Diagenesis of Oligocene and Eocene Sandstones at the
Greeley Oil Field, Southern San Joaquin Basin,
California

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ABSTRACT

The Vedder Formation (Oligocene) and Eocene sands at the Greeley oil field consist of arkosic to subarkosic arenites and graywackes. Grain size ranges from fine to coarse sand and the sands vary from poorly to well sorted. Burial depths of the Vedder sands exceed 10,350 ft and the reservoir temperature is 255ºF. The Eocene sands are buried at greater than 12,861 ft and the reservoir temperature is estimated to be around 275ºF. These sands are currently at or very near their deepest burial depths.

Porosity within the Vedder and Eocene sands is controlled by compaction, dissolution of framework grains, and cementation. Mechanical compaction is evident by long, concavo-convex and sutured grain-to-grain contacts, fractured and broken framework grains and cements, and deformed labile grains. Compaction reduced primary porosity through readjustment of grains, fracturing and subsequent rotation of grain fragments, and deformation of micas and labile grains. Precipitation of cements, including phosphate, clays, calcite, dolomite, K-feldspar, quartz, barite, anhydrite, and pyrite, also reduced porosity at various times during burial. Other diagenetic processes included glauconization of feldspars, quartz, and chert, phosphate replacing feldspars, glauconite, and quartz, replacement of framework silicates by carbonates, alteration of biotite, albition of feldspars, dissolution of framework grains and carbonates, and dolomite replacing calcite.

Dissolution of feldspars, quartz, volcanics, micas, and carbonates created secondary porosity and altered QFRf and QFL ratios. Deeper samples are quartz-rich relative to shallower samples, suggesting feldspar removal through dissolution. Dissolution affected
plagioclase more than K-feldspar. Continued compaction reduced both primary and secondary porosity and most likely permeability, while continued dissolution of framework grains and cements maintained an open pore network, thus facilitating the migration and accumulation of hydrocarbons. Pyrite formed after emplacement of hydrocarbons suggesting continuing thermal maturation within the reservoir.

Textural relationships of the diagenetic minerals suggest syndepositional formation of glauconite, phosphate, and early pyrite, followed by early precipitation of pore-lining clay coatings and carbonate cements, along with framework-grain fracturing and possibly dissolution. With increasing burial, dissolution of framework grains continued, accompanied by albitization of feldspars, formation of K-feldspar and quartz overgrowths, precipitation of kaolinite and other clays, and possibly precipitation of late carbonate cements. Finally, hydrocarbon migration and formation of late pyrite occurred during late diagenesis.
INTRODUCTION

Predicting reservoir quality in sandstones is a valuable tool for hydrocarbon exploration and production. In the southern San Joaquin basin (Fig. 1), hydrocarbon production mainly comes from sandstone reservoirs. As these sandstones were buried, they underwent diagenesis. Diagenetic processes include compaction, deformation, dissolution, cementation, replacement, and recrystallization of minerals. These processes significantly alter the reservoir quality by reducing or increasing porosity and permeability (Schmidt and McDonald, 1979; Ehrenberg, 1990). Understanding the diagenetic processes of the target reservoir may increase the possibility of exploration and production success (Galloway, 1979; Hayes, 1979).

The Greeley oil field is located 10 miles northwest of Bakersfield, California (Fig. 1). It has been producing hydrocarbons since 1936. Production comes mainly from sandstones in the Vedder Formation and the Stevens sands within the Monterey Formation (California DOGGR, 1998). Burial depths of the Vedder Formation exceed 10,350 ft. The Eocene sands within the Kreyenhagen Formation are buried at depths greater than 12,861 ft. Petrologic aspects of the Vedder Formation along the eastern margin of the basin and of Eocene sands on the western margin of the basin have been well documented (i.e. Clarke, 1973; Olson et al., 1986; Bent, 1988; Hayes and Boles, 1992; Taylor, 2007), however, there have been no detailed published studies of the Vedder and Eocene sands from near the axis of the basin. The purpose of this study is to determine the mineralogy and interpret the diagenetic processes of the Vedder and Kreyenhagen Formations sandstones at the Greeley oil field.
Fig. 1. The location of Campen 1, KCL 11-17, Lewis 3 and 4, R.A. Moore 2 and 3, Scofield and Vale 1, and Elrich Community 1 wells at the Greeley oil field, located in the southern San Joaquin basin, and stratigraphic column of Vedder and Eocene sands. Modified from Gautier and Scheirer (2007).
GEOLOGIC SETTING

The San Joaquin basin is bounded by the Sierra Nevada on the east, Temblor Range on the west, and San Emigdio and Tehachapi Mountains on the south. It is part of the Great Valley forearc basin that formed during Late Jurassic time (Bartow, 1991). The San Joaquin basin contains ~30,000 ft of marine and non-marine sediments, deposited from Late Mesozoic through Cenozoic time (Bandy and Arnal, 1969; Bartow, 1991).

In the southern San Joaquin basin, the stratigraphic sections on the eastern margin consist of continental facies while stratigraphic sections on the western side consist of shallow to deep marine facies (Bartow, 1991; Wagoner, 2009). Structurally, the eastern margin of the basin is little-deformed compared to the western margin of the basin. En echelon fold sets on the west side are associated with the migration of the Mendocino triple junction and the formation of the San Andreas transform fault in the Oligocene (Bartow, 1991), as well as more recent transpression (Niemi and Hall, 1992; Grove and Niemi, 2005). Active tectonics along the western margin of the North American plate resulted in periods of uplift and subsidence within the basin. The marine Vedder and Kreyenhagen Formations are transgressive units deposited in the Oligocene and Eocene (Bartow and McDougal, 1984; Bloch and Olson, 1990; Bartow, 1991).

The Vedder Formation underlies the Rio Bravo sands of the Freeman-Jewett Formation and is separated from the Kreyenhagen Formation by the Tumey Formation (Fig. 1) (Gautier and Scheirer, 2007). The Vedder Formation covers a large portion of the San Joaquin basin and ranges in thickness from 0 ft on the eastern margin of the basin to 2,000 ft close to the southern basin boundary (Richardson, 1966). It is ~1,250 ft thick at the Greeley oil field (Sullivan and Weddle, 1960; Bloch and Olson, 1990). The upper
portion of the formation consists of well sorted, very fine- to coarse-grained, gray sandstones. The lower portion of the formation consists of dark brown shale; it is separated from the upper portion by thin, tight, gray sands. The Vedder Formation sands are exposed on the eastern margin of the southern San Joaquin basin, where they range from 0 to 262 ft thick, and are composed of light gray, well-sorted, fine to medium sand (Sullivan and Weddle, 1960). These sands were derived from the Sierra Nevada and deposited in a shallow-marine setting (Bent, 1985; Bent, 1988; Olson, 1988; Bloch and Olson, 1990).

The late Middle to Late Eocene Kreyenhagen Formation is composed of mostly deep-marine shales with minor sandstones and siltstones. The formation is thickest to the west and thins out to the north and east (Isaacson and Blueford, 1984). The upper portion of the formation consists of the informal Famoso sand member (Wagoner, 2009) and the lower portion of the formation has not been correlated at the Greeley oil field. The Kreyenhagen Formation covers most of the San Joaquin basin and was derived from source areas to the south, west, and east of the basin (Clarke, 1973). It is one of the basin’s major hydrocarbon source rocks (Isaacson and Blueford, 1984; Lillis and Magoon, 2007).

**STRUCTURE**

The Greeley oil field is located just off the crest on the north flank of the Bakersfield arch, a northeast-southwest trending anticline that separates the Buttonwillow sub-basin to the north from the Maricopa (aka Tejon) sub-basin to the south and along which many important San Joaquin basin oil fields are located. The Greeley oil field is four miles long and ranges from one to two miles wide. The structure of the field is a
northwest-southeast trending anticlinal fold, part of a series of en-echelon fold sets that host oil reservoirs both on and off the Bakersfield arch. On the eastern margin of the field lies the Greeley fault, a normal fault with the downthrown side to the east. The fault has a vertical displacement of ~250 ft (Sullivan and Weddle, 1960).

METHODS

Forty-nine thin sections of Vedder sands from eight wells (Campen 1, KCL 11-17, Lewis 3 and 4, R.A. Moore 2 and 3, Scofield 1, and Vale 1) and fourteen thin sections of Eocene sands from one well (Elrich Community 1) (Fig. 1) were analyzed using a standard transmitted-light petrographic microscope, located in the California State University, Bakersfield Geological Sciences Department. The depths of the samples from Campen 1, KCL 11-17, Lewis 3 and 4, R.A. Moore 2 and 3, Scofield 1, and Vale 1 are between 11,300 to 11,517 ft, and Elrich Community 1 (ELR) well are between 13,446 to 13,512 ft. Each thin section was point-counted (300 points per thin section) using the petrographic microscope. The mineralogy, grain size, roundness, and sorting were recorded for each thin section. Diagenetic features such as cementation, alteration, dissolution, and compaction were also recorded.

The data collected from petrographic analysis are plotted on three ternary diagrams following the methodologies of Dickinson (1970), Dott (1964) as modified by Pettijohn et al. (1987), and Harris (1989). Quantitative analysis of compaction of these sandstones were documented using the contact index (CI) and tight-packing index (TPI) following the methodologies of Wilson and McBride (1998). Selected thin sections were analyzed using a Hitachi scanning electron microscope (SEM) equipped with a back-scattered electron (BSE) imaging and Gatan cathode luminescence (CL) system, and an Oxford
INCA energy-dispersive x-ray spectrometer (EDS). The SEM-EDS analytical system provided the chemical components of the minerals while the SEM-CL system provided the textural relationships between the detrital grains, cements, and fractures.

The point count results were also used to calculate the mass transfer of aluminum by comparing the volumes of authigenic kaolinite and secondary porosity formed by feldspar dissolution (Hayes and Boles, 1992). The calculations assumed dissolved feldspars released aluminum ions that precipitated as kaolinite. The composition of detrital An$_{30}$ was used based on Boles and Ramseyer’s (1988) study on albitization in the San Joaquin basin as well as detrital plagioclase compositions determined during this study. For each mole of plagioclase dissolved, 0.65 mole of kaolinite could precipitate:

$$\text{Na}_0.7\text{Ca}_0.3\text{Al}_{1.3}\text{Si}_{2.7}\text{O}_8 + \text{H}^+ + 3.75\text{H}_2\text{O} \rightarrow$$

$$0.65\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + 1.4\text{H}_4\text{SiO}_4 + 0.7\text{Na}^+ + 0.3\text{Ca}^{2+} + 0.3\text{OH}^-$$

(Plagioclase) (Kaolinite)

For each mole of K-feldspar dissolved, 0.5 mole of kaolinite could precipitate:

$$\text{KAlSi}_3\text{O}_8 + \text{H}^+ + 4.5\text{H}_2\text{O} \rightarrow 0.458\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + 2\text{H}_4\text{SiO}_4 + \text{K}^+$$

(K-feldspar) (Kaolinite)

The percent imbalance of kaolinite indicates whether aluminum has been exported or imported on the scale of the thin section during diagenesis. This was calculated by comparing the observed kaolinite volume and the expected volume based on observed feldspar dissolution:

$$\% \text{ Imbalance} = \frac{\text{Kaolinite Volume Reported} - \text{Expected Volume of Kaolinite}}{\text{Expected Volume of Kaolinite}}$$

Other sources of aluminum ions are volumetrically minor and have been excluded from the mass-balance calculations. Also, the expected volumes of kaolinite do not take into account secondary porosity for which the dissolved minerals could not be determined and
are, therefore, conservative.

RESULTS

Detrital Composition and Texture

The Vedder sands range in size from fine to medium sand (Figs. 2a, b). The Eocene sands range from fine to coarse sand (Figs. 2c, d). Grain size is typically smaller in graywackes. Framework grains in both sands vary from angular to round and sorting varies from poorly to well sorted. In general, the sands are moderately sorted with subangular grains. Poor sorting in some samples is due to smaller fragments created by fracturing of the framework grains.

Fig. 2. Porosity is filled with blue epoxy. (a-b) Typical and atypical textures of the Vedder sands. (c-d) Typical and atypical textures of the Eocene sands.
Compositional data is presented in Table 1. The sandstones are composed of quartz (mainly monocrystalline grains), plagioclase and K-feldspars (microcline and orthoclase), and minor rock fragments. The mean value for the Vedder sands is $Q_{34}F_{52}Rf_{14}$ and Eocene sands is $Q_{69}F_{24}Rf_{7}$. Accessory detrital minerals include biotite, muscovite, chlorite, epidote, hornblende, titanite, and zircon. Fossils occurred in very small amounts in some of the samples, but no attempt was made to identify them. The Vedder Formation sandstones consist of arkosic arenites and graywackes (Fig. 3). The Eocene sandstones consist of arkosic to subarkosic arenites and graywacke (Fig. 3). The Vedder sands plot in the basement uplift field on a QFL diagram (Dickinson, 1970) and Eocene sands plot in the transitional continental field (Fig. 4).

**Fig. 3.** QFRf ternary diagram (Pettijohn et al., 1987) for Vedder and Eocene sands. The results suggest deeper samples (Eocene sands) are more quartz-rich than shallower samples (Vedder sands).
Fig. 4. QFL ternary diagram (Dickinson, 1970) for Vedder and Eocene sands. The results indicate most of the samples are derived from basement uplift and transitional continental.

Quartz is most abundant in the Eocene sands. Quartz generally luminesces blue (Figs. 5, 6, 7, 8) or is non-luminescent (Figs. 5, 6), however, some quartz within the Vedder sands luminesces brownish-red (Fig. 5).

Fig. 5. (a-b) SEM-BSE and -CL images of plagioclase (Pl), quartz (Q), polycrystalline quartz (Q_P), and porosity (Φ). Pl_a is Ca-rich, Pl_b is Na-rich, Pl_c is Ba-rich, and Pl_d is under the detection limit. Plagioclase luminesces pinkish-purple (Pl_a), pink (Pl_b and Pl_c), and blue (Pl_d). Quartz luminesces blue (green fonts), brownish-red (blue fonts), and non-luminescent (pink font). Well: KCL 11-17, depth: 11,324 ft.
Fig. 6. (a-b) SEM-BSE and -CL images of albitized (Ab) plagioclase (Pl), Ba-rich K-feldspar (K_B), K-feldspar overgrowths (K_O), and quartz (Q). Albitization occurs along the radiating fractures in plagioclase. K-feldspar overgrowths formed along plagioclase and Ba-rich K-feldspar grain boundaries. Plagioclase luminesces pink, Ba-rich K-feldspar luminesces bright pink, albite and K-feldspar overgrowths are non-luminescent, and quartz luminesces blue and non-luminescent. Well: R.A. Moore 2, depth: 11,408 ft.

Fig. 7. (a) SEM-BSE image of fractured (Fr) quartz (Q) and quartz overgrowth (Q_O) on quartz grain. The yellow arrows point at the possible original grain boundary between detrital and authigenic quartz. (b) Composite image of SEM-BSE and -CL images revealing quartz overgrowth (Q_O) on a rounded quartz grain (red arrows) and multiple episodes of fracturing. Early fractures (F_E) in quartz were healed by secondary quartz whereas late fractures (F_L) remain open. Notice quartz luminesces blue. Well: ELR, depth: 13,464 ft.
Fig. 8. (a) SEM-BSE image of almost completely albited (Ab) Ba-rich K-feldspar (K_B) surrounded by quartz (Q). (b) Composite image of SEM-BSE and -CL images of authigenic albite (Ab_{AU}) replacing Ba-rich K-feldspar, but not albite from perthite (Ab_P). K-feldspar and albite from perthite luminesce pink, quartz luminesces blue, and authigenic albite is non-luminescent. Well: ELR, depth: 13,464 ft.

Feldspars decrease with depth (Figs. 9a, 10). Plagioclase (Fig. 9b) decreases at a faster rate compared to K-feldspars (Fig. 9c). Plagioclase averages 20% in volume in the Vedder sands and 7% in volume in the Eocene sands. SEM-EDS analyses indicate detrital plagioclase compositions in the Vedder Formation range from An_{55} to An_{2} (Fig. 11). Detrital plagioclase ranges from An_{38} to An_{8} in the Eocene sands, but only two analyses exceeded An_{30}. Some plagioclase grains also contain up to 1.0 wt% of Sr and/or 0.1 wt% of Ba (Fig. 12); there is a significant decrease in the Sr content of plagioclase in the Eocene sands as compared to the Vedder Formation. Detrital plagioclase luminesces pink (Figs. 5, 6), pinkish-purple (Fig. 5), and blue (Fig. 5).
Feldspar decreases with increasing depth, N=63.
Fig. 10. QKP ternary diagram plotted for the Vedder and Eocene sands following the methodology of Harris (1989). The compositions are adjusted for dissolution. The arrows point to the present composition, they originate at the reconstructed compositions. This suggests significant plagioclase dissolution has occurred as evidenced by the arrows pointing toward the quartz corner. The Dots indicate no change in composition.
Fig. 11. K, Na, Ca ternary diagram of detrital and authigenic feldspars. Calcic plagioclase was preferentially removed as indicated by a shift towards more sodic compositions in deeper samples. Authigenic K-feldspar and albite are almost pure.

Ba AND Sr VS. DEPTH

Fig. 12. Depth vs. Ba and Sr (wt%) in plagioclase of the Vedder and Eocene sands. The amounts of Ba remain the same in both sandstones while the amounts of Sr decrease with depth.
Both the Vedder and Eocene sandstones contain an average 12.5% K-feldspars (Fig. 9c). The Vedder sands consist of 7.5% microcline and 5.1% orthoclase. In the Eocene sands, 8.1% is microcline and 4.0% is orthoclase. Most detrital K-feldspars contain some Na (Fig. 11) and some are Ba-rich (Figs. 6, 8). K-feldspars luminesce pink (Figs. 6, 8) and blue.

Rock fragments include metamorphics, volcanics, cherts, and microphanerites. In some instances labile rock fragments were squashed to form pseudomatrix.

**Compaction**

Quantitative analysis (Table 2) of compaction in arenite samples of the Vedder (N=12) and Eocene sands (N=11) have been investigated following the methodologies of Wilson and McBride (1988). The number of contacts between grains is reported as contact index (CI) and tight-packing index (TPI). The CI for the Vedder sands ranges from 2.9 to 6.1 and TPI ranges from 2.3 to 6.0 (Fig. 13). For the Eocene sands, CI ranges from 4.9 to 7.0 and TPI ranges from 3.5 to 6.8 (Fig. 13). The CI of the Vedder and Eocene sands shows a minor increase with depth, but there is no significant change in the TPI. Floating grains are not common in arenites but are more common in those samples with significant cement (phosphate or carbonate) volumes.

Detrital feldspars, volcanics, glauconite, biotite, and muscovite are commonly deformed. Some volcanics, feldspars, and biotite (Fig. 14) have been altered and squeezed into adjacent pore spaces to form pseudomatrix. Early compaction between the framework grains created point and tangential contacts. Late compaction between the framework grains caused pressured-induced dissolution, forming long, concavo-convex, and sutured contacts.
Fig. 13. Contact index (a) and tight-packing index (b) of the Vedder and Eocene sands.

Fig. 14. Deformed and altered biotite forming pseudomatrix (Ps). Well: KCL 11-17, depth: 11,300 ft.
Fractures

Fracturing of the feldspars (Fig. 6), quartz (Figs. 7, 15), and micas is common. Fracture growth occurred along grain boundaries and/or cleavage planes. Fracturing within detrital grains (Fig. 6) and cement crystals (Fig. 16) is common at shallower depths. Through-going fractures are more common in deeper samples (Figs. 7, 15). Fracturing created various sizes of angular fragments, thus increasing the angularity of grains and decreasing the degree of sorting.

Fig. 15. (a) SEM-BSE image shows remnants of feldspars (F_R) and fractured (Fr) quartz (Q). Small remnants of feldspars within porosity (Φ_S) suggests porosity created by dissolved feldspars. (b) Composite image of SEM-BSE and –CL images shows authigenic quartz (Q_{AU}) healed fractures (F_H) within quartz grains. Subsequent compaction reopened (F_O) the healed fractures within quartz and may have collapsed secondary porosity created by feldspar dissolution. Well: ELR, depth: 13,464 ft.

Fig. 16. Fractured dolomite (Do) crystal in pore space. Well: Campen 1, depth: 11,400 ft.
**Authigenic Minerals**

*Glauconite*

Glauconite grains range from subround to round (Fig. 17). Glauconite replaced chert, feldspars, and quartz. Replacement by glauconite ranges from partial to complete and occurred along the fractures and grain boundaries. Complete replacement by glauconite often occurred in feldspars. Glauconite is most common in medium sand with abundant matrix.

![Fig. 17. Zoned phosphate (P) replacing glauconite (Gl). The red arrows point to the original grain boundary. Well: R.A. Moore 2, depth: 11,408 ft.](image)

*Phosphate*

Phosphate is present in several samples in the Vedder sands. It occurred as individual grains, coatings on framework grains, and cement. The phosphate coatings occur as light, medium, and dark brown zones (Fig. 17). The outer zones are darker than the inner zones. Phosphate replaced feldspars, glauconite (Fig. 17), and quartz. Phosphate replacement often occurred along the grain boundaries and sometimes along fractures. Phosphate cement filled the intergranular pore space. Some phosphate cement contains
fragments of feldspars and quartz. The cement occurred as light and dark brown zones. The outer zones are darker than the inner zones.

*Pyrite*

Authigenic pyrite crystals occur throughout the sandstones, ranging from 0 to 5% of the rock. Pyrite formed along the biotite cleavage planes, within hydrocarbon-filled pores (Fig. 18), and between feldspar and phosphate coating. The crystal shapes range from subhedral to euhedral, up to 40 µm long. Pyrite occurs as isolated crystals or cement.

![Fig. 18. Pyrite (Py) formed within hydrocarbon (Hy) in secondary pore created by framework-grain dissolution. (a) Transmitted light, (b) Reflected light. Well KCL 11-17, depth: 11,470 ft.](image)
Clays

Authigenic clays occurred as coatings on detrital grains (Figs. 19, 20) and cement crystals (Fig. 21), and as pore-lining and pore-filling cements (Fig. 22). The authigenic clays have been observed within the petrographic microscope and confirmed using SEM-EDS analyses. They include mixed-layer illite/smectite (I/S) (Fig. 22) and illite/chlorite (I/C), chlorite, and kaolinite (Fig. 19). Most samples contain all four species; they range from 0 to 18% of the rock volume (Table 1). Clays in these sandstones are mostly products of altered feldspars (Fig. 19) and rock fragments.

Fig. 19. Kaolinite (Ka) formed adjacent to remnants of feldspar ($F_R$) within a clay coating (yellow arrows) suggests kaolinite precipitated from dissolved feldspar. Unstable grain completely dissolved and left a clay coating behind (red arrows). Well: R.A. Moore 3, depth: 11,474 ft.
Fig. 20. Quartz (Q) exhibit fluid inclusion trains (F\text{IT}) and clay coating (black arrows). Fluid inclusion trains suggest authigenic quartz healed fractures within detrital quartz. The clay coating on quartz separates the detrital grain from overgrowth (Q\text{O}). Well: ELR, depth: 13,464 ft.

Fig. 21. Dolomite formed in pore space created by quartz (Q\text{A}) dissolution (purple arrow). Dolomite (Do) cement replaced feldspar (F) and quartz (Q\text{B}). The blue and green arrows point to the original grain boundaries of quartz (Q\text{B}) and feldspar. Dolomite exhibiting clay coatings (red arrows) suggest at least two episodes of dolomite precipitation. Well: Campen 1, depth: 11,370 ft.
Fig. 22. SEM-BSE image of partially dissolved K-feldspar overgrowths ($K_0$) on detrital K-feldspar (K) grains. Mixed layer illite/smectite (I/S) formed on the edge of K-feldspar with tightly-packed framework grains (red arrows) suggests the clays formed during late diagenesis. Well: ELR, depth: 13,464 ft.

I/S and I/C often occur as pore linings or coatings and are commonly found near or sometimes intergrown with pore-filling kaolinite. These clays range from 0 to 18% in volume, with the average volume of 2%. In some cases I/S or I/C coatings occur between detrital quartz grains and overgrowths.

Chlorite is present in very small amounts. It commonly occurs as a product of biotite alteration, in which patches of chlorite are found along biotite cleavage planes.
Kaolinite is present in most samples as pore-filling cement, ranging from traces to 9% in volume (average 2%). It commonly occurs as booklets, up to 20 µm thick, partially to completely filling the pore space. Kaolinite often formed adjacent to dissolved feldspars or enclosed within remnant clay coatings from partially dissolved feldspars (Fig. 19). In the Lewis 3 well, kaolinite completely replaced precursor grains. In volcanic rock fragments, feldspars partially altered to kaolinite while the rest of the grains remain unaltered. SEM-EDS analyses indicate that kaolinite contains a minor amount of Na and Sr, probably within undissolved remnants of detrital feldspars.

**Carbonate**

Carbonate cements occur in most of the samples, ranging from small traces to 57%. These include dolomite (Figs. 21, 23) and calcite (Figs. 24, 25), with calcite being the most abundant. Calcite occurs as poikilotopic cement filling the pore spaces and replacing quartz (Fig. 24), plagioclase (Fig. 24), K-feldspars, and volcanics. In early stages of calcite replacement, large portions of the grains remained unaltered and the minerals can be identified. In later stages of calcite replacement, the grains are completely replaced and cannot be identified. As a result, the porosity is reduced to 0 in several samples and the framework grains appeared to be floating.
Fig. 23. SEM-BSE image of zoned dolomite (Do) cemented sandstone. Albitized (Ab) plagioclase (Pl) with remnants of original plagioclase and albitized Ba-rich K-feldspar (K_B) grains exhibit K-feldspar overgrowths (K_O), but quartz (Q) does not. Remnants of dolomite (D_R) within K-feldspar overgrowths (K_O) suggest that the overgrowths have replaced dolomite. Secondary porosity (\(\Phi_S\)) within the plagioclase and dolomite indicate a later dissolution event that did not affect the authigenic K-feldspar. Also notice the cross-cutting relationship of K-feldspar overgrowth around euhedral dolomite, indicating K-feldspar formed after dolomite. Well: KCL 11-17, depth: 11,470 ft.
Fig. 24. SEM back-scattered electron (BSE) image of calcite (C), quartz (Q), and albitized (Ab) plagioclase (Pl) and K-feldspar (K). Calcite has replace quartz and plagioclase; the red and green arrows show the original plagioclase and quartz edges respectively. Well: ELR, depth: 13,464 ft.

Fig. 25. Sharp contact between calcite (C) cement and quartz (Q) overgrowth (red arrow) suggests quartz overgrowth formed prior to calcite precipitation. Well: Campen 1, depth: 11,406 ft.
Albite

Authigenic albite replaced plagioclase (Figs. 6, 23, 24, 26) and K-feldspars (Figs. 8, 23). Albitization of detrital feldspars occurred along the fractures (Figs. 6, 8, 23, 24, 26) and/or original grain boundaries (Fig. 8). Some detrital feldspars in deeper samples (Fig. 8) are more albitized compared to detrital feldspars in shallower samples (Figs. 6, 23, 26). The average composition for albite in shallower samples is Ab$_{97.3}$An$_{2.2}$Or$_{0.5}$ and in deeper samples is Ab$_{98.5}$An$_{1.0}$Or$_{0.5}$. SEM-CL imaging revealed authigenic albite is non-luminescent (Figs. 6, 8) in these sandstones.

![Fig. 26. SEM-BSE image of albitized (Ab) plagioclase (Pl) exhibiting K-feldspar infilled (K$_i$) fractures. The cross-cutting relationship between albite and K-feldspar infilled fractures indicates albitization occurred before authigenic K-feldspar. Well: KCL 11-17, depth: 11,324 ft.](image)

K-feldspar

Authigenic K-feldspar occurred as overgrowths and within fractures in plagioclase (Figs. 6, 23, 26) and K-feldspar (Figs. 6, 22, 23). It is most abundant in shallower samples, especially in the KCL 11-17 well. The overgrowths usually exhibit an optical
discontinuity between the detrital grains, and they are non-luminescent (Fig. 6). In some cases K-feldspar overgrowths replaced dolomite cement (Fig. 23). Partial dissolution of the K-feldspar overgrowths occurred in deeper samples (Fig. 22). SEM-EDS analyses indicate the K-feldspar overgrowth is almost pure (Fig. 11) with average compositions of Or$_{98.9}$Ab$_{0.9}$An$_{0.2}$ in Vedder sandstones and Or$_{99.5}$Ab$_{0.4}$An$_{0.1}$ in Eocene sandstones.

**Quartz**

Authigenic quartz occurs as overgrowths (Figs. 7, 20, 25) and fills fractures (Figs. 7b, 15) within detrital quartz grains. Authigenic quartz is usually optically continuous with the detrital grains and often cannot be identified under the petrographic microscope. Some detrital quartz grains have clay coatings (Fig. 20), separating them from the overgrowths. In other cases, euhedral crystal faces (Figs. 7a, 25) indicate the presence of overgrowths. Fluid inclusion trains within detrital quartz grains suggest secondary-quartz-healed fractures (Fig. 20). Petrographic and SEM-BSE (Fig. 7a) images only show open fractures within detrital quartz grains, but SEM-CL images reveal non-luminescent secondary quartz that has healed fractures in detrital quartz grains (Fig. 7b). Continuing compaction resulted in subsequent formation of open fractures (Fig. 15).

**Pseudomatrix**

Pseudomatrix occurs scattered throughout the rock, ranging from 0 to 2% of the rock volume. It is most common in samples with small amounts of volcanic rock fragments. Pseudomatrix formed from squeezing of micas (Fig. 14) and rock fragments into the adjacent pore throats. Some partially dissolved feldspars formed pseudomatrix as well.

**Rutile**
Diagenetic rutile crystals occur in very small amounts within the Vedder sands. The crystals occur in association with pyrite crystals and clays. These subhedral to euhedral crystals are up to 20 µm long and 10 µm wide.

**Barite**

Barite cement was observed in very small amounts in three samples. It occurs as poikilotopic cement within the pore space and possibly replacing feldspars. The framework grains were tightly-packed before barite precipitation.

**Anhydrite**

Small amounts of anhydrite have been identified using SEM-EDS. It occurs as coatings on carbonate cements and between biotite cleavage planes. The actual amount of anhydrite is unknown as some probably dissolved during thin section manufacture.

**Hydrocarbons**

Although most hydrocarbons were removed during thin section manufacture, patches of hydrocarbons occur within pore spaces in most samples (Fig. 18). Volatile loss from these old cores most likely changed the nature of these hydrocarbons, so no attempt was made to further characterize them.

**Porosity**

Porosity within these sandstones varies from traces to 20% (Fig. 27, Table 1). While porosity fluctuates between samples collected from similar depth intervals, there is a general trend of porosity decreasing with depth. Intragranular porosity averages 0.5% and intergranular porosity averages 7% of the rock volume. Intragranular porosity is most likely of secondary origin while intergranular porosity can be of primary or secondary origin. Following the methodologies of Schmidt and McDonald (1979) and Shanmungam
(1985), primary porosity in these rocks is estimated to range between 0 and 50% of the intergranular porosity. Porosity within graywackes is significantly less than within arenites due to the presence of matrix. Cementation by carbonates, as well as K-feldspar, and quartz, has significantly reduced porosity in some samples. The formation of pseudomatrix resulted in a minor porosity reduction.

Secondary porosity commonly resulted from dissolution of detrital feldspars (Figs. 15, 19), particularly plagioclase (Fig. 23). However, carbonate and K-feldspar cements, as well as detrital quartz, micas, and volcanics were also affected by dissolution. Figure 28 is a ternary diagram adjusted for grain dissolution (Harris, 1989) indicating shifts toward more quartz-rich compositions in the arenites but little change in the graywackes.
Fig. 28. QFRf ternary diagram for Vedder and Eocene sands. The compositions are adjusted for grain dissolution. The arrows point to the present composition, they originate from the reconstructed compositions (Harris 1989). This suggests that on-going dissolution results in more quartz-rich compositions. The Dots indicate no change in composition.

**Mass Balance**

The potential for mass transfer of aluminum into or out of the sands was investigated. The amounts of kaolinite cement present in the samples were compared to the amounts of kaolinite cement that would have been produced if all aluminum released during documented feldspar dissolution was incorporated into kaolinite. The percent imbalance of kaolinite suggests export or import of aluminum during diagenesis.

The amounts of kaolinite cement precipitated from dissolved plagioclase and K-feldspar assumes that there is 0% microporosity in the kaolinite. The microporosity of kaolinite in these sandstones was examined by using the SEM-BSE images from 650 to 1,300X magnifications. The results indicate kaolinite has an average of 40% microporosity. The amount of kaolinite cement, adjusted for 40% microporosity, that
could precipitate from one volume of dissolved plagioclase is 1.08 and one volume of dissolved K-feldspar is 0.76. The average volume of authigenic kaolinite is 0.92 of the volume of dissolved feldspars.

The percent imbalance of kaolinite is shown in Table 3. The results suggest aluminum export in 54% of the samples, aluminum import in 30%, and neither export or import of aluminum in 16%, at least on the scale of a thin section. These calculations are conservative in that completely dissolved (and thus unidentified) grains were not included, nor was any adjustment made for secondary porosity that may have been destroyed by subsequent compaction.

DISCUSSION

Various diagenetic processes have been identified in the Vedder and Eocene sands including compaction, deformation, dissolution, cementation, alteration, and recrystallization of minerals. These processes are controlled by the pore-water chemistry, depositional environment, temperature, and pressure (Hayes and Boles, 1992). The paragenetic sequence (Fig. 29) is established based on the textural relationships of the diagenetic minerals. These events started at the time of deposition and some continue to the present day.

The syndepositional formation of glauconite suggest these sandstones were deposited in submarine conditions between 328 to 984 ft (Jimenez-Millan et al., 1998), although Stonecipher (1999) concluded glauconite can be reworked and deposited in any depositional sequence. Glauconite grains can be altered from clays (Stonecipher, 1999), micas (Tapper and Fanning, 1968), fossil-rich sediments, and fecal pellets (Harder, 1980) in very early diagenesis. Glauconization of chert and feldspars ranging from partial to
complete suggests ongoing glauconization at deeper depths during early diagenesis.

### PARAGENETIC SEQUENCE

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<thead>
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<tr>
<td>Hydrocarbon Migration</td>
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</table>

Fig. 29. Paragenetic sequence for the Vedder and Eocene sands.

Phosphate replaced quartz, feldspars, and glauconite (Fig. 17). The presence of phosphate nucleating on glauconite indicates phosphate formed after glauconite. Phosphate occurred in three zones (Fig. 17) suggests at least three episodes of phosphatization.

Some pyrite formed between cleavage planes and expanded the fabric of biotite. It also formed between feldspar and phosphate coatings. These suggest pyrite precipitation during early diagenesis.

Authigenic clays are present in almost all of the samples. They include chlorite, kaolinite (Fig. 19), and mixed-layer I/S (Fig. 22) and I/C. The precipitation of clays as pore-linings and pore-fillings reduced both the porosity and permeability. Authigenic clays were derived from many different sources and are discussed below.

Mixed-layer I/S and I/C often occur as coatings on detrital grains and cement crystals, and sometimes separate the detrital grains from overgrowths. This suggests that
the clay coatings formed during early diagenesis. I/S and I/C are more abundant in shallower samples than deeper samples. They may have formed from alteration of micas and volcanic grains. In deeper samples, these clays occur on the edges of partially dissolved quartz and feldspar (Fig. 22) grains, suggesting that the clays formed during later diagenesis.

Biotite has commonly been altered to chlorite and clay. Alteration typically occurred along the cleavage planes, which suggests the event occurred during late diagenesis after significant compaction.

Authigenic kaolinite occurs as booklets filling the pore space. It precipitated adjacent to partially and completely dissolved grains. In some instances kaolinite precipitated adjacent to remnants of feldspar within a remnant clay coating (Fig. 19) suggesting that Al$^{3+}$ for kaolinite precipitation was derived from dissolved feldspar. Kaolinite cement formed after significant compaction and dissolution of the framework grains suggesting that it formed during late diagenesis.

Some calcite cement formed during early diagenesis. It precipitated into pore spaces and replaced framework grains. The framework grains sometimes can be identified by unreplaced remnants of the grains within the cement. In other instances, calcite cement filled the pore space and completely replaced the framework grains, and original pore spaces and framework grains can no longer be distinguished.

Dolomite crystals formed in pore spaces and between biotite cleavage planes. They are commonly finer than the framework grains. Some crystals exhibit clay coatings and are usually well formed (Fig. 21). This suggests that at least two episodes of dolomite precipitation have occurred. Dolomite also formed as poikilotopic cement that filled the
pore spaces and partially replaced quartz (Fig. 21), feldspars (Fig. 21), and calcite cement.

Compaction of the framework grains started after deposition. It rearranged the grains creating point and tangential contacts during early diagenesis. As compaction increased, long, concavo-convex, and sutured grain-to-grain contacts formed by pressure-induced dissolution. Micas (Fig. 14) and volcanic-rock fragments were often deformed thus creating pseudomatrix that filled the adjacent pore space. As a result, porosity and permeability were reduced.

The detrital grains within these sandstones contain an average of at least three contacts with adjacent grains (Table 2). Although these sandstones did not show a significant change in CI and TPI with depth, other sandstones in the western San Joaquin basin have shown an increase of CI and TPI with increasing depth (Taylor, 2007; Horton et al., 2009).

Compaction created fractures within individual grains and cement crystals. Fractures occurred in feldspars (Figs. 6, 8), micas, quartz (Figs. 7, 15), and dolomite-cement crystals (Fig. 16). This allowed the exchange of ions between the grains’ interiors and pore fluids, resulting in formation of dolomite crystals between biotite cleavage planes as well as albitization (Figs. 6, 8, 23, 24, 26) and dissolution (Figs. 15, 19, 23) of feldspars. Other minerals that also underwent dissolution include micas, volcanics, quartz (Fig. 21), and carbonate cements (Fig. 23). Fracturing created various sizes of angular fragments. With increasing burial, those fragments rotated relative to each other changing the textures of the sandstones.

Albitization of detrital feldspars is common in these sandstones. The composition
of albite is almost pure (Fig. 11). Most of the feldspars in deeper samples (Fig. 8) are
more albitized compared to feldspars in shallower samples (Figs. 6, 23, 26). Albitization
replaced detrital plagioclase (Figs. 6, 23, 24, 26) and K-feldspar (Figs. 8, 23, 24), but not
detrital albite (Fig. 8b). Albitization occurs in a wide (Gold, 1987; Boles and Ramseyer,
1988) or narrow (Boles, 1982; Morad et al., 1990) range of temperature in middle of
diagenesis. Albitization may occur between 75°C (Morad et al., 1990) to 124°C, between
5,906 to 11,154 ft in depth at the Greeley oil field.

Authigenic quartz (Figs. 7, 15, 20, 25) and K-feldspar (Figs. 6, 22, 23, 26) are
present in more than half of the samples. The absence of quartz and K-feldspar
overgrowths in some calcite-cemented samples indicate calcite formed during early
diagenesis before the quartz and K-feldspar overgrowths. In addition, the presence of
euhedral quartz overgrowths in sharp contact with some calcite cement (Fig. 25) suggests
authigenic quartz formed prior to late calcite precipitation during late diagenesis.

The cross-cutting relationship between the albite and K-feldspar-infilled fractures
indicates that albitization occurred before precipitation of authigenic K-feldspar (Fig. 26).
K-feldspar overgrowths replaced dolomite cement and penetrated into the albitized
plagioclase grain (Fig. 23) indicating the overgrowth formed after precipitation of
dolomite and dissolution of plagioclase.

Dissolution is most common in feldspars (Figs. 15, 19, 23). Preferential dissolution
of feldspars shifted the composition of sands towards the quartz corner on the ternary
diagrams as shown in Figures 10 and 28. Plagioclase (Fig. 9b) was affected by
dissolution more than K-feldspar (Fig. 9c). Plagioclase in greywackes is more calcic than
in the arenites, though the data are limited. Calcic-plagioclase was more susceptible to
dissolution as indicated by a shift towards more sodic compositions in deeper samples (Fig. 11) (Boles, 1984; Milliken et al., 1989). The significant loss of Ca-rich plagioclase between 11,300 ft and 13,512 ft suggests a pronounced period of dissolution at these depths.

The normal range of Sierran plagioclase is An$_{15}$-An$_{50}$ (Boles and Ramseyer, 1988). Calcite-cemented Eocene (Famoso) sands at the nearby Wasco oil field contain plagioclase in the An$_{30}$-An$_{50}$ range whereas uncemented sands do not (Horton et al., 2014). The loss of the most calcic-plagioclase (An$_{30}$-An$_{50}$) at Greeley was accompanied by decrease in the Sr contents of plagioclase (Fig. 12) suggesting Sr substitution for Ca (Schultz et al., 1989) in the plagioclase.

Hydrocarbon migration occurred during late diagenesis after significant dissolution of detrital and authigenic minerals. Continued hydrocarbon maturation within the reservoir resulted in formation of pyrite (Fig. 18) as Fe$^{2+}$ in the pore waters reacted with sulfur liberated from the hydrocarbons.

Porosity was reduced in these sandstones by compaction, cementation (Figs. 6, 7, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26), precipitation of clays (Figs. 19, 20, 21, 22), and formation of pseudomatrix (Fig. 14); and it was increased by the dissolution of the framework grains (Figs. 15, 19, 21, 23) and cements (Fig. 23). As dissolution progressed, continued compaction further reduced primary porosity as well as secondary porosity, thus causing secondary intergranular porosity to resemble primary porosity (Schmidt and McDonald, 1979; Horton et al., 2009).

Mass balance calculations suggest, on the scale of a thin section, an overall export of aluminum (Table 3). These calculations do not take into account albitization of
plagioclase, dissolution of other alumino-silicates, secondary porosity for which the precursor mineral could not be determined, or any secondary porosity that may have been destroyed by continued compaction, all of which would have released additional aluminum into the pore fluids. Thus an overall export of aluminum from these sands is likely.

Laumontite cement has been widely documented in the San Joaquin basin (e.g. Bloch et al., 1993; Noh and Boles, 1993; Taylor, 2007) but no laumontite was observed during the present study. Laumontite can precipitate as result of dissolution or albitization of plagioclase (Boles and Coombs, 1977; Boles, 1982; Helmold and van de Kamp, 1984). Laumonite precipitation requires significant amounts of Si$^{+4}$ and Na$^{+}$ if albitization is involved (Helmold and van de Kamp, 1984). Dissolution of quartz provides some Si$^{+4}$ ions and connate water could supply a small portion of Na$^{+}$ ions (Boles and Coombs, 1977), but a large portion of Si$^{+4}$ (Boles and Frank, 1979) ions and Na$^{+}$ (Helmold and van de Kamp, 1984) ions may be derived from smectite converting to illite in the shale layers above and below these sandstones.

The formation of laumontite can occur at different temperatures and depths (McCulloh et al., 1979). The reported temperature of the Vedder sands at the Greeley field is 255ºF, but the temperature of the Eocene sands is unknown (California DOGGR, 1998). However, at the Wasco oil field, ~16 miles northwest of the Greeley field, the measured temperatures reported for the Standard Oil Mushrush 5 well (log on file with California DOGGR) were reported as 275ºF for the Vedder Formation and 293ºF for the Eocene sands. As the Eocene sands at Greeley are buried to approximately the same depth as the Vedder Formation at Wasco, an estimated temperature ~275ºF for the
Eocene sands at the Greeley field is reasonable. Laumontite cement is common in the Eocene sandstones and present in small amounts in the Vedder Sandstones at the Wasco oil field (R. Horton, personal communication), but it is absent at the Greeley field. Albitization (Figs. 6, 23, 24, 26) and dissolution (Fig. 23) of plagioclase is widespread in the Vedder and Eocene sands at the Greeley oil field, which could provide Ca\(^{+2}\) ions for laumontite precipitation. The lack of laumontite at the Greeley oil field suggests that the temperature of the Vedder sands at the Greeley field is too low for laumontite to form and the temperature of the Eocene sands is at the boundary in which laumontite could precipitate. It also suggests that these sands are currently at or very near their deepest burial depths.

This has significant implications for the structural history of this portion of the San Joaquin basin. The Greely oil field sits near the crest of the Bakersfield arch, and the Eocene sands occur at approximately 1,640 ft shallower depth than the Eocene sands at Wasco. If the Eocene sands at Greeley are currently at their maximum burial depth as indicated by the lack of laumontite, then the Bakersfield arch must have formed before deposition of the uppermost 1,640 ft of sediments in the overlying strata. At Wasco the top of the Pliocene Etchegoin Formation is approximately 4,347 ft thick with its top at a depth of approximately 4,396 ft (California DOGGR, 1998). At Greeley the Etchegoin Formation is only 3,904 ft thick with its top at a depth of 3,445 ft (California DOGGR, 1998). As the difference in elevation between the two oil fields is less than 66 ft, the differences in the burial depths and the thicknesses of what are generally interpreted as shallow marine sandstones (Scheirer and Magoon, 2007) are best explained by growth of
the Bakersfield arch during deposition of the Etchegoin Formation in Early to middle Pliocene time and continuing into the Late Pliocene or early Pleistocene.

SUMMARY

The Vedder and Eocene sands at the Greeley oil field are arkosic to subarkosic arenites and graywackes (Fig. 3). The sandstones contain abundant quartz, plagioclase and K-feldspars, and minor rock fragments. Common accessory minerals include biotite, muscovite, chlorite, epidote, glauconite, hornblende, titanite, pyrite, and zircon. The deeper Eocene samples are more quartz-rich than shallower Vedder (Oligocene) samples (Fig. 3) due to preferential dissolution of feldspars (Figs. 10, 28). Dissolution affected plagioclase (Fig. 9b) more than K-feldspar (Figs. 9c) and preferentially removed those with highest calcium contents (Fig. 11) in deeper samples, resulting in higher K-feldspar/plagioclase ratios and more Na-rich plagioclase.

Porosity within the Vedder sands ranges from 0 to 20% (Fig. 26); it is controlled by compaction, cementation (Figs. 6, 7, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26), and dissolution of framework grains (Figs. 15, 19, 21, 23) and cements (Fig. 23). Mechanical compaction is evidenced by long, concavo-convex and sutured grain-to-grain contacts, fractured and broken framework grains, fractures within cements (Fig. 16), and deformed labile grains. Compaction reduced primary porosity through readjustment of grains, fracturing and subsequent rotation of grain fragments, deformation of micas (Fig. 14) and labile grains, and precipitation of cements including quartz (Figs. 7, 15, 20, 25), K-feldspar (Figs. 6, 22, 23, 26), phosphate (Fig. 17), clays (Figs. 19, 20, 21, 22), calcite (Figs. 24, 25), dolomite (Figs. 21, 23), barite, anhydrite, and pyrite (Fig. 18). Other diagenetic processes included albitization of feldspars (Figs. 6, 8, 23, 24, 26),
glauconization of feldspars, quartz, and chert, alteration of biotite, phosphate replacing feldspars, glauconite (Fig. 17), and quartz, carbonate replacing framework silicates (Figs. 21, 24), and calcite replaced by dolomite. Dissolution of feldspars (Figs. 15, 19, 23), quartz (Fig. 21), volcanics, and micas created secondary porosity that may have significantly altered the QFRf (Fig. 28) and QFL ratios. Continued compaction further reduced porosity while continued dissolution of the framework grains maintained an open pore network thus facilitating the migration and accumulation of hydrocarbons.

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REFERENCES


Geology of the San Joaquin basin: Pacific Section SEPM, v. 60, p. 129-139.


Harris, N. B., 1989, Diagenetic quartzarenite and destruction of secondary porosity: an example from the Middle Jurassic Brent sandstone of northwest Europe: Geology, v. 17, p. 361-364.


McCulloh, T. H., Cashman, S. M., and Stewart, R. J., 1979, Diagenetic baselines for interpretive reconstructions of maximum burial depths and paleotemperatures in clastic sedimentary rocks in Oltz, D. F., eds., A Symposium in Geochemistry:


Schultz, J., Boles, J. R., and Tilton, G., 1989, Tracking calcium in the San Joaquin basin,


Stonecipher, S. A., 1999, Genetic characteristics of glauconite and siderite: Implications for the origin of ambiguous isolated marine sand bodies, in Isolated shallow marine sand bodies: Sequence stratigraphic analysis and sedimentologic interpretation, SEPM Special Publication 64, 191-204.


Taylor, B. L., 2007, Petrography and diagenesis of the Eocene Point of Rocks Sandstone, McKittrich oil field, Kern County, California (MS Thesis): Bakersfield, California, California State University, 273 p.


APPENDIX I

Table 1. Petrographic data of the Vedder and Eocene sands.

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Data are in percent.
Q = Quartz
F = Felspar
RF = Rock Fragments
Li = Lithics
AM = Accessory Minerals
OC = Carbonate Cements
CL.C = Clay Cements
OC = Other Cements
INTRA = Intragranular Porosity
INTER = Intergranular Porosity
### Table 2. Contact index and tight-packing index of the Vedder and Eocene sands.

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CI = Contact Index  
TPI = Tight-Packing Index  
NA = Not evaluated
### APPENDIX III

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**Comments**: Hymecite: plagioclase + K-feldspar. Sericite: quartz + plagioclase + chert. Rutile needles in quartz. Carbonate cement replacing clays, quartz + feldspar. Some quartz grains are perfectly rounded.
THIN SECTION: Cam-1 11370  
FORMATION (AGE):  
LOCATION: Greeley oil field  
DEPTH: 11370  
SORTING: Mod - well sorted  
SIZE: Mod sand  

PROJECT: EXAMINED BY: Nguyen NS  
ROCK NAME:  
POINT COUNTS: 910  
COMPAC TION: Slightly compacted due to cement, abundant point contact  
ANGULARITY: Rounded  

1. Quartz  
   Moneocrystalline  
   Polyocrystalline  
   Microphanerite  
   Volcanic Rock Fragment  
   Quartz Arenite  
   Other Sedimentary  
   Metasandite  
   Other Metamorphic  
   Crystalline  

2. K-Feldspar  
   Microcline  
   Orthoclase  
   Plagioclase  
   Sanidine  
   Microphanerite  
   Volcanic Rock Fragment  
   Sedimentary  
   Metamorphic  

3. Plagioclase  
   Microphanerite  
   Volcanic Rock Fragment  
   Sedimentary  
   Metamorphic  

4. Volcanics  

5. Microphanerites  
   Hornblende  
   Muscovite  
   Mica  
   Microcline  

6. Accessory Minerals  

7. Carbonate  
   Cement  
   Calcite  
   Dolomite  

8. Matrix  
   Pseudomatrix  
   Clay-Altered Grains  

9. Clay  
   Cement  

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

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

12. Other  
   Mammelke  
   Chert (shell or bone)  
   Photocopy in intergranular  

COMMENTS:  

SECONDARY INTRAGRAINULAR POROSITY  

FRAGMENT-INDUCED DISSOLUTION  

Q  
K  
P  
VRF Q  
PRF Q  
K  
P  
GALACTS GRIAN EDGE DISSOLUTION  

Q  
K  
P  
VERSIZE/ELONGATE POLES  

Q  
P  
OTHER  

PARAGENESIS  

Grains deposited → dissolved → calcite (formed in 2nd porosity)  
Grains deposited → CaCO₃ cement formed → dissolution → more CaCO₃ cement
THIN SECTION: Com-1 11480 T-1
FORMATION (AGE): Cretaceous
LOCATION: Cawley Oil Field
DEPTH: 11480' 
SORTING: Poorly to mod. Sorted
SIZE: Red Sands

PROJECT: Nguyen MS
EXAMINED BY: Nguyen

ROCK NAME: 
POINT COUNTS:

COMPACATION: compacted; long grain contacts common
ANGULARITY: subangular - rounded

COMMENTS

1. Quartz
   - Monocrystalline
   - Polycrystalline
   - Microphenocrysts
   - Granitic
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic
   - Calcschist

2. K-Feldspar
   - Orthoclase
   - Microcline
   - Sanidine
   - Microphenocrysts
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

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

4. Volcanics
   - 

5. Microphenocrysts
   - 

6. Accessory Minerals
   - 
   - Muscovite
   - Hornblende
   - Garnet
   - 

7. Carbonate Cement
   - Calcite
   - Dolomite

8. Matrix / Pseudomatrix
   - Clay-Altered Grains

9. Clay Cement
   - 

10. Intergranular Porosity
    - VRF Q
    - K
    - PRF Q
    - K
    - P

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

12. Other
    - Myrmekite
    - Phosphate (Bone)
    - Sericite
    - Muscovite
    - Chlorite
    - Exsolution

COMMENTS
- Phosphate: calcite cement in pore space and replacing plagioclase, quartz, K-feldspar, calcite, dolomite, and other minerals
- Intergranular dissolution of calcite and dolomite
- Fractures and grain edge dissolution
- Phosphate (Bone) in fractures

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION
- Q
  - K
  - P
  - PRF Q
  - PRF K
  - PRF P

GRAIN-EDGE DISSOLUTION
- Q
  - K
  - P
  - PRF Q
  - PRF K
  - PRF P

OVERSIZE/ELONGATE PORES
- Q
  - K
  - P
  - PRF Q
  - PRF K
  - PRF P

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### Petrography Data:

- **Thin Section**: Cam-1
- **Formation (Age)**: 11406-2b
- **Location**: Greeley Oil Field
- **Depth**: 11406
- **Sorting**: Poorly sorted
- **Size**: Med. sand
- **Comments**: Subangular-rounded

### Rock Name:

- **Project**: Nguyen MS
- **Examined by**: Nguyen

### Compaction:

- Very tight, deformed bile + Mica + Sutured + long contacts common

### Secondary Intergranular Porosity

- Calcite cement formed after deposition, compaction cause calcite cement to fracture and more k-spar (feldspar) dissolved after see pic

- Zoned sanidine, rutile needles are common in quartz, Perlitic calcite cement replacing plagioclase, quartz, k-spar, and vol.
- Volcanic glass in quartz, some plagioclase almost completely altered to albite, some k-spar contain blebs of quartz

### Fracture-Induced Dissolution

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<td>Grains:</td>
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### Grain-Edge Dissolution

- Volcanic glass in quartz, some plagioclase almost completely altered to albite, some k-spar contain blebs of quartz
**SANDSTONE PETROGRAPHY DATA**

**FORMATION (ABG):**

**LOCATION:**

**DEPTH:**

**SORTING:** Med. Sorted

**SIZE:** Med. - coarse sands

**PROPAGENESIS**

- calcite cementation along edge of grain.

**COMMENTS**

- Overgrowth - hard to see any grain boundary.
- Inclusions in quartz (likely to be clay).
SANDSTONE PETROGRAPHY DATA

PROJECT: Nguyen MS
EXAMINED BY: Nguyen

LOCATION: Gunley Oil Field

DEPTH: 13447'

THIN SECTION: ESP-3

SORTING: Moderately to poorly

SIZE: Med Sand

FORMATIONS (AGE):

COMPACTION: Very tight deformed labile fabric

Angularity:

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

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanidine
   - Microphanerite
   - Quartz
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

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

4. Volcanics

5. Microphanerites
   - Cheek
   - Metamorphic
   - Microphanerite
   - Muscovite

6. Accessory Minerals
   - Sphene
   - Muscovite
   - Palaeic

7. Carbonate
   - Calcite

8. Matrix / Pseudomatrix
   - Clay-Modified Grains

9. Clay
   - Shale
   - Mudstone

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

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

12. Other
    - Petroleum in intragranular

COMMENTS
- Stained for K-spar and plagioclase cement
- Calcite cement replacing quartz and overgrowths
- Paleic calcite cement
- Dissolution of K-spar and quartz
- Battle nodules and min inclusions in quartz

PARAGENESIS
- Myrmekite in K-spar
- Some K-spar contain blebs of quartz

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION
- Q
- K
- P

GRAIN-EDGE DISSOLUTION
- Q
- K
- P

OVERSIZE/ELONGATE HOLES
- Q
- K
- P

OTHER

---
SANDSTONE PETROGRAPHY DATA
PROJECT: NGUYEN
EXAMINED BY: NGUYEN

ROCK NAME: 
POINT COUNTS: 
COMPACTION: very tight; grains are fractured
ANGLULARITY: subrounded

SORTING: poorly sorted
SIZE: fine sands - med

**COMMENTS**

1. Quartz
   - Monocrystalline
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metakaolinite
   - Other Metamorphic

2. K-Feldspar
   - Orthoclase
   - Sanidine
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

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

4. Volcanics
5. Microphanerites
6. Accessory Minerals
   - Biotite
   - Chlorite
   - Muscovite
   - Spinel
   - Calcite

7. Carbonate
   - Calcite
8. Matrix
   - Pseudomatrix
   - Clay-Altered Grains
9. Clay
   - Illite
10. Intragranular Porosity
    - Quartz
    - K-Feldspar
    - Plagioclase
    - VRF Q
    - PRF Q
    - K
    - P
11. Intragranular Porosity
    - Fractures
    - Fracture-induced dissolution
    - Oversize/elongate pores
    - Grain-edge dissolution
    - Other
12. Other
    - Carbonate coating
    - Calcite
    - Intra-granular

**PARAGENESIS**
- Glaucicite replace ± chlorite, sericite, biotite
- Chlorite, sericite, biotite

**SECONDARY INTERGRANULAR POROSITY**
FRACTURE-INDUCED DISSOLUTION
- Q
- K
- P
- OTHER

GRAIN-EDGE DISSOLUTION
- Q
- K
- P

OVERSIZE/ELONGATE PORES
- Q
- P
- OTHER

- Sericite, biotite, chlorite
- Glaucicite, sericite
- Chlorite, biotite, sericite
**SANDSTONE PETROGRAPHY DATA**

**PROJECT:**

**EXAMINED BY:** [Handwritten name]

**FORMAION (AGE):**

**LOCATION:**

**DEPTH:** 3514 ft.

**SORTING:**

**SIZE:** Med sands

**COMPACTION:**

**ANGULARITY:**

**COMMENTS:**

<table>
<thead>
<tr>
<th>1. Quartz</th>
<th>Monocrystalline</th>
<th>Polycrystalline</th>
<th>Microphanerite</th>
<th>Granite</th>
<th>Volcanic Rock Fragment</th>
<th>Quartz Arenite</th>
<th>Other Sedimentary</th>
<th>Metaquartzite</th>
<th>Other Metamorphic</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. K-Feldspar</td>
<td>Microcline</td>
<td>Orthoclase</td>
<td>Sanidine</td>
<td>Microphanerite</td>
<td>Granite</td>
<td>Volcanic Rock Fragment</td>
<td>Sedimentary</td>
<td>Metamorphic</td>
<td></td>
</tr>
<tr>
<td>3. Plagioclase</td>
<td>Microphanerite</td>
<td>Granite</td>
<td>Volcanic Rock Fragment</td>
<td>Sedimentary</td>
<td>Metamorphic</td>
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<tr>
<td>5. Microphanerites</td>
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<td>6. Accessory Minerals</td>
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<tr>
<td>7. Carbonate Cement</td>
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<tr>
<td>8. Matrix / Pseudomatrix</td>
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<tr>
<td>9. Clay Cement</td>
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<tr>
<td>10. Intragranular Porosity</td>
<td>Quartz</td>
<td>K-Feldspar</td>
<td>Plagioclase</td>
<td>VRF Q</td>
<td>FRF Q</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Intragranular Porosity</td>
<td>Fractures</td>
<td>Fracture-induced dissolution</td>
<td>Oversize/elongate pores</td>
<td>Grain-edge dissolution</td>
<td></td>
<td></td>
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<td>12. Other</td>
<td>Bule cement</td>
<td>Other</td>
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**SECONDARY INTRAGranULAR POROSITY**

**FRACTURE-INDUCED DISSOLUTION**

<table>
<thead>
<tr>
<th>Q</th>
<th>vrfQ</th>
<th>prfQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>vrfK</td>
<td>prfK</td>
</tr>
<tr>
<td>P</td>
<td>vrfP</td>
<td>prfP</td>
</tr>
</tbody>
</table>

**GRAIN-EDGE DISSOLUTION**

<table>
<thead>
<tr>
<th>Q</th>
<th>vrfQ</th>
<th>prfQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>vrfK</td>
<td>prfK</td>
</tr>
<tr>
<td>P</td>
<td>vrfP</td>
<td>prfP</td>
</tr>
</tbody>
</table>

**OVERSIZE/ELONGATE POROSES**

<table>
<thead>
<tr>
<th>Q</th>
<th>vrfQ</th>
<th>prfQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>vrfK</td>
<td>prfK</td>
</tr>
<tr>
<td>P</td>
<td>vrfP</td>
<td>prfP</td>
</tr>
</tbody>
</table>

**OTHER**

**PARAGENESIS**

Abundant pressure induced dissolution, some extreme concavo-convex.
### SANDSTONE PETROGRAPHY DATA

**EXAMINED BY:** [Signature]

**PROJECT:** Diemps

**LOCATION:** Gentry Oil Field

**DEPTH:** 1344' (525m)

**SORTING:** 
- Poor-Moderate

**SIZE:** 
- Medium Sand
  - Dirt + 50% Limestone - 60% Clay

**COMPACTNESS:**
- Very Tight - Deformed beds, micro, long
- Contours, Grain interpenetration

**ANGULARITY:** Subrounded

### COMMENTS

1. **Quartz**
   - Monocrystalline
   - Polycrystalline
   - Microgranular
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. **K-Feldspar**
   - Mosaic
   - Orthoclase
   - Microcline
   - Sanidine
   - Microgranular
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. **Plagioclase**
   - Microgranular
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

4. **Volcanics**
   - Microgranular
   - Metastable

5. **Accessory Minerals**
   - Mosaic
   - Orthoclase
   - Microcline
   - Sanidine
   - Microgranular
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

6. **Carbonate**
   - Cement
   - Precipitate
   - Mix of multi-crystals
   - Mix of multi-crystals

7. **Clay-Altered Grains**
   - Mix of multi-crystals
   - Mix of multi-crystals
   - Mix of multi-crystals

8. **Grain-Edge Dissolution**
   - Mix of multi-crystals
   - Mix of multi-crystals

9. **Fracture-Induced Dissolution**
   - Mix of multi-crystals
   - Mix of multi-crystals

10. **Secondary Intergranular Porosity**
    - Mix of multi-crystals

11. **Other**
    - Mix of multi-crystals

**SECONDARY INTERGRANULAR POROSITY**

**FRACTURE-INDUCED DISSOLUTION**
- Q: vrfQ
- K: vrfK
- P: vrfP

**GRAIN-EDGE DISSOLUTION**
- Q: vrfQ
- K: vrfK
- P: vrfP

**OVERSIZE/ELONGATE PORES**
- Q: vrfQ
- K: vrfK
- P: vrfP

**OTHER**

---

**PARAGENESIS**
**SANDSTONE PETROGRAPHY DATA**

**EXAMINED BY:** Nguyen MS

**PROJECT:**

**LOCATION:** Greeley Oil Field

**DEPTH:** 5846 ft

**SORTING:** poorly sorted

**SIZE:** medium-coarse grained

**COMMENTS:**
- Monocrystalline
- Polycrystalline
- Microphanerite
- Volcanic Rock Fragment
- Quartz Arenite
- Other Sedimentary
- Metaquartzite
- Other Metamorphic

**1. Quartz**

<table>
<thead>
<tr>
<th>Monocrystalline</th>
<th>Polycrystalline</th>
<th>Microphanerite</th>
<th>Volcanic Rock Fragment</th>
<th>Quartz Arenite</th>
<th>Other Sedimentary</th>
<th>Metaquartzite</th>
<th>Other Metamorphic</th>
</tr>
</thead>
</table>

**2. K-Feldspar**

<table>
<thead>
<tr>
<th>Microcline</th>
<th>Orthoclase</th>
<th>Sanidine</th>
<th>Microphanerite</th>
<th>Volcanic Rock Fragment</th>
<th>Sedimentary</th>
<th>Metamorphic</th>
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</thead>
</table>

**3. Plagioclase**

<table>
<thead>
<tr>
<th>Microphanerite</th>
<th>Volcanic Rock Fragment</th>
<th>Sedimentary</th>
<th>Metamorphic</th>
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</thead>
</table>

**4. Volcanics**

**5. Microphanerites**

<table>
<thead>
<tr>
<th>Chert</th>
<th>Quartzite</th>
<th>Muscovite</th>
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</table>

**6. Accessory Minerals**

<table>
<thead>
<tr>
<th>Spinel</th>
<th>Biotite</th>
<th>Rutile</th>
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**7. Carbonate**

<table>
<thead>
<tr>
<th>Calcite</th>
</tr>
</thead>
</table>

**8. Matrix / Pseudomatrix**

<table>
<thead>
<tr>
<th>Clay-Altered Grain</th>
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</thead>
</table>

**9. Clay**

<table>
<thead>
<tr>
<th>Calcite</th>
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</thead>
</table>

**10. Intragranular Porosity**

<table>
<thead>
<tr>
<th>Quartz</th>
<th>K-Feldspar</th>
<th>Plagioclase</th>
</tr>
</thead>
</table>

**11. Intragranular Porosity**

<table>
<thead>
<tr>
<th>Fractures</th>
<th>Fracture-induced dissolution</th>
<th>Oversize/elongate pores</th>
<th>Grain-edge dissolution</th>
<th>Other</th>
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</thead>
</table>

**12. Other**

<table>
<thead>
<tr>
<th>Primary cement</th>
<th>Other</th>
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**SECONDARY INTERGRANULAR POROSITY**

**FRACTURE-INDUCED DISSOLUTION**

<table>
<thead>
<tr>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>vRv</td>
<td>P</td>
<td>P</td>
</tr>
</tbody>
</table>

**GRAIN-EDGE DISSOLUTION**

<table>
<thead>
<tr>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>vRv</td>
<td>P</td>
<td>P</td>
</tr>
</tbody>
</table>

**OVERSIZE/ELONGATE PORES**

<table>
<thead>
<tr>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>vRv</td>
<td>P</td>
<td>P</td>
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</tbody>
</table>

**OTHER**

<table>
<thead>
<tr>
<th>Thanes</th>
<th>P</th>
</tr>
</thead>
</table>

**PARAGENESIS**

- Feldspar alteration + sericite
- Feldspar alteration + trona
- Feldspar alteration + clay (plagioclase)
- Subconite replacing feldspar
- Bone replaced by quartz
- Yellow glauconite replacing f. ???? + phosphate
- Chlorite replacing, Berlin blue
SANDSTONE PETROGRAPHY DATA

THIN SECTION: 13484.2
FORMATION (AGE):
LOCATION: Greeley Oil Field
DEPTH: 13484.2
SORTING: Moderately Sorted
SIZE: Med. Sand

1. Quartz
   - Monocrystalline
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metarockite
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanidine
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

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

4. Volcanics

5. Microphanerites
   - Quartz

6. Accessory Minerals
   - Epidote
   - Biotite
   - Muscovite
   - Hornblende
   - Rutile
   - Calcite

7. Carbonate Cement

8. Matrix / Pseudomatrix
   - Clay-Altered Grains

9. Clay Cement

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

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

12. Other Porosity
    - Chalky cement in intragranular porosity

COMMENTS

- Stained + K-sp and plag.
- Uplifted kaolinite cement in the pore space + blue grains.
- Potassic calcite cement and replacing other grains and spars.
- Metamorphic chlorite inclusions + detrital + PARAGENESIS myrmekite.
- Rutile needles + zircon inclusions in quartz.
- Some K-sp + contain blebs of quartz.
- Myrmekite in K-sp + plag.

SECONDARY INTERGRANULAR POROSITY

<table>
<thead>
<tr>
<th>FRACTURE-INDUCED DISSOLUTION</th>
<th>OVERSIZE/ELONGATE PORES</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
<td>vrfQ</td>
<td>vrfQ</td>
</tr>
<tr>
<td>K</td>
<td>vrfK</td>
<td>vrfK</td>
</tr>
<tr>
<td>P</td>
<td>vrfP</td>
<td>vrfP</td>
</tr>
</tbody>
</table>

GRAIN-EDGE DISSOLUTION

| Q                          | vrfQ                   | vrfQ  |
| K                          | vrfK                   | vrfK  |
| P                          | vrfP                   | vrfP  |

OVERSIZE/ELONGATE PORES

| Q                          | vrfQ                   | vrfQ  |
| K                          | vrfK                   | vrfK  |
| P                          | vrfP                   | vrfP  |

OTHER

| Q                          | vrfQ                   | vrfQ  |
| K                          | vrfK                   | vrfK  |
| P                          | vrfP                   | vrfP  |
SANDSTONE PETROGRAPHY DATA

PROJECT: Nguyen MS

ROCK NAME: 

POINT COUNTS:

COMPACTION: very tight - detrital lamination + micro fissility + sutured grain contacts

ANGULARITY: subrounded - rounded

COMMENTS

THIN SECTION: ELF-1 13499-1

FORMATION (AGE): 

LOCATION: Gueley Oil Field

DEPTH: 13499'

SORTING: Moderately-poorly

SIZE: Med. sand

1. Quartz
   - Monocrystalline
   - Polycrystalline
   - Microporphyritic
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanidine
   - Microperthite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

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

4. Volcanics

5. Microperthites
   - Microcline
   - Orthoclase
   - Sanidine
   - Microperthite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

6. Accessory Minerals
   - Zircon
   - Sphene

7. Carbonate Cement

8. Matrix / Pseudomatrix
   - Clay-Altered Grains

9. Clay Cement

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

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

12. Other
    - Muscovite (sphere)
    - Petroleum in intergranular

COMMENTS

Primary porosity is dominated by plagioclase in play grain
Little needles ill quartz
Some K-felspar contain blebs of quartz

Hypidiomorphic (plagioclase + K-feldspar)

PARAGENESIS

Clay cement formed on edge of grain and open pore system
Carbonate cement replacing other grains
Carbonate inclusions (plagioclase + K-feldspar) in quartz
THIN SECTION: ELPI 1399 T2
FORMATION (AGE):
LOCATION: Greely oil field
DEPTH: 15499 ft

SORTING: Moderately Sorted
SIZE: Fine sands

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

2. K-Feldspar
Microcline
Orthoclase
Sanidine
Microphanerite
Volcanic Rock Fragment
Sedimentary
Metamorphic

3. Plagioclase
Microphanerite
Volcanic Rock Fragment
Sedimentary
Metamorphic

4. Volcanics

5. Microphanerites

6. Accessory Minerals
Pyrite
Chalcopyrite
Chlorite

7. Carbonate Cement
Calcite

8. Matrix / Pseudomatrix
Clay-Altered Grains

9. Clay Cement

10. Intergranular Porosity
Quartz
K-Feldspar
Plagioclase

11. Intergranular Porosity
Fractures
Fracture-induced dissolution
Overgrowths
Grain-edge dissolution

12. Other
Pyrite cement

COMMENTS
Faltering to clay (illite/muscovite)
Calcite cement replacing feldspar grains
Pyritic alteration to chalcopyrite
Rutile needles in Q
Pyrite
Grains are more rounded than other TS

PARAGENESIS
White cement replacing feldspar grains
Pyrite often formed by bottle cleaning

SECONDARY INTERGRANULAR POROSITY
FRAC TURE-INDUCED DISSOLUTION
Q
K
P
R
G R A I N - E D G E DISSOLUTION
Q
K
P
O E R Y SIZE/ELONGATE F O R E S
Q
K
P
O T H E R

PROJECT: Nguyen NS
EXAMINED BY: Nguyen

ROCK NAME:
POINT COUNTS:
COMPACTION: Very tight, abundant long
ANGULARITY: Subangular - Rounded
THIN SECTION: ELF1 3499-13
FORMATION (AGE): Monticello
LOCATION: Gravelly
DEPTH: 3499'
SORTING: Mod Sorted
SIZE: Med Sands

| 1. Quartz | Monocrystalline | Polycrystalline | Micropanerite | Granite
|-----------|----------------|----------------|--------------|--------|
|           |                |                |              | Volcanic Rock Fragment
|           |                |                |              | Quartz Arenite
|           |                |                |              | Other Sedimentary
|           |                |                |              | Metaquartzite
|           |                |                |              | Other Metamorphic

| 2. K-Feldspar | Microcline | Orthoclase | Sanidine | Micropanerite | Granite
|                |            |            |           | Volcanic Rock Fragment
|                |            |            |           | Sedimentary
|                |            |            |           | Metamorphic

| 3. Plagioclase | Micropanerite | Granite
|               |                 |                | Volcanic Rock Fragment
|               |                 |                | Sedimentary
|               |                 |                | Metamorphic

<table>
<thead>
<tr>
<th>4. Volcanics</th>
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<table>
<thead>
<tr>
<th>5. Micropanerites</th>
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<table>
<thead>
<tr>
<th>6. Accessory Minerals</th>
<th>Biotite</th>
<th>Chlorite</th>
<th>Muscovite</th>
<th>Sphecid</th>
<th>Epidote</th>
<th>Calcite</th>
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<tbody>
<tr>
<td>Biotite</td>
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<tr>
<td>Chlorite</td>
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<tr>
<td>Muscovite</td>
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<td>Sphecid</td>
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<td>Epidote</td>
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<tr>
<td>Calcite</td>
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<table>
<thead>
<tr>
<th>7. Carbonate Cement</th>
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</table>

<table>
<thead>
<tr>
<th>8. Matrix / Pseudomatrix</th>
<th>Clay-Altered Grains</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>9. Clay Cement</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>10. Intergranular Porosity</th>
<th>Quartz</th>
<th>K-Feldspar</th>
<th>Plagioclase</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF Q</td>
<td>K</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>PRF Q</td>
<td>K</td>
<td>P</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11. Intergranular Porosity</th>
<th>Fractures</th>
<th>Fracture-induced dissolution</th>
<th>Oversize/elongate pores</th>
<th>Grain-edge dissolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12. Other</th>
<th>Biotite cement</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>COMMENTS</th>
</tr>
</thead>
</table>

SECONDARY INTERGRANULAR POROSITY

<table>
<thead>
<tr>
<th>Fracture-Induced Dissolution</th>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF Q</td>
<td>K</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>PRF Q</td>
<td>K</td>
<td>P</td>
<td>P</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grain-Edge Dissolution</th>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF Q</td>
<td>K</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>PRF Q</td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oversize/Elongate Pores</th>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF Q</td>
<td>K</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>PRF Q</td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other</th>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
</tbody>
</table>

PARAGENESIS

<table>
<thead>
<tr>
<th>Biotite alteration to chlorite</th>
<th>Kspar overgrowth</th>
<th>Biotite needles in Q.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammillate spherulite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sericite (F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flation to sericite + clays</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overgrowth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biotite cement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Myrmelate texture and partially altered</th>
<th>To myrmelate firm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kspar</td>
<td></td>
</tr>
<tr>
<td>OVERSIZE/ELONGATE PORES</td>
<td>Q</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---</td>
</tr>
<tr>
<td>VRF Q</td>
<td>K</td>
</tr>
<tr>
<td>PRF Q</td>
<td>P</td>
</tr>
<tr>
<td>OTHER</td>
<td></td>
</tr>
</tbody>
</table>
SANDSTONE PETROGRAPHY DATA

FORMATION (AGE): EEL-1 13499-TY
LOCATION: Eelkley oil field
DEPTH: 13499

SORTING: Mod. sorted
SIZE: med. - coarse

COMPACTION: Very tight - little pt contacts
ANGULARITY: Sub-angular to subrounded

1. Quartz
   Monocrystalline
   Polycrystalline
   Microphaneritic Quadratic
   Volcanic Rock Fragment
   Quartz Arenite
   Other Sedimentary
   Metakatimite
   Other Metamorphic

2. K-Feldspar
   Microcline
   Orthoclase
   Sanidine
   Microphaneritic Quadratic
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

3. Plagioclase
   Microphaneritic Quadratic
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

4. Volcanics

5. Micropahenites
   Chert

6. Accessory Minerals
   Zircon
   Zircon
   Ilmenite
   Muscovite

7. Carbonate Cement
   Dolomite
   Calcite

8. Matrix
   Pseudomatrix
   Clay-Altered Grains

9. Clay
   Illite/Smectite
   Clay

10. Intragranular Porosity
    Quartz
    K-Feldspar
    Plagioclase

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

12. Other

COMMENTS

- Barite altering to chlorite
- Sericite (Patches to sericite)
- Epitaxial replace F = RF (not diagenetic)
- Ovary growth: P = + Q
- F altered zeolite
- Calcite replacing two grains, but mainly filled open pore space

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION
Q
K
P

GRAIN-EDGE DISSOLUTION
Q
K
P

OVERSIZE/ELONGATE PORES
Q
K
P

OTHER

6
7
8
9
10
11
12

EXAMINED BY: Nguyen
PROJECT: Nguyen HS

ROCK NAME:
POINT COUNTS:

abundant concave convex & long contacts

i

ii

III

IV

V

VI

VII
**SANDSTONE PETROGRAPHY DATA**

**PROJECT:** Nguyen NS

**EXAMINED BY:** Nguyen

**FORMAON (AGE):** 13512

**LOCATION:** Creek oil field

**DEPTH:** 13512

**SORTING:** well sorted

**SIZE:** medium sands

**1. Quartz**
- Moneystalline
- Polycrystalline
- Microgranular
- Volcanic Rock Fragment
- Quartz Aretite
- Other Sedimentary
- Metasandite
- Other Metamorphic

**2. K-Feldspar**
- Microcline
- Orthoclase
- Sanidine
- Microgranular
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

**3. Plagioclase**
- Microgranular
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

**4. Volcanics**
- Pyroxene

**5. Microgranulars**
- Chees
- Grossite
- Manganite

**6. Accessory Minerals**
- Muscovite
- Biotite
- Calcite
- Gneiss
- Epsomite

**7. Carbonate Cement**
- Calcareous

**8. Matrix / Pseudomatrix**
- Clay-Altered Grains
- Epsomite

**9. Clay Cement**
- Epsomite

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

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

**12. Other**

**COMMENTS**
- Kspar overgrowth

**SECONDARY INTERGRANULAR POROSITY**

**FRACTURE-INDUCED DISSOLUTION**
- Q
- K
- P
- prfQ
- prfK
- prfP

**GRAIN-EDGE DISSOLUTION**
- Q
- K
- P
- prfQ
- prfK
- prfP

**OVERSIZE/ELONGATE PORES**
- Q
- K
- P
- prfQ
- prfK
- prfP

**OTHER**

**PARAGENESIS**
THIN SECTION: ECR-1 3512-TY
FORMATION (AGE): 13512
LOCATION: Greeley oil Field
DEPTH: 13512
SORTING: Mod sorted
SIZE: Med sand

SANDSTONE PETROGRAPHY DATA
PROJECT:
EXAMINED BY: Nguyen

ROCK NAME: POINT COUNTS:
COMPAC TION: Very tight
ANGULARITY: Subrounded - rounded

COMMENTS

1. Quartz
   Monocrystalline
   Polycrystalline
   Microphanerite
   Volcanic Rock Fragment
   Quartz Arete
   Other Sedimentary
   Metasomatite
   Other Metamorphic

2. K-Feldspar
   Microcline
   Orthoclase
   Sanidine
   Microphanerite
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

3. Plagioclase
   Microphanerite
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

4. Volcanics

5. Microphanerites

6. Accessory Minerals
   Zircon
   Sphene
   Biotite
   Micaceous
   Calcite

7. Carbonate
   Calcite

8. Matrix / Pseudomatrix
   Clay-Altered Grains

9. Clay
   kaolinite.f.

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

11. Intergranular Porosity
    Fractures
    Fracture-Induced dissolution
    Overgrowths
    Grain-edge dissolution
    Other

12. Other

COMMENTS

Paragenesis

SECONDARY INTERGRANULAR POROSITY
FRACTURE-INDUCED DISSOLUTION
Q
K
P
VRF K
VRF P
PRF P
PRF K
PRF Q
OVERSIZE/ELONGATE PORES
Q
K
P
VRF Q
VRF K
VRF P
PRF P
PRF Q
OTHER

Overgrowth - abundant
Overgrowth boutle needle in Quartz
Paragenesis
## Sandstone Petrography Data

**Examined by:** Nguyen MS

### Thin Section: 18512-S
- **Formation (Age):**
- **Location:** Geeyeh Oil Field
- **Depth:** 18512

### Rock Name: Compaction:
- Volumetrically tight; deformed mica + clays

### Sorting: Med Sand

### Angularity: rounded

### Comments

#### Minerals

<table>
<thead>
<tr>
<th>Category</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Quartz</td>
<td>Monocrystalline, Polycrystalline, Microgranite, Volcanic Rock Fragment, Quartz Arenite, Other Sedimentary, Metaquartzite, Other Metamorphic</td>
</tr>
<tr>
<td>2. K-Feldspar</td>
<td>Microcline, Orthoclase, Sillimanite, Glaucophane, Granitic, Volcanic Rock Fragment, Sedimentary, Metamorphic</td>
</tr>
<tr>
<td>3. Plagioclase</td>
<td>Microcline, Granitic, Volcanic Rock Fragment, Sedimentary, Metamorphic</td>
</tr>
<tr>
<td>4. Volcanics</td>
<td>Granitic, Muscovite</td>
</tr>
<tr>
<td>5. Microgranites</td>
<td>Plagioclase, Muscovite</td>
</tr>
<tr>
<td>6. Accessory</td>
<td>Muscovite, Hornblende, Epidote</td>
</tr>
<tr>
<td>7. Carbonate</td>
<td>Calcite</td>
</tr>
<tr>
<td>8. Matrix / Pseudomatrix</td>
<td>Clay-Altered Grains</td>
</tr>
<tr>
<td>9. Clay</td>
<td>Illite, Smectite, Chlorite</td>
</tr>
<tr>
<td>10. Intragranular Porosity</td>
<td>Quartz, K-Feldspar, Plagioclase</td>
</tr>
<tr>
<td>11. Intragranular Porosity</td>
<td>Fractures, Fracture-induced dissolution, Oversize/elongate pores, Grain-edge dissolution</td>
</tr>
<tr>
<td>12. Other</td>
<td>Muscovite, Sericite</td>
</tr>
</tbody>
</table>

### Secondary Intergranular Porosity

- **Fracture-induced dissolution**
  - Q:
    - VrfQ, prfQ, prfK, prfP
  - K:
    - VrfK, prfK, prfP
  - P:
    - VrfP, prfP

- **Grain-edge dissolution**
  - Q:
    - VrfQ, prfQ, prfK, prfP
  - K:
    - VrfK, prfK, prfP
  - P:
    - VrfP, prfP

- **Oversize/elongate pores**
  - Q:
    - VrfQ, prfQ, prfK, prfP
  - K:
    - VrfK, prfK, prfP
  - P:
    - VrfP, prfP

- **Other**
  - VrfQ, prfQ, prfK, prfP

### Comments

- Stained for plagioclase, muscovite in plagioclase, biotite needles in quartz grain.
- Quartz grains are more fractured than the feldspars; plagioclase cement observed.
- Some K-feldspar contain blebs of quartz.
- Fractured quartz feldspar grains and dissolved grain fragments.
- Clay allowing to sericite.
**THIN SECTION: KCL 11-17 11300**
**FORMATION (AGE):**
**LOCATION:** Geyley Oil Field
**DEPTH:** 11300

**SORTING:** poorly sorted
**SIZE:** med - coarse

**COMPACATION:** very tight, but grains replaced by calcite
**ANGULARITY:** subrounded - subangular

**COMMENTS**

<table>
<thead>
<tr>
<th>1. Quartz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monocrystalline</td>
</tr>
<tr>
<td>Polycrystalline</td>
</tr>
<tr>
<td>Microphanerite</td>
</tr>
<tr>
<td>Volcanic Rock Fragment</td>
</tr>
<tr>
<td>Quartz Arenite</td>
</tr>
<tr>
<td>Other Sedimentary</td>
</tr>
<tr>
<td>Metaturritzo</td>
</tr>
<tr>
<td>Other Metamorphic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. K-Feldspar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcline</td>
</tr>
<tr>
<td>Orthoclase</td>
</tr>
<tr>
<td>Sanidine</td>
</tr>
<tr>
<td>Microphanerite</td>
</tr>
<tr>
<td>Volcanic Rock Fragment</td>
</tr>
<tr>
<td>Sedimentary</td>
</tr>
<tr>
<td>Metamorphic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Plagioclase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microphanerite</td>
</tr>
<tr>
<td>Volcanic Rock Fragment</td>
</tr>
<tr>
<td>Sedimentary</td>
</tr>
<tr>
<td>Metamorphic</td>
</tr>
</tbody>
</table>

| 4. Volcanics        |

<table>
<thead>
<tr>
<th>5. Microphanerites</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>6. Accessory Minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alunite</td>
</tr>
<tr>
<td>Analcime</td>
</tr>
<tr>
<td>Catslim</td>
</tr>
<tr>
<td>Calcite</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7. Carbonate Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcite</td>
</tr>
<tr>
<td>Gypsum</td>
</tr>
<tr>
<td>Dolomite</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8. Matrix Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudomatrix</td>
</tr>
<tr>
<td>Clay-Altered Grains</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9. Clay Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaolinite</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10. Intragranular Porosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
</tr>
<tr>
<td>K-Feldspar</td>
</tr>
<tr>
<td>Plagioclase</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11. Intergranular Porosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractures</td>
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<tr>
<td>Fracture-induced dissolution</td>
</tr>
<tr>
<td>Oversize/elongate pores</td>
</tr>
<tr>
<td>Grain-edge dissolution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12. Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphate</td>
</tr>
</tbody>
</table>

**PARAGENESIS**

- Bleached biotite
- Biotite altering to clay + chlorite
- Myrmekite
- Calcite replacing fw grains
- Palygorskite replacing clay

**SECONDARY INTERGRANULAR POROSITY**

<table>
<thead>
<tr>
<th>FRACTURE-INDUCED DISSOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
</tr>
<tr>
<td>K</td>
</tr>
<tr>
<td>P</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GRAIN-EDGE DISSOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
</tr>
<tr>
<td>K</td>
</tr>
<tr>
<td>P</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OVERSIZE/ELONGATE PORES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
</tr>
<tr>
<td>K</td>
</tr>
<tr>
<td>P</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
</tr>
<tr>
<td>K</td>
</tr>
<tr>
<td>P</td>
</tr>
</tbody>
</table>
**THIN SECTION:** Greeley oil Field  
**FORMATION (AGE):**  
**LOCATION:**  
**DEPTH:** 1324  
**SORTING:** Fairly well sorted  
**SIZE:** Med size  
**PROJECT:**  
**EXAMINED BY:** Nguyen W  
**ROCK NAME:**  
**POINT COUNTS:**  
**COMPACTION:** Very tight  
**ANGULARITY:** Angular-round  
**COMMENTS:**

<table>
<thead>
<tr>
<th>1. Quartz</th>
<th>Monocrystalline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polycrystalline</td>
<td></td>
</tr>
<tr>
<td>Microphanerite</td>
<td></td>
</tr>
<tr>
<td>Granitic</td>
<td></td>
</tr>
<tr>
<td>Volcanic Rock Fragment</td>
<td></td>
</tr>
<tr>
<td>Quartz Arenite</td>
<td></td>
</tr>
<tr>
<td>Other Sedimentary</td>
<td></td>
</tr>
<tr>
<td>Metaquartzite</td>
<td></td>
</tr>
<tr>
<td>Other Metamorphic</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. K-Feldspar</th>
<th>Microcline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthoclase</td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
</tr>
<tr>
<td>Granite</td>
<td></td>
</tr>
<tr>
<td>Volcanic Rock Fragment</td>
<td></td>
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<tr>
<td>Sedimentary</td>
<td></td>
</tr>
<tr>
<td>Metaorphic</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Plagioclase</th>
<th>Microphanerite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granite</td>
<td></td>
</tr>
<tr>
<td>Volcanic Rock Fragment</td>
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<tr>
<td>Sedimentary</td>
<td></td>
</tr>
<tr>
<td>Metaorphic</td>
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</tbody>
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<table>
<thead>
<tr>
<th>4. Volcanics</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Microphanerites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
</tr>
<tr>
<td>Plagioclase</td>
</tr>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6. Accessory Minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>7. Carbonate Cement</th>
<th>Dolomite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<table>
<thead>
<tr>
<th>8. Matrix/Pseudomatrix</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>9. Clay/Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>10. Intragranular Porosity</th>
<th>Quartz</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-Feldspar</td>
<td>VRF Q K</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
</tr>
<tr>
<td></td>
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</tr>
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</table>

<table>
<thead>
<tr>
<th>11. Intragranular Porosity</th>
<th>Fractures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture-induced dissolution</td>
<td></td>
</tr>
<tr>
<td>Oversize/elongate pores</td>
<td></td>
</tr>
<tr>
<td>Grain-edge dissolution</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12. Other</th>
<th>Zoites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petro in intergranular</td>
<td></td>
</tr>
</tbody>
</table>

**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**

**COMMENTS**

- Sig of petro and volcanics  
- Zoned Plagioclase  
- Biotite alters to clay  
- Pyrite in petro  
- TPI high due to high C of volcanic  

**PARAGENESIS**

- Albite healed flag fractures  
- Overgrowth
SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Nguyen

PROJECT: Nguyen MS

LOCATION: Crude oil field

DEPTH: 11524

SORTING: Moderately sorted

SIZE: Med sand

COMMENTS:

1. Quartz
   - Monocrystalline
   - Polycrystalline
   - Microgranular
   - Volcanic Rock Fragment
   - Quartz Aretite
   - Other Sedimentary
   - Metapelite
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanidine
   - Micropheneite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Micropheneite
   - Granitic
   - Muscovite

4. Volcanics

5. Micropheneites
   - Chert
   - Granite

6. Accessory Minerals
   - Muscovite

7. Carbonate
   - Calcite

8. Matrix
   - Clay-Altered Grains

9. Clay
   - Feldspathic

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

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

12. Other
    - Phosphate bone

COMMENTS:

Secondary intergranular porosity

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

1. Q
   - K
   - P

2. Q
   - K
   - P

GRAIN-EDGE DISSOLUTION

OVERSIZE/ELONGATE PORES

OTHER

PARAGENESIS

Secondary & often are created by unstable grain dissolution. Most unstable win are completely dissolved.

Compaction -> grain deformation + fracture -> albite healed fractures + formed etch of grain

Zoned play

kaolinite book

mica needles in quartz

Abundant of dissolved feldspar

Play overgrowth, zone albite + healed fractures

Muscovite

Secondary + often are created by unstable grain dissolution. Most unstable win are completely dissolved.
SANDSTONE PETROGRAPHY DATA

FORMED (AGE):
LOCATION: Greeley Oil Field
DEPTH: 1134.75
SORTING: Poorly sorted
SIZE: Med. sands

COMMENTS

1. Quartz
- Mosaic crystalline
- Polycrystalline
- Micropanaritic
- Volcanic Rock Fragment
- Quartz Aretite
- Other Sedimentary
- Metaquartzite
- Other Metamorphic

2. K-Feldspar
- Microcline
- Orthoclase
- Sanidine
- Micropanaritic
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

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

4. Volcanic Glass

5. Micropanarites

6. Accessory
- Biotite
- Rutile

7. Carbonate Cement
- Dolomite

8. Matrix / Pseudomatrix

9. Clay Cement
- Kaolinite

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

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

12. Other
- Phosphate
- Stained TS
- Zeolite
- Biotite alters to clay
- Overgrowths

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION
- Q
- K
- P

GRAIN-EDGE DISSOLUTION
- Q
- K
- P

OVERSIZE/ELONGATE PORES
- Q
- K
- P

OTHER

EXAMINED BY: Nguyen
PROJECT: Nguyen MS

ROCK NAME: Compaction: Very High
ANGULARITY: Angular - Subrounded
THIN SECTION: Kel 11-17
LOCATION: Cherry
DEPTH: 11353
SORTING: Poorly sorted
SIZE: Fine - Med

1. Quartz
   Monocrystalline
   Polycrystalline
   Microgranular
   Volcanic Rock Fragment
   Quartz Arenite
   Other Sedimentary
   Metasandstone
   Other Metamorphic

2. K-Feldspar
   Microcline
   Orthoclase
   Sanidine
   Microcline
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

3. Plagioclase
   Microgranular
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

4. Volcanics

5. Microgranularites

6. Accessory Minerals
   Muscovite
   Sphene
   Pyrite

7. Carbonate Cement
   Dolomite

8. Matrix
   Pseudomatrix
   Clay-Altered Grains

9. Clay Cement

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

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

12. Other
    Phosphatic

COMMENTS
- Biotite alters to clay + chlorite
- Feldspar to sericite
- Petro w/ pyrite + calcite

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY
FRACTURE-INDUCED DISSOLUTION
Q
K
P

GRAIN-EDGE DISSOLUTION
Q
K
P

OVERSIZE/ELONGATE PORES
Q
K
P

OTHER

--------
**SANDSTONE PETROGRAPHY DATA**

**PROJECT:** Nguyen MS

**LOCATION:** Greeley Oil Field

**FORMATTION (AGE):** 1153.3

**DEPTH:**

**SORTING:** poorly sorted

**SIZE:** Fine

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<th>Microphanerite</th>
<th>Volcanic Rock Fragment</th>
<th>Quartz Arenite</th>
<th>Other Sedimentary</th>
<th>Metakaolinite</th>
<th>Other Metamorphic</th>
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</thead>
<tbody>
<tr>
<td></td>
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<table>
<thead>
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<th>2. K-Feldspar</th>
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<th>Orthoclase</th>
<th>Sandine</th>
<th>Microphanerite</th>
<th>Volcanic Rock Fragment</th>
<th>Sedimentary</th>
<th>Metamorphic</th>
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<thead>
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<th>Microphanerite</th>
<th>Volcanic Rock Fragment</th>
<th>Sedimentary</th>
<th>Metamorphic</th>
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<thead>
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<th>4. Volcanic</th>
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<table>
<thead>
<tr>
<th>6. Accessory Minerals</th>
<th>Muscovite</th>
<th>Biotite</th>
<th>Rutile</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>7. Carbonate Cement</th>
<th>Dolomite</th>
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<tbody>
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<table>
<thead>
<tr>
<th>8. Matrix</th>
<th>Pseudomatrix</th>
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<tbody>
<tr>
<td>Clay-Altered Grains</td>
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<table>
<thead>
<tr>
<th>9. Clay Cement</th>
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<tr>
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<table>
<thead>
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<th>10. Intragranular Porosity</th>
<th>Quartz</th>
<th>K-Feldspar</th>
<th>Plagioclase</th>
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<tbody>
<tr>
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<td>K</td>
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<table>
<thead>
<tr>
<th>11. Intergranular Porosity</th>
<th>Fractures</th>
<th>Fracture-induced dissolution</th>
<th>Oversize/elongate pores</th>
<th>Grain-edge dissolution</th>
<th>Other</th>
</tr>
</thead>
</table>

| 12. Other | Eruptive White cement | Opaque XP |

**COMMENTS**

- sig cJ of matrix
- come kind of cement?
- zeolites

**PARAGENESIS**

**SECONDARY INTERGRANULAR POROSITY**

**FRACTURE-INDUCED DISSOLUTION**

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<thead>
<tr>
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<td>P</td>
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**GRAIN-EDGE DISSOLUTION**

<table>
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<th>prfQ</th>
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<td>P</td>
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</tbody>
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**Oversize/Elongate Pores**

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<thead>
<tr>
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<th>prfQ</th>
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<tbody>
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<td></td>
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<td>P</td>
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**OTHER**

<p>| | | |</p>
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<tr>
<td>P</td>
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</table>
**SANDSTONE PETROGRAPHY DATA**

**FORMATION (AGE):**
KCL 11-11 11453 11

**LOCATION:**
Greeley Oil Field

**DEPTH:**
11453

**SORTING:**
Mod. sorted

**SIZE:**
Med. sands

**ROCK NAME:**
Granite

**POINT COUNTS:**
Very tight

**ANGULARITY:**
Subangular - Subrounded

---

**COMMENTS**

1. **Quartz**
   - Monocrystalline
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metagranite
   - Other Metamorphic

2. **K-Feldspar**
   - Microcline
   - Orthoclase
   - Spodumene
   - Sillimanite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

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

4. **Volcanics**

5. **Phaneritic Microphanerites**
   - Granite - Muscovite - Biotite

6. **Accessory Minerals**
   - Muscovite
   - Spinel
   - Biotite

7. **Carbonate Cement**
   - Calcite
   - Dolomite

8. Matrix / Pseudomatrix
   - Clay-Altered Grains

9. Clay Cement
   - Illite - Saponite

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

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

12. **Other**
    - Phosphate

---

**SECONDARY INTERGRANULAR POROSITY**

**FRACTURE-INDUCED DISSOLUTION**

<table>
<thead>
<tr>
<th>Q</th>
<th>vrfQ</th>
<th>prfQ</th>
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<tbody>
<tr>
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<tr>
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<td>prfP</td>
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**GRAIN-EDGE DISSOLUTION**

<table>
<thead>
<tr>
<th>Q</th>
<th>vrfQ</th>
<th>prfQ</th>
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<tbody>
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<td>prfK</td>
</tr>
<tr>
<td>P</td>
<td>vrfP</td>
<td>prfP</td>
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</table>

**OVERSIZE/ELONGATE PORES**

<table>
<thead>
<tr>
<th>Q</th>
<th>vrfQ</th>
<th>prfQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
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<td>prfK</td>
</tr>
<tr>
<td>P</td>
<td>vrfP</td>
<td>prfP</td>
</tr>
</tbody>
</table>

**OTHER**

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**PARAGENESIS**

White alteration to clay
Nynystik
Oversilicification
Equidimensional (M/0.1P)
THIN SECTION: KCC-11-1433 3 T3
FORMATION (AGE): Olympic Oil Field
DEPTH: 11433'...
SORTING: Poorly sorted
SIZE: Med. - Em. sand

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

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanidine
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

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

4. Volcanics

5. Microphanerites
   - Granitic - Muc

6. Accessory Minerals
   - Rutile
   - Zircon
   - Chlorite

7. Carbonate Cement
   - Dolomite

8. Matrix
   - Clay-Altered Grain

9. Clay Cement
   - Euhedral Chlorite

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

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

COMMENTS
- Overgrowth + healed fractures
- Biotite replacing few grains
- Overgrowth
- Biotite to chlorite
- PARAGENESIS
- Myrmekite

SECONDARY INTERGRANULAR POROSITY

<table>
<thead>
<tr>
<th>Fracture-Induced Dissolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
</tr>
<tr>
<td>K</td>
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<td>P</td>
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</table>

<table>
<thead>
<tr>
<th>Grain-Edge Dissolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
</tr>
<tr>
<td>K</td>
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<tr>
<td>P</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Oversize/elongate pores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
</tr>
<tr>
<td>K</td>
</tr>
<tr>
<td>P</td>
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<table>
<thead>
<tr>
<th>Other</th>
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**SANDSTONE PETROGRAPHY DATA**

**PROJECT:** Greeley Oil Field

**EXAMINED BY:** Nguyen M.S

**ROCK NAME:**

**POINT COUNTS:**

**SORTING:** Mod. Sorted

**ANGULARITY:** Subangular - Subrounded

**COMMENTS**

<table>
<thead>
<tr>
<th>1. Quartz</th>
<th>Monocrystalline</th>
<th>Polycrystalline</th>
<th>Granitic</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

<table>
<thead>
<tr>
<th>2. K-Feldspar</th>
<th>Microcline</th>
<th>Orthoclase</th>
<th>Muscovite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>3. Plagioclase</th>
<th>Microcline</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>4. Volcanics</th>
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<table>
<thead>
<tr>
<th>5. Microphanerites</th>
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<table>
<thead>
<tr>
<th>6. Accessory Minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biotite</td>
</tr>
<tr>
<td>Muscovite</td>
</tr>
<tr>
<td>Zircon</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7. Carbonate Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dolomite</td>
</tr>
</tbody>
</table>

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

| 9. Clay Cement |
|                |
| Dicarbonate    |

<table>
<thead>
<tr>
<th>10. Intragranular Porosity</th>
</tr>
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<tbody>
<tr>
<td>Quartz</td>
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<table>
<thead>
<tr>
<th>11. Intergranular Porosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractures</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
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</tbody>
</table>

| 12. Other |
| Bone Phosphate |

**SECONDARY INTERGRANULAR POROSITY**

**FRACTURE-INDUCED DISSOLUTION**

<table>
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<tr>
<th>Q</th>
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<th>prfQ</th>
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<td>P</td>
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<td>prfP</td>
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**GRAIN-EDGE DISSOLUTION**

<table>
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<tr>
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<tr>
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<td>prfP</td>
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**OVERSIZE/ELONGATE PORES**

<table>
<thead>
<tr>
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<th>vrfQ</th>
<th>prfQ</th>
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<tbody>
<tr>
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<td>prfK</td>
</tr>
<tr>
<td>P</td>
<td>vrfP</td>
<td>prfP</td>
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**OTHER**


**PARAGENESIS**

- Calcite Halite replacing fume grains
- Rutile needles in Q
SANDSTONE PETROGRAPHY DATA

PROJECT: Nguyen MS
EXAMINED BY: Nguyen

THIN SECTION: KCL 11-17 114.705
FORMATION (AGE): Veedol
LOCATION: Gweley Oil Field
DEPTH: 114.705

SORTING: Moderately Poor Sorted
SIZE: Med Sand

1. Quartz
   Microcrystalline
   X-Grained
   Calcite Cement
   Other Sedimentary
   Other Metamorphic

2. K-Feldspar
   Microcline
   Orthoclase
   Other
   Volcanic Rock Fragment
   Metamorphic

3. Plagioclase
   Microcline
   X-Grained
   Calcite Cement
   Other Sedimentary
   Metamorphic

4. Volcanics

5. Microphanerites
   Metamorphic
   
6. Accessory Minerals
   Muscovite
   Hematite
   Chlorite
   
7. Carbonate Cement
   Calcite
   Dolomite
   
8. Matrix / Pseudomatrix
   Clay-Altered Grains
   
9. Clay
   
10. Intragranular Porosity
    
11. Intergranular Porosity
    
12. Other
    

COMMENTS

SECONDARY INTERGRANULAR POROSITY

FRAC'TURE-INDUCED DISSOLUTION

<table>
<thead>
<tr>
<th>Q</th>
<th>K</th>
<th>P</th>
<th>PRF Q</th>
<th>K</th>
<th>P</th>
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GRAIN-EDGE DISSOLUTION

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OVERSIZE/ELONGATE HONES

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<th>Q</th>
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</table>

OTHER

PARAGENESIS

Calcite replaces quartz, feldspar, chlorite, muscovite, clays. Some plagioclase does not exhibit twinning, due to calcite cement.

PHOSPHATE (zone?)

PETROGRAPHIC REACTIVITY

Pyrite replaces feldspar, calcite replaces feldspar.
THIN SECTION: ECL 1191 1973 T 3
FORMATION (AGE): Greenley Oil Field
LOCATION: 11473
DEPTH: 134
SORTING: Poorly sorted
SIZE: 1/418

ROCK NAME: Sandstone
POINT COUNTS:
COMPACTION: Very tight
ANGULARITY: Angular - Subrounded

1. Quartz
   Monocrystalline
   Polycrystalline
   Microphaneritic
   Volcanic Rock Fragment
   Quartz Arenite
   Other Sedimentary
   Metaquartzite
   Other Metamorphic

2. K-Feldspar
   Microcline
   Orthoclase
   Sanidine
   Microphaneritic
   Granitic
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

3. Plagioclase
   Microphaneritic
   Granitic
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

4. Volcanics

5. Microphanerites
   Chert
   Granitic
   Plutonic

6. Accessory Minerals
   Biotite
   Pyrite
   Sphalerite

7. Carbonate
   Dolomite
   Calcite

8. Matrix / Pseudomorphic
   Clay-Altered Grain

9. Clay
   Clay
   Silt
   Sand

10. Intragranular Porosity
    Quartz
    K-Feldspar
    Plagioclase

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

12. Other
   Starch
   Mucilaginous
   Overgrowth

COMMENTS
   Biotite alters to clay
   Mirmecic
   G overgrowth

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

<table>
<thead>
<tr>
<th>Fracture-Induced Dissolution</th>
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</thead>
<tbody>
<tr>
<td>Q</td>
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<td>K</td>
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<td>P</td>
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<table>
<thead>
<tr>
<th>Grain-Edge Dissolution</th>
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<tbody>
<tr>
<td>Q</td>
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<tr>
<td>K</td>
</tr>
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<td>P</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Oversized/Elongate Pores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
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<tr>
<td>K</td>
</tr>
<tr>
<td>P</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>-------</td>
</tr>
</tbody>
</table>
### Sandstone Petrography Data

**Formation (Age):** Greeley Oil Field

**Depth:** 11475 ft

**Sorting:** Moderately Sorted

**Compaction:** Very Tight

**Angularity:** Angular - Subrounded

#### Comments
- Minor alteration to Chlorite from Bottle Minerals

#### Paragenesis

<table>
<thead>
<tr>
<th>Secondary Intergranular Porosity</th>
<th>Fracture-Induced Dissolution</th>
<th>Grain-Edge Dissolution</th>
<th>OverSize/Elongate Pores</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
<td>vfrQ</td>
<td>prfQ</td>
<td>prfK</td>
<td>prfK</td>
</tr>
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<td>vfrP</td>
<td>prfP</td>
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</table>

**Thin Section:** K-117 I11475 T7

**Project:** Nguyen MS

**Rock Name:** Sandstone

**Examined By:** Nguyen MS

**Size:** Medium Sand
SANDSTONE PETROGRAPHY DATA

LOCATION: Gainesville Oil Field
PROJECT: Nguyen MS
EXAMINED BY: Nguyen MS

THIN SECTION: KCL 11-17 11/1993 11
FORMATION (AGE): 11/1993
DEPTH: 11/1993
SORTING: Med sands
SIZE: Med sands

ROCK NAME: Granitic
COMPACTION: very tight
ANGULARITY: subrounded, some subangular

COMMENTS

1. Quartz
   - Monocrystalline
   - Polycrystalline
   - Microphanerite
   - Granitic
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metasandstone
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanidine
   - Microphanerite
   - Granitic
   - Volcanic Rock Fragment
   - Metasandstone
   - Other Metamorphic

3. Plagioclase
   - Microphanerite
   - Granitic
   - Volcanic Rock Fragment
   - Metasandstone
   - Other Metamorphic

4. Volcanics
   - Chert

5. Microphanerites
   - Biotite
   - Muscovite

6. Accessory Minerals
   - Biotite
   - Muscovite

7. Carbonate Cement
   - Dolomite

8. Matrix / Pseudomatrix
   - Clay-Altered Grains

9. Clay Cement
   - Illite
cement

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

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

12. Other

COMMENTS
   - Carbonate cement replacing few grains. Did not see spherule/iron.

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION
- Q
- K
- P

GRAIN-EDGE DISSOLUTION
- Q
- K
- P

OVERSIZE/ELONGATE PORES
- Q
- K
- P

OTHER
**SANDSTONE PETROGRAPHY DATA**

**PROJECT:** EXAMINED BY: **Nguyen**

**FORMATION (AGE):**

**LOCATION:** Greenley oil field

**DEPTH:** 1518 ft

**SORTING:** Poorly sorted

**SIZE:** Med sand

### 1. Quartz
- Monocrystalline
- Polycrystalline
- Microgranite
- Granite
- Volcanic rock fragment
- Quartz arenite
- Other sedimentary
- Metapelite
- Other metamorphic

### 2. K-Feldspar
- Microcline
- Orthoclase
- Microcline (biotite)
- Granitic (biotite)
- Muscovite
- Muscovite (biotite)
- Felspar
- Biotite
- Amphibole
- Chlorite
- Other

### 3. Plagioclase
- Microcline
- Orthoclase
- Microcline (biotite)
- Granitic (biotite)
- Muscovite
- Muscovite (biotite)
- Felspar
- Biotite
- Amphibole
- Chlorite
- Other

### 4. Volcanics

### 5. Microgranites

### 6. Accessory Minerals
- Quartz
- Biotite
- Muscovite
- Chlorite
- Other

### 7. Carbonate
- Calcite
- Dolomite
- Other

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

### 9. Clay

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

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

### COMMENTS
- Nygmethic
- Senescent of plagioclase.
- Play altered to zeolite
- Calcite replaces biotite, feldspar, quartz, reactivated
- Sensitization of feldspar
- Feldspar alkali to clay
- Quartz overgrowth

**PARAGENESIS**
- Clay replaces biotite, calcite replaces clay
- Calcite ppt in 2nd stage after grains have dissolved
- Silicates dissolved providing Ca+CO3

### SECONDARY INTERGRANULAR POROSITY

**FRACTURE-INDUCED DISSOLUTION**
- Q
- K
- F

**GRAIN-EDGE DISSOLUTION**
- Q
- K
- F

**OVERSIZE/ELONGATE PORES**
- Q
- K
- F

**OTHER**
- Q
- K
- F
THIN SECTION: Lewis
FORMATION (AGE): Niobrara
LOCATION: Cheyenne Oil-Field
DEPTH: 11,401 ft
SORTING: Moderately
SIZE: Med

SANDSTONE PETROGRAPHY DATA
PROJECT: Nguyen MS
EXAMINED BY: Nguyen
ROCK NAME: 
POINT COUNTS: 
COMPACTION: very tight - concave up 
ANGULARITY: subrounded - rounded

1. Quartz
Monocrystalline
Polycrystalline
Microphanerite
Volcanic Rock Fragment
Quartz Arenite
Other Sedimentary
Metasiltite
Other Metamorphic
Quartz cement

2. K-Feldspar
Microcline
Orthoclase
Sanidine
Microphanerite
Volcanic Rock Fragment
Sedimentary
Metamorphic

3. Plagioclase
Microphanerite
Volcanic Rock Fragment
Sedimentary
Metamorphic

4. Volcanics

5. Microphanerite

6. Accessory Minerals

7. Carbonate cement

8. Matrix / Pseudomatrix
Clay-Altered Grain

9. Clay

10. Intrgranular Porosity
Quartz
K-Feldspar
Plagioclase

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

12. Other
Phosphate, diagenetic + intergranular
Phosphate, authigenic + intergranular + matrix
Phosphate associated with clay
gypsum
Phosphate replaced by silica
Pyrite
Altered baryte to clay

COMMENTS
Phosphate coating which contains fibrous
Pyrite associated baryte
Pyrite replaced by silica
Pyrite
telope + clay quartz overgrowth
QUARTZ OVERGROWTH
Grains dep -> calcite thurout
teldspar replaced by clay + more

PARAGENESIS
Zeolite cement +? or baryte?

SECONDARY INTERGRANULAR POROSITY
FRACUTURE-INDUCED DISSOLUTION
Q Q Q Q Q Q Q Q
K K K K K K K K
P P P P P P P P

GRAIN-EDGE DISSOLUTION
Q Q Q Q Q Q Q Q
K K K K K K K K
P P P P P P P P

OVERSIZE/ELONGATE PORES
Q Q Q Q Q Q Q Q
K K K K K K K K
P P P P P P P P

OTHER
Baryte

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<td>ANGULARITY: Subrounded-Rounded</td>
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<td>Volcanic Rock Fragment</td>
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<tr>
<td>Quartz Arenite</td>
</tr>
<tr>
<td>Other Sedimentary</td>
</tr>
<tr>
<td>Metaquartzite</td>
</tr>
<tr>
<td>Other Metamorphic</td>
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<th>2. K-Feldspar</th>
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<tbody>
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<td>Microcline</td>
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<td>Orthoclase</td>
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<td>Metamorphic</td>
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<th>4. Volcanics</th>
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<th>5. Microphanerites</th>
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<td>Microsile</td>
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<th>6. Accessory Minerals</th>
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<tbody>
<tr>
<td>Calciomircite</td>
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<tr>
<td>Muscovite</td>
</tr>
<tr>
<td>Biotite</td>
</tr>
<tr>
<td>Zircon</td>
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<th>7. Carbonate Cement</th>
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<tbody>
<tr>
<td>Dolomite</td>
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<table>
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<th>8. Matrix / Pseudomatrix</th>
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<tr>
<td>Clay-Altered Grains</td>
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<table>
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<th>9. Clay Cement</th>
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</thead>
<tbody>
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<td>Kaolinite</td>
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<thead>
<tr>
<th>10. Intragranular Porosity</th>
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<tbody>
<tr>
<td>Quartz</td>
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<tr>
<td>K-Feldspar</td>
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<table>
<thead>
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<th>11. Intergranular Porosity</th>
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</thead>
<tbody>
<tr>
<td>Fractures</td>
</tr>
<tr>
<td>Fracture-Induced dissolution</td>
</tr>
<tr>
<td>OverSize/elongate Pores</td>
</tr>
<tr>
<td>Grain-edge dissolution</td>
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<table>
<thead>
<tr>
<th>12. Other Phosphate Cement</th>
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<tbody>
<tr>
<td>Sericite</td>
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<tr>
<td>Biotite</td>
</tr>
<tr>
<td>Dolomite replacing feldspar</td>
</tr>
<tr>
<td>Orthoclase occurring on grain</td>
</tr>
<tr>
<td>Large Kaolinite &quot;books&quot; or zeolite cement ?</td>
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<tr>
<td>Mmmyerite</td>
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<table>
<thead>
<tr>
<th>COMMENTS</th>
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<th>SECONDARY INTERGRANULAR POROSITY</th>
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<th>Fracture-Induced Dissolution</th>
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<tbody>
<tr>
<td>Q vsF vsK vsP prF prK prP</td>
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<table>
<thead>
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<th>Grain-Edge Dissolution</th>
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<tbody>
<tr>
<td>Q vsF vsK vsP prF prK prP</td>
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<thead>
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<th>OverSize/Elongate Pores</th>
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</thead>
<tbody>
<tr>
<td>Q vsF vsK vsP prF prK prP</td>
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<table>
<thead>
<tr>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>prF prK prP</td>
</tr>
</tbody>
</table>
**Thin Section: Lewisville 1-1-1460**

**Location:** Creek oil field

**Depth:** 1460 ft

**Sorting:** Moderately sorted

**Size:** Fine sand

---

### Petrographic Data

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<thead>
<tr>
<th>Component</th>
<th>Description</th>
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<tbody>
<tr>
<td>1. Quartz</td>
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<tr>
<td></td>
<td>Polycrystalline</td>
</tr>
<tr>
<td></td>
<td>Microporous</td>
</tr>
<tr>
<td></td>
<td>Clastic</td>
</tr>
<tr>
<td></td>
<td>Volcanic Rock Fragment</td>
</tr>
<tr>
<td></td>
<td>Chert</td>
</tr>
<tr>
<td></td>
<td>Other Sedimentary</td>
</tr>
<tr>
<td></td>
<td>Metaquartz</td>
</tr>
<tr>
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<td>Other Metamorphic</td>
</tr>
<tr>
<td>2. K-Feldspar</td>
<td>Microcline</td>
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<td></td>
<td>Orthoclase</td>
</tr>
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<td></td>
<td>Sanidine</td>
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<td>Microphenelite</td>
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<tr>
<td>3. Plagioclase</td>
<td>Microphenelite</td>
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<td>Metamorphic</td>
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<tr>
<td>4. Volcanics</td>
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</tr>
<tr>
<td>5. Microporous</td>
<td></td>
</tr>
<tr>
<td>6. Accessory Minerals</td>
<td></td>
</tr>
<tr>
<td>7. Carbonate Cement</td>
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</tr>
<tr>
<td>8. Matrix / Pseudomatrix</td>
<td></td>
</tr>
<tr>
<td>9. Clay Cement</td>
<td></td>
</tr>
<tr>
<td>10. Intragranular Porosity</td>
<td></td>
</tr>
<tr>
<td>11. Intragranular Porosity</td>
<td></td>
</tr>
<tr>
<td>12. Other</td>
<td></td>
</tr>
</tbody>
</table>

---

**Comments:**
- Clumping of clay
- Sericite: Plagioclase, quartz, and kaolinite
- Some 2nd porosity observed
- Some grains are broken
- Not all replacement only
- Other paragenesis unknown
- Other quartz

---

**Secondary Intragranular Porosity Dissolution**

<table>
<thead>
<tr>
<th>Fracture-Induced Dissolution</th>
<th>Fracture-Induced Dissolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oversize/elongate pores</td>
<td>Other</td>
</tr>
</tbody>
</table>

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**Secondary Intragranular Porosity Dissolution**

<table>
<thead>
<tr>
<th>Dissolution Type</th>
<th>Q</th>
<th>K</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>Fracture-Induced</td>
<td>vff</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oversize/elongate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grain-edge dissolution</td>
<td></td>
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</tbody>
</table>

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<table>
<thead>
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<td></td>
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<tr>
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<td></td>
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<td></td>
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</tr>
<tr>
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<td></td>
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<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grain-edge dissolution</td>
<td></td>
<td></td>
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</tbody>
</table>
**SANDSTONE PETROGRAPHY DATA**

**EXAMINED BY:** Nguyen MS

**PROJECT:**

**ROCK NAME:**

** POINT COUNTS:**

**COMPACTION:**

**ANGULARITY:**

**COMMENTS**

<table>
<thead>
<tr>
<th>1. Quartz</th>
<th>Monocrystalline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polycrystalline</td>
<td></td>
</tr>
<tr>
<td>Microphanerite</td>
<td></td>
</tr>
<tr>
<td>Granitic</td>
<td></td>
</tr>
<tr>
<td>Volcanic Rock Fragment</td>
<td></td>
</tr>
<tr>
<td>Quartz Arenite</td>
<td></td>
</tr>
<tr>
<td>Other Sedimentary</td>
<td></td>
</tr>
<tr>
<td>Metaquartzite</td>
<td></td>
</tr>
<tr>
<td>Other Metamorphic</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. K-Feldspar</th>
<th>Microcline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthoclase</td>
<td></td>
</tr>
<tr>
<td>Sanidine</td>
<td></td>
</tr>
<tr>
<td>Microphanerite</td>
<td></td>
</tr>
<tr>
<td>Granitic</td>
<td></td>
</tr>
<tr>
<td>Volcanic Rock Fragment</td>
<td></td>
</tr>
<tr>
<td>Sedimentary</td>
<td></td>
</tr>
<tr>
<td>Metamorphic</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Plagioclase</th>
<th>Microphanerite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granitic</td>
<td></td>
</tr>
<tr>
<td>Volcanic Rock Fragment</td>
<td></td>
</tr>
<tr>
<td>Sedimentary</td>
<td></td>
</tr>
<tr>
<td>Metamorphic</td>
<td></td>
</tr>
</tbody>
</table>

| 4. Volcanics | Mafic |

<table>
<thead>
<tr>
<th>5. Microphanerites</th>
<th>Schist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metamorphic</td>
<td></td>
</tr>
<tr>
<td>Granitic - muscovite, biotite</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6. Accessory Minerals</th>
<th>Biotite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscovite</td>
<td></td>
</tr>
<tr>
<td>Vesicles</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7. Carbonate Cement</th>
<th>Calcite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dolomite</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8. Matrix / Pseudomatrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay-Altered Grains</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9. Clay Cement</th>
<th>Illite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaolinite</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10. Intragranular Porosity</th>
<th>Quartz</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-Feldspar</td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>11. Intragranular Porosity</th>
<th>Fractures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture-induced dissolution</td>
<td></td>
</tr>
<tr>
<td>Oversize/elongate pores</td>
<td></td>
</tr>
<tr>
<td>Grain-edge dissolution</td>
<td></td>
</tr>
<tr>
<td>Other</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12. Other</th>
<th>Metamorphic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blebs of calcite</td>
<td></td>
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<tr>
<td>Karstic porosity</td>
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</tr>
<tr>
<td>Paragenesis</td>
<td></td>
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</tbody>
</table>

**SECONDARY INTERGRANULAR POROSITY**

**FRACTURE-INDUCED DISSOLUTION**

<table>
<thead>
<tr>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>vfrQ</td>
<td>vfrK</td>
<td>vfrP</td>
</tr>
<tr>
<td>prQ</td>
<td>prK</td>
<td>prP</td>
</tr>
</tbody>
</table>

**GRAIN-EDGE DISSOLUTION**

<table>
<thead>
<tr>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>vfrQ</td>
<td>vfrK</td>
<td>vfrP</td>
</tr>
<tr>
<td>prQ</td>
<td>prK</td>
<td>prP</td>
</tr>
</tbody>
</table>

**OVERSIZE/ELONGATE HOLES**

<table>
<thead>
<tr>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>vfrQ</td>
<td>vfrK</td>
<td>vfrP</td>
</tr>
<tr>
<td>prQ</td>
<td>prK</td>
<td>prP</td>
</tr>
</tbody>
</table>

**OTHER**

paragenesis:

- Sericite: planar K-fspar, quartz
- Zoned calcite/dolomite cement are common
- Planar K-fspar are almost completely altered to alabaster altering to clay - purple muscovite observed
- Kaolinite,books observed
- Carbonate cement, replacing clays

paragenesis:

- Calcite: planar K-fspar, quartz
- Metamorphic chlorite exhibiting Bimin blue
- Dissolution along etch of quartz, grains are common

- Calcite: planar K-fspar, quartz
- Metamorphic chlorite exhibiting Bimin blue
- Dissolution along etch of quartz, grains are common

- Calcite: planar K-fspar, quartz
- Metamorphic chlorite exhibiting Bimin blue
- Dissolution along etch of quartz, grains are common
SANDSTONE PETROGRAPHY DATA

PROJECT: Nguyen MS
EXAMINED BY: Nguyen MS

FORM: Lewis - 11180
LOCATION: Ewing oil field
DEPTH: 11180

SORTING: poorly sorted
SIZE: med. sand

COMMENTS

1. Quartz
   Monocrystalline
   Polycrystalline
   Microtexture
   Grains, U.
   Volcanic Rock Fragment
   Quartz Arete
   Other Sedimentary
   Metaquartzite
   Other Metamorphic

2. K-Feldspar
   Microcline
   Orthoclase
   Sanidine
   Microperthite
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

3. Plagioclase
   Microphanerite
   Grains, III
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

4. Volcanics
   Grains, III

5. Microperthite
   Orthoclase
   Microperthite
   Metamorphic

6. Accessory Minerals
   Biotite
   Muscovite
   Siderite
   Hornblende

7. Carbonate Cement
   Dolomite, winkle
   Calcite

8. Matrix / Pseudomatrix
   Biotite alteration to clay
   Clay-Altered Grains
   Calcite
   Other

9. Clay Cement
   Calcite
   Other

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

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

12. Other
    Muscovite
    Mica
    Mica
    Other intragranular...
THIN SECTION: Lewis-11491
FORMATION (AGE): 
LOCATION: Gilley Oil Field
DEPTH: 11491'
SORTING: Mod. sorted
SIZE: Med. sand

1. Quartz
   - Mosaic
   - Polycrystalline
   - Microcrystalline
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metacarbonate
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanidine
   - Microcline
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. Plagioclase
   - Microcline
   - Granitic
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

4. Volcanics
   - <IIII>

5. Microphanerites
   - Cheek-
   - Muscovite

6. Accessory Minerals
   - Pyrite
   - Muscovite
   - Actinolite

7. Carbonate
   - Dolomite
   - Calcite

8. Matrix / Pseudomatrix
   - Clay-Altered Grains

9. Clay
   - Clay
   - Other

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

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

12. Other
    - Fossil
    - Biofilm
    - Intragranular...

COMMENTS
- Toned dolomite
- Biotite altering to clay + chlorite
- Dolomite next to biotite + pyrite b/w cleavage
- Siderite
- Navajinite

PARAGENESIS

SECONDARY INTRAGRAINULAR POROSITY

<table>
<thead>
<tr>
<th>FRACTURE-INDUCED DISSOLUTION</th>
<th>Q</th>
<th>K</th>
<th>P</th>
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<tbody>
<tr>
<td>G</td>
<td>vrfQ</td>
<td>vrfK</td>
<td>vrfP</td>
</tr>
<tr>
<td>GRAIN-EDGE DISSOLUTION</td>
<td>Q</td>
<td>K</td>
<td>P</td>
</tr>
<tr>
<td>G</td>
<td>vrfQ</td>
<td>vrfK</td>
<td>vrfP</td>
</tr>
<tr>
<td>OVERSIZE/ELONGATE PORES</td>
<td>Q</td>
<td>K</td>
<td>P</td>
</tr>
<tr>
<td>G</td>
<td>vrfQ</td>
<td>vrfK</td>
<td>vrfP</td>
</tr>
<tr>
<td>OTHER</td>
<td>Q</td>
<td>K</td>
<td>P</td>
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<tr>
<td>G</td>
<td>vrfQ</td>
<td>vrfK</td>
<td>vrfP</td>
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<tr>
<td>SORTING:</td>
<td>Mud silted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIZE:</td>
<td>Mud sand</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SANDSTONE PETROGRAPHY DATA**

**PROJECT:** Nguyen, MS

**EXAMINED BY:** Nguyen, MS

**ROCK NAME:**

**POINT COUNTS:**

**COMPACtion:** very tight

**ANGULARITY:** subangular - subrounded

---

### 1. Quartz
- Monocrystalline
- Polycrystalline
- Microphanerite
- Quartz Arenite
- Other Sedimentary
- Metaquartzite
- Other Metamorphic

### 2. K-Feldspar
- Microline
- Orthoclase
- Sanidine
- Microphanerite
- Sedimentary
- Metamorphic

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

### 4. Volcanics

### 5. Microphanerites
- Coarse - Muscovite

### 6. Accessory Minerals
- Biotite
- Muscovite
- Sericite

### 7. Carbonate Cement
- Dolomite
- Calcite

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

### 9. Clay Cement
- Kaolinite

### 10. Intragnular Porosity
- Quartz
- K-Feldspar
- Plagioclase

### 11. Intergranular Porosity
- Fractures
- Fracture-induced dissolution
- Overgrowths
- Grain-edge dissolution

### 12. Other
- Sporadic coatings

**COMMENTS**
- Fallers to zeolite - carbonate replace FV grains
- Biotite altered to clay by pyrite wi bitulite cleavage
- Kspar overgrowths
- Dolomite replacing calcite

**PARAGENESIS**

---

**SECONDARY INTERGRANULAR POROSITY**

**FRACTURE-INDUCED DISSOLUTION**

<table>
<thead>
<tr>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
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<td>vrfK</td>
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**GRAIN-EDGE DISSOLUTION**

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<th>K</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>VRF</td>
<td>vrfQ</td>
<td>vrfK</td>
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</tbody>
</table>

**OVERSIZE/ELONGATE FORES**

**OTHER**

---
SANDSTONE PETROGRAPHY DATA

THIN SECTION: Moore - L, 114108-1
FORMATION (AGE): ascribed as 114108-2
LOCATION: in Lab
DEPTH: 114108

SORTING: poorly sorted
SIZE: fine -med.

COMPACTION: floating due to silt, carbonate cement replacing fabric grains
ANGULARITY: angular - subangular

PROJECT: Nguyen IMS
EXAMINED BY: Nguyen

1. Quartz
   Monocrystalline
   Polycrystalline
   Microcrystalline
   Volcanic Rock Fragment
   Quartz Arenite
   Other Sedimentary
   Metakaolin
   Other Metamorphic

2. K-Feldspar
   Microcline
   Orthoclase
   Sanidine
   Microcline
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

3. Plagioclase
   Microcline
   Plagioclase
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

4. Volcanics

5. Microperthites

6. Accessory Minerals
   Carbonate
   M. Calcite
   Others

7. Carbonate Cement
   Calcite
   Dolomite

8. Matrix / Pseudomatrix
   Clay-Altered Grains

9. Clay

10. Intragranular Porosity
    Quartz
    K-Feldspar
    Plagioclase

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

12. Other

COMMENTS
- Fractured glauconite, dolomite, replace glauconite
- Along fracture and phosphate
- Abundant dolomite cement and phosphate
- Nodes and coatings
- Fumed plag

SECONDARY INTRAGRAIN POROSITY

FRACtURE-INDUCED DISSOLUTION

Q
P
K
PRF Q
PRF K
PRF P

GRAIN-EDGE DISSOLUTION

Q
P
K
PRF Q
PRF K
PRF P

OVERSIZE/ELONGATE PORES

Q
P
K
PRF Q
PRF K
PRF P

OTHER

PARAGENESIS
- Partially dissolved feldspar, plag, oil moved in space formed phosphate, dolomite, cement
- Phosphate -> converted phosphate -> phosphatite replacement glauconite
- Glauconite -> dolomite, replace glauconite
- Dolomite replace glauconite

PRF Q
PRF K
PRF P
SANDSTONE PETROGRAPHY DATA

FORMED ON: Mav 12 11418-2
LOCATION: Geelely oil field
DEPTH: 11418
SORTING: Moderately sorted
SIZE: Med sand

1. Quartz
- Monocrystalline
- Polycrystalline
- Microcrystalline
- Volcanic Rock Fragment
- Quartz Arenite
- Other Sedimentary
- Metapelite
- Metamorphic

2. K-Feldspar
- Microcline
- Orthoclase
- Anorthoclase
- Microcrystalline
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

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

4. Volcanics

5. Micaceous
- Chlorite
- Muscovite
- Vermiclite

6. Accessory Minerals
- Zircon
- Smaragdite
- Muscovite

7. Carbonate
- Calcite
- Dolomite

8. Matrix
- Pseudomatrix
- Clay-Altered Grain

9. Clay
- Fadinite
- Illite

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

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

12. Other
- Manganite
- Zeolite

COMMENTS
- Botite altering to clay
- Coating on Glaucnite like x1/40-1TS
- Stained for K-spar
- pure plan + quartz (mamkite) or f-spar exhibited
- Sensitization of feldspar (saw 1 feldspar alters to zeolite)

PARAGENESIS
- Dolomite replacing framework grains
- Sig of 2nd order created by dissolution
- Feldspar (plag?) replaced by kaolinite?
SANDSTONE PETROGRAPHY DATA

EXAMINED BY: Nguyen

PROJECT:

FORMATION (AGE):

LOCATION: Greeley Oil Field

DEPTH: 11474

SORTING: Poorly Sorted

SIZE: Med Sands

### 1. Quartz
- Monocrystalline
- Polycrystalline
- Microcrystalline
- Volcanic Rock Fragment
- Oriented
- Other Sedimentary
- Metagreywacke
- Other Metamorphic

### 2. K-Feldspar
- Orthoclase
- Microcline
- Plagioclase
- Microcline
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

### 3. Plagioclase
- Orthoclase
- Microcline
- Volcanic Rock Fragment
- Sedimentary
- Metamorphic

### 4. Volcanics

### 5. Microfabrics
- Chert
- Granite
- Schist

### 6. Accessory Minerals
- Sphene

### 7. Carbonate Cement
- Dolomite
- Calcite

### 8. Matrix / Pseudomatrix

### 9. Clay Cement
- Chlorite

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

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

### 12. Other Porosity
- Phosphate

### COMMENTS
- Bottle necks to clay
- Zonal quartz overgrowth
- Zonal carbonate overgrowth
- Phosphate coating on grains
- Fractures healed by overgrowth

### SECONDARY INTRAGRANULAR POROSITY

<table>
<thead>
<tr>
<th>Fracture-Induced Dissolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>fracture-induced dissolution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grain-Edge Dissolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain edge dissolution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oversize/Elongate Pores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oversize/elongate pores</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OTHER</th>
</tr>
</thead>
</table>

**PARAGENESIS**
### SANDSTONE PETROGRAPHY DATA

**EXAMINED BY:** Nguyen MS  
**PROJECT:** Various  
**THIN SECTION:** Various  
**FORMATION (AGE):** Various  
**LOCATION:** Various  
**DEPTH:** Various  
**SORTING:** Various  
**SIZE:** Various  
**ROCK NAME:** Various  
**COMPACTION:** Various  
**ANGULARITY:** Various  

### COMMENTS

1. Quartz  
   - Monoclinic  
   - Polycrystalline  
   - Micaceous  
   - Graniitic  
   - Variscan  
   - Early diagenetic  
   - Late diagenetic  

2. K-Feldspar  
   - Micaceous  
   - Orthoclase  
   - Plagioclase  
   - Graniitic  
   - Variscan  

3. Plagioclase  
   - Micaceous  
   - Orthoclase  
   - Plagioclase  
   - Graniitic  
   - Variscan

4. Volcanics  
   - Micaceous  
   - Graniitic  
   - Variscan

5. Microphanerites  
   - Micaceous  
   - Graniitic  
   - Variscan

6. Accessory Minerals  
   - Bioite  
   - Prehnite  
   - Siderite  
   - Muscovite  

7. Carbonate Cement  
   - Dolomite  

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

9. Clay  
   - Dolomite  
   - Microcrystalline  

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

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

12. Other Phosphate (bone)  
    - Bioaltered  
    - Zeolite cement  
    - Hyaloclastite  
    - Phyllitic texture  
    - Lots of zeolites  
    - Clay  

### SECONDARY INTERGRANULAR POROSITY

**FRACtURE-INDUCED DISSOLUTION**  
- Q  
- K  
- P  

**GRAIN-EDGE DISSOLUTION**  
- Q  
- K  
- P  

**OVERSIZE/ELONGATE PORES**  
- Q  
- K  
- P  

**OTHER**  
- Q  
- K  
- P
**SANDSTONE PETROGRAPHY DATA**

**PROJECT:** Nguyen MS

**THIN SECTION:** Moro-3

**LOCATION:** Greeley oil field

**DEPTH:** 

**SORTING:** Mod. Corked

**SIZE:** Med. sands

**COMMENTS**

| 1. Quartz | Monecrystalline |  
| Polyformed |  
| Microcrystalline |  
| Granite |  
| Volcanic Rock Fragment |  
| Quartz Arenite |  
| Other Sedimentary |  
| Metaquartzite |  
| Other Metamorphic |  

| 2. K-Feldspar | Microcline |  
| Orthoclase |  
| Sanidine |  
| Microphaneritic |  
| Granite |  
| Volcanic Rock Fragment |  
| Sedimentary |  
| Metamorphic |  

| 3. Plagioclase | Microphaneritic |  
| Granite |  
| Volcanic Rock Fragment |  
| Sedimentary |  
| Metamorphic |  

| 4. Volcanics |  
|  
|  
|  
|  

| 5. Microphanerites | Chert |  
| granite |  
| Volcanic |  

| 6. Accessory Minerals | Anhydrite |  
| Bottke |  
| Lithic |  
| Epidote |  
| Augenite |  
| Dolomite |  

| 7. Carbonate Cement |  

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

| 9. Clay Cement |  
| Fossil |  
| Siltstone |  

| 10. Intragranular Porosity | VRF Q |  
| K |  
| PRF Q |  
| P |  

| 11. Intragranular Fractures | Fracture-induced dissolution |  
| Overorg/inclongate pores | Grain-edge dissolution |  
| Other |  

| 12. Other Zeolite cement | Zeolite cement |  
| Myrmekite |  
| Bottke alters to clay |  
| Enchimaren |  
| Zeolite formed with cleavage to warp |  
|  

**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/ELONGATEPORES**

- Q: vrfQ, prfQ
- K: vrfK, prfK
- P: vrfP, prfP

**OTHER**

---

**PARAGENESIS**
THIN SECTION: MOR 3.1114.16
FORMATION (AGE): 
LOCATION: Greeley Oil Field
DEPTH: 6171.7
SORTING: Moderately Sorted
SIZE: Med

SANDSTONE PETROGRAPHY DATA

PROJECT: Nguyen GS
EXAMINED BY: Nguyen

ROCK NAME: 
POINT COUNTS: 

COMMENTS:

1. Quartz
   Monocrystalline
   Polycrystalline
   Microcrystalline
   Volcanic Rock Fragment
   Quartz Arenite
   Other Sedimentary
   Metaplutonite
   Other Metamorphic

2. K-Feldspar
   Microcline
   Orthoclase
   Sanidine
   Microphanerite
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

3. Plagioclase
   Microphanerite
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

4. Volcanics

5. Microphanerites

6. Accessory Minerals
   Biotite
   Chlorite
   Coalitic
   Rutile

7. Carbonate Cement

8. Matrix / Pseudomatrix
   Clay-Altered Grains

9. Clay Cement

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

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

12. Other Phosphatic Bone

COMMENTS:
- Biotite alteration to clay, chlorite, sericite
-Falts to zoned clays: zeolitic cements
-Mutualite
-Abundant secondary F caused by dissolution
-Zoned plag.
-Biomineral coating on grain
-Pseudomorphic overgrowth

SECONDARY INTRAGRANULAR POROSITY
FRACTURE-INDUCED DISSOLUTION

Q4 K P
K4 P K
P4 P P

GRAIN-EDGE DISSOLUTION
Q4 K
K4 K
P4 P

OVERSIZE/ELONGATE PORES
Q4 K
K4 K

OTHER
**SANDSTONE PETROGRAPHY DATA**

**PROJECT:** Nguyen M.S.

**EXAMINED BY:** Nguyen

**FORMATION (AGE):** Greeley Oil Field

**LOCATION:**

**DEPTH:** 11480 ft

**SORTING:** Poorly sorted

**SIZE:** Fine sands

---

<table>
<thead>
<tr>
<th><strong>1. Quartz</strong></th>
<th>Monocrystalline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Polycrystalline</td>
</tr>
<tr>
<td></td>
<td>Microphanerite</td>
</tr>
<tr>
<td></td>
<td>Quartzarenite</td>
</tr>
<tr>
<td></td>
<td>Other Sedimentary</td>
</tr>
<tr>
<td></td>
<td>Metasandstone</td>
</tr>
<tr>
<td></td>
<td>Other Metamorphic</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th><strong>2. K-Feldspar</strong></th>
<th>Microcline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Orthoclase</td>
</tr>
<tr>
<td></td>
<td>Sanidine</td>
</tr>
<tr>
<td></td>
<td>Microphanerite</td>
</tr>
<tr>
<td></td>
<td>Volcanic Rock Fragment</td>
</tr>
<tr>
<td></td>
<td>Sedimentary</td>
</tr>
<tr>
<td></td>
<td>Metamorphic</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th><strong>3. Plagioclase</strong></th>
<th>Microphanerite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Volcanic Rock Fragment</td>
</tr>
<tr>
<td></td>
<td>Sedimentary</td>
</tr>
<tr>
<td></td>
<td>Metamorphic</td>
</tr>
</tbody>
</table>

---

| **4. Volcanics** | Chert |

---

| **5. Microphanerites** | Chert |

---

<table>
<thead>
<tr>
<th><strong>6. Accessory Minerals</strong></th>
<th>Muscovite</th>
</tr>
</thead>
</table>

---

| **7. Carbonate Cement** | Dolomite |

---

<table>
<thead>
<tr>
<th><strong>8. Matrix</strong></th>
<th>Clay-Altered Grains</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pseudomatrix</td>
</tr>
</tbody>
</table>

---

| **9. Clay Cement** | Talcite |

---

<table>
<thead>
<tr>
<th><strong>10. Intergranular Porosity</strong></th>
<th>Quartz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K-Feldspar</td>
</tr>
<tr>
<td></td>
<td>Plagioclase</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>11. Intergranular Porosity</strong></th>
<th>Fractures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fracture-induced dissolution</td>
</tr>
<tr>
<td></td>
<td>Oversize/elongate pores</td>
</tr>
<tr>
<td></td>
<td>Grain-edge dissolution</td>
</tr>
</tbody>
</table>

| **12. Other** | Shell |

---

**COMMENTS:**

- Stained for K-Feldspar
- Dolomite replacing 
- Quartz (dolomite appears 
- Altered to clay

**PARAGENESIS**

**SECONDARY INTERGRANULAR POROSITY**

<table>
<thead>
<tr>
<th><strong>FRACTURE-INDUCED DISSOLUTION</strong></th>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
<td>vrfQ</td>
<td>vrfK</td>
<td>vrfP</td>
</tr>
<tr>
<td>K</td>
<td>vrfK</td>
<td>vrfK</td>
<td>vrfP</td>
</tr>
<tr>
<td>P</td>
<td>vrfP</td>
<td>vrfP</td>
<td>vrfP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>GRAIN-EDGE DISSOLUTION</strong></th>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
<td>vrfQ</td>
<td>vrfK</td>
<td>vrfP</td>
</tr>
<tr>
<td>K</td>
<td>vrfK</td>
<td>vrfK</td>
<td>vrfP</td>
</tr>
<tr>
<td>P</td>
<td>vrfP</td>
<td>vrfP</td>
<td>vrfP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>OVERSIZE/ELONGATE POROSITY</strong></th>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
<td>vrfQ</td>
<td>vrfK</td>
<td>vrfP</td>
</tr>
<tr>
<td>K</td>
<td>vrfK</td>
<td>vrfK</td>
<td>vrfP</td>
</tr>
<tr>
<td>P</td>
<td>vrfP</td>
<td>vrfP</td>
<td>vrfP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>OTHER</strong></th>
</tr>
</thead>
</table>

---
THIN SECTION: Schooler 11430-74
FORMATION (AGE): Greeley Oil Field
LOCATION: 11430
DEPTH: 11430

SORTING: Not Sorted
SIZE: Med-Fine

COMMENTS

1. Quartz
   - Monocrystalline
   - Polycrystalline
   - Microphaneritic
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metasandstone
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanidine
   - Microphaneritic
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

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

4. Volcanics

5. Microphanerites
   - Chert

6. Accessory
   - Rutile
   - Biotite
   - Muscovite
   - Sphene
   - Zircon
   - Muscovite

7. Carbonate
   - Cement

8. Matrix / Pseudomatrix
   - Clay-Alterite

9. Clay
   - Cement

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

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

12. Other
    - Dolomite

COMMENTS
- Abundant petroleum
- Zeolites
- Fallores to sericitic clay

PARAGENESIS
- F. dissolved & overgrowth remained:
  - Q overgrowth?

SECONDARY INTERGRANULAR POROSITY

<table>
<thead>
<tr>
<th>Fracture-Induced Dissolution</th>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF Q</td>
<td>K</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>PRF Q</td>
<td>K</td>
<td>P</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grain-Edge Dissolution</th>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF Q</td>
<td>K</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>PRF Q</td>
<td>K</td>
<td>P</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oversize/Elongate Pores</th>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF Q</td>
<td>K</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>PRF Q</td>
<td>K</td>
<td>P</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other</th>
<th>Volcanic</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF Q</td>
<td>K</td>
</tr>
<tr>
<td>PRF Q</td>
<td>P</td>
</tr>
</tbody>
</table>

PROJECT: Nguyen MS
EXAMINED BY: Nguyen MS

COMPACTION: Very Tight
ANGULARITY: Subangular-Round
SANDSTONE PETROGRAPHY DATA

PROJECT: Nguyen

EXAMINED BY: Nguyen

ROCK NAME:

LOCATION: Cinchey oil field

DEPTH: 11,480 ft

SORTING: poorly sorted

SIZE: fine sands

COMMENTS

1. Quartz
   - Monocrystalline
   - Polycrystalline
   - Microgranite
   - Volcanic Rock Fragment
   - Quartz Arete
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Orthoclase
   - Microcline
   - sanidine
   - Microphaneritic
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

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

4. Volcanics

5. Microphanerites

6. Accessory Minerals
   - Biotite
   - Illite
   - Chlorite
   - Illite/smectite
   - Spheene

7. Carbonate Cement
   - Dolomite
   - Calcite
   - Calcareous

8. Matrix
   - Pseudomatrix
   - Clay-Altered Grains
   - Illite/smectite

9. Clay
   - Kaolinite
   - Illite/smectite

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

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

12. Other
    - Biotite alteration to chlorite and/or kaolinite
    - illite/smectite overgrowth

PARAGENESIS
   - Dolomite replacing calcite

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION
   - Q
   - K
   - P

GRAIN-EDGE DISSOLUTION
   - Q
   - K
   - P

OVERSIZE/ELONGATE PORES
   - Q
   - K
   - P

OTHER
   - Q
   - K
   - P
SANDSTONE PETROGRAPHY DATA

PROJECT: Nguyen
EXAMINED BY: Nguyen

ROCK NAME: Shale
POINT COUNTS:

COMPACTON: Very tight

ANGULARITY: Angular - Subangular

COMMENTS

1. Quartz
   - Monocrystalline
   - Polycrystalline
   - Microgranite
   - Granite
   - Volcanic Rock Fragment
   - Quartz Aretite
   - Other Sedimentary
   - Metaklase
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanidine
   - Microgranite
   - Granite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

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

4. Volcanic Rocks

5. Microgranites

6. Accessory Minerals
   - Sphene
   - Chlorite
   - Tourmaline

7. Carbonate
   - Dolomite
   - Calcite

8. Maturation
   - Pseudomatrix
   - Clay-ALTERED Grains

9. Clay
   - Cement

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

11. Intergranular Porosity
   - Fractures
   - Fracture-induced dissolution
   - OverSize/Elongate pores
   - Grain-edge dissolution
   - Other

12. Other

SECONDARY INTERGRANULAR POROSITY

FRACUTURE-INDUCED DISSOLUTION
- Q vrfQ
- K vrfK
- P vrfP

GRAIN-EDGE DISSOLUTION
- Q vrfQ
- K vrfK
- P vrfP

OVERSIZE/ELONGATE PORES
- Q vrfQ
- K vrfK
- P vrfP

OTHER

PARAGENESIS

- Comments
  - Matrix contains clays + some petroclls
  - Overgrowth to clay

- Laminated

- Bottle apple to clay
SANDSTONE PETROGRAPHY DATA
THIN SECTION: Vale Oil Field
PROJECT: Nguyen NS
FORMATION (AGE):
LOCATION: Greeley Oil Field
DEPTH: 14125
SORTING: poorly sorted
SIZE: very fine sand

<table>
<thead>
<tr>
<th>COMMENTS</th>
</tr>
</thead>
</table>
1. Quartz  
Monocrystalline  
Polycrystalline  
Microphanerite  
Volcanic Rock Fragment  
Quartz Arenal  
Other Sedimentary  
Metaquartzite  
Other Metamorphic  

2. K-Feldspar  
Microcline  
Orthoclase  
Sanidine  
Microphanerite  
Volcanic Rock Fragment  
Sedimentary  
Metamorphic  

3. Plagioclase  
Microphanerite  
Volcanic Rock Fragment  
Sedimentary  
Metamorphic  

4. Volcanics  

5. Microphanerites  
Microcline  
Orthoclase  
Sanidine  
Microphanerite  
Volcanic Rock Fragment  
Sedimentary  
Metamorphic  

6. Accessory Minerals  
Muscovite  
Biotite  
Phlogopite  

c | 22 |  |  |  |  |
|---|---|---|---|---|

cement | 85 | |  |  |
Pseudomatrix  
Clay-Altered Grains  

7. Carbonate Cement  

8. Matrix  
Microphanerite  
Volcanic Rock Fragment  
Sedimentary  
Metamorphic  

9. Clay Cement  

10. Intragranular Porosity  
Quartz  
K-Feldspar  
Plagioclase  

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

12. Other  
Phosphatic (Bone)  

COMMENTS  
Abundant matrix: clay + organic  
Biofilm + frailer + chlorite  
Grained for K-spar  

PARAGENESIS  
SECONDARY INTERGRANULAR POROSITY  
FRACTURE-INDUCED DISSOLUTION  
Q K P  prfQ prfK prfP  
GRAIN-EDGE DISSOLUTION  
Q K P  prfQ prfK prfP  
OVERSIZE/ELONGATE PORES  
Q K P  prfQ prfK prfP  
OTHER  

SANDSTONE PETROGRAPHY DATA

PROJECT: Ngyuen 5
EXAMINED BY: Ngyuen

ROCK NAME: Geyv oil field
POINT COUNTS:

SORTING: Poorly sorted

SIZE: Fine to medium sand

1. Quartz
   Monocrystalline
   Polycrystalline
   Micropoerative
   Volcanic Rock Fragment
   Quartz Arenite
   Other Sedimentary
   Metaoquartzite
   Other Metamorphic

2. K-Feldspar
   Microcline
   Orthoclase
   Sanidine
   Microperative
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

3. Plagioclase
   Microperative
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

4. Volcanics

5. Microperatives
   Chlorite - Muscovite

6. Accessory Minerals
   Rutile
   Magnetite
   Chlorite
   Calcite

7. Carbonate
   Dolomite
   Calcite

8. Pseudomatrix

9. Clay
   Illite/Smectite

10. Intragranular Porosity
    Quartz
    K-Feldspar
    Plagioclase
    VRFQ
    PRFQ
    K
    P

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

12. Other
    Fossil
    Matrix contains organic
    Inter-grown matrix and intergranular

COMMENTS
- Stained for K-spar
- Abundant matrix
- Metamorphic biotite
- Matrix contains clay
- Little epsomite indicating myrmecitic texture

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION
Q
K
P

GRAIN-EDGE DISSOLUTION
Q
K
P

OVERSIZE/Elongate pores
Q
K
P

OTHER

PARAGENESIS
- Biotite altering to clay and chlorite, chlorite exhibiting blue in color
# Sandstone Petrography Data

**Thin Section:** Vale 1 11190 4 3 11190

**Formation (Age):** Greeley

**Location:** Greeley

**Depth:** 11190

**Sorting:** Poorly Sorted

**Size:** Fine sands

**Rock Name:**

- Compaction: Slightly compacted
- Angularity: Subangular

### Comments

1. **Quartz**
   - Monocrystalline
   - Polycrystalline
   - Microcrystalline
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metavolcanic
   - Other Metamorphic

2. **K-Feldspar**
   - Microcline
   - Orthoclase
   - Microcline
   - Granitic
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. **Plagioclase**
   - Microcrystalline
   - Granitic
   - Muscovite

4. **Volcanics**

5. **Microgranites**

6. **Accessory Minerals**
   - Zircon
   - Feldspar
   - Muscovite
   - Hornblende

7. **Carbonate Cement**
   - Dolomite
   - Calcite

8. **Matrix / Pseudomatrix**

9. **Clay-Altered Grain / Illite / I-Smectite**

10. **Interglacial Porosity**
    - K-Feldspar
    - Plagioclase

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

12. **Other**

### Comments

- Intracrystalline: plagioclase
- E-spar exhibiting alignment texture + plagioclase
- Breccia altering to clays and calcite
- Some grains are completely altered to sericite
- Metamorphic grains + carbonate veins + quartz veins
- Some plagioclase is common

### Paragenesis

- Volcanics: zeolite, fibrous + clay coated
- Calcite replaced by dolomite
- Albite replaced by plagioclase
- Some plagioclase grains are almost completely replaced by albite
THIN SECTION: Wale 11492 T 3C
FORMATION (AGE): Okeequy oil Field
LOCATION: H1124
DEPTH: 11492
SORTING: Mod. Very coarsely
SIZE: Med. Sands

SANDSTONE PETROGRAPHY DATA

PROJECT: Nguyen MS
EXAMINED BY: Nguyen

ROCK NAME: Point counts:
COMPACATION: Very tight: little Pt contact
CONCORD-CONVEX + Plan contacts common
ANGULARITY: Subangular - Subrounded

1. Quartz
   - Monocrystalline
   - Polycrystalline
   - Microphanerite
   - Quartz Rock Fragment
   - Quartz Acrete
   - Other Sedimentary
   - Metat赒zite
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - orthoclase
   - Pericline
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

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

4. Volcanics
   - Micrite
   - Micritic
   - Siltite
   - Siltite

5. Microphanerites
   - Microcline
   - Orthoclase
   - Pericline
   - Biotite
   - Muscovite
   - Biotite
   - Zircon

6. Accessory Minerals

7. Carbonate
   - Dolomite
   - Calcite
   - Dolomite
   - Calcite

8. Matrix / Pseudomatrix
   - Clay-Altered Grains

9. Clay Cement
   - Illite
   - Smectite
   - Clay

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

11. Intergranular Porosity
    - Fractures
    - Fracture-Induced dissolution
    - Overgrowth liens
    - Grain-edge dissolution
    - Other

12. Other

COMMENTS

Biotite alteration to clay
effecting to clay zeolites
Fremontite
Hydrocerite
Dolomite replacing few quartz

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION
- Q
- K
- F
- P
- P
- P

GRAIN-EDGE DISSOLUTION
- Q
- K
- P
- P
- P

Oversize/Elongate Pores
- Q
- K
- P
- P
- P

Other
- Q
- K
- P
- P
- P
THIN SECTION: Vale 1-11493
FORMATION (AGE): 
LOCATION: Greenly oil field
DEPTH: 11493

SORTING: Moderately sorted
SIZE: Med sand

SANDSTONE PETROGRAPHY DATA
PROJECT: Nguyen MS
EXAMINED BY: Nguyen MS

ROCK NAME:
POINT COUNTS:

COMPACION: very tight; abundant/some convex-long contacts, little pt. contacts.
ANGULARITY: angular - subangular

1. Quartz
   - Monocrystalline
   - Polycrystalline
   - Microcrystalline
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metasandstone
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanidine
   - Microcrystalline
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

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

4. Volcanics

5. Microcrystalline

6. Accessory Minerals
   - Biотite
   - Muscovite
   - Sillimanite
   - White

7. Carbonate Cement
   - Dolomite
   - Calcite

8. Matrix / Pseudomatrix
   - Clay-Altered Grains

9. Clay
   - Kaolinite

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

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

12. Other
    - Other

COMMENTS
- Biotite alters to clay
- Fails to zeolites
- Overgrowth
- Senite

PARAGENESIS

SECONDARY INTERGRANULAR POROSITY
FRACUTRE-INDUCED DISSOLUITION
   - Q K P
   - PrfK PrfP
GRAIN-EDGE DISSOLUTION
   - Q K P
   - PrfK PrfP
OVERSIZE/ELONGATE PORES
   - Q K P
   - PrfK PrfP
OTHER
   - Q K P
   - PrfK PrfP

---
SANDSTONE PETROGRAPHY DATA

PROJECT: Nguyen MS

FORMANATION (AGE):

LOCATION: Greeley oil field

DEPTH: 11497

SORTING: Poorly sorted

SIZE: Med sand

1. Quartz
   Monocrystalline
   Polycrystalline
   Microflakes
   Volcanic Rock Fragment
   Quartz Arenite
   Other Sedimentary
   Metasandstone
   Other Metamorphic

2. K-Feldspar
   Microcline
   Orthoclase
   Sanidine
   Microflakes
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

3. Plagioclase
   Microflakes
   Volcanic Rock Fragment
   Sedimentary
   Metamorphic

4. Volcanic
   

5. Microphyllous
   

6. Accessory
   Minerals
   

7. Carbonate
   Cement
   

8. Authigenic / Pseudomatrix
   Clay-Amorphous
   

9. Clay
   Cement
   

10. Intergranular
    Porosity
    Quartz
    K-Feldspar
    Plagioclase
    

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

12. Other
    

COMMENTS

SECONDARY INTERGRANULAR POROSITY

FRACTURE-INDUCED DISSOLUTION

Q: K
K: K
P: P

GRAIN-EDGE DISSOLUTION

Q: K
K: K
P: P

OVERSIZE/ELONGATE pores

Q: K
K: K
P: P

OTHER

---
**SANDSTONE PETROGRAPHY DATA**

**EXAMINED BY:** Nguyen MS

**PROJECT:** Nguyen MS

**FORMATION (AGE):**

**LOCATION:** Chelsley oil field

**DEPTH:** 1,119 ft

**SORTING:** Poorly sorted

**SIZE:** Fine sand

---

1. Quartz
   - Monocrystalline
   - Polycrystalline
   - Microphaneritic
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic

2. K-Feldspar
   - Microcline
   - Orthoclase
   - Sanidine
   - Microphaneritic
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

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

4. Volcanics

5. Microphanerites
   - Chester
   - Diabase

6. Accessory Minerals
   - Biotite
   - Muscovite
   - Chlorite

7. Carbonate Cement
   - Dolomite

8. Matrix / Pseudomatrix
   - Clay-Altered Grains

9. Clay Cement
   - Clay-slimy

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

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

12. Other
    - Calcite cement

---

**COMMENTS**

**Evolution:** Chester, Plagioclase, quartz K-Feldspar, clay. Chlorite is the most deformed. Dolomite cement is quite abundant, some dolomite crystals are euhedral, others are poikilitic. Grains are slightly deformed, mostly post contact. Little long grain sutures and contacts.

**Paragenesis:** Biotite being replaced by clay minerals, carbonate cement replacing quartz, feldspar, clays, and micas. Abundant dissolution of grains - K-Feldspar, clay coating prior to feldspar dissolution. Hydrocarbon replacing carbonate cement.

**SECONDARY INTRAGRAINULAR POROSITY**

**FRACTURE-INDUCED DISSOLUTION**

<table>
<thead>
<tr>
<th>Q</th>
<th>K</th>
<th>P</th>
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<tbody>
<tr>
<td>prQ</td>
<td>prK</td>
<td>prP</td>
</tr>
</tbody>
</table>

**GRAIN-EDGE DISSOLUTION**

<table>
<thead>
<tr>
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<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>prQ</td>
<td>prK</td>
<td>prP</td>
</tr>
</tbody>
</table>

**OVERSIZE/ELONGATE PORES**

<table>
<thead>
<tr>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>prQ</td>
<td>prK</td>
<td>prP</td>
</tr>
</tbody>
</table>

**OTHER**

<table>
<thead>
<tr>
<th>Q</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>prQ</td>
<td>prK</td>
<td>prP</td>
</tr>
</tbody>
</table>
**SANDSTONE PETROGRAPHY DATA**

**THIN SECTION:**
- **FORMATTION (AGE):**
- **LOCATION:**
- **DEPTH:**

**SORTING:** poorly sorted

**SIZE:** fine - Med sand

**COMPACTION:** packed, not alot of sutured and convavo convex

**ANGLULARITY:** angular - subrounded

**COMMENTS**

1. **Quartz**
   - Monocrystalline
   - Polycrystalline
   - Microcline
   - Granite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metagranite
   - Other Metamorphic

2. **K-Feldspar**
   - Microcline
   -orthoclase
   - Sanidine
   - Microcline
   - Granite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. **Plagioclase**
   - Microcline
   - Granite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

4. **Volcanic Glass**

5. **Microcline**
   - Sericite
   - Muscovite

6. **Accessory Minerals**
   - Muscovite
   - Biotite
   - Glaucophane
   - Pyrite

7. **Carbonate**
   - Dolomite
   - Calcite

8. **Pseudomatrix**
   - Clay-Altered Grains

9. **Cement**

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

11. **Intragranular Porosity**
    - Fracture
    - Fracture-induced dissolution
    - Overgrow/elongate pores
    - Grain-edge dissolution

12. **Other**
    - Phosphate
    - Shell material

**SECONDARY INTRAGRAINULAR POROSITY**

**FRACTURE-INDUCED DISSOLUTION**
- **Fracture-induced dissolution**
  - VRF Q
  - PRF Q

**GRAIN-EDGE DISSOLUTION**
- **Grain-edge dissolution**
  - VRF Q
  - PRF Q

**OVERSIZE/ELONGATE HOLES**
- **Overgrow/elongate pores**
  - VRF Q
  - PRF Q

**OTHER**

**COMMENTS**
- stained 15% for K-spar
- Matrix w/fractures. Less matrix appeared along fracture
- Dolomite cement
- Phosphate replacing Q, F, chert, and volcanics
- Pyrite in petro
**THIN SECTION:** Vale-1
**FORMATION (AGE):**
**LOCATION:** Greeley
**DEPTH:** 11499

**SORTING:** Poorly sorted
**SIZE:** 8m - mid sand

- **COMMENTS:**

1. **Quartz**
   - Monocrystalline
   - Polycrystalline
   - Microphanerite
   - Volcanic Rock Fragment
   - Quartz Arenite
   - Other Sedimentary
   - Metacarbonate
   - Other Metamorphic

2. **K-Feldspar**
   - Microcline
   - Orthoclase
   - Sanidine
   - Microphanerite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

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

4. **Microphanerites**
   - Chert

5. **Accessory Minerals**
   - Sphene
   - Rutile
   - Zircon
   - Glauconite
   - Calcite
   - Dolomite

6. **Carbonate Cement**

7. **Matrix / Pseudomatrix**
   - Clay-Altered Grains

8. **Clay**
   - Kaolinite

9. **Intragranular Porosity**
   - Fractures
   - Fracture-induced dissolution
   - Oversize/elongate pores
   - Grain-edge dissolution

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

11. **Other**
    - Phosphate cement

**SECONDARY INTERGRANULAR POROSITY**

<table>
<thead>
<tr>
<th>Fracture-Induced Dissolution</th>
<th>OverSize/Elongate Pores</th>
<th>Grain-Edge Dissolution</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF Q</td>
<td>PRF Q</td>
<td>Q</td>
<td>K</td>
</tr>
<tr>
<td>K</td>
<td>P</td>
<td>Q</td>
<td>K</td>
</tr>
<tr>
<td>P</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**COMMENTS:**
- Phosphate cement stained for Kspar
- Silt will petrologically modify phosphate cement

**PARAGENESIS**
**SANDSTONE PETROGRAPHY DATA**

**PROJECT:** Nguyen US  
**EXAMINED BY:** Nguyen

**ROCK NAME:**  
**POINT COUNTS:**

**SORTING:** Mod - poorly sorted  
**COMPACTION:** Slightly compacted, deformed  
**ANGLURITY:** Angular - sub-rounded

1. **Quartz**  
   - Monocrystalline
   - Polycrystalline
   - Microphyllitic  
   - Granitic
   - Quartz Arenite
   - Other Sedimentary
   - Metaquartzite
   - Other Metamorphic
   - Chalcedony

2. **K-Feldspar**  
   - Microcline
   - Orthoclase
   - Sanidine
   - Microperthite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

3. **Plagioclase**  
   - Microperthite
   - Granitic
   - Orthoclase
   - Microperthite
   - Volcanic Rock Fragment
   - Sedimentary
   - Metamorphic

4. **Volcanics**  

5. **Microperthites**

6. **Accessory Minerals**
   - Biotite
   - Sericite
   - Muscovite
   - Calcite

7. **Carbonate**  
   - Dolomite

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

9. **Clay**

10. **Intergalular Porosity**
    - Quartz
    - K-Feldspar
    - Plagioclase

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

12. **Other**
    - Limestone cement
    - Sericite
    - Muscovite
    - Zoned sanidine

**COMMENTS**

- Sensitization: play + Kspar
- Carbonate cement: play + Kspar, quartz, clay
- They formed in pore space along fractures, + grain edge dissolution
- Rutile needle in quartz: Kspar exhibit
- Paragenesis: grain edge dissolution, biotite altered to clay, then clay being altered to dolomite
- Play alloying to clay

**SECONDARY INTERGRANULAR POROSITY**

<table>
<thead>
<tr>
<th>Fracture-induced Dissolution</th>
<th>PRF Q</th>
<th>K P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q K P</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GRAIN-EDGE DISSOLUTION**

<table>
<thead>
<tr>
<th>PRF Q</th>
<th>K P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q K P</td>
<td></td>
</tr>
</tbody>
</table>

**OVERSIZE/ELONGATE PORES**

<table>
<thead>
<tr>
<th>PRF Q</th>
<th>K P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q K P</td>
<td></td>
</tr>
</tbody>
</table>
**THIN SECTION:** Vale-1 11511 - 140  
**FORMATION (AGE):**  
**LOCATION:** Greeley oil field  
**DEPTH:** 11511'  
**SORTING:** Poorly sorted  
**SIZE:** Med sand  

**SANDSTONE PETROGRAPHY DATA**  
**EXAMINED BY:** Nguyen MS  
**ROCK NAME:**  
**POINT COUNTS:**  
**COMPACtion:** Very tight, little pt contac  
**ANGULARITY:** Angular - Subrounded  

<table>
<thead>
<tr>
<th>1. Quartz</th>
<th>Monocrystalline</th>
<th>Polycrystalline</th>
<th>Microcrystalline</th>
<th>Volcanic Rock Fragment</th>
<th>Quartz Arenite</th>
<th>Other Sedimentary</th>
<th>Metaquartzite</th>
<th>Other Metamorphic</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. K-Feldspar</td>
<td>Microcline</td>
<td>Orthoclase</td>
<td>Sanidine</td>
<td>Microperthite</td>
<td>Volcanic Rock Fragment</td>
<td>Sedimentary</td>
<td>Metamorphic</td>
<td></td>
</tr>
<tr>
<td>3. Plagioclase</td>
<td>Microperthite</td>
<td>Volcanic Rock Fragment</td>
<td>Sedimentary</td>
<td>Metamorphic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Volcanics</td>
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<td>5. Microperthite</td>
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<td></td>
</tr>
<tr>
<td>6. Accessory Minerals</td>
<td>Barite</td>
<td>Muscovite</td>
<td>Chlorite</td>
<td>Sericite</td>
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<td>7. Carbonate Cement</td>
<td>Volomite</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>8. Matrix/Cement</td>
<td>Pseudomatrix</td>
<td>Clay-Altered Grains</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>9. Clay Cement</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Intragranular Porosity</td>
<td>Quartz</td>
<td>K-Feldspar</td>
<td>Plagioclase</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Intragranular Porosity</td>
<td>Fractures</td>
<td>Fracture-Induced dissolution</td>
<td>Oversize/elongate pores</td>
<td>Grain-edge dissolution</td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| **COMMENTS** | Matrix (little) | Zeolite and a product of alteration. Bottle of zeolite to clay grain growth.  
| **PARAGENESIS** |  
| **SECONDARY INTERGRANULAR POROSITY** | FRACTURE-INDUCED DISSOLUTION | | |
| | Q | vfrQ | prfQ | |
| | K | vfrK | prfK | |
| | P | vfrP | prfP | |
| **GRAIN-EDGE DISSOLUTION** | Q | vfrQ | prfQ | |
| | K | vfrK | prfK | |
| | P | vfrP | prfP | |
| **OVERSIZE/ELONGATE HOLES** | Q | vfrQ | prfQ | |
| | K | vfrK | prfK | |
| | P | vfrP | prfP | |
| **OTHER** |  |  |  | |
**THIN SECTION:** Vale 11513a  
**PROJECT:** Nguyen MS  
**LOCATION:** Greeley Oil Field  
**FORMATION (AGE):**  
**DEPTH:** 11513’  
**SORTING:** Poorly sorted  
**SIZE:** Medium-grained sand

<table>
<thead>
<tr>
<th>No.</th>
<th>Component</th>
<th>Minerals/Phases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Quartz</td>
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<tr>
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<td>Polycrystalline</td>
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<td>Volcanic Rock Fragment</td>
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<td>Quartz Anhite</td>
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<td>Other Sedimentary</td>
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<td>Other Metamorphic</td>
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<tr>
<td>2.</td>
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<td>Grain-edge dissolution</td>
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<td>Other</td>
<td>Dolomite + Muscovite + Chlorite</td>
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**COMMENTS:**
- Significant fracture dissolution
- Minor carbonate cement
- Siltite
- Pseudomorphs of sericite and zeolite
- Dolomite + Muscovite cleavage
- Paragenesis

**SECONDARY INTRAGRANULAR POROSITY**

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