrital
① Floating Framework grains

*glauconite pseudomatrix
*glauconite altering to chlorite

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K!

THIN SECTION: 27
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
ROCK NAME:
DEPTH: 7892' 516-8
POINT COUNTS: 302
SORTING: Moderately sorted
COMPACTION:
SIZE: 0.85mm
Coarse sand.
ANGULARITY:

COMMENTS

1. Quartz
- Moncrystalline [tally] — replacement by calcite (poly + mono).
- Polycrystalline [tally]
- Microphanerite
- Volcanic Rock Fragment [tally]
- Quartz Arenite
- Other Sedimentary
- Metaquartzite
- Other Metamorphic

2. K-Feldspar — some perthite
- Microcline [tally]
- Orthoclase [tally]
- Sanadine
- Microphanerite — M / O
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

3. Plagioclase
- Microphanerite [tally]
- Volcanic Rock Fragment [tally]
- Sedimentary [tally]
- Metamorphic

4. Volcanics [tally]

5. Microphanerites

6. Accessory Minerals
- glauconite
- muscovite [tally]
- pyrite [tally]

7. Carbonate Cement
- Calcite [tally]

8. Matrix / Pseudomatrix

Clay-Altered Grains

9. Clay Cement
- kaolinite [tally]

10. Intragranular Porosity
- Quartz
- K-Feldspar
- Plagioclase [tally]

VRF Q, K, P

PRF Q, K, P

11. Intergranular Porosity
- Fractures
- Fracture-induced dissolution
- Oversize/elongate pores
- Grain-edge dissolution [tally]

Other

12. Other
- organic matter [tally]

COMMEMTS

*Calcite cement keeps grains from dissolving, being replaced etc.

*Calcite → dissolution → kaolinite/pyrite precipitation.

*Replacement of Feldspar + quartz by calcite.

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q [tally]	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 28
PROJECT: McKittrick
FORMATION (AGE): Oligocene - Miocene
LOCATION: Temblor Formation
ROCK NAME:
DEPTH: 7897' T-10 516-8
POINT COUNTS: 304

SORTING: Poorly - Moderately
COMPACTION:

SIZE: 2.65mm
ANGULARITY: Sub - Angular

Granule (Mostly very coarse).

COMMENTS

1. Quartz
   - 98 Moncrystalline
   - 8 Polycrystalline
   - 2 Microphanerite ___
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary ________
   - Metaquartzite
   - Other Metamorphic ________

2. K-Feldspar
   - 1 Microcline
   - 41 Orthoclase
   - Sanadine
   - Microphanerite ________ M / O
   - 3 Volcanic Rock Fragment
   - Sedimentary ________
   - Metamorphic ________

3. Plagioclase
   - 1 Microphanerite ___ · being replaced by calcite.
   - 1 Volcanic Rock Fragment
   - 25 Sedimentary
   - Metamorphic ________

4. Volcanics 3

5. Microphanerites ________

6. Accessory Minerals
   - Pyrite
   - Zircon
   - 2 Biotite

7. Carbonate Cement 98 Calcite
   - · poikilotopic
   - · replaces grains.
   - · fossils

8. Matrix /
   - 3 Pseudomatrix
   - 1 Clay-Altered Grains 1
   - VRF 1 ______ → pseudomatrix
   - VRF ______ → clay altered grai

9. Clay Cement 4 Kaolinite

10. Intragranular Porosity
    - Quartz
    - K-Feldspar
    - 3 Plagioclase
    - VRF Q / K / P
    - PRF Q / K / P

11. Intergranular Porosity 1
    - Fractures
    - Fracture-induced dissolution
    - Oversize/elongate pores
    - Grain-edge dissolution
    - Other ________

12. Other
    - 4 Shale Clast
    - 2 Phosphate
    - 3 Hydro Carbon

COMMEMTS

* Lots of fossils → precipitated out to form cement.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

1. Calcite filling pores. (dissolution + replacement of grains).
2. Grains dissolving
3. Dissolved porosity filled w/ kaolinite.

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K!

THIN SECTION: 30
FORMATION (AGE): Oligocene - Miocene
LOCATION: Temblor
DEPTH: 7897 - 7943 T-6 516-8

PROJECT: McKittrick

ROCK NAME:
POINT COUNTS: 301

SORTING: Poorly Sorted

COMPACTION:

SIZE: > Very Coarse grained (Almost ~3mm = granule).

ANGULARITY: Sub-Round.

COMMENTS

1. Quartz
   - Moncrystalline ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| |||||
   - Polycrystalline ||
   - Microphanerite
   - Volcanic Rock Fragment |
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline ||||
   - Orthoclase ||||| ||||| ||||| |||||
   - Sanadine
   - Microphanerite ≤ M O
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment ||||
   - Sedimentary ||||| |||||
   - Metamorphic

4. Volcanics

5. Microphanerites

6. Accessory Minerals
   - Hornblend
   - MUSCOVITE |
   - Zircon

7. Carbonate Cement
   - Calcite ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| |
   - · some large smooth areas with 'X' patterns. other 'crumbly' looking bits.

8. Matrix / Pseudomatrix

Clay-Altered Grains

9. Clay Cement

10. Intragranular Porosity
   - Quartz
   - K-Feldspar
   - Plagioclase |
   - VRF Q K P
   - PRF Q K P

11. Intergranular Porosity |||||
   - Fractures
   - Fracture-induced dissolution |||
   - Oversize/elongate pores |
   - Grain-edge dissolution
   - Other

12. Other
   - Plagioclase replaced by calcite |
   - Shale Clast ||||

COMMEMTS

· Lots of Floating grains + poikilotopic calcite cement.
· grain edge dissolution
· much of the calcite is replacing old grains. → can't identify.

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K |	vrfK	prfK
P ||	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K.

THIN SECTION: 31
PROJECT: McKittrick
FORMATION (AGE): Oligocene - Miocene
LOCATION: ~~McKittrick~~ Temblor
ROCK NAME:
DEPTH: 7943 - 7961 T-2
516-8
POINT COUNTS: 316
SORTING: Poorly Sorted (tons of little Fragments).
COMPACTION:
SIZE:
ANGULARITY:

COMMENTS

1. Quartz
   - Moncrystalline [tally marks]
   - Polycrystalline [tally marks] 81
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

   • one grain looks metamorp polycrystalline.

2. K-Feldspar
   - Microcline [tally marks]
   - Orthoclase [tally marks]
   - Sanadine
   - Microphanerite M / O
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

   • some of the microcline has perthitic texture.

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary [tally marks]
   - Metamorphic

4. Volcanics 1

5. Microphanerites PYRITE 1 → as volcanic

6. Accessory Minerals Rutile

7. Carbonate Cement
   - CALCITE [tally marks]
   - DOLOMITE 1

8. Matrix / Pseudomatrix — RF.
   - Illite/Smectite 1
   - Pseudomatrix II
   - Clay-Altered Grains — volcanics?

9. Clay Cement
   - KAOLINITE [tally marks]
   - ILLITE/SMECTITE II

   • sometimes ~~overgrowth~~ coatin on grain.

10. Intragranular Porosity
    - Quartz
    - K-Feldspar II
    - Plagioclase II
    - VRF Q K P
    - PRF Q K P

11. Intergranular Porosity [tally marks]
    - Fractures [tally marks]
    - Fracture-induced dissolution II
    - Oversize/elongate pores [tally marks]
    - Grain-edge dissolution II
    - Other

12. Other
    - ORGANIC MATTER [tally marks]
    - SHALE CLAST III
    - CARBONATE CLAST III

COMMEMTS

• Lots of tiny Fragments → mechanical rearrangements.
• Some kaolinite Filling pore spaces.
• Perthitic Microcline.
• Perthite
• grains + microphanerites w/plag + microcline.

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q 1	vrfQ	prfQ
K 1	vrfK	prfK
P 1	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q 1	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 32
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor Formation
ROCK NAME:
DEPTH: 7943 - 7961 T-3 516-8
POINT COUNTS: 301
SORTING: Poorly Sorted.
COMPACTION:
SIZE: Very coarse (1.1cm = largest).
ANGULARITY: Angular.

COMMENTS

1. Quartz
   - Moncrystalline ~~~~
   - Polycrystalline ~~~~
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

   • many dissolving along grain edge.
   • many fractures.

2. K-Feldspar
   - Microcline ~~~~
   - Orthoclase ~~~~ ~~~~ ~~~~ ~~~~ ~~~~ ~~~~ ~~~~ ~~~~ IIII
   - Sanadine
   - Microphanerite ∠ M I, O
   - Volcanic Rock Fragment ~~~~ II
   - Sedimentary
   - Metamorphic
   - Perthite III orthoclase

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary ~~~~ ~~~~ ~~~~ ~~~~
   - Metamorphic
   - Partially dissolving I

4. Volcanics II

5. Microphanerites

6. Accessory Minerals
   - Biotite
   - MUSCOVITE I
   - Pyrite I

7. Carbonate Cement

8. Matrix / Pseudomatrix
   - Clay-Altered Grains

9. Clay Cement
   - KAOLINITE ~~~~ ~~~~ ~~~~ I

   • mixed w/ biotite and pieces of pyrite as seen in SEM

10. Intragranular Porosity
   - Quartz
   - K-Feldspar
   - Plagioclase I

   VRF Q, K, P — PRF Q, K, P

11. Intergranular Porosity ~~~~ ~~~~ ~~~~ ~~~~ ~~~~ ~~~~ II
   - Fractures III
   - Fracture-induced dissolution ~~~~ IIII
   - Oversize/elongate pores ~~~~ ~~~~ ~~~~ ~~~~ ~~~~ ~~~~ IIII
   - Grain-edge dissolution ~~~~ ~~~~
   - Pore w/ kaolinite II
   - Other

   • one k-spar = microcline

12. Other
   - Phosphate I
   - Calcite Clast Fossil I
   - Carbonate clast II
   - grain Fragments in pore space I

COMMEMTS

More quartz. less calcite allows for more dissolution and precip of kaolinite. of Feldspars.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q III	vrfQ	prfQ
K III	vrfK	prfK
P II	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q IIII	vrfQ	prfQ
K II	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

• dissolution → sometimes kaolinite fills pores and rarely pyrite but sometimes

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K.

THIN SECTION: 33
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
DEPTH: 7963 - 8015 T-12 516-8

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: 303

SORTING: Moderately sorted - well
COMPACTION:

SIZE: 0.6mm Coarse sand.
ANGULARITY: Sub-angular

COMMENTS

1. Quartz
   - Moncrystalline ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ |||
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline ~~||||~~
   - Orthoclase ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ||||
   - Sanadine
   - Microphanerite M / O
   - Volcanic Rock Fragment |
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~
   - Metamorphic

   •many/most are undergoing dissolution - many w/twinning still.

4. Volcanics ~~||||~~ ~~||||~~ |

5. Microphanerites

6. Accessory Minerals
   - Biotite
   - Pyrite ~~||||~~
   - muscovite ||||
   - hornblenel
   - Chlorite |
   - Phosphate
   - ~~Horn~~
   - glauconite
   - Biotite on Pyrite ||

7. Carbonate Cement
   - Dolomite ~~||||~~
   - Calcite ~~||||~~ |

8. Matrix / |||
   Pseudomatrix ~~||||~~ ~~||||~~ ~~||||~~
   Clay-Altered Grains ~~||||~~ ||||

9. Clay Cement
   - Kaolinite ~~||||~~ ||||
   - illite/smectite ~~||||~~
   - unidentified ||||
   - phosphate/clay |

10. Intragranular Porosity
    - Quartz
    - K-Feldspar ||
    - Plagioclase ~~||||~~ ||||
    - Fossils |
    - VRF Q K P
    - PRF Q K P

11. Intergranular Porosity ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ||
    - Fractures ||
    - Fracture-induced dissolution ~~||||~~ ||
    - Oversize/elongate pores ~~||||~~ ~~||||~~ ||
    - Grain-edge dissolution ~~||||~~ |
    - Other

12. Other
    - Carbonate Clast ||||
    - Shale Clast
    - Fossils
    - Organic Matter ||

COMMEMTS

•Phosphate surrounded by kaolinite/chlorite.
•A lot of clay rims and overgrowths.
-areas sprinkled w/small dolomite crystals.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K |	vrfK	prfK
P |	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q ||||	vrfQ	prfQ
K	vrfK	prfK
P ||	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K!

THIN SECTION: 34
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
ROCK NAME:
DEPTH: 7963-8015 T-13 516-8
POINT COUNTS: 307

SORTING: Moderately sorted
COMPACTION:

SIZE: 0.6mm Coarse Sand
ANGULARITY: Sub-angular

COMMENTS

1. Quartz
   - Moncrystalline ||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline ||||
   - Orthoclase ||||||||||||||||||||||||||||||
   - Sanadine
   - Microphanerite — M / O
   - Volcanic Rock Fragment ||||
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary |||||||||||||||
   - Metamorphic

4. Volcanics ||||||||||||

5. Microphanerites

6. Accessory Minerals
   - Muscovite
   - Pyrite |||

7. Carbonate Cement
   - Calcite ||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

8. Matrix / | Pseudomatrix ||||

Clay-Altered Grains

9. Clay Cement
   - Kaolinite ||||||||||||||
   - unidentified ||||

10. Intragranular Porosity |
    - Quartz
    - K-Feldspar
    - Plagioclase |||
    - Fossil |
    - VRF Q K P
    - PRF Q K P

11. Intergranular Porosity ||||||||
    - Fractures |
    - Fracture-induced dissolution |
    - Oversize/elongate pores ||
    - Grain-edge dissolution |
    - Other

12. Other
    - Fossil Carbonate |
    - Phosphate |||
    - Organic Matter ||||

· lots of round phosphate grains

COMMEMTS

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q |	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q |	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K.

THIN SECTION: 35
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor Formation
DEPTH: 7963 - 8015 T-2
SORTING: Moderately Sorted
SIZE: 0.45mm medium grained

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: 300
COMPACTION:
ANGULARITY: Sub-Angular

COMMENTS

1. Quartz 96
   - Moncrystalline ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ||
   - Polycrystalline ||||
   - Microphanerite 1
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar 32
   - Microcline
   - Orthoclase ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ||
   - Sanadine
   - Microphanerite M / O 1
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. Plagioclase 13
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary ~~||||~~ ~~||||~~ |||
   - Metamorphic

4. Volcanics ~~||||~~ ~~||||~~

5. Microphanerites

6. Accessory Minerals
   - MUSCOVITE ||
   - BIOTITE
   - PYRITE ~~||||~~ |||
   - Biotite ⇔ Pyrite |||
   - OM ⇔ Pyrite |
   - glauconite |
   - Chlorite |

7. Carbonate Cement
   - Calcite |
   - Dolomite |

8. Matrix / Pseudomatrix ~~||||~~ ~~||||~~

Clay-Altered Grains ~~||||~~ ~~||||~~ |

9. Clay Cement 38
   - KAOLINITE ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ |||
   - Chlorite

10. Intragranular Porosity
    - Quartz
    - K-Feldspar |
    - Plagioclase |||

VRF Q K P | PRF Q K P

11. Intergranular Porosity ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ||||
    - Fractures |||
    - Fracture-induced dissolution |
    - Oversize/elongate pores ~~||||~~ ~~||||~~ ~~||||~~ |
    - Grain-edge dissolution ~~||||~~ ~~||||~~
    - Other

12. Other
    - Shale Clasts |
    - FOSSILS
    - Carbonate Clast ||

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K |	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q ~~||||~~	vrfQ	prfQ
K |	vrfK	prfK
P ||	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 36
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
ROCK NAME:
DEPTH: 7963-8015 T-4 516-8
POINT COUNTS: 300

SORTING: Moderate-Well
COMPACTION:

SIZE: .95 mm
Coarse Grained
ANGULARITY: Sub-angular

COMMENTS

1. Quartz
   - Moncrystalline
   - Polycrystalline
   - Microphanerite ________
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary ________
   - Metaquartzite
   - Other Metamorphic ________

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanadine
   - Microphanerite ________ M / O
   - Volcanic Rock Fragment
   - Sedimentary ________
   - Metamorphic ________

3. Plagioclase
   - Microphanerite ________
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic ________

4. Volcanics

5. Microphanerites ________

6. Accessory Minerals
   - Muscovite
   - Biotite
   - Glauconite
   - Chlorite
   - Pyrite
   - Garnet
   - Zircon

7. Carbonate Cement
   - Dolomite
   - Calcite

8. Matrix / Pseudomatrix
   - Clay-Altered Grains

9. Clay Cement
   - Kaolinite
   - Unidentified

*unidentified looks greenish possibly clay altered grains.

10. Intragranular Porosity
    - Quartz
    - K-Feldspar
    - Plagioclase
    - VRF Q K P
    - PRF Q K P

11. Intergranular Porosity
    - Fractures
    - Fracture-induced dissolution
    - Oversize/elongate pores
    - Grain-edge dissolution
    - Other ________

12. Other
    - Shale Clast
    - Phosphate
    - Organic matter.

COMMEMTS

*Some random layers of matrix
-probably due to bioturbation.
-the matrix contains dolomite rhombs.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K!

THIN SECTION: 37
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
DEPTH: ~~[illegible]~~ 8015-8064 T-2 516-8
SORTING: Well sorted
SIZE: 0.5mm medium

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: 300
COMPACTION:
ANGULARITY: Sub-angular

COMMENTS

1. Quartz
   - Moncrystalline ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| |||
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline ||
   - Orthoclase ||||| ||||| ||||| ||||| |||
   - Sanadine
   - Microphanerite M O
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment ||||
   - Sedimentary ||||| |||||
   - Metamorphic

4. Volcanics ||||| ||||| ||||| |

5. Microphanerites

6. Accessory Minerals
   - Muscovite ||
   - Glauconite |||
   - Pyrite ||||
   - Biotite ||

7. Carbonate Cement
   - Dolomite ||||| ||||| ||||
   - Calcite

   *dolomite within matrix/organic matter.
   *calcite as clasts

8. Matrix / Pseudomatrix ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| |
   Clay-Altered Grains ||

9. Clay Cement
   - Kaolinite ||||| |||
   - unidentified ||||| ||||| ||||| ||||| ||||| |||||

10. Intragranular Porosity
    - Quartz
    - K-Feldspar ||||
    - Plagioclase ||||| ||||| ||||| |||
    - Fossils

    VRF Q K P — PRF Q K P

11. Intergranular Porosity ||||| |||||
    - Fractures ||||
    - Fracture-induced dissolution
    - Oversize/elongate pores ||||
    - Grain-edge dissolution ||||
    - Other

12. Other
    - Shale Clasts ||||
    - Organic Matter ||||| |||||
    - Phosphate ||||| ||

    *shale clast might be phosphate.

COMMEMTS

*Lots of matrix and organic matter

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q |||	vrfQ	prfQ
K	vrfK	prfK
P ||	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

6it

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K.

THIN SECTION: 38
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
DEPTH: 8085 T-8 516-8

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: 116

SORTING: Well sorted (moderately)
COMPACTION:

SIZE: 0.85 Coarse sand
ANGULARITY: Sub-angular

COMMENTS

1. Quartz
- Moncrystalline ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| |
- Polycrystalline ||||| ||
- Microphanerite ________
- Volcanic Rock Fragment |
- Quartz Arenite
- Other Sedimentary ________
- Metaquartzite
- Other Metamorphic ________

2. K-Feldspar
- Microcline ||||
- Orthoclase ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||
- Sanadine
- Microphanerite ________ ≤ M O
- Volcanic Rock Fragment |
- Sedimentary ________
- Metamorphic ________

3. Plagioclase
- Microphanerite |
- Volcanic Rock Fragment
- Sedimentary ||||| ||||| ||||| ||||||||
- Metamorphic ________

4. Volcanics ||||| |||||

5. Microphanerites ________

6. Accessory Minerals
- Biotite
- Glauconite
- MUSCOVITE |
- Zircon
- Hornblend
- Chlorite |
- Pyrite |||

* Alteration of biotite to chlorite. Remnant pyrite helps identify this.

7. Carbonate Cement
- Dolomite |||
- Calcite ||

8. Matrix / Pseudomatrix ||||| ||||||
.......Clay-Altered Grains... |

9. Clay Cement
- Kaolinite ||||| ||||| ||||| ||||| ||||| ||||| ||||

pseudomatrix / illite/smectite ? SEM!

10. Intragranular Porosity
- Quartz |
- K-Feldspar ||||
- Plagioclase ||||| |||||||
- VRF Q K P
- PRF Q K P

11. Intergranular Porosity ||||| ||||| ||||| ||||| ||||
- Fractures ||||
- Fracture-induced dissolution ||||
- Oversize/elongate pores ||||| ||||||
- Grain-edge dissolution ||||
- Other ________

12. Other
- Carbonate Clast / Fossil
- organic matter |

Q

COMMEMTS

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q |	vrfQ	prfQ
K	vrfK	prfK
P |||	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q |	vrfQ	prfQ
K	vrfK	prfK
P ||||	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K!

THIN SECTION: 39
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
DEPTH: 8088 T-19 516-8

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: 300

SORTING: ~~Poorly~~ - Moderately
COMPACTION:

SIZE: 1.05 mm
Very Coarse Sand
ANGULARITY: Sub-Angular

COMMENTS

1. Quartz
   - Moncrystalline 卌 III
   - Polycrystalline 卌 II
   - Microphanerite ________
   - Volcanic Rock Fragment 9
   - Quartz Arenite
   - Other Sedimentary ________
   - Metaquartzite
   - Other Metamorphic ________

2. K-Feldspar
   - Microcline IIII
   - Orthoclase 卌 卌 卌 卌 卌 卌 卌 卌 — Perthite II
   - Sanadine
   - Microphanerite ________ ≤ M O
   - Volcanic Rock Fragment III
   - Sedimentary ________
   - Metamorphic ________

3. Plagioclase
   - Microphanerite ________
   - Volcanic Rock Fragment III
   - Sedimentary 卌 卌 卌 卌
   - Metamorphic ________

4. Volcanics 卌 卌 卌 卌

5. Microphanerites ________

6. Accessory Minerals
   - Pyrite
   - Muscovite
   - Biotite
   - hornblende
   - Glauconite
   - Chlorite
   - Zircon

7. Carbonate Cement
   - Calcite III
   - Dolomite I

8. Matrix / Pseudomatrix 卌 卌
   - Clay-Altered Grains I

9. Clay Cement
   - ~~Cat~~ Kaolinite 卌 卌 IIII
   - unidentified III
   - Chlorite I

10. Intragranular Porosity
   - Quartz I
   - K-Feldspar IIII
   - Plagioclase IIII
   - VRF Q K P
   - PRF Q K P

11. Intergranular Porosity 卌 卌 卌 卌 II
   - Fractures III
   - Fracture-induced dissolution III
   - Oversize/elongate pores 卌 卌 卌 卌
   - Grain-edge dissolution III
   - Other ________

12. Other
   - Shale clast II
   - organic matter

COMMEMTS

* many oversized pores

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q I	vrfQ	prfQ
K I	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q II	vrfQ	prfQ
K	vrfK	prfK
P I	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K.

THIN SECTION: 40
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor Formation
DEPTH: 8088 - 8139 T-11

PROJECT: McKittrick

ROCK NAME:
POINT COUNTS: 304

SORTING: Well sorted

COMPACTION:

SIZE: 0.85mm
Coarse sand

ANGULARITY: Sub-Angular

COMMENTS

1. Quartz
   - Moncrystalline ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| |||||
   - Polycrystalline |||||
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline |||||
   - Orthoclase ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||
   - Sanadine
   - Microphanerite — M / O
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

· clay alteration - organic matter.
· one perthite grain

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary ||||| ||||| ||||| |||||

   - Metamorphic

4. Volcanics ||||| |||||

5. Microphanerites

6. Accessory Minerals
   - MUSCOVITE |
   - GLAUCONITE
   - Pyrite ||
   - Chlorite |
   - Hornblende
   - Pyrite/OM ||
   - Garnet
   - Sphene
   - Zircon
   - Biotite |

7. Carbonate Cement
   - Dolomite |
   - Calcite ||||| ||||

8. Matrix / ||
   Pseudomatrix ||||| |||||||
   Clay-Altered Grains ||

9. Clay Cement
   - Kaolinite ||||| ||||
   - ~~[illegible]~~ illite/smectite |||||||
   - unidentified ||||| ||||| ||||
   - Chlorite ||

* as grains mostly

10. Intragranular Porosity
    - Quartz
    - K-Feldspar |||||||
    - Plagioclase ||||| ||||| |||

    VRF Q, K, P — PRF Q, K, P

11. Intergranular Porosity ||||| ||||| ||||| ||||| ||||| ||||| |||
    - Fractures ||
    - Fracture-induced dissolution ||||||
    - Oversize/elongate pores ||
    - Grain-edge dissolution |
    - Other

12. Other
    - Carbonate Clast
    - Fossil Carbonate |
    - Organic Matter ||||| |||
    - Shale Clast |
    - Phosphate

COMMEMTS

~~Hots~~
* One/two major matrix rich bands.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K |||	vrfK	prfK
P |||	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P		vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K!

THIN SECTION: 41
FORMATION (AGE): Oligocene - Miocene
LOCATION: Temblor
DEPTH: 8088 - 8139 T-3 516-8
SORTING: Moderately sorted
SIZE: 0.85mm
Coarse Sand

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: 302
COMPACTION:
ANGULARITY: Sub-Round → sub-angular

COMMENTS

1. Quartz
- Moncrystalline
- Polycrystalline
- Microphanerite
- Volcanic Rock Fragment
- Quartz Arenite
- Other Sedimentary
- Metaquartzite
- Other Metamorphic

2. K-Feldspar · VRFs contain pyrite generally
- Microcline
- Orthoclase
- Sanadine
- Microphanerite — M / O
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

3. Plagioclase · VRFs contain pyrite generally.
- Microphanerite
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

4. Volcanics

5. Microphanerites

6. Accessory Minerals
- MUSCOVITE
- BIOTITE
- HORNBLENDE
- PYRITE
- ZIRCON
- GLAUCONITE

7. Carbonate Cement
- Calcite

8. Matrix / Pseudomatrix

Clay-Altered Grains

9. Clay Cement
- KAOLINITE

10. Intragranular Porosity
- Quartz
- K-Feldspar
- Plagioclase
- FOSSIL

VRF Q, K, P

PRF Q, K, P

11. Intergranular Porosity
- Fractures
- Fracture-induced dissolution
- Oversize/elongate pores
- Grain-edge dissolution
- Other

12. Other
- PHOSPHATE
- SHALE CLAST
- ORGANIC MATTER

*phosphat w/chbrite/glauconite/pyrit mixture oftentimes.

COMMEMTS

*unlike other samples in that there is very little clay alteration, matrix, pseudomatrix or clay/cement. The carbonates present are random, like clasts, but they still fill pore space like precipitated cement.
*More Feldspars than other samples too. probably due to less alteration.

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa

THIN SECTION: 42
PROJECT: McKittrick
FORMATION (AGE): Oligocene - Miocene
LOCATION: Temblor Formation
ROCK NAME:
DEPTH: 8155 T-11 516-8
POINT COUNTS: 303

SORTING: ~~Moderately~~ - Well sorted.
COMPACTION:

SIZE: Medium grained (~ .4mm greatest)
ANGULARITY: Angular

COMMENTS

1. Quartz
   - Moncrystalline 𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸 I
   - Polycrystalline II
   - Microphanerite ~~[illegible]~~ igneous II
   - Volcanic Rock Fragment III
   - Quartz Arenite
   - Other Sedimentary ________
   - Metaquartzite
   - Other Metamorphic ________

2. K-Feldspar — • many w/ dissolution
   - Microcline I
   - Orthoclase 𝍸𝍸𝍸𝍸 IIII
   - Sanadine
   - Microphanerite ________ M / O
   - Volcanic Rock Fragment 𝍸
   - Sedimentary ____ [illegible]
   - Metamorphic ________

3. Plagioclase — • many w/ dissolution.
   - Microphanerite igneous I
   - Volcanic Rock Fragment I
   - Sedimentary 𝍸𝍸 IIII
   - Metamorphic ________

4. Volcanics 𝍸𝍸𝍸

5. Microphanerites ________

6. Accessory Minerals
   - Glauconite
   - Muscovite I
   - Pyrite 𝍸 IIII
   - Biotite I
   - Chlorite III

7. Carbonate Cement ________

8. Matrix / Pseudomatrix 𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸 / 𝍸𝍸𝍸 II — • matrix is littered w/ pyrite and grain fragments.
   - Clay-Altered Grains 𝍸

9. Clay Cement — • sometimes chlorite is squashed (or precip.) between pores, sometimes as clast.
   - Kaolinite 𝍸𝍸 IIII
   - Illite/Smectite III
   - Chlorite I

10. Intragranular Porosity
    - Quartz II
    - K-Feldspar II
    - Plagioclase 𝍸 IIII
    - VRF Q K P
    - PRF Q K P

11. Intergranular Porosity 𝍸𝍸𝍸
    - Fractures ~~[illegible]~~ III
    - Fracture-induced dissolution III
    - Oversize/elongate pores 𝍸
    - Grain-edge dissolution 𝍸 II
    - Other ________

12. Other
    - Carbonate Clast IIII → fossil pieces.
    - organic matter 𝍸
    - fossil fragments.
    - Shale clast II

sometimes difficult to distinguish between chlorite + kaolinite.

COMMEMTS

• Some biotite altering to pyrite.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P III	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q I	vrfQ	prfQ
K I	vrfK	prfK
P III	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

____
____

PARAGENESIS

not authigenic.
• clay first → likely deposition
• dissolution 2nd
• kaolinite secondary as cement.
• chlorite secondary as cement.
• abundant glauconite grains.

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K.

THIN SECTION: 43
FORMATION (AGE): 8155 T-9 516-8 Oligocene/Miocene
PROJECT: McKittrick
LOCATION: Temblor
ROCK NAME:
DEPTH: 8155 T-9 516-8
POINT COUNTS: 307
SORTING: Moderately
COMPACTION:
SIZE: 0.6mm (most is smaller tho) Coarse Sand.
ANGULARITY: Sub-angular

COMMENTS

1. Quartz
   - Moncrystalline ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| |||||||||
   - Polycrystalline ||
   - Microphanerite ||
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase ||||| ||||| ||||| ||||| ||||| ||||| ||
   - Sanadine
   - Microphanerite — M / O
   - Volcanic Rock Fragment ||||
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary ||||| ||||| ||
   - Metamorphic

4. Volcanics ||||| ||||| ||

5. Microphanerites

6. Accessory Minerals
   - MUSCOVITE ||
   - PYRITE ||||| |
   - BIOTITE ||
   - GLAUCONITE ||
   - SPHENE
   - CHLORITE
   - OM/Pyrite |
   - HORNBLENDE

7. Carbonate Cement
   - DOLOMITE ||||| |||||

8. Matrix / ||||| ||||| ||||| ||||| ||||| ||||| ||
   Pseudomatrix ||||| ||||| ||||| ||||| ||||| |
   Clay-Altered Grains ||

9. Clay Cement
   - KAOLINITE ||||| ||||| ||||| |
   - UNIDENTIFIED ||||| ||||| ||||| |||||

10. Intragranular Porosity
    - Quartz
    - K-Feldspar ||
    - Plagioclase ||||| ||||| ||||| |
    - VRF Q / K / P
    - PRF Q / K / P

11. Intergranular Porosity ||||| |||
    - Fractures ||
    - Fracture-induced dissolution ||||| |||
    - Oversize/elongate pores
    - Grain-edge dissolution ||||
    - Other

12. Other
    - PHOSPHATE
    - ORGANIC MATTER ||||| |||||

COMMEMTS

- Clay matrix everywhere full of carbonate (dolomite or ankerite).
- Lots of plagioclase dissolution.
- Matrix/pseudomatrix sometimes unclear.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q |	vrfQ	prfQ
K ||	vrfK	prfK
P |||	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K ||	vrfK	prfK
P ||	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K!

THIN SECTION: 8944
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
DEPTH: 8155 T-2

PROJECT: McKittrick

ROCK NAME:
POINT COUNTS: 301

SORTING: Well sorted
COMPACTION:

SIZE: 0.7mm Coarse Sand.
ANGULARITY: Sub-angular

COMMENTS

1. Quartz
   - Moncrystalline
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment ||
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline ||
   - Orthoclase
   - Sanadine
   - Microphanerite ≤ M O
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

4. Volcanics

5. Microphanerites

6. Accessory Minerals
   - BIOTITE |
   - PYRITE ||||
   - MUSCOVITE |
   - CHLORITE |
   - (83,24) → HORNBLENDE
   - Pyrite/OM
   - glauconite |

7. Carbonate Cement
   - Calcite |
   - Dolomite |

8. Matrix / | Pseudomatrix
   - Clay-Altered Grains

9. Clay Cement
   - KAOLINITE
   - Illite/SMECTITE
   - Unidentified

10. Intragranular Porosity
    - Quartz |
    - K-Feldspar |||
    - Plagioclase
    - VRF Q K P
    - PRF Q K P

11. Intergranular Porosity
    - Fractures ||||
    - Fracture-induced dissolution
    - Oversize/elongate pores
    - Grain-edge dissolution |
    - Other

12. Other
    - Shale Clast
    - Phosphate
    - Carbonate Clast |||
    - Fossil Carbonate |
    - Organic Matter |||

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q |	vrfQ	prfQ
K ||	vrfK	prfK
P |	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P |	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K.

THIN SECTION: 45
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor Form.
DEPTH: 8204 T-11 516-8
SORTING: ~~Moderate~~ → WELL
SIZE: 0.45
Medium grained.

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: 300
COMPACTION:
ANGULARITY: Sub-angular

COMMENTS

1. Quartz
   - Moncrystalline 𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸 |
   - Polycrystalline
   - Microphanerite ||
   - Volcanic Rock Fragment ||
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar — · some albitization present.
   - Microcline
   - Orthoclase 𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸 |
   - Sanadine
   - Microphanerite — M, O ||
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary 𝍸𝍸𝍸𝍸 |
   - Metamorphic

4. Volcanics 𝍸𝍸 ||||

5. Microphanerites

6. Accessory Minerals
   - ~~BIOTITE~~
   - MUSCOVITE ||
   - ~~PYRITE~~
   - ~~GLAUCONITE~~
   - SPHENE |||
   - ~~HORNBLENDE~~
   - ~~HEMATITE~~

7. Carbonate Cement
   - ~~DOLOMITE~~
   - CALCITE ||||

8. Matrix / 𝍸𝍸 ||
   Pseudomatrix 𝍸𝍸 |||
   Clay-Altered Grains. 𝍸 |

9. Clay Cement — *unidentified often times greenish/brown
   - UNIDENTIFIED 𝍸𝍸𝍸𝍸 ||
   - Kaolinite 𝍸𝍸𝍸 |||
   - Chlorite 𝍸 |

10. Intragranular Porosity
    - Quartz ||
    - K-Feldspar 𝍸 |
    - Plagioclase ||
    - FOSSIL
    - VRF Q K P
    - PRF Q K P

11. Intergranular Porosity
    - ~~PRIMARY~~
    - ~~SECONDARY~~ 𝍸𝍸
    - Fractures 𝍸 |||
    - Fracture-induced dissolution ||
    - Oversize/elongate pores ||
    - Grain-edge dissolution 𝍸 |
    - Other

12. Other
    - FOSSIL
    - ORGANIC MATTER 𝍸 ||||
    - PHOSPHATE

COMMEMTS

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K |	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K |	vrfK	prfK
P ||	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K!

THIN SECTION: 46
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
DEPTH: 8561 T-11 516-8

PROJECT: McKittrick

ROCK NAME:
POINT COUNTS: 298

SORTING: Moderately - Poorly
COMPACTION:

SIZE: 0.9mm Coarse Sand
ANGULARITY: Angular

COMMENTS

1. Quartz
   - Moncrystalline
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanadine
   - Microphanerite — M / O
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

4. Volcanics

5. Microphanerites

6. Accessory Minerals
   - PYRITE
   - HORNBLENDE
   - MUSCOVITE
   - ZIRCON

7. Carbonate Cement
   - CALCITE

8. Matrix / Pseudomatrix

Clay-Altered Grains

9. Clay Cement
   - KAOLINITE
   - UNIDENTIFIED

10. Intragranular Porosity
    - Quartz
    - K-Feldspar
    - Plagioclase

VRF Q K P — PRF Q K P

11. Intergranular Porosity
    - Fractures
    - Fracture-induced dissolution
    - Oversize/elongate pores
    - Grain-edge dissolution
    - Other

12. Other
    - Phosphate/Glauconite/Chlorite
    - ORGANIC MATTER
    - PHOSPHATE
    - SHALE CLAST

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K.

THIN SECTION: 47
FORMATION (AGE): Oligocene - Miocene
LOCATION: McKittrick
DEPTH: 8561 T-9 516-8

PROJECT: McKittrick.
ROCK NAME:
POINT COUNTS: 297

SORTING: Poorly - Moderately.
(.95mm = largest)
SIZE: Coarse Sand

COMPACTION:
ANGULARITY: Angular

COMMENTS

1. Quartz 135
   - 135 Moncrystalline
   - 1 Polycrystalline I
   - Microphanerite
   - 1 Volcanic Rock Fragment I
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

III
· more grain edge dissolution than @ shallower depths → likely due to less Feldspar

2. K-Feldspar
   - Microcline
   - 36 Orthoclase
   - 2 Sanadine — M I, O I
   - Microphanerite
   - 1 Volcanic Rock Fragment I
   - Sedimentary
   - Metamorphic
   - 1 Perthite I

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - 11 Sedimentary
   - Metamorphic
   - ~~Perthite~~

6 4. Volcanics

5. Microphanerites

4 6. Accessory Minerals
   - PYRITE III
   - MUSCOVITE
   - Biotite → Pyrite I

1 7. Carbonate Cement
   - Calcite I
   - Dolomite

19 8. Matrix / Pseudomatrix
Clay-Altered Grains

· pseudomatrix includes tiny fragments I can't identify. and volcanics that have been squished.

20 9. Clay Cement
   - Chlorite
   - kaolinite

9 10. Intragranular Porosity
   - Quartz I
   - K-Feldspar III
   - Plagioclase IIII
   - Dolomite I

VRF Q K P — PRF Q K P

11. Intergranular Porosity
   - Fractures I
   - Fracture-induced dissolution
   - Oversize/elongate pores
   - Grain-edge dissolution
   - Other

12. Other
   - Carbonate Clasts

COMMEMTS

· lots of Fractures and pieces moved to fill pore space.
· Individual dolomite Rohmbs.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q II	vrfQ	prfQ
K II	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q I	vrfQ	prfQ
K III	vrfK	prfK
P II	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P I	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K.

THIN SECTION: 48
FORMATION (AGE): Oligocene-Miocene
LOCATION: McKittrick
DEPTH: 9938

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: 301

SORTING: Well sorted.
COMPACTION: Surrounded by clay + dolomite

SIZE: 0.65 (largest grain -> coarse) Mostly medium
ANGULARITY: Sub-Angular

COMMENTS

1. Quartz
- 88 Moncrystalline
- 4 Polycrystalline
- 2 Microphanerite
- Volcanic Rock Fragment
- Quartz Arenite
- Other Sedimentary
- Metaquartzite
- Other Metamorphic

2. K-Feldspar
- 6 Microcline
- 28 Orthoclase
- Sanadine
- Microphanerite M / O
- 2 Volcanic Rock Fragment
- Sedimentary
- Metamorphic

3. Plagioclase
- 2 Microphanerite
- Volcanic Rock Fragment
- 20 Sedimentary
- Metamorphic

4. Volcanics 22

5. Microphanerites Pyrite 4

6. Accessory Minerals 8
- Muscovite 1
- Glauconite 1
- Biotite
- Pyrite
- Chlorite

7. Carbonate Cement
- 70 Dolomite
- 8 Calcite

8. Matrix 10
- 4 Pseudomatrix
- 1 Clay-Altered Grains

9. Clay Cement 16 illite/smectite

10. Intragranular Porosity
Quartz, K-Feldspar, Plagioclase — VRF Q, K, P — PRF Q, K, P

11. Intergranular Porosity
Fractures
Fracture-induced dissolution
Oversize/elongate pores
Grain-edge dissolution
Other

12. Other
- Phosphate
- 6 OM

Phosphate is usually early diagenetic, or bone.

COMMEMTS

- volcanic glass altered to zeolite
- Dolomite Everywhere, likely formed w/in the clay/matrix.
- Pore filled w/ dolomite, unidentified clay, Hydrocarbons

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION
Q vrfQ prfQ
K vrfK prfK
P vrfP prfP

GRAIN-EDGE DISSOLUTION
Q vrfQ prfQ
K vrfK prfK
P vrfP prfP

OVERSIZE/ELONGATE PORES
Q vrfQ prfQ
K vrfK prfK
P vrfP prfP

OTHER

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 50
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor Formation
DEPTH: 9957

PROJECT: McKittrick CCS

ROCK NAME:
POINT COUNTS: 300

SORTING: Well Sorted

COMPACTION:

SIZE: 0.40 mm Medium

ANGULARITY: Sub-Angular

COMMENTS

1. Quartz
   - 102 Moncrystalline
   - 8 Polycrystalline
   - 6 Microphanerite granitic
   - 2 Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary ________
   - Metaquartzite
   - Other Metamorphic ________

2. K-Feldspar
   - 2 Microcline
   - 26 Orthoclase
   - Sanadine
   - 2 Microphanerite albitized M / O
   - Volcanic Rock Fragment
   - Sedimentary ________
   - Metamorphic ________

3. Plagioclase
   - 2 Microphanerite granitic
   - Volcanic Rock Fragment
   - 18 Sedimentary
   - Metamorphic ________

4. Volcanics 16

5. Microphanerites ________

6. Accessory Minerals 8
   - Muscovite
   - Glauconite
   - Chlorite
   - Pyrite
   - Zircon

7. Carbonate Cement

40 8. Matrix /
4 Pseudomatrix
22 Clay-Altered Grains

9. Clay Cement 29
   - ~~illite~~/smectite
   - ~~?~~ greenish
   - unkown

10. Intragranular Porosity
    - Quartz
    - K-Feldspar
    - 2 Plagioclase

VRF Q K P

PRF Q K P

11. Intergranular Porosity
    - Fractures
    - Fracture-induced dissolution
    - Oversize/elongate pores
    - Grain-edge dissolution

Other ________

12. Other
    - 10 OM/HC
    - 2 carbonate clast

COMMEMTS

* Any biotite has been altered to chlorite
* several clay altered grains.
* Difficult to determine clay from matrix.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K.

THIN SECTION: 52 PROJECT: McKittrick CCS
FORMATION (AGE): Oligocene-Miocene
LOCATION: McKittrick → Temblor ROCK NAME:
DEPTH: 9984' POINT COUNTS: 300

SORTING: Moderate COMPACTION: Difficult to determine.

SIZE: 0.45 mm ANGULARITY: Sub-Angular
Medium

COMMENTS

1. Quartz
   - 82 Moncrystalline
   - 4 Polycrystalline
   - 6 Microphanerite granitic
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary ________
   - Metaquartzite
   - Other Metamorphic ________

2. K-Feldspar
   - 4 Microcline
   - 30 Orthoclase
   - Sanadine
   - 2 Microphanerite granitic M / O
   - Volcanic Rock Fragment
   - Sedimentary ________
   - Metamorphic ________

3. Plagioclase
   - Microphanerite ________
   - Volcanic Rock Fragment
   - 24 Sedimentary
   - Metamorphic ________

4. Volcanics 16

5. Microphanerites ________

6. Accessory Minerals 14
   - 2 Glauconite
   - 2 Muscovite
   - 2 Chlorite
   - 8 Pyrite
   - Zircon

7. Carbonate Cement 22 Calcite

8. Matrix / 12
   - 2 Pseudomatrix
   - 26 Clay-Altered Grains

9. Clay Cement 40 illite/smectite

10. Intragranular Porosity
    - Quartz
    - K-Feldspar
    - Plagioclase
    - VRF Q K P
    - PRF Q K P

11. Intergranular Porosity
    - Fractures
    - Fracture-induced dissolution
    - Oversize/elongate pores
    - Grain-edge dissolution
    - Other ________

12. Other 16
    - Fossil (Carbonate)
    - Phosphate
    - OM

COMMEMTS

* Quartz sometimes occurs w/one or more zircon inclusions suggesting igneous/detrital. (possibly apatite inclusions).

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

- Glauconite → Chlorite → replacing quartz
  - same calcite replacement in same quartz grain.
- More pyrite w/in + surrounded by calcite.
  - → Early pyrite or late calcite.

15, 66

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K.

THIN SECTION: 53
PROJECT:
FORMATION (AGE): Temblor (Oligocene)
LOCATION: McKittrick
ROCK NAME:
DEPTH: 7886'
POINT COUNTS: ~~315~~ 317
SORTING:
COMPACTION:
SIZE:
ANGULARITY: Sub-Anguleer

COMMENTS

1. Quartz
   - 102 Moncrystalline
   - 4 Polycrystalline
   - 2 Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - 2 Metaquartzite → Rock fragment?
   - Other Metamorphic

108

2. K-Feldspar
   - 5 Microcline
   - 55 Orthoclase
   - Sanadine
   - Microphanerite
   - 1 Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

54
60

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - 32 Sedimentary
   - Metamorphic

albite from albitization of k-Feldspar (also mark as k-spar)

33

4. Volcanics 14

+ some grains are undergoing dissolution

14

5. Microphanerites

6. Accessory Minerals 5
   - muscovite 2
   - biotite 2
   - zircon
   - dolomite 1 (not as cement)
   - ~~shale clast~~

7

7. Carbonate Cement

8. Pseudomatrix 5

5

....Clay-Altered Grains....

9. Clay Cement

10. Intragranular Porosity 19 (within grains)
   - Quartz
   - K-Feldspar
   - Plagioclase

VRF Q K P — PRF Q K P

19

11. Intergranular Porosity 65 (between grains)
   - Fractures
   - Fracture-induced dissolution
   - Oversize/elongate pores
   - Grain-edge dissolution
   - Other

65

12. Other
   - 4 organic matter
   - 2 shale clast

4

COMMEMTS

- grain-edge dissolution on quartz (more).
- albitized Feldspar – can tell by staining
- most of the grain-edge dissolution and especially intragranular & result in honey-comb pores.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa

THIN SECTION: 54
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor Formation
ROCK NAME: Arkosic Arenite
DEPTH: 7897-7943' T-13 516-8
POINT COUNTS: 308

SORTING: Poorly ~~moderately~~
COMPACTION:

SIZE: Very Coarse Sand (largest 1.4mm)
ANGULARITY: Sub-Round / ~~Sub-Angular~~

COMMENTS

110
107
1. Quartz
- Moncrystalline
- Polycrystalline
- Microphanerite
- Volcanic Rock Fragment
- Quartz Arenite
- Other Sedimentary
- Metaquartzite
- Other Metamorphic

46
43
2. K-Feldspar
- Microcline
- Orthoclase
- Sanadine
- Microphanerite M / O
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

49
45
3. Plagioclase
- Microphanerite
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

9 4. Volcanics

5. Microphanerites

6. Accessory Minerals: Zircon

surprisingly no micas..

21 7. Carbonate Cement: calcite

clear replacement of entire grains + pores.

4 8. Matrix / Pseudomatrix

Clay-Altered Grains

9. Clay Cement

3 10. Intragranular Porosity
- Quartz
- K-Feldspar
- Plagioclase

VRF Q K P

PRF Q K P

67 11. Intergranular Porosity
- Fractures
- Fracture-induced dissolution
- Oversize/elongate pores
- Grain-edge dissolution

Other

12. Other

COMMEMTS

22.7% φ

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa

THIN SECTION: 55

PROJECT: McKittrick

FORMATION (AGE): Oligocene - Miocene

LOCATION: Temblor Formation

ROCK NAME: Arkosic greywacke

DEPTH: 7963-8015 T-1 516-8

POINT COUNTS: 313

SORTING: Well-Sorted

COMPACTION:

SIZE: Med - Coarse Sand (.65mm lg).

ANGULARITY: Sub-Angular

COMMENTS

1. Quartz (65) — Moncrystalline ~~~~ ; Polycrystalline |||| ; Microphanerite || ; Volcanic Rock Fragment ||| ; Quartz Arenite ; Other Sedimentary ; Metaquartzite ; Other Metamorphic
   - Comments: • Many Floating grains. • some completely Fractured pieces still go extinct together • Few w/zircon + appatite within it, usually w/in poly x-stallin.

2. K-Feldspar (58 3) — Microcline || ; Orthoclase ~~~~ ; Sanadine ; Microphanerite ∠ M / O1 ; Volcanic Rock Fragment || ; Sedimentary ; Metamorphic
   - Comments: Replacement by calcite.

3. Plagioclase (26 4) — Microphanerite ; Volcanic Rock Fragment || ; Sedimentary ~~~~ ||| ; Metamorphic
   - Comments: • many w/intragranular ϕ caused by dissolution. • some clay-altered. • so many pieces broken that sometimes hard to determine. • dissolution + prevelant Fracturing.

4. Volcanics (5) ~~||||~~
   - • pseudomatrix.

5. Microphanerites — Muscovite |

6. Accessory Minerals (6) — Glauconite ; Muscovite |||| ; Pyrite ; BIOTITE | ; Chlorite | ; APPATITE ; ZIRCON

7. Carbonate Cement (120) — Calcite ~~~~
   - • Looks like a beleminite was replaced. Image. • huge 'ribbons' of calcite within grains and even more calcite. poikilotopic cement

8. Matrix / Pseudomatrix (6) |||
   - ....Clay-Altered Grains. |||

9. Clay Cement

10. Intragranular Porosity — Quartz | ; K-Feldspar | ; Plagioclase ~~||||~~ |||| ; VRF Q K P ; PRF Q K P

11. Intergranular Porosity (5.1% ϕ) | — Fractures | ; Fracture-induced dissolution || ; Oversize/elongate pores | ; Grain-edge dissolution ; Other

12. Other — organic matter |||

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K |	vrfK	prfK
P |	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P |	vrfP	prfP

OTHER

PARAGENESIS

Calcite Replacement of remnant plagioclase suggesting dissolution occured before calcite replacement. Calcite replacement of Quartz.

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa

THIN SECTION: 56
FORMATION (AGE): Miocene - Oligocene
LOCATION: Temblor
DEPTH: 7963 - 8015 V-16 516-8

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: 307

SORTING: Well - Sorted
SIZE: Medium - Coarse Sand (.65mm)

COMPACTION:
ANGULARITY: Sub - Angular

COMMENTS

1. Quartz
   - Moncrystalline ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ |||
   - Polycrystalline ||
   - Microphanerite |
   - Volcanic Rock Fragment ||
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

   replaced by calcite in some cases.

2. K-Feldspar
   - Microcline |
   - Orthoclase ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ |
   - Sanadine
   - Microphanerite M / O
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

   · some altered by organic matter → or covered by it.
   · possibly some being replaced by albite.

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment |||
   - Sedimentary ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~
   - Metamorphic

4. Volcanics ~~||||~~ ||

5. Microphanerites

6. Accessory Minerals
   - Muscovite
   - ~~B.~~ Pyrite |
   - Chlorite
   - Glauconite

   · Pyrite in volcanic grains → biotite either turned into pyrite. it is OM.

7. Carbonate Cement
   - Calcite ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ||

   · many perfect rhombs
   · occasional covered with organic material.

8. Matrix / Pseudomatrix ~~||||~~ ~~||||~~ ||

   · All pseudomatrix - no matrix

Clay-Altered Grains |

9. Clay Cement

10. Intragranular Porosity
    - Quartz |
    - K-Feldspar ||||
    - Plagioclase ~~||||~~ ~~||||~~ ||||

    VRF Q K P

    PRF Q K P

11. Intergranular Porosity ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ||
    - Fractures ~~||||~~ ~~||||~~ ||||
    - Fracture-induced dissolution ||
    - Oversize/elongate pores ~~||||~~ ~~||||~~ |
    - Grain-edge dissolution |||
    - Other

12. Other
    - Organic Matter |||
    - Phosphate

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION → poly Q.

Q	vrfQ |	prfQ
K |	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q |||	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P |	vrfP	prfP

OTHER

PARAGENESIS

· calcite cement filled pore space, then framework grains ~~dissolved~~ were replaced.
· Sometime framework grains dissolved out after calcite cement filled pore space.

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa

THIN SECTION: 57
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor Formation
ROCK NAME: Arkosic Arenite
DEPTH: 7963-8015 T-6 516-8
POINT COUNTS: 303

SORTING: ~~[illegible]~~
COMPACTION:

SIZE: ~~Angular~~ med-coarse sand
ANGULARITY: Angular

0.6mm largest grain

COMMENTS

1. Quartz
   - Moncrystalline ꟾꟾꟾꟾ̸ (×19) ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ — · many sutured contacts
   - Polycrystalline I
   - Microphanerite I
   - Volcanic Rock Fragment III
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

   qv u

2. K-Feldspar
   - Microcline I
   - Orthoclase ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ I
   - Sanadine
   - Microphanerite — M; O II
   - Volcanic Rock Fragment I
   - Sedimentary
   - Metamorphic

   sv m

3. Plagioclase
   - Microphanerite III
   - Volcanic Rock Fragment III
   - Sedimentary ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ IIII
   - Metamorphic

   vm v

4. Volcanics ꟾꟾꟾꟾ̸ I — · many form pseudomatrix (v)

5. Microphanerites MUSCOVITE II (v)

6. Accessory Minerals
   - MUSCOVITE II
   - SERICITE
   - BIOTITE
   - PYRITE II

7. Carbonate Cement
   - CALCITE I
   - DOLOMITE

   · tiny crystals floating around.

8. Matrix / Pseudomatrix IIII — · pseudomatrix is usually VRF or micas. ~~sometim~~

Clay-Altered Grains ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸

9. Clay Cement

10. Intragranular Porosity
    - Quartz
    - K-Feldspar I
    - Plagioclase ꟾꟾꟾꟾ̸ IIII
    - VRF Q, K, P I
    - PRF Q, K, P

11. Intergranular Porosity ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ II (27.7% ϕ)
    - Fractures ꟾꟾꟾꟾ̸ IIII
    - Fracture-induced dissolution ꟾꟾꟾꟾ̸ IIII
    - Oversize/elongate pores ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ I
    - Grain-edge dissolution ꟾꟾꟾꟾ̸ ꟾꟾꟾꟾ̸ III
    - Other

12. Other
    - Phosphate
    - organic matter ꟾꟾꟾꟾ̸ II

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q IIII	vrfQ	prfQ
K 0	vrfK	prfK
P IIII	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q ꟾꟾꟾꟾ̸ II	vrfQ	prfQ
K III	vrfK	prfK
P II	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K II	vrfK	prfK
P III	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa

THIN SECTION: 58
PROJECT: McKittrick
FORMATION (AGE): ~~Temblor~~ Oligocene-Miocene
LOCATION: Temblor Formation
ROCK NAME: Arkosic Greywacke
DEPTH: 8015 - 8069 T-9 516-8
POINT COUNTS: 316

SORTING: Well-sorted
COMPACTION:

SIZE: Coarse Sand (.75mm largest).
ANGULARITY: Sub-Angular

COMMENTS

82 1. Quartz
- Moncrystalline ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ||
- Polycrystalline
- Microphanerite
- Volcanic Rock Fragment |
- Quartz Arenite
- Other Sedimentary
- Metaquartzite
- Other Metamorphic

Comments: • can see calcite replacing the edges of grains.

53 2. K-Feldspar
- Microcline |
- Orthoclase ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ||
- Sanadine
- Microphanerite — M / O
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

26 / 10 3. Plagioclase
- Microphanerite |
- Volcanic Rock Fragment ~~||||~~ ||||
- Sedimentary ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ |
- Metamorphic

Comments: • skeletal grains common.

9 4. Volcanics ~~||||~~ ||||

5 5. Microphanerites Muscovite ~~||||~~

6. Accessory Minerals
- Muscovite ~~||||~~ |
- Biotite
- Glauconite
- CHLORITE
- Pyrite |||
- Zircon

52 7. Carbonate Cement
- Calcite ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ||

Comments: • entirely replaced grains, and some partially replaced. • poikiolitopic cement predominant

5 8. Matrix / Pseudomatrix ||
- Clay-Altered Grains |||

9. Clay Cement

19% 10. Intragranular Porosity
- Quartz
- K-Feldspar ~~||||~~ |
- Plagioclase ~~||||~~ ~~||||~~ ~~||||~~ |||

VRF Q K P — PRF Q K P

11. Intergranular Porosity ~~||||~~ ~~||||~~ ~~||||~~ |
- Fractures
- Fracture-induced dissolution ~~||||~~
- Oversize/elongate pores ~~||||~~ ~~||||~~
- Grain-edge dissolution ~~||||~~
- Other

12. Other
- organic matter ||||

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q |	vrfQ	prfQ
K ||	vrfK	prfK
P	vrfP |	prfP

GRAIN-EDGE DISSOLUTION

Q |	vrfQ	prfQ
K |	vrfK	prfK
P ||	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P ||	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa

THIN SECTION: 59
PROJECT: Temblor
FORMATION (AGE): Oligocene - Eocene
LOCATION: McKittrick
ROCK NAME:
DEPTH: 8073' T-4
POINT COUNTS: 317
SORTING: moderate-well sorted.
COMPACTION:
SIZE:
ANGULARITY: Angular (sub-angular maybe)

COMMENTS

1. Quartz (82)
   - Moncrystalline ||||| ...
   - Polycrystalline ||||
   - Microphanerite ||
   - Volcanic Rock Fragment |
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

   • Found one quartz grain biaxial BURP...
   • another one dissolving and beginning to be replaced by calcite!

2. K-Feldspar (59)
   - Microcline ||||
   - Orthoclase ||||| ...
   - Sanadine
   - Microphanerite ≤ M O
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

   • some staining is sporadic on grains suggesting albitization
   • some undergoing dissolution causing intragranular porosity.

3. Plagioclase (30)
   - Microphanerite |
   - Volcanic Rock Fragment |
   - Sedimentary ||||| ...
   - Metamorphic

   • most plagioclase grains are undergoing some amount of dissolution

4. Volcanics (6) |||||| • some clay altered or covered in organic matter. • many undergoing dissolution and/or becoming pseudomatrix

5. Microphanerites (1) quartz | • also looks maybe volcanic.

6. Accessory Minerals (x)
   - Glauconite
   - Muscovite ||
   - Zircon
   - Appatite
   - Pyrite ||||
   - Biotite

   • also marked w/ HC's below. (only 4)

7. Carbonate Cement (25) calcite ||||| ... — calcite is rarely pore-filling, just little rhombs.

8. Matrix / Pseudomatrix (33) ||||| ... — • oftentimes jumbled with and around calcite rhombs. • maybe calcite 1st, then pseudomatrix

Clay-Altered Grains

9. Clay Cement

10. Intragranular Porosity (22)
    - Quartz ||||
    - K-Feldspar ||||
    - Plagioclase ||||| ...
    - VRF Q K P
    - PRF Q K P

11. Intergranular Porosity (46) ||||| ...
    - Fractures
    - Fracture-induced dissolution ||
    - Oversize/elongate pores ||
    - Grain-edge dissolution |||||||
    - Other

12. Other (9)
    - Hydrocarbon ||||||||
    - Hydrocarbon + Pyrite |

    • It's likely things marked as HC's might have pyrite in the

COMMEMTS

• Pyrite/Organic matter "sprinkled" everywhere. Mostly within pseudomatrix.
• ~~Half~~ 1/3 of this TS. is ~~so~~ filled w/ matrix and calcite (lengthwise) the ~~other~~ ~~half~~ has normal' porosity void spaces. 2/3

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q |	vrfQ	prfQ
K	vrfK	prfK
P |	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q ||||	vrfQ	prfQ
K	vrfK	prfK
P ||	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

- calcite rhombs grow after dissolution

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa

THIN SECTION: 60
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
ROCK NAME:
DEPTH: 8088 - 8139' T-7
POINT COUNTS: 309
SORTING: Well Sorted
COMPACTION:
SIZE: Coarse sand (.55-.6mm)
ANGULARITY: Sub-Angular

COMMENTS

1. Quartz (70)
   - Moncrystalline ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ |||
   - Polycrystalline ~~||||~~
   - Microphanerite |
   - Volcanic Rock Fragment |
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

   Comments: · the microphanerite I found is polycrystalline. · one quartz grain is almost entirely dissolved -no remnants like pl... · many partially replaced by calcite.

2. K-Feldspar (39)
   - Microcline ||
   - Orthoclase ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~
   - Sanadine
   - Microphanerite M / O |
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

   Comments: · some replaced by calcit...

3. Plagioclase (29)
   - Microphanerite ||
   - Volcanic Rock Fragment
   - Sedimentary ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ||
   - Metamorphic

   not counted in point count: · plagioclase replaced by calcite · plagioclaseal replace by sericite

4. Volcanics || (2)

5. Microphanerites

6. Accessory Minerals (13)
   - Chlorite
   - Muscovite
   - Pyrite ~~||||~~ ~~||||~~
   - Biotite | → pyrite replacement. || (not as common)
   - Biotite altering to chlorite |
   - Zircon
   - Glauconite
   - Sericite

   Pyrite, w/in pore space, on grain. w/in HC's.

7. Carbonate Cement (86) — probably dolomite SEM.
   - ~~Calcite~~ / Dolomite ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ |

   · sometimes lands on a calcite grain that is still in the process of replacing a quartz grain. + plagioclase + k-spa...

8. Matrix / Pseudomatrix ~~||||~~ | (6)
   ....Clay-Altered Grains

9. Clay Cement (1)
   - kaolinite |

10. Intragranular Porosity (18) — some pore space filled w/ kaolinite cement. (very little).
    - Quartz
    - K-Feldspar ||
    - Plagioclase ~~||||~~ ~~||||~~ ~~||||~~ |
    - VRF Q K P
    - PRF Q K P

11. Intergranular Porosity (39) ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ||
    - Fractures
    - Fracture-induced dissolution |
    - Oversize/elongate pores ||
    - Grain-edge dissolution |||
    - Other

12. Other (7)
    - Hydro Carbon ~~||||~~ || — usually w/pyrite.

COMMEMTS

· One huge grain - all calcite, pyrite, and HC's.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q |	vrfQ	prfQ
K	vrfK	prfK
P |	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q |||	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

· Biotite alteration to pyrite.
· calcite replacement of quartz + Feldspars.
· Fracturing of quartz, Fracture Filled w/ pseudomatrix, then calcite formation (dolomite?).
· plagioclase replaced by sericite.

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K.

THIN SECTION: 61
FORMATION (AGE): Oligocene - Miocene
LOCATION: Temblor Formation
DEPTH: 8139 T-2

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: 302

SORTING: Well sorted
COMPACTION:

SIZE: Coarse sand (0.7 mm)
ANGULARITY: Sub-Angular

COMMENTS

1. Quartz
   - 126 Moncrystalline
   - 3 Polycrystalline |||
   - 4 Microphanerite ||||
   - 1 Volcanic Rock Fragment |
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

   microphanerite polycristalline 1

   - grain edge dissolution
   - lots of sutured contacts.
   - some poly looks like quartz cement filling in around grains.
   - some undergoing dissolution along fracturing.

2. K-Feldspar
   - 3 Microcline |||
   - 46 Orthoclase
   - Sanadine
   - Microphanerite — M, O
   - 1 Volcanic Rock Fragment |
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - 3 Microphanerite |||
   - 1 Volcanic Rock Fragment |
   - 11 Sedimentary
   - Metamorphic

   - ~~when looks~~
   - undergoing dissolution ~ 50% or more 1 NOT IN PC.
   - some w/severe clay alteration.

19 4. Volcanics

5. Microphanerites muscovite 1
2 R.F. volcanic

5 6. Accessory Minerals
   - Muscovite 1
   - Biotite 1 converted to pyrite 1 (Not P.C.)
   - Pyrite ||| pyrite/HC's 1 (Not P.C.)

4 7. Carbonate Cement: calcite |||| poikilotopic 1 NOT in P.C.

8 8. Matrix / Pseudomatrix ||| 1 · mostly volcanics
   Clay-Altered Grains ||||

8 9. Clay Cement: Kaolinite 8

10. Intragranular Porosity
   - 1 Quartz |
   - 3 K-Feldspar |||
   - 15 Plagioclase

   VRF Q K P — PRF Q K P

56 11. Intergranular Porosity 22
   - 4 Fractures ||||
   - 5 Fracture-induced dissolution
   - 13 Oversize/elongate pores
   - 12 Grain-edge dissolution

   Other

12. Other
   - VRF shale clast |||
   - RF. carbonate clast 1
   - organic matter 1

COMMEMTS

- Muscovite + biotite fill pore space when found. → indicates more compaction than previous slides.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q |||	vrfQ	prfQ
K	vrfK	prfK
P ||	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q 7	vrfQ	prfQ shale 1
K |||	vrfK	prfK
P		vrfP	prfP

OVERSIZE/ELONGATE PORES

Q		vrfQ	prfQ
K	vrfK	prfK
P		vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA EXAMINED BY: A Lyssa

THIN SECTION: 62
FORMATION (AGE): Oligocene - Miocene
LOCATION: Temblor
DEPTH: 8155 T-13

PROJECT: McKittrick
ROCK NAME: Arkosic Greywacke
POINT COUNTS: 304

SORTING: moderate-well
COMPACTION:

SIZE: Medium grained
ANGULARITY: sub-angular to angular

COMMENTS

1. Quartz
63
3
- Moncrystalline ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ |
- Polycrystalline |||
- Microphanerite |||
- Volcanic Rock Fragment
- Quartz Arenite
- Other Sedimentary
- Metaquartzite
- Other Metamorphic
- partially dissolved |

2. K-Feldspar
41
- Microcline ||||/ |
- Orthoclase ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ ||||/
- Sanadine
- Microphanerite M / O
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

3. Plagioclase
33
1
- Microphanerite |
- Volcanic Rock Fragment |
- Sedimentary ||||/ ||||/ ||||/ ||||/ ||||/ ||||
- Metamorphic
- partially clay altered ||

9 4. Volcanics ||||/ |||| — oftentimes clay-altered

5. Microphanerites

6. Accessory Minerals
8
- Muscovite ||
- Chlorite ||
- Glauconite
- Pyrite |||
- Zircon
- hornblende
- Biotite |

7. Carbonate Cement

8. Matrix / Pseudomatrix ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ |
89
most clay alteration appears to be volcanic. or ~~plagioclase grains~~
Clay-Altered Grains ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ ||||/ |||

9. Clay Cement

10. Intragranular Porosity
19
- Quartz |||
- K-Feldspar |||
- Plagioclase ||||/ ||||/ |||

VRF Q K P — PRF Q K P

16.4% Ø

11. Intergranular Porosity ||||/ ||||/ ||||
31
- Fractures ||||/ |
- Fracture-induced dissolution ||
- Oversize/elongate pores
- Grain-edge dissolution ||||/ ||||
- Other

6 12. Other
- Shell Fragments ||
- organic matter ||||

COMMEMTS

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q ||	vrfQ	prfQ
K |||	vrfK	prfK
P |||	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER
Fracture Q |
Fracture P ||

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 63
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: ~~McK~~ Temblor Formation
ROCK NAME:
DEPTH: 8204' T-1 516-8
POINT COUNTS: 308
SORTING: Well sorted
COMPACTION:
SIZE: Medium-Coarse Sand (.5mm)
ANGULARITY: ~~Angular~~ ~~Sub~~ Angular-Sub-Angul

COMMENTS

1. Quartz
 - Moncrystalline 卌卌卌卌卌卌卌卌卌卌卌卌卌卌卌卌卌卌卌卌卌卌卌卌 IIII
 - Polycrystalline II
 - Microphanerite II
 - Volcanic Rock Fragment II
 - Quartz Arenite
 - Other Sedimentary ____
 - Metaquartzite
 - Other Metamorphic ____

2. K-Feldspar
 - Microcline II
 - Orthoclase 卌卌卌卌卌卌卌卌 IIII
 - Sanadine
 - Microphanerite ____ M / O I
 - Volcanic Rock Fragment
 - Sedimentary ____
 - Metamorphic ____

 clay altered M ____ O I

3. Plagioclase
 - Microphanerite I
 - Volcanic Rock Fragment III
 - Sedimentary 卌卌卌卌卌
 - Metamorphic ____

4. Volcanics 卌 I

5. Microphanerites

6. Accessory Minerals
 - Muscovite II
 - Glauconite
 - Pyrite 卌 II
 - Biotite
 - Zircon

 altered From Biotite. Chlorite I

7. Carbonate Cement

8. Matrix / Pseudomatrix 卌卌卌卌卌 II

 · sometimes difficult to tell from matrix → look for detrital chun[ks] · oftentimes w/pyrite.

 Clay-Altered Grains III

9. Clay Cement
 - illite/smectite
 - Kaolinite 卌 IIII

10. Intragranular Porosity
 - Quartz III
 - K-Feldspar I
 - Plagioclase 卌卌卌 II

 VRF Q K P — PRF Q K P

11. Intergranular Porosity 卌卌卌卌卌卌
 - Fractures
 - Fracture-induced dissolution I
 - Oversize/elongate pores III
 - Grain-edge dissolution 卌卌
 - Other ____

12. Other
 - Hydro Carbon II
 - RF. carbonate clast III
 - HC/Pyrite II

COMMEMTS

· K-Feldspar dissolution happens all over grain, consistently. Plagioclase happens along Fractures, Quartz happens along grain edge.
· Biotite alteration to chlorite.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P I	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q 卌 III	vrfQ	prfQ
K II	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA EXAMINED BY: A Lyssa

THIN SECTION: 64
PROJECT: McKittrick
FORMATION (AGE): Oligocene - Miocene
LOCATION: Temblor
ROCK NAME: Arkosic greywacke
DEPTH: 8204' T-13
Well: 516-8
POINT COUNTS: 301
SORTING: Well sorted.
COMPACTION:
SIZE: Medium grained (.45mm largest grain).
ANGULARITY: Sub-angular

COMMENTS

1. Quartz (67)
   - Moncrystalline 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 — some Fracture-induced dissolution.
   - Polycrystalline 卌 卌 卌 ||
   - Microphanerite ________
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary ________
   - Metaquartzite
   - Other Metamorphic ________

2. K-Feldspar (48)
   - Microcline |
   - Orthoclase 卌 卌 卌 卌 卌 卌 卌 卌 卌 || — some undergoing dissolution
   - Sanadine
   - Microphanerite ________
   - Volcanic Rock Fragment
   - Sedimentary ________
   - Metamorphic ________

3. Plagioclase (41)
   - Microphanerite ________ — • sometimes clay altered.
   - Volcanic Rock Fragment — • many grains are skeletal.
   - Sedimentary 卌 卌 卌 卌 卌 卌 卌 卌 |
   - Metamorphic ________

4. Volcanics (15) 卌 卌 卌 — * some are considerably altered or act as pseudomatrix

5. Microphanerites ________

6. Accessory Minerals
   - PYRITE |
   - MUSCOVITE ||
   - BIOTITE
   - Zircon
   - CALCITE 卌 → didn't look like cement.
   - ~~Shale clast~~

7. Carbonate Cement (8): calcite 卌 |||

8. Pseudomatrix (47) 卌 卌 卌 卌 卌 — Pseudomatrix is always (almost) VRFs
   Clay-Altered Grains 卌 卌 卌 |||| — matrix: ||||

9. Clay Cement

10. Intragranular Porosity (24 within grains K secondary)

Quartz 卌		VRF Q	PRF Q
K-Feldspar 卌 |		K	K
Plagioclase 卌 卌 |||		P	P

11. Intergranular Porosity (35, 19.6%) 卌 卌 卌 卌 卌 — Primary or Secondary
   - Fractures |||
   - Fracture-induced dissolution 卌
   - Oversize/elongate pores |
   - Grain-edge dissolution |
   - Other ________

12. Other (8)
   - organic matter 卌 ||
   - shale clast |

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q |	vrfQ	prfQ
K |	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q |	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P |	vrfP	prfP

OTHER

FRACTURE K |

PARAGENESIS

Ventura Basin

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa Kaess

THIN SECTION: 65 SP-32X

PROJECT: McKittrick

FORMATION (AGE): Oligocene-Miocene

LOCATION: Temblor Formation

ROCK NAME:

DEPTH: 9947' SP-32X

POINT COUNTS: 308

SORTING: Moderate Sorting.

COMPACTION:

SIZE: .5mm Med-Coarse Grained.

ANGULARITY: Sub-Angular/Sub-Round

COMMENTS

1. Quartz
   - Moncrystalline (tally) — · Found one dissolving through the middle.
   - Polycrystalline III
   - Microphanerite I
   - Volcanic Rock Fragment III
   - Quartz Arenite
   - Other Sedimentary ____
   - Metaquartzite
   - Other Metamorphic ____

2. K-Feldspar
   - Microcline (tally)
   - Orthoclase (tally)
   - Sanadine
   - Microphanerite ____ M / O
   - Volcanic Rock Fragment I
   - Sedimentary ____
   - Metamorphic ____

   · Broken up, Filling pore space, mushed with other grains. · albitization occuring. III

3. Plagioclase
   - Microphanerite II → sometimes albitized K-spar.
   - Volcanic Rock Fragment IIII
   - Sedimentary (tally)
   - Metamorphic ____

   · some are undergoing dissolution. II Not in P.C.

4. Volcanics IIII

5. Microphanerites ____

6. Accessory Minerals
   - Muscovite II
   - Biotite III
   - Chlorite I ← usually altered from biotite.
   - Pyrite IIII
   - Pyrite/HC (tally) → Formed From HC authigenic
   - Glauconite I

7. Carbonate Cement
   - Calcite (tally) — poikilotopic calcite cement.

8. Matrix / (tally)
   - RF. ← Pseudomatrix (tally)
   - Clay-Altered Grains (tally)

   · pseudomatrix = shale clasts and volcanics. I have been call brittle deformation pseudomatrix when I don't know what it is.

9. Clay Cement
   - Kaolinite (tally)

10. Intragranular Porosity
    - Quartz — VRF Q — PRF Q
    - K-Feldspar — K — K
    - Plagioclase — P — P

11. Intergranular Porosity (tally)
    - Fractures
    - Fracture-induced dissolution I
    - Oversize/elongate pores
    - Grain-edge dissolution
    - Other ____

HC = Φ

12. Other
    - Hydro Carbon II
    - RF. ← Carbonate Clast I
    - Shale Clast I

COMMEMTS

· everything is very compacted, altered, and rearranged so no contact index.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P I	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 66
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor Formation
ROCK NAME:
DEPTH: 9952' SP-32X
POINT COUNTS: 300
SORTING: Well Sorted
COMPACTION:
SIZE: Med-grained. .45mm
ANGULARITY: Sub Angular | Rounded.

COMMENTS not P.C.

1. Quartz
   - Moncrystalline ~~||||~~ (tally)
   - Polycrystalline ~~||||~~ |
   - Microphanerite ________
   - Volcanic Rock Fragment ||||
   - Quartz Arenite
   - Other Sedimentary ________
   - Metaquartzite
   - Other Metamorphic ________

   Comments: Spar dissolution |; clay altered ~~||||~~ | — these often occur together.

2. K-Feldspar
   - Microcline ||
   - Orthoclase (tally)
   - Sanadine
   - Microphanerite ________ M | O
   - Volcanic Rock Fragment |||
   - Sedimentary ________
   - Metamorphic ________

   Comments: clay altered ||| ; albitized || — Not P.C.

3. Plagioclase
   - Microphanerite ________
   - Volcanic Rock Fragment ~~||||~~ ~~||||~~ |
   - Sedimentary ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ||||
   - Metamorphic |

   Comments: clay altered ~~||||~~ | Not P.C.; albitization of k-spar |

4. Volcanics ||||
   Comment: one glass volcanic altered to zeolites.

5. Microphanerites ________

6. Accessory Minerals
   - Glauconite
   - Pyrite |
   - Pyrite/HC? |
   - Muscovite
   - Biotite
   - Chlorite |
   - sericite | (seritization)

7. Carbonate Cement ~~Kaolinite~~ ~~Illite/smectite~~ L

8. Matrix / Pseudomatrix (tally)
   CAG: ________ VRF; ~~||||~~ Don't know
   Clay-Altered Grains ~~||||~~ ||||

9. Clay Cement
   - illite/smectite |||
   - kaolinite ~~||||~~ ||

10. Intragranular Porosity
   - Quartz — VRF Q — PRF Q
   - K-Feldspar — K — K
   - Plagioclase — P — P

11. Intergranular Porosity ~~||||~~ ~~||||~~ |||
   - Fractures
   - Fracture-induced dissolution
   - Oversize/elongate pores
   - Grain-edge dissolution
   - Other ________

   at least 2 @ edge → maybe due to grinding.

12. Other ~~Φ dissolved detrital grains ||~~ Not P.C.
   - O.M. & Hydro Carbon |||
   - Shale clast |||

COMMEMTS

- Great grain (plagioclase) + seritization. (image)
- matrix often Filled with pyrite.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

____
____

PARAGENESIS

- compaction
- dissolution 1st of plagioclase
- deformation of labiles.
- clay cement after pseudomatrix.
- albitization.

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K.

THIN SECTION: 67
FORMATION (AGE): Oligocene - Miocene
LOCATION: Temblor Formation
DEPTH: 9990' SP-32X

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: 311

SORTING: Moderate - Poorly Sorted
COMPACTION:

SIZE: ~~Coar~~ Medium Sand .45mm
ANGULARITY: Sub-Angular

		COMMENTS
1. Quartz	Moncrystalline 𝍸 III – Polycrystalline II Microphanerite I Volcanic Rock Fragment II Quartz Arenite Other Sedimentary ____ Metaquartzite Other Metamorphic ____	· severely Fractured, replaced by calcite, broken.
2. K-Feldspar	Microcline III Orthoclase 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 IIII Sanadine Microphanerite ____ ≤ M, O II Volcanic Rock Fragment Sedimentary ____ Metamorphic ____	albitized IIII clay altered I
3. Plagioclase	Microphanerite ____ Volcanic Rock Fragment I Sedimentary 𝍸 𝍸 𝍸 𝍸 IIII Metamorphic ____	
4. Volcanics	𝍸 𝍸 III	volcanic glass → zeolite.
5. Microphanerites	____	
6. Accessory Minerals	Glauconite I Chlorite I — From Biotite I — NOT P.C. Muscovite Pyrite III Zircon Pyrite / HC 𝍸 Biotite I	
7. Carbonate Cement	CALCITE 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 III	· some tiny pieces within matrix but mostly poikilotopic cement
8. Matrix / Pseudomatrix	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 I Pseudomatrix 𝍸 𝍸 𝍸 𝍸 𝍸 II Clay-Altered Grains 𝍸	pseudomatrix → usually clay altered and cannot tell what remnant grain was.
9. Clay Cement	Illite/Smectite III	
10. Intragranular Porosity	Quartz K-Feldspar Plagioclase	VRF Q, K, P PRF Q, K, P
11. Intergranular Porosity I	Fractures Fracture-induced dissolution Oversize/elongate pores Grain-edge dissolution Other ____	
12. Other	Fossil II — NOT P.C. HC's I	· Hydrocarbons w/in shell and later turned to pyrite.

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION		
Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP
GRAIN-EDGE DISSOLUTION		
Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP
OVERSIZE/ELONGATE PORES		
Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

· Calcite Filling Fractures,
· Glauconite being replaced by calcite.
· Biotite altering to pyrite.

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K.

THIN SECTION: 68
PROJECT: McKittrick
FORMATION (AGE): Oligocene - Miocene
LOCATION: Temblor Formation
ROCK NAME:
DEPTH: 7890' 516-8
POINT COUNTS: 310
SORTING: Poorly Sorted
COMPACTION:
SIZE: .9mm Coarse Sand.
ANGULARITY: Sub-Round

COMMENTS

1. Quartz
   - Moncrystalline ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| |||||
   - Polycrystalline |||
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| |
   - Sanadine
   - Microphanerite — M / O
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment |
   - Sedimentary ||||| ||||| ||||| ||||| |||||
   - Metamorphic

4. Volcanics ||||

5. Microphanerites

6. Accessory Minerals
   - HC's + Pyrite ||
   - MUSCOVITE |

7. Carbonate Cement
   - Calcite ||||| ||||| || → ||||| carbonate clast. + (R.F.) HUGE

8. Matrix / Pseudomatrix |||||

Clay-Altered Grains

9. Clay Cement
   - kaolinite ||

10. Intragranular Porosity
   - Quartz |
   - K-Feldspar ||||
   - Plagioclase ||||| |||
   - VRF Q / K / P
   - PRF Q / K / P

11. Intergranular Porosity ||||| ||||| ||||| ||||| ||||| ||||| |||
   - Fractures ||
   - Fracture-induced dissolution ||||| |
   - Oversize/elongate pores ||||| ||||| ||||| ||
   - Grain-edge dissolution ||||| ||
   - Other

12. Other R.F. shale clast ||
   - Phosphate |

COMMEMTS

* Lots of broken pieces and grain Fragments, probably affecting reservoir quality and porosity / permeability.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q |	vrfQ	prfQ
K	vrfK	prfK
P ||||	vrfP |	prfP

GRAIN-EDGE DISSOLUTION

Q ||||	vrfQ	prfQ
K	vrfK	prfK
P |||	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P |||	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K!

THIN SECTION: 69
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: ~~[illegible]~~ Temblor
ROCK NAME:
DEPTH: 7897-7943 T-5
POINT COUNTS: 300

SORTING: Poorly Sorted (due to band of crushed rocks).
COMPACTION:
SIZE: 0.65mm Coarse Sand
ANGULARITY: Sub-Round → Sub-Angular

COMMENTS

1. Quartz
   - Moncrystalline ~~𝍸~~ 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 — *grain-edge dissolution common.
   - Polycrystalline
   - Microphanerite ______
   - Volcanic Rock Fragment ||
   - Quartz Arenite
   - Other Sedimentary ______
   - Metaquartzite
   - Other Metamorphic ______

2. K-Feldspar
   - Microcline
   - Orthoclase 𝍸 𝍸 𝍸 𝍸 𝍸 |||
   - Sanadine
   - Microphanerite ______ M / O
   - Volcanic Rock Fragment ||
   - Sedimentary ______
   - Metamorphic ______

3. Plagioclase
   - Microphanerite ______ — grain edge dissolution |
   - Volcanic Rock Fragment ||||
   - Sedimentary 𝍸 𝍸 𝍸 𝍸
   - Metamorphic ______

4. Volcanics ~~[illegible]~~ 𝍸 𝍸 𝍸 𝍸 ||||

5. Microphanerites ______

6. Accessory Minerals
   - Muscovite
   - Hematite (SEM)
   - Pyrite ||
   - Biotite ||
   - Hornblende
   - Zircon
   - Rutile
   - Sphene
   - ~~[illegible]~~

   *biotite is usually altered → to maybe pyrite or ~~[illegible]~~. covered in OM.

7. Carbonate Cement
   - Calcite |
   - Dolomite

   *Dolomite usually as random rhombs within matrix.

8. Matrix / Pseudomatrix 𝍸 𝍸 𝍸 |||
   Clay-Altered Grains

9. Clay Cement
   - Kaolinite 𝍸 𝍸
   - Unidentified 𝍸 |

10. Intragranular Porosity
    - Quartz ||
    - K-Feldspar ||
    - Plagioclase 𝍸 𝍸 ||||
    - VRF Q / K / P
    - PRF Q / K / P

11. Intergranular Porosity 𝍸 𝍸 ||||
    - Fractures ||
    - Fracture-induced dissolution 𝍸 |
    - Oversize/elongate pores 𝍸 𝍸 ~~[illegible]~~ 𝍸 𝍸 𝍸 ||
    - Grain-edge dissolution 𝍸 𝍸 𝍸 𝍸 ||||
    - Other ______

12. Other
    - Phosphate ||
    - organic matter
    - Calcite Clast |

    *phosphate looks like some glauconite w/it.

COMMEMTS

*Plagioclase mostly albite as most grains that twin are not stained.

*one band/area w/tons of tiny fractured grains difficult to identify.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K |	vrfK	prfK
P |	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q 𝍸	vrfQ	prfQ
K ||	vrfK |	prfK
P ||~~[illegible]~~|	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q |	vrfQ	prfQ
K	vrfK	prfK
P |||	vrfP	prfP

OTHER

PARAGENESIS

*Fracture → dissolution.

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa

THIN SECTION: 70
PROJECT: McKittrick
FORMATION (AGE): 7897 - 7961 T-16
LOCATION: Temblor
ROCK NAME:
DEPTH: Oligocene - Miocene
POINT COUNTS: 301

SORTING: Poorly sorted
COMPACTION:

SIZE: 1.8mm
ANGULARITY: Sub-Round

Very Coarse Sand

COMMENTS

1. Quartz
   - Moncrystalline
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline ||
   - Orthoclase
   - Sanadine
   - Microphanerite M / O
   - Volcanic Rock Fragment ||
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

4. Volcanics

5. Microphanerites

6. Accessory Minerals
   - Zircon
   - Garnet

7. Carbonate Cement
   - Dolomite
   - Calcite

8. Matrix / Pseudomatrix

Clay-Altered Grains

9. Clay Cement
   - Kaolinite ||
   - Unidentified ||

10. Intragranular Porosity
   - Quartz
   - K-Feldspar
   - Plagioclase ||

   VRF Q, K, P — PRF Q, K, P

11. Intergranular Porosity
   - Fractures
   - Fracture-induced dissolution ||
   - Oversize/elongate pores
   - Grain-edge dissolution ||
   - Other

12. Other
   - Calcite Clast
   - Phosphate ||||

COMMEMTS

*large albitized orthoclase grains.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q ||	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q ||	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P ||	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K.

THIN SECTION: 71
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: 7963 - 8015 T-18 516-8
ROCK NAME:
DEPTH: Temblor Formation
POINT COUNTS: 300
SORTING: Moderately Sorted
COMPACTION:
SIZE: 0.55mm Coarse Sand
ANGULARITY: Sub - Round

COMMENTS

1. Quartz
   - Moncrystalline
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanadine
   - Microphanerite — M / O
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. Plagioclase — extensive dissolution.
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

4. Volcanics

5. Microphanerites

6. Accessory Minerals
   - MUSCOVITE
   - BIOTITE
   - PYRITE
   - CHLORITE

7. Carbonate Cement
   - Calcite
   - Dolomite

8. Matrix / Pseudomatrix
   - Clay-Altered Grains

9. Clay Cement
   - KAOLINITE
   - UNIDENTIFIED
   - Chlorite

10. Intragranular Porosity
    - Quartz
    - K-Feldspar
    - Plagioclase
    - FOSSIL

    VRF Q K P — PRF Q K P

11. Intergranular Porosity
    - Fractures
    - Fracture-induced dissolution
    - Oversize/elongate pores
    - Grain-edge dissolution
    - Other

12. Other
    - FOSSILS / Calcite Clast
    - PHOSPHATE
    - organic matter.

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K.

THIN SECTION: 72
PROJECT: McKittrick
FORMATION (AGE): Oligocene - Miocene
LOCATION: Temblor
ROCK NAME:
DEPTH: 7963-8015 T-8
POINT COUNTS: 320

SORTING: Poorly sorted
COMPACTION:

SIZE: 0.75mm Coarse Sand
ANGULARITY: Sub - round

COMMENTS

1. Quartz
   - Moncrystalline
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanadine
   - Microphanerite — M / O
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

   *albitization

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

   *much of this part of the grain is undergoing dissolution.

4. Volcanics

5. Microphanerites

6. Accessory Minerals
   - Muscovite
   - Hornblende
   - Pyrite
   - Biotite
   - Hematite — tiny cement
   - glauconite

7. Carbonate Cement
   - Calcite
   - Dolomite

8. Matrix / Pseudomatrix

....Clay-Altered Grains....

9. Clay Cement
   - Kaolinite
   - unidentified

10. Intragranular Porosity
    - Quartz
    - K-Feldspar
    - Plagioclase
    - Fossil

    VRF Q K P — PRF Q K P

11. Intergranular Porosity
    - Fractures
    - Fracture-induced dissolution
    - Oversize/elongate pores
    - Grain-edge dissolution
    - Other

12. Other
    - Phosphate
    - Organic Matter

COMMEMTS

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K.

THIN SECTION: 73
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
DEPTH: 8065 - 8066 T-1 516-8

PROJECT: McKittrick
ROCK NAME:
POINT COUNTS: 302

SORTING: Moderate → Well sorted
COMPACTION:

SIZE: 1mm Very Coarse
ANGULARITY: Sub-Round

COMMENTS

1. Quartz
   - Moncrystalline
   - Polycrystalline ||
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline ||||
   - Orthoclase
   - Sanadine
   - Microphanerite M / O
   - Volcanic Rock Fragment ||
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

4. Volcanics

5. Microphanerites

6. Accessory Minerals
   - Muscovite
   - Zircon
   - Hornblende

7. Carbonate Cement
   - Calcite

8. Matrix / Pseudomatrix

Clay-Altered Grains ||

9. Clay Cement
   - illite/smectite
   - kaolinite ||

10. Intragranular Porosity
   - Quartz ||
   - K-Feldspar ||
   - Plagioclase ||

VRF Q K P — PRF Q K P

11. Intergranular Porosity
   - Fractures
   - Fracture-induced dissolution
   - Oversize/elongate pores
   - Grain-edge dissolution
   - Other

12. Other
   - Phosphate
   - organic matter
   - Clay clasts

COMMEMTS

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q ||||	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q ||	vrfQ	prfQ
K	vrfK	prfK
P ||||	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K.

THIN SECTION: 74
PROJECT: McKittrick
FORMATION (AGE): Oligocene - Miocene
LOCATION: Temblor
ROCK NAME:
DEPTH: 8088 T-16 516-8
POINT COUNTS: 361
SORTING: Well sorted
COMPACTION:
SIZE: 0.6mm Coarse Sand
ANGULARITY: Sub-angular

COMMENTS

1. Quartz
- Moncrystalline
- Polycrystalline
- Microphanerite
- Volcanic Rock Fragment
- Quartz Arenite
- Other Sedimentary
- Metaquartzite
- Other Metamorphic

2. K-Feldspar
- Microcline
- Orthoclase
- Sanadine
- Microphanerite — M / O
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

3. Plagioclase
- Microphanerite
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

4. Volcanics

5. Microphanerites

6. Accessory Minerals
- Muscovite
- Biotite
- Chlorite
- Zircon
- Spinel
- glauconite

7. Carbonate Cement
- Calcite
- Fossils/calcite

8. Matrix / Pseudomatrix
- Clay-Altered Grains

9. Clay Cement
- Kaolinite
- unidentified

*most unidentified looks orange/brown -> possibly illite/smectite.

10. Intragranular Porosity
- Quartz
- K-Feldspar
- Plagioclase
- Fossils

VRF Q K P

PRF Q K P

11. Intergranular Porosity
- Fractures
- Fracture-induced dissolution
- Oversize/elongate pores
- Grain-edge dissolution
- Other

12. Other
- Shale Clast
- Fossils
- organic matter
- Phosphate

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

PARAGENESIS

OTHER

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K!

THIN SECTION: 75
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
ROCK NAME:
DEPTH: 8088-8139 T-2 516-8
POINT COUNTS: 300
SORTING: Poorly Sorted
COMPACTION:
SIZE: 0.95mm
ANGULARITY: Sub-Round

COMMENTS

1. Quartz
- Moncrystalline 𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸 ||
- Polycrystalline ||
- Microphanerite
- Volcanic Rock Fragment
- Quartz Arenite
- Other Sedimentary
- Metaquartzite /
- Other Metamorphic

2. K-Feldspar
- Microcline ||||
- Orthoclase 𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸𝍸 ||
- Sanadine
- Microphanerite M / O
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

3. Plagioclase
- Microphanerite
- Volcanic Rock Fragment
- Sedimentary 𝍸𝍸𝍸 |||
- Metamorphic

4. Volcanics 𝍸𝍸𝍸 |||

5. Microphanerites

6. Accessory Minerals
- Muscovite ||||
- BIOTITE ||
- Pyrite

7. Carbonate Cement
- Calcite 𝍸𝍸𝍸𝍸𝍸𝍸 ||

8. Matrix / Pseudomatrix 𝍸𝍸 ||||
Clay-Altered Grains

9. Clay Cement
- Kaolinite
- unidentified ||

10. Intragranular Porosity
- Quartz
- K-Feldspar 𝍸 |
- Plagioclase 𝍸𝍸
- Phosphate ||

VRF Q K P — PRF Q K P

11. Intergranular Porosity 𝍸𝍸𝍸𝍸 𝍸𝍸
- Fractures
- Fracture-induced dissolution ||||
- Oversize/elongate pores 𝍸𝍸
- Grain-edge dissolution ||||
- Other

12. Other
- Phosphate ||||
- Organic Matter

COMMEMTS

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q ||	vrfQ	prfQ
K ||	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q ||	vrfQ	prfQ
K	vrfK	prfK
P ||	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P ||||	vrfP	prfP

OTHER

Von SEM

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K

THIN SECTION: 76
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
ROCK NAME:
DEPTH: 8155 ~~T-9~~ T-16 516-8
POINT COUNTS: 303
SORTING: Well sorted
COMPACTION:
SIZE: 0.45mm
ANGULARITY: Sub-Round

COMMENTS

1. Quartz 56
   - Moncrystalline |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| ||||
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment ||
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar 16
   - Microcline ||
   - Orthoclase |||| |||| ||||
   - Sanadine
   - Microphanerite — M, O
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. Plagioclase 14
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary |||| |||| ||||
   - Metamorphic

4. Volcanics 2 ||

5. Microphanerites

6. Accessory Minerals 6
   - Glauconite ||
   - Pyrite ||||
   - Muscovite
   - Zircon
   - hornblend
   - Biotite
   - Chlorite

7. Carbonate Cement 174
   - Dolomite |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| ||||
   - Calcite | |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| ||||

8. Matrix / Pseudomatrix
   - Clay-Altered Grains

9. Clay Cement 6
   - Kaolinite |||
   - Unidentified |||

10. Intragranular Porosity 5
    - Quartz
    - K-Feldspar
    - Plagioclase ||||
    - Phosphate |
    - VRF Q, K, P
    - PRF Q, K, P

11. Intergranular Porosity 22 |||| |||| |||| |||
    - Fractures
    - Fracture-induced dissolution
    - Oversize/elongate pores
    - Grain-edge dissolution ||||
    - Other

12. Other 2
    - organic matter
    - shale clast
    - Phosphate ||

COMMEMTS

* Tiny Rhombs of carbonate EVERYWHERE
* Floating grains dominate
* Bands of red staining throughout might be calcite vs. dolomite.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q |	vrfQ	prfQ
K ||	vrfK	prfK
P |	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K.

THIN SECTION: 77
PROJECT: McKittrick
FORMATION (AGE): Oligocene - Miocene
LOCATION: McKittrick
ROCK NAME:
DEPTH: 8155 T-9 516-8
POINT COUNTS: 302
SORTING: Well sorted
COMPACTION:
SIZE: 0.55mm
ANGULARITY: Sub-angular

COMMENTS

1. Quartz
   - Moncrystalline
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanadine
   - Microphanerite (M / O)
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

4. Volcanics

5. Microphanerites

6. Accessory Minerals
   - Muscovite
   - Glauconite
   - Biotite
   - Zircon
   - Pyrite
   - Sphene

7. Carbonate Cement
   - Calcite

8. Matrix / Pseudomatrix

Clay-Altered Grains

9. Clay Cement
   - Kaolinite
   - Unidentified

10. Intragranular Porosity
   - Quartz
   - K-Feldspar
   - Plagioclase
   - VRF Q, K, P
   - PRF Q, K, P

11. Intergranular Porosity
   - Fractures
   - Fracture-induced dissolution
   - Oversize/elongate pores
   - Grain-edge dissolution
   - Other

12. Other
   - Fossils
   - organic matter
   - Phosphorite

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K.

THIN SECTION: 78
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
ROCK NAME:
DEPTH: 8561 T-13 516-8
POINT COUNTS: 300
SORTING: Poorly Sorted
COMPACTION:
SIZE: 1.45 mm Very Coarse Grain
ANGULARITY: Sub-angular

COMMENTS

1. Quartz
   - Moncrystalline — overgrowths
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanadine
   - Microphanerite — M / O
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

4. Volcanics

5. Microphanerites — hornblende

6. Accessory Minerals — muscovite

7. Carbonate Cement — Calcite

8. Matrix /
   - Pseudomatrix
   - Clay-Altered Grains

9. Clay Cement
   - kaolinite
   - unidentified

10. Intragranular Porosity

Quartz	VRF Q	PRF Q
K-Feldspar	K	K
Plagioclase	P	P

11. Intergranular Porosity
    - Fractures
    - Fracture-induced dissolution
    - Oversize/elongate pores
    - Grain-edge dissolution
    - Other

12. Other
    - organic matter
    - phosphate 1.
    - shale clast

COMMEMTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS

SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Alyssa K.

THIN SECTION: 79
PROJECT: McKittrick
FORMATION (AGE): Oligocene-Miocene
LOCATION: McKittrick → Temblor
ROCK NAME:
DEPTH: 8561' T-5
POINT COUNTS: 300
SORTING: Moderately Sorted
COMPACTION:
SIZE: 1.1mm
Very Coarse Grained
ANGULARITY: Sub-Round/Round

COMMENTS

1. Quartz
   - 140 Moncrystalline
   - 2 Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - 2 Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

• lots of Fracturing, overgrowths that fill ~~and con~~ pore and connect grains.

2. K-Feldspar
   - 2 Microcline
   - 20 Orthoclase
   - Sanadine
   - Microphanerite (M / O)
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

• some w/albitization.

3. Plagioclase
   - Microphanerite
   - Volcanic Rock Fragment
   - 10 Sedimentary
   - Metamorphic

• very little plag and what I can find seems to be altered/dissolving.

4. Volcanics 12

5. Microphanerites

6. Accessory Minerals 4
   - Pyrite
   - Zircon

7. Carbonate Cement 2
   - Calcite
   - Dolomite

8. Matrix / Pseudomatrix 4

....Clay-Altered Grains.

9. Clay Cement 42
   - kaolinite

• sometimes mixed w/grain fragme
• slight pink → maybe Ca rich from plagioclase?

10. Intragranular Porosity
   - Quartz
   - K-Feldspar
   - Plagioclase

VRF Q K P — PRF Q K P

11. Intergranular Porosity 26
   - Fractures 2
   - Fracture-induced dissolution 6
   - Oversize/elongate pores 16
   - Grain-edge dissolution 12
   - Other

12. Other
   - Phosphate
   - Organic Matter 2

COMMEMTS

*lots of kaolinite → possibly accounts for so little feldspar and volcanics.
*The few carbonates = ½ dolomite/ankerite, ½ calcite. strange dissolution in middle of grains..

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q 2	vrfQ	prfQ
K	vrfK	prfK
P 2	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q 5	vrfQ	prfQ
K 1	vrfK	prfK
P 6	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q 2	vrfQ	prfQ
K	vrfK	prfK
P 6	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K!

THIN SECTION: 81
FORMATION (AGE): ~~9961~~ Temblor
LOCATION: Oligocene-Miocene
DEPTH: 9961'

PROJECT: McKittrick

ROCK NAME:
POINT COUNTS: 340

SORTING: Well Sorted

COMPACTION:

SIZE: Medium grained
0.35mm

ANGULARITY: Sub-Angular

COMMENTS

1. Quartz 108
   - Moncrystalline |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - 2 Microcline ||
   - 32 Orthoclase |||| |||| |||| |||| |||| |||| ||
   - Sanadine
   - Microphanerite ≤ M O
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - 2 Microphanerite granitic ||
   - Volcanic Rock Fragment
   - 28 Sedimentary |||| |||| |||| |||| |||| |||
   - Metamorphic

4. Volcanics 18 |||| |||| |||| |||

5. Microphanerites

6. Accessory Minerals 16
   - Glauconite ||
   - Muscovite ||||
   - Pyrite |||| |||
   - Chlorite ||

7. Carbonate Cement 50 Calcite |||| |||| |||| |||| |||| |||| |||| |||| |||| ||||

8. Matrix / 7 |||| ||
   - 7 Pseudomatrix |||| ||
   - 8 Clay-Altered Grains 8 |||| |||

9. Clay Cement 54 unidentified |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| ||||

10. Intragranular Porosity
   - Quartz
   - K-Feldspar
   - Plagioclase
   - VRF Q K P
   - PRF Q K P

11. Intergranular Porosity
   - Fractures
   - Fracture-induced dissolution
   - Oversize/elongate pores
   - 2 Grain-edge dissolution ||
   - Other

12. Other 6
   - OM |||| |
   - Phosphate
   - Fossils

COMMEMTS

* Pyrite/OM difficult to distinguish.
* Pseudomatrix and clay altered grains make ct and TPI difficult to obtain.
* Glauconite is labile and sometimes fills pore spaces (images).

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q ||	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

SANDSTONE PETROGRAPHY DATA EXAMINED BY: Alyssa K!

THIN SECTION: 82
FORMATION (AGE): Oligocene-Miocene
LOCATION: Temblor
DEPTH: 9966'
SORTING: Moderate → Poorly
SIZE:

PROJECT: McKittrick CCS
ROCK NAME:
POINT COUNTS: 302
COMPACTION:
ANGULARITY: Sub-Angular

COMMENTS

1. Quartz
   - 86 Moncrystalline
   - 4 Polycrystalline
   - 8 Microphanerite granitic
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary ________
   - Metaquartzite
   - Other Metamorphic ________

2. K-Feldspar
   - 2 Microcline
   - 30 Orthoclase
   - Sanadine
   - 2 Microphanerite granitic < M O
   - Volcanic Rock Fragment
   - Sedimentary ________
   - Metamorphic ________

3. Plagioclase
   - 4 Microphanerite ~~[illegible]~~ granitic
   - Volcanic Rock Fragment
   - 30 Sedimentary
   - Metamorphic ________

4. Volcanics 24

5. Microphanerites 6 muscovite/granitic; pyrite

6. Accessory Minerals: Muscovite, Glauconite, Biotite, Chlorite, Pyrite, Zircon, Hornblende

7. Carbonate Cement 8 calcite

8. Matrix / 54
   - 16 Pseudomatrix
   - 12 Clay-Altered Grains

9. Clay Cement 14 unidentified; kaolinite

10. Intragranular Porosity: Quartz, K-Feldspar, Plagioclase; VRF Q, K, P; PRF Q, K, P

11. Intergranular Porosity: Fractures; Fracture-induced dissolution; Oversize/elongate pores; Grain-edge dissolution; Other ________

12. Other 2 OM/HC; Phosphate

COMMEMTS

* Fractures everywhere that are due to polishing most likely.

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

GRAIN-EDGE DISSOLUTION

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OVERSIZE/ELONGATE PORES

Q	vrfQ	prfQ
K	vrfK	prfK
P	vrfP	prfP

OTHER

PARAGENESIS