PRELIMINARY RESULTS OF MINERALOGY AND PETROLOGY OF THE MID-FLUVIAL I INTERVAL (Depth 4960-5300 FT.), DRILL CORE MWX-1

by

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INTRODUCTION

Sandia National Laboratories is conducting and directing the Multi-Well Experiment (MWX) core analysis program as part of the Western Gas Sands Project for the Department of Energy's Unconventional Gas Sands Program. Sandia National Laboratories will carry out sample selection, sample distribution, prioritization of analyses, distribution of data, and coordination of interagency analyses. The U.S.G.S., along with Sandia, will provide interpretation of analytical results. A sedimentological model of the Mesaverde Group at the Multi-Well site will be published by J.C. Lorenze (Sandia).

The Petrology Laboratory of Bendix Field Engineering Corporation is providing routine mineralogic and petrologic analyses of MWX core samples and interpretations, as detailed in this report. These are preliminary results to be used primarily for characterization of the general mineralogy and textures of an interval so that variations in mineralogic trends can be delineated. This report is the eleventh of fifteen which will present the results of petrologic analyses of the fifteen intervals to be submitted from drill holes MWX-1 and 2. Included here are mineralogic and petrologic data from the Mid-Fluvial I Interval of drill hole MWX-1.

PROCEDURES

SAMPLE PREPARATION

The Mid-Fluvial I Interval was represented by fifty-six samples from drill core MWX-1. This interval extends from hole depths of 4690 to 5300 feet. The samples were received December 17, 1982, and consisted entirely of end-chips from core plugs which were used for routine core

analysis. Thin section preparation, thin section analyses, clay mineral and other X-ray diffraction (XRD) analyses were done as described for the Coastal Interval, MWX-1.

Representative clay separates were treated with hydrochloric acid to distinguish high-iron chlorite from kaolinite. Clay separates from sample depths 4968.7, 4969.6, 4998.2, 5011.8, 5022.5, 5064.5, 5133.7, 5143.6, 5146.5, 5149.5, 5168.5, 5234.5, and 5272.5 ft. were acid-treated. These samples were chosen after initial clay mineral analyses were completed. The clay mineral separates were boiled for one hour in 2N hydrochloric acid to dissolve the chlorite. XRD analyses were done on the acid-treated clays and results were compared to the initial clay XRD patterns. The acid-treated clay for sample depth 5064.5 ft. was heated to 330°C for one hour to assist in the identification of an interstratified clay.

RESULTS

LITHOLOGY

The rock types present in the Mid-Fluvial I Interval are different from those found in previous intervals. The predominant rock types are arkoses and lithic arkoses with some feldspathic litharenites and litharenites. The Fracture Zone and High Fluvial I and II Intervals had predominately feldspathic litharenites and litharenites with lesser amounts of sublitharenites, subarkoses, and arkoses. These intervals are all interpreted as fluvial sandstone deposits.

The sandstones of the Mid-Fluvial I Interval are generally moderately to well sorted. The average grain size of the detrital framework ranges from very fine sand-sized to medium sand-sized. The sandstones are compacted;

long and concavo-convex grain contacts are most common. Original quartz grain boundaries and contacts between quartz grains are commonly obscured due to quartz overgrowths and pressure solution (Photo 1). Calcite cement is patchy in occurrence although some samples in the Mid-Fluvial I Interval have the porosity totally occluded by the calcite cement (Photo 2).

MINERALOGY

The major detrital framework consists of quartz, feldspars, and lithics. The ratio of lithics (including chert) to feldspars is quite variable throughout the interval. The only discernable trend is a lithic-to-feldspar ratio of less than one in the top two-thirds of the interval which becomes greater than one in many of the samples of the lower third of the interval. Micas and chert are minor constituents of this interval. Common accessory minerals are opaques (mostly hydrated iron oxides), garnet, zircon, and tourmaline. Other accessory minerals are anatase (detrital), epidote, sphene, monazite, rutile, glauconite/celadonite, and apatite. Authigenic minerals include secondary quartz overgrowths, calcite, pyrite, clay minerals, and anatase. Characteristics of the mineralogy are outlined below.

Quartz - Detrital quartz is mostly monocrystalline; lesser amounts of polycrystalline varieties are present. Some rutilated grains are observed.

Feldspar - Plagioclase and K-feldspars (microcline, orthoclase, and their microperthites) are present. Plagioclase is the predominant feldspar. Plagioclase typically exhibits sericitic alteration, rarely dissolution (secondary moldic porosity), or replacement by

Photo 1. Quartz grains cemented by quartz overgrowths and pressure solution. Total occlusion of porosity by quartz overgrowths and pressure solution is a localized phenomenon in this interval. 5056.5 ft., 160x, crossed polarizers.

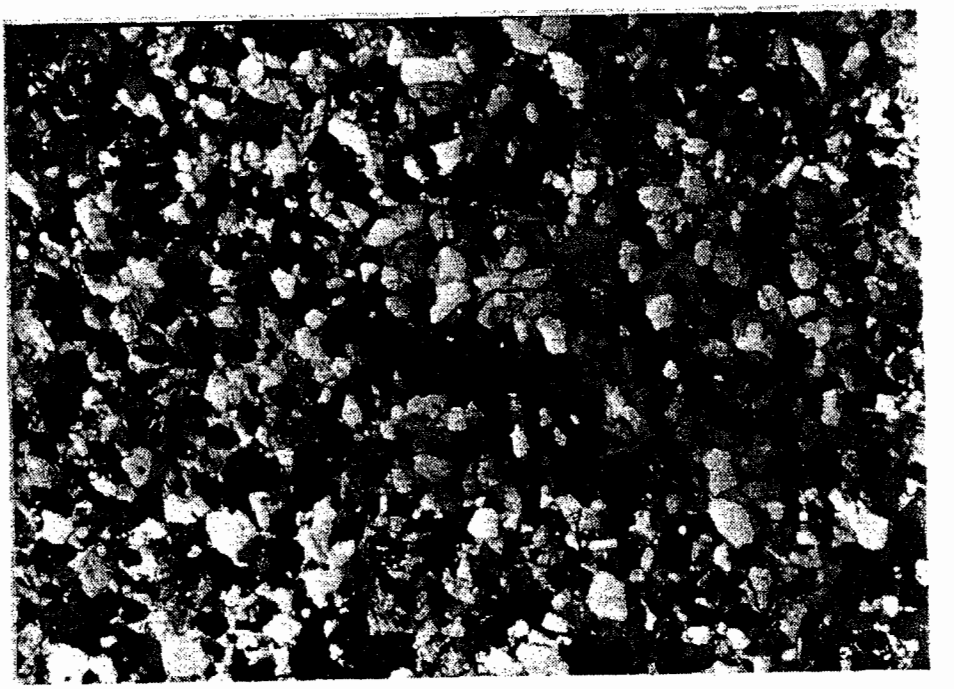

Photo 2. Total occlusion of porosity by poikilotopic calcite cementation. 5033.6 ft., 16x, crossed polarizers.

calcite. The common alterations for K-feldspar are dissolution creating secondary moldic porosity, replacement by calcite, and minor argillic.

Lithics - The most common lithic is volcanic in the upper portion of the interval. Sedimentary lithics (claystones and mudstones) increase in abundance with increasing depth. Carbonate lithics (calcite and dolomite, sparitic and micritic varieties) are common only at the bottom of this interval. Plutonic lithics are generally rare. No identifiable metamorphic lithics were observed.

Micas - Biotite and muscovite are present in all samples of this interval. Biotite is more abundant than muscovite. Biotite is typically altered to chlorite or vermiculite.

Chert - Both clear and cloudy varieties are observed; some chert grains are silicified volcanic lithics.

Accessory Minerals - Opaques are the predominant accessory mineral; these are mostly hydrated iron oxides occasionally associated with anatase as an alteration product of ilmenite or titaniferous magnetite. The predominant resistate minerals are garnet and zircon, although tourmaline is also observed in many samples. Other accessory minerals are anatase, epidote, sphene, monazite, rutile, glauconite/celadonite, and apatite.

Secondary Quartz Overgrowths - Overgrowths occur in many samples although total occlusion of intergranular space is rare (Photo 1). In most samples, secondary quartz overgrowths occur on early authigenic clay (chlorite) rims on detrital quartz. In some areas, the authigenic clay inhibited the overgrowths (Photo 3). Quartz crystals occur in intergranular (may be secondary moldic) porosity (Photo 4).

Photo 3. Authigenic clay lining a pore which inhibited the formation of quartz overgrowths except for a small breach in the lining. 5052.3 ft., 396x, crossed polarizers.

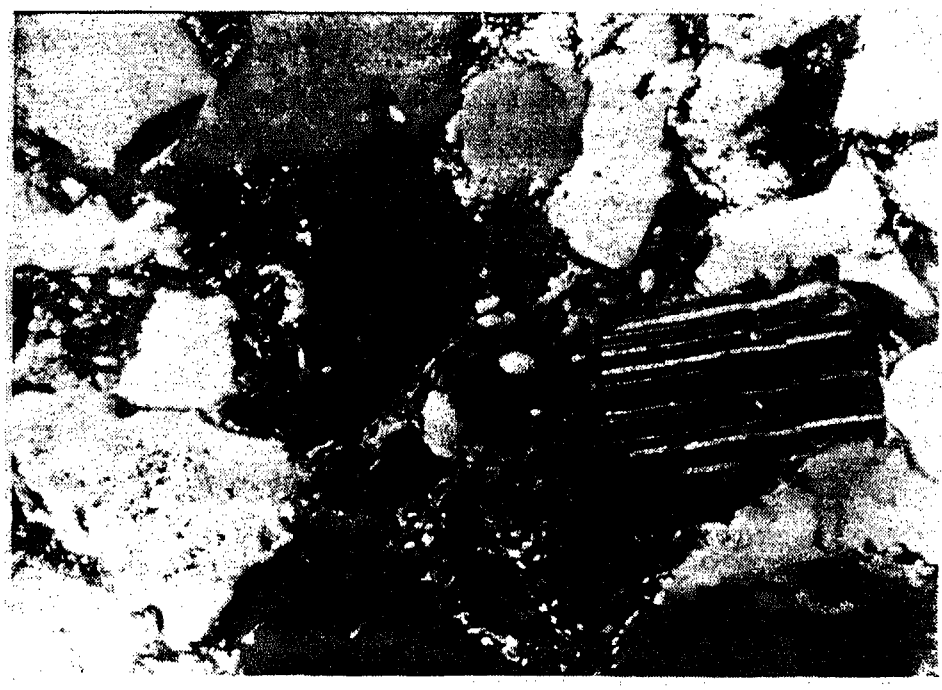

Photo 4. Quartz crystals occur in an intergranular pore. 5149.5 ft., 160x, crossed polarizers.

Calcite - Calcite is the only cement other than quartz overgrowths or authigenic clay. Calcite occurs as intergranular sparite and coarse-grained poikilotopic patches. Calcite is commonly twinned and occasionally occurs in veins (Photo 5). Calcite commonly replaces K-feldspar to varying degrees (Photo 6). Some detrital grains are totally replaced by calcite leaving grain outlines defined by authigenic clay (Photo 6).

Pyrite - Pyrite usually occurs as framboids associated with carbonaceous material.

Carbonaceous Material - Carbonaceous materials occur as scattered debris and as thin stringers defining bedding.

Anatase - Authigenic anatase occurs as an in-place replacement product of titanium-bearing, detrital phase(s); the outline of the former detrital grain is usually defined by anatase crystals with secondary moldic porosity in the central portion (Photo 7).

CLAY MINERALOGY

There are three principle clay minerals in the Mid-Fluvial I Interval: Randomly interstratified illite-montmorillonite, chlorite, and a "low-angle clay." Minor amounts of illite and randomly interstratified chlorite-illite are present in a few samples below 5100 feet. A typical XRD pattern is presented in Chart 1. Acid treatment of representative samples from this interval failed to identify kaolinite (Charts 2 and 3).

Tests were performed to identify the "low-angle clay." The (001) reflection occurs between 22 and 32Å (2.7°-4° 2θ). This reflection is typically broad and asymmetric. Clay minerals with a large basal reflection are regularly interstratified and have integral sub-order reflections.

Photo 5. Calcite occurring in veins exhibits a columnar structure suggesting shear. Poikilotopic calcite cement is in optical continuity with parts of the vein. This calcite may be pre-compaction. The sample is not as well compacted as other sandstones in this interval. 5033.6 ft., 16x, crossed polarizers.

Photo 6. Calcite is partially replacing K-feldspar in this photomicrograph. An outline marks the position of another grain, totally replaced by calcite. 5091.2 ft., 160x, crossed polarizers.

TABLE 1
RESULTS OF CLAY MINERAL ANALYSES
XRD PEAK COMPARISONS

MID-FLUVIAL I INTERVAL, MWX-1

DEPTH (Ft.)[1]	KAOLINITE	ILLITE AND ILLITE/MONTMORILLONITE	CHLORITE	MIXED LAYER[2]	SAMPLES TREATED WITH ACID
4968.7	--	Dom	Mod	Subd	X
4969.6	--	Mod	Dom	Mod	X
4973.7	--	Subd	Dom	Subd	
4982.2	--	Dom	Min	Subd	
4988.5	--	Subd	Dom	Mod	
4993.7	--	Mod	Dom	Mod	
4998.2	--	Dom	Subd	Mod	X
5001.2	--	Subd	Dom	Mod	
5006.5	--	Min	Dom	Min	
5011.8	--	Dom	Mod	Mod	X
5013.7	--	Min	Dom	Min	
5020.4	--	Mod	Dom	Mod	
5022.5	--	Subd	Dom	Mod	X
5026.8	--	Mod	Dom	Mod	
5033.6	--	Mod	Dom	Mod	
5035.8	--	Min	Dom	Min	
5041.5	--	Min	Dom	Min	
5044.3	--	Mod	Dom	Min	
5064.5	--	Mod	Dom	Mod	X
5088.5	--	Dom	Subd	Mod	
5091.2	--	Min	Dom	Min	
5093.8	--	Subd	Dom	Mod	
5096.2	--	Mod	Dom	Min	
5098.4	--	Mod	Dom	Min	
5102.3	--	Mod	Dom[3]	Min	
5129.5	--	Subd	Dom	Mod	
5131.5	--	Dom	Mod	Mod	
5133.7	--	Dom	Subd	Mod	X
5143.6	--	Dom	Min	Subd	X
5144.1	--	Dom	Min	Subd	
5146.5	--	Subd	Min	Dom	X
5149.5	--	Mod	Mod	Dom	X
5153.5	--	Subd	Subd	Dom	
5168.5	--	Mod	Dom	Mod	X
5196.4	--	Min	Dom	Mod	
5199.1	--	Mod	Dom	Mod	
5220.2	--	Mod	Dom	Mod	
5234.5	--	Codom	Codom	Codom	X
5248.7	--	Mod	Dom	Mod	
5259.7	--	Mod	Dom	Mod	

TABLE 1 CONTINUED
RESULTS OF CLAY MINERAL ANALYSES
XRD PEAK COMPARISONS

MID-FLUVIAL I INTERVAL, MWX-1

DEPTH (Ft.)[1]	KAOLINITE	ILLITE AND ILLITE/MONTMORILLONITE	CHLORITE	MIXED LAYER[2]	SAMPLES TREATED WITH ACID
5268.5	--	tr	Dom	tr	
5271.6	--	Min	Dom	Min	
5272.5	--	Codom	Codom	Codom	X
5287.3	--	Subd	Dom	Subd	
5294.5	--	Mod	Dom	Mod	

Dom = Dominant (strongest peak)
Codom = Co-dominant (dominant peaks of two or more phases have the same relative intensities)
Subd - Subdominant (peak nearly as strong as dominant peak)
Mod - Moderate (peak approximately 1/2 as strong as dominant peak)
Min = Minor (peak approximately 1/3 as strong as dominant peak)
tr = Trace (very small peak)

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[1]Only samples analyzed for clay are listed in this table.

[2]1:1 regularly interstratified chlorite-illite.

[3]Also contains randomly interstratified chloride-montmorillonite.

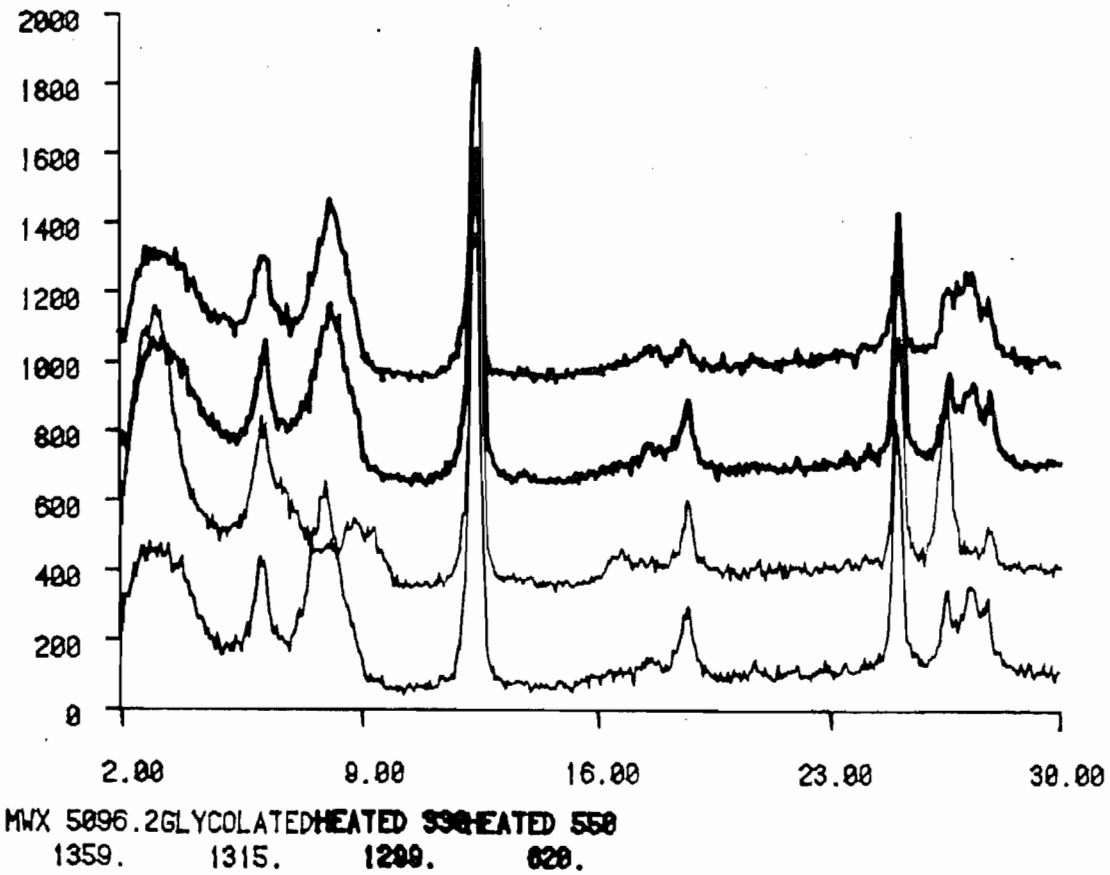

Chart 1. Typical X-ray diffraction pattern of clay minerals in the Mid-Fluvial I Interval showing dominant chlorite, moderate randomly interstratified illite-montmorillonite, and minor 1:1 regularly interstratified chlorite-illite (low-angle). Sample depth 5096.2 ft. Bottom to top: Air dried; glycolated; heated to 330°C; heated to 550°C.

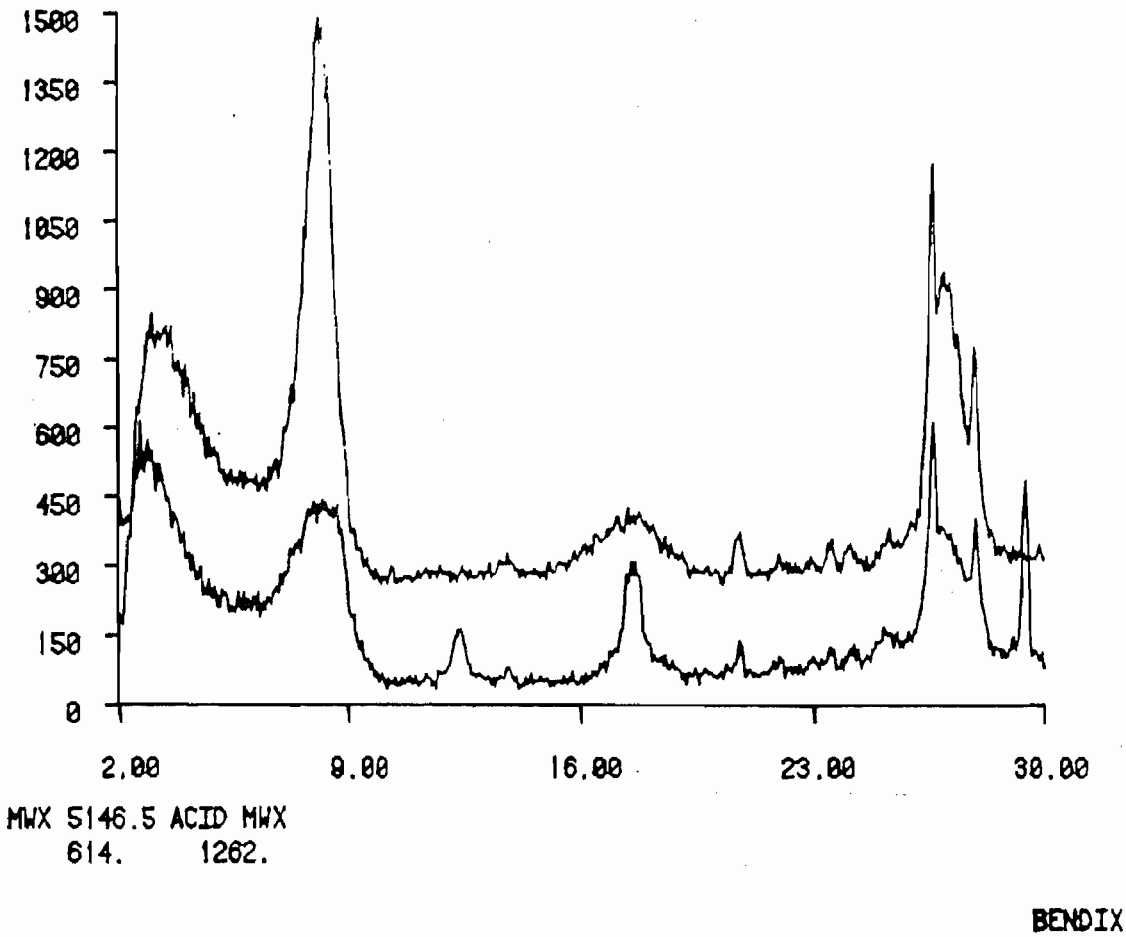

Chart 2. Comparison of X-ray diffraction patterns for air-dried (bottom) and acid-treated clays (top). Note the absence of the 7.13 Å peak (chlorite) on the acid-treated pattern. Sample depth 5146.5 ft.

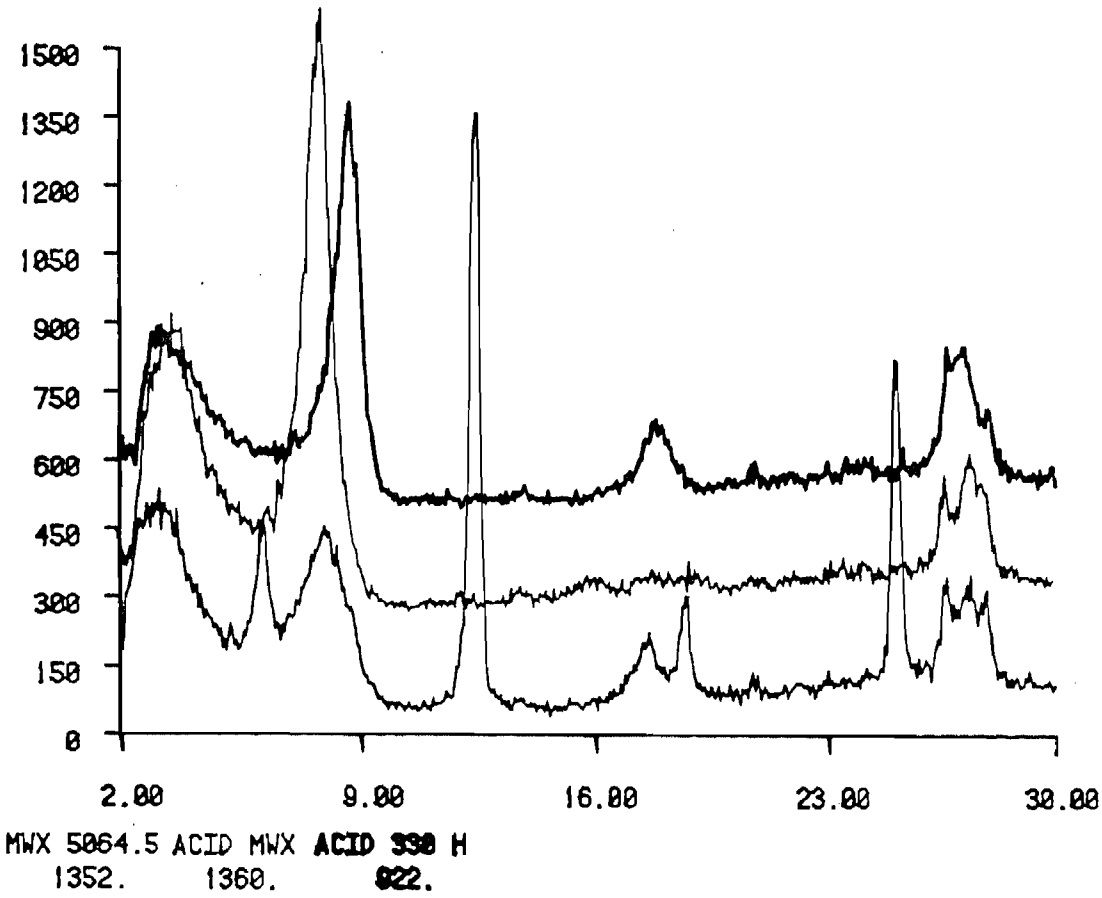

Chart 3. Comparison of X-ray diffraction patterns for air dried (bottom), acid-treated clay (center), and acid-treated, heated to 330°C (top). Note the absence of the 14.38 and 7.13 Å peaks on the acid-treated patterns, and the shift of the randomly interstratified illite-montmorillonite peak from 11.14 Å on the acid-treated pattern to 10.21 Å on the acid-treated, heated to 550°C pattern. This reflects the dehydration of interstratified montmorillonite layers in the mixed layer clay. Sample depth 5064.5 ft.

The "low-angle clay" in this interval has weakly developed to absent sub-order reflections. Glycolation of this clay increases the intensity of the basal reflection without an increase in d-spacing. Heating to 330° and 550°C decreases the intensity of the basal reflection from the glycolated run, again with no shift in d-spacing. Acid treatment causes a slight decrease in d-spacing (Charts 2 and 3). Oriented clay mounts using a smear technique rather than the membrane-peel technique exhibit a basal reflection (air-dried) at about 24 Å (Chart 4). Discussions with clay mineralogists have failed to better characterize this clay mineral. Based on the 24 Å air-dried basal reflection using the smear technique, this "low-angle clay" may be a 1:1 regularly interstratified chlorite-illite. Acid-treatment may not attack all of the interstratified chlorite. Additional work should be done to better characterize this clay.

Randomly interstratified illite-montmorillonite is the predominant phase in clay matrix-rich samples. Randomly interstratified illite-montmorillonite also appears to be the main phase in claystone lithics.

Chlorite occurs as grain coatings with basal cleavage aligned perpendicular to grain surfaces. This is similar to the Top and High Fluvial II Intervals. Chlorite also occurs as an alteration product of detrital grains such as biotite.

The origin and occurrence of the 1:1 regularly interstratified chlorite-illite is not apparent. The strength of the basal reflection is not dependent on variations in authigenic clay or clay matrix.

PORE SPACE

Porosity and permeability of the Mid-Fluvial I Interval sandstones has been greatly reduced by compaction, calcite cementation, clay minerals, and

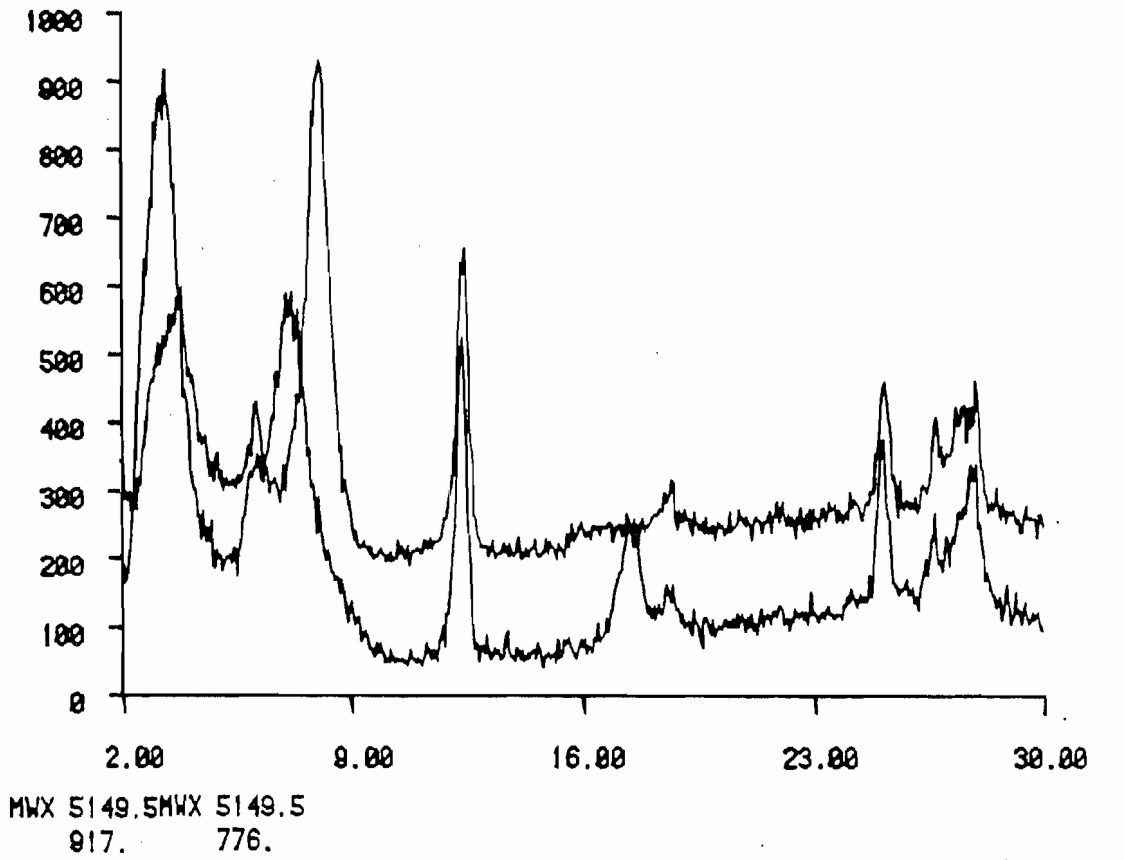

Chart 4. Quality control comparison of membrane-peel (bottom) and smear techniques (top) for preparing oriented clay mounts for X-ray diffraction. Note the shift of the "low-angle clay" from 27.3 Å (peeled) to 24.8 Å (smeared). This clay may be very fine-grained and improve orientation by the sedimentation method (smear). A 24.8 Å clay which does not shift upon glycolation or heating corresponds to a regularly interstratified 1:1 chlorite-illite. The shift of the randomly interstratified illite-montmorillonite reflects the change of ambient humidity. The peeled slide was prepared at 65% humidity (12.26 Å) and the smeared slide at 15% humidity (10.96 Å). Sample depth 5149.5 ft.

quartz overgrowths. The porosity types are reduced primary, secondary intragranular moldic, and microporosity in intergranular clays. In general, pore space is directly proportional to the grain size of detrital constituents.

Reduced primary porosity is the result of incomplete compaction or cementation of a sandstone. This type of porosity was common in the High Fluvial I and II Intervals of MWX-1 and is present in this interval in a zone between 5041 and 5129 feet depth. The reduced primary pores are lined and occasionally filled by authigenic chlorite which bridges pore throats and fills capillaries between pores. Where authigenic chlorite fills the pores, microporosity is observed as evidenced by the infiltration of blue epoxy. Secondary quartz and calcite cement also reduce this porosity.

Secondary moldic porosity is caused by the dissolution of feldspars. These pores are occasionally filled by authigenic clay (Photo 8). This type of porosity is present in almost every sandstone of the Mid-Fluvial I Interval. The exception to this rule is in calcitic sandstones; calcite may fill these secondary pores. Where porosity is limited to dissolution of detrital feldspar, the pore space is scattered and poorly connected. Another type of secondary moldic porosity is the alteration of a titanium-bearing detrital phase leaving a void lined by anatase (Photo 7). Dissolution of calcite cement and lithics, observed in the High Fluvial Intervals, is absent in the Mid-Fluvial I Interval.

LITHOLOGIC AND MINERALOGIC TRENDS

Subtle variations in texture and mineralogy are fairly common in the Mid-Fluvial I Interval. Relative variations in abundances of major framework components (quartz, feldspars, lithics, and chert), detrital grain

Photo 7. Alteration of a titanium-bearing detrital grain has left an outline of anatase crystals around a secondary moldic pore now filled by calcite. 5026.8 ft., 635x, crossed polarizers.

Photo 8. Two altered K-feldspar grains are present in this photomicrograph: a partially dissolved grain (secondary moldic porosity) in the center and a grain partially replaced by calcite above center. The secondary moldic pore contains authigenic clay. 5149.5 ft., 160x, crossed polarizers.

size, clay content and mineralogies were used to define the following lithologic subintervals. Changes in mineralogy and porosity will be discussed in more detail in their respective sections.

Depth 4968.7 Ft.

This is a sandy mudstone consisting of floating grains of quartz, feldspar, lithics, zircon, and tourmaline in a clay matrix. The clay is partially recrystallized and contains stringers of carbonaceous material. The dominant clay mineral is randomly interstratified illite-montmorillonite.

Depth 4969.6 Ft.

The rock at this depth is a lithic arkose containing silt-to-fine sand-sized quartz, feldspars, lithics, micas, chert, zircon, garnet, and anatase in clay matrix. This sample also contains minor-to-trace amounts of calcite cement and trace amounts of carbonaceous stringers. There is no observable porosity. The dominant clay mineral is chlorite.

Depth 4973.7 Ft.

This sample is a siltstone consisting of silt-to-fine sand-sized quartz, feldspars, lithics, chert, and micas in clay matrix. Accessory minerals include opaques (goethite), garnet, zircon, and tourmaline. Fine lenticular carbonaceous material defines structures which may be cross-bedding. The dominant clay mineral is chlorite with subdominant randomly interstratified illite-montmorillonite.

Depth 4982.2 Ft.

The lithology at this depth is a clay matrix-supported arkose with silt-to-medium sand-sized quartz, feldspars, lithics, micas, and chert. Accessory minerals are opaques (goethite), zircon, garnet, and epidote. The sample also contains some carbonaceous material. Clay matrix is

partially recrystallized. The dominant clay mineral is randomly interstratified illite-montmorillonite.

Depth 4988.5 - 5013.7 Ft.

This zone consists of lithic arkoses and arkoses, generally moderate to well sorted, with subrounded-to-subangular detrital framework grains. This zone is very well compacted with no observable porosity. Samples in this zone contain 2 to 46 volume percent clay matrix and trace to 4 percent calcite. The dominant clay mineral is chlorite and the randomly interstratified illite-montmorillonite content is proportional to the amount of clay matrix.

Depth 5020.4 Ft.

This sample is texturally similar to the last zone but calcite cement is present rather than clay matrix. No porosity is observed. The dominant clay mineral is chlorite.

Depth 5022.5 - 5032.7 Ft.

This zone is characterized by intergranular porosity. The porosity is inversely proportional to the amount of calcite cement. The arkoses and lithic arkoses in this zone are texturally similar to the last two zones. Chlorite is the primary clay mineral.

Depth 5033.6 - 5035.8 Ft.

This zone is characterized by the presence of twinned, poikilotopic calcite cement. These samples are calcitic arkoses that exhibit moderate sorting. Chlorite is the primary clay mineral. The sample at 5033.6 ft. contains vein calcite (Photo 5) in optical continuity with the calcite cement. The vein exhibits columnar crystals orthogonal to vein boundaries which suggest strain. These samples are not as compacted as the other sandstones of this interval.

Depth 5041.5 - 5088.5 Ft.

The lithic arkoses and arkoses of this zone have authigenic clay (chlorite) coating the detrital framework grains. Clay matrix is present at the top and bottom of this zone. Silica overgrowths on detrital quartz are found in most of these samples (Photo 1). Calcite cement varies from a trace to 4 volume percent. Intergranular pore space and secondary moldic porosity (dissolution of K-feldspar) are present in all of the samples except at 5041.5 feet. Several cycles of graded bedding may be present in this zone. The clay mineral assemblage reflects the lack of clay matrix in many of these samples. Chlorite is the primary clay mineral.

Depth 5091.2 Ft.

The calcitic lithic arkose at this depth contains twinned, poikilotopic calcite cement. Calcite is observed replacing feldspars and silica overgrowths on detrital quartz. Porosity is totally occluded by the calcite cement. Other than the calcite cement, this sample is similar to the previous zone.

Depth 5093.8 - 5098.4 Ft.

This zone is virtually identical to the zone between 5041.5 and 5088.5 feet. One cycle of graded bedding is present in this zone.

Depth 5102.3 Ft.

This sample is a sandy claystone consisting of partially recrystallized clay matrix and floating detrital grains of quartz, feldspars, lithics, chert, micas, opaques (goethite), and zircon. Randomly oriented stringers of carbonaceous material mineralized by pyrite are observed. Discrete illite and randomly interstratified chlorite-montmorillonite are present in

addition to chlorite, randomly interstratified illite-montmorillonite, and 1:1 regularly interstratified chlorite-illite.

Depth 5129.5 Ft.

This sample is virtually identical to the samples in the zones 5041.5 - 5088.5 and 5093.8 - 5098.4 feet. This interval will be collectively hereafter referred to as the "porous zone." A detrital grain of glauconite/celadonite is observed in this sample.

Depth 5131.5 - 5144.1 Ft.

This zone appears to be an orderly transition from an arkoses, similar to those found in the "porous zone," to claystones and sandy claystones at the base of the zone. The upper arkose contains appreciable clay matrix which increases in abundance with depth to the claystones at the base. The XRD clay mineral assemblage reflects the change from authigenic clay in the "porous zone" to clay matrix. The trace amount of porosity in the upper arkose (voids with clay) may be secondary moldic rather than reduced primary.

Depth 5146.5 Ft.

This sample is a calcitic arkose. The calcite cement is fine-grained and exhibits textures from intergranular to detrital. The dominant clay mineral is 1:1 regularly interstratified chlorite-illite with subdominant randomly interstratified illite-montmorillonite (claystone lithics). Authigenic clay coatings constitute a trace volumetrically. This is reflected in minor amounts of chlorite identified by XRD. There is no porosity in this sample.

Depth 5149.5 - 5153.5 Ft.

This zone is virtually identical to the samples in the "porous zone." One cycle of graded bedding is present. Secondary moldic porosity

(dissolution of K-feldspar) in sample depth 5149.5 feet is more pronounced than in the other samples observed. These secondary pores contain authigenic clay (Photo 8).

Depth 5168.5 - 5196.4 Ft.

This zone may be one cycle of graded bedding. The lithology of the uppermost sample is a calcitic siltstone. The other two samples are calcitic feldspathic litharenites. The average grain size increases with sample depth. The uppermost sample grain size is silt; the lowermost is fine sand-sized. Calcite cement decreases in quantity with depth coupled with an increase in clay matrix. Calcite cement is poikilotopic in the uppermost and lowermost samples; the calcite cement in the central sample is intergranular to clasts. Twinned calcite is only observed in the central sample from this zone. All of the samples in this interval exhibit thin authigenic clay-coatings on clasts. There is no porosity in this zone.

Depth 5199.1 - 5234.5 Ft.

The three samples in this zone are a sandy claystone, a claystone, and a mudstone (top to bottom). The three samples contain clasts floating in an iron-stained clay matrix. The detrital grains also occur with point contacts. Carbonaceous material is found in all three samples of this zone. There is no porosity in this zone. A detrital grain of glauconite/celadonite is observed in the sample at 5199.1 feet.

Depth 5248.7 - 5259.7 Ft.

Although the lithologies of the two samples of this zone are different (arkose and mudstone), they are grouped together due to finely laminated textures. The upper sample is laminated claystone and sandstone, the lower

is siltstone and claystone. Both samples contain clay matrix, calcite cement; and carbonaceous material. There is no porosity in this zone.

Depth 5268.5 - 5271.6 Ft.

The samples in this zone may represent a lithological trend from a lithic arkose at the top to a feldspathic litharenite and a (calcitic) litharenite at the base. There may be an inverse relationship between clay matrix and calcite cement. Clay matrix decreases with depth, calcite cement increases with depth. Porosity increases from none at the top to 1 volume percent at the base. The uppermost sample (5268.5 ft.) is a bimodal sandstone containing clay matrix and structurally controlled, coarsely-crystalline authigenic clay (Photo 9).

Depth 5272.5 - 5287.3 Ft.

The samples of this zone are claystones containing floating detrital grains. The sample at 5272.5 contains calcite and dolomite lithics (Photo 10). This sample also contained a carbonate microfossil.

Depth 5294.5 Ft.

This sample is a finely laminated, calcitic feldspathic litharenite containing minor clay matrix. Lithics in this sample are carbonates (calcite>dolomite), claystones, and volcanics. The calcite cement is twinned.

DIAGENESIS

The diagenetic sequence for the Mid-Fluvial I Interval is similar to the sequence for the High Fluvial I and II intervals. The diagenetic sequence is as follows (early to late):

- Early authigenic clay (chlorite)
- Compaction and feldspar alteration

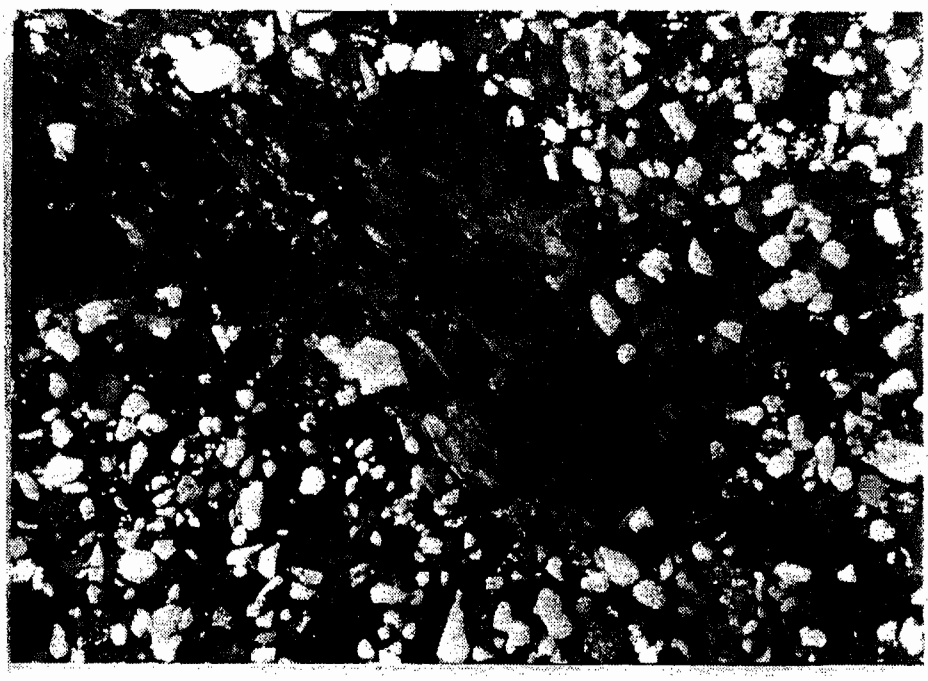

Photo 9. This photomicrograph shows coarsely crystalline, structurally-controlled authigenic clay. 5268.5 ft., 40x, crossed polarizers.

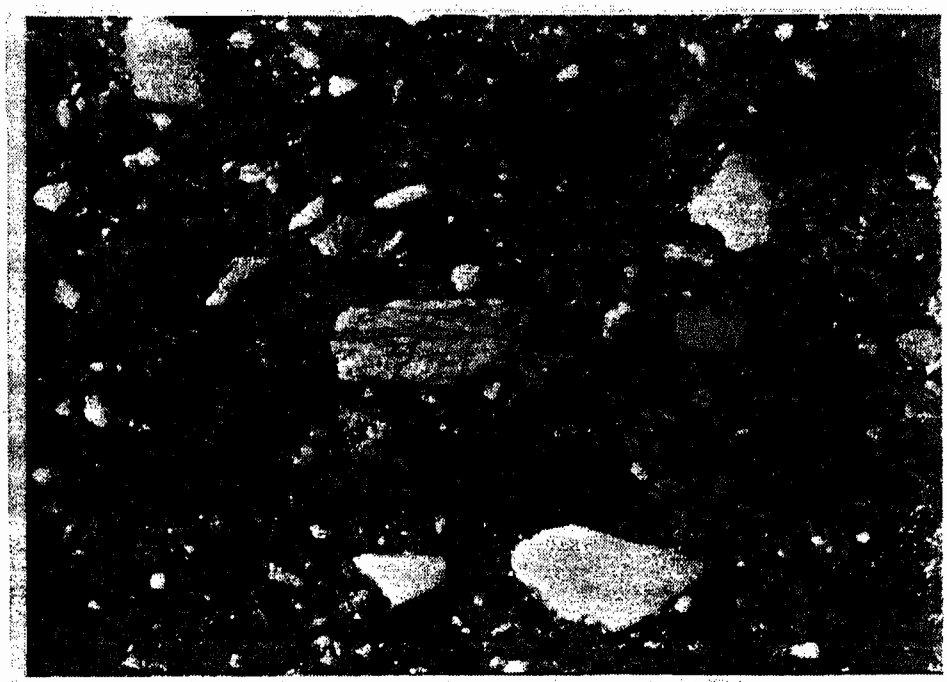

Photo 10. Carbonate lithics occur in this claystone. The sparite grain in the center does not exhibit a calcite stain; however, other carbonate lithics in this field of view show well-developed stains. 5272.5 ft., 160x, crossed polarizers.

- Later authigenic clay (chlorite)
- Quartz overgrowths
- Calcite cement
- Secondary intragranular moldic porosity

Many of these processes occurred contemporaneously and continued throughout the remainder of diagenesis. The later authigenic clay continued through the secondary intragranular moldic porosity phase. The zone at 5033.6 - 5035.8 ft. contains early calcite (post-early clay, pre-compaction). Samples in this zone are not as compacted as the other sandstones in the Mid-Fluvial I Interval. This is the only zone exhibiting early calcite.

The main difference between the Mid-Fluvial I and High Fluvial Intervals is the lack of pore-filling, authigenic kaolinite in the Mid-Fluvial I samples. The early authigenic clay coats most clasts, including along contacts, and helps preserve some primary pore space as in the High Fluvial Intervals. Clays previously found inhibiting quartz overgrowths were observed in a few samples of the Mid-Fluvial I Interval.

SUMMARY

Sandstones in the Mid-Fluvial I Interval are mineralogically and texturally similar to the other fluvial intervals, especially the High Fluvial intervals. The dominant pore space in most of this interval is secondary except for reduced primary porosity in the "porous zone." Clay filling of pore throats severely limits the permeability as does compaction, pressure solution, and calcite cementation.

The clastic mineralogy and textures observed support a fluvial depositional environment. Sandstones show gradational textural changes

and interlayering with claystones, mudstones, and siltstones. A broad range of roundness and sorting of detrital components are observed. The presence of scattered placer horizons (5270.5 ft.) would be expected in a fluvial environment.

There is a general trend of increasing sedimentary rock fragments (claystones, carbonates) and decreasing plutonic feldspars and rock fragments with increasing depth in this interval. This relationship suggests that these sands fluctuate between sedimentary and plutonic sources. A plutonic source appears to be somewhat more influential toward the top of this fluvial interval. Fluctuating source rocks have been observed in other fluvial intervals of the MWX project.

APPENDIX A
SUMMARY OF RESULTS
MID-FLUVIAL I INTERVAL, MWX-1

DEPTH (ft.)	ROCK NAME[1]	MEAN GRAIN SIZE (mm)	% PORE SPACE	% CALCITE	SORTING	CLAY ANALYSES (BY XRD)
4968.7	Sandy Mudstone	Silt	--	--	Bimodal	X
4969.6	Lithic Arkose	0.12	--	1	M-W	X
4973.7	Siltstone	Silt	--	--	M-W	X
4982.2	Arkose	0.14	--	tr	M-P	X
4988.5	Lithic Arkose	0.25	--	4	M-W	X
4993.7	Arkose	0.13	--	2	M-W	X
4998.2	Arkose	0.18	--	tr	P	X
5001.2	Lithic Arkose	0.11	--	tr	M	X
5006.5	Lithic Arkose	0.20	--	tr	M	X
5011.8	Arkose	0.08	--	tr	M-P	X
5013.7	Arkose	0.14	--	2	M-W	X
5020.4	Cal. Arkose	0.11	--	36	M	X
5022.5	Arkose	0.17	6	tr	M-W	X
5026.8	Arkose	0.28	2	1	M	X
5032.7	Arkose	0.25	tr	5	M-W	
5033.6	Cal. Arkose	0.30	--	27[2]	M-W	X
5035.8	Cal. Arkose	0.11	--	36	M	X
5041.5	Arkose	0.20	--	1	M-W	X
5044.3	Arkose	0.42	3	2	M	X
5048.5	Lithic Arkose	0.27	3	1	M-W	
5050.6	Lithic Arkose	0.35	4	1	M-W	
5051.6	Lithic Arkose	0.35	2	1	M	
5052.3	Lithic Arkose	0.42	1	2	M	
5056.5	Arkose	0.28	2	tr	M-W	
5061.7	Arkose	0.34	1	1	M-W	
5064.5	Lithic Arkose	0.25	2	3	W	X
5084.8	Lithic Arkose	0.25	tr	4	W	
5086.9	Arkose	0.22	tr	2	M-W	
5088.5	Lithic Arkose	0.33	3	1	M-W	X
5091.2	Cal. Lith. Ark.	0.24	--	17	W	X
5093.8	Lithic Arkose	0.18	2	1	W	X
5096.2	Arkose	0.23	2	2	M-W	X
5098.4	Lithic Arkose	0.35	2	4	M-W	X
5102.3	Sandy Claystone	Silt	--	--	M	X
5129.5	Lithic Arkose	0.25	2	2	W	X
5131.5	Arkose	0.17	tr	2	W	X
5133.7	Arkose	0.12	--	1	M-W	X
5143.6	Claystone	Clay	--	--	Bimodal	X
5144.1	Sandy Claystone	Silt	--	--	Bimodal	X
5146.5	Cal. Arkose	0.29	--	30	M-W	X
5149.5	Arkose	0.31	3	2	M	X
5153.5	Lithic Arkose	0.45	4	2	M-W	X

APPENDIX A CONTINUED
SUMMARY OF RESULTS
MID-FLUVIAL I INTERVAL, MWX-1

DEPTH (ft.)	ROCK NAME*	MEAN GRAIN SIZE (mm)	% PORE SPACE	% CALCITE	SORTING	CLAY ANALYSES (BY XRD)
5168.5	Cal. Siltstone	Silt	—	40	W	X
5189.1	Cal. Feld. Lith.	0.09	--	32	W	
5196.4	Cal. Feld. Lith.	0.18	—	11	M-W	X
5199.1	Sandy Claystone	Silt	--	--	M-W	X
5220.2	Claystone	Silt	—	--	M	X
5234.5	Mudstone	Silt	--	tr	W	X
5248.7	Arkose	0.09	--	2	M-P	X
5259.7	Mudstone	Silt	--	tr	Bimodal	X
5268.5	Lithic Arkose	0.11	--	1	Bimodal	X
5270.5	Feld. Lith.	0.16	tr	2	W	
5271.6	Cal. Lith.	0.23	1	11	M-W	X
5272.5	Claystone	Clay	—	tr[3]	Bimodal	X
5287.3	Claystone	Clay	--	--[3]	Bimodal	X
5294.5	Cal. Feld. Lith.	0.09	--	29[3]	W	X

[1]Classification from Folk, R.L., 1980, Petrology of Sedimentary Rocks (2d ed.): Austin, Texas, Hemphill Publishing Company, 184 p.

[2]Sample contains calcite vein.

[3]Dolomite identified from bulk.

APPENDIX B

PRIORITY INTERVALS AND
THE TENTATIVE DATES OF COMPLETION
(IN ORDER OF PRIORITY) FOR
MINERALOGY AND PETROLOGY ANALYSES

(Revised 9-12-83)

Priority	Depth	Well	Interval	Tentative Completion Date
1	6435-6580	MWX-1	Coastal	07-02-82
2	7817-7900	MWX-1	Cozzette	07-02-82
3	7832-8141	MWX-2	Corcoran & Cozzette	08-31-82
4	5690-5870	MWX-1	Fracture Zone	10-18-82
5	7080-7390	MWX-2	Paludal	12-22-82
6	6400-6580	MWX-2	Coastal	01-22-83
7	4840-4960	MWX-1	High Fluvial I	02-26-83
8	4180-4400	MWX-1	Top	03-26-83
9	5690-5870	MWX-2	Fracture Zone	04-23-83
10	4490-4830	MWX-1	High Fluvial II	06-04-83
11	4690-5300	MWX-1	Mid Fluvial I	09-30-83
12	5300-5690	MWX-1	Mid Fluvial II	10-30-83
13	5870-6345	MWX-1	Low Fluvial	11-30-83
14	6580-6830	MWX-1	Bottom Fluvial	12-30-83
15	4880-4950	MWX-2	High Fluvial I	12-30-83

APPENDIX C

PETROGRAPHIC DATA SHEETS
MID-FLUVIAL I INTERVAL
MWX-1

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-4968.7
INTERVAL: Mid Fluvial I

Petrologist: R. Dayvault
Date: August 31, 1983

Rock Type: Sandy Mudstone

% Pore Space: None
Sorting (est.): P to M
Angularity (est.): SA

GENERAL DESCRIPTION: Mottled sandy mudstone-slightly darker areas contain fine-grained fraction. Bedding not visible. Quartz, plagioclase, K-feldspar, lithics, opaques, zircon and tourmaline float in clayey matrix. Clay contains some organic stringers and has been partly recrystallized.

COMPOSITION	%	COMMENTS
Clay Minerals		
Illite (XRD)	Dom	Randomly interstratified with montmorillonite.
Chlorite (XRD)	Mod	
Mixed Layer (XRD)	Subd	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-4969.6
INTERVAL: Mid-Fluvial I

Petrologist: R. Dayvault
Date: August 27, 1983

Rock Type: Lithic Arkose
Mean Grain Size (mm): 0.12
Grain Size Range (mm): 0.05 to 0.21

% Pore Space: None
Sorting (est.): M-W
Angularity (est.): SA

GENERAL DESCRIPTION: Very tight rock with clay matrix (21%), chloritic micaceous. Areas of authigenic clay - colloform texture in the matrix.

COMPOSITION	%	COMMENTS
Quartz	37	
K-Feldspar	9	Fairly fresh
Plagioclase	10	Argillic alteration, some calcite alteration
Chert	2	
Lithics	14	Few volcanics and plutonics. Most gone to clay and indistinguishable.
Authigenic Minerals		
Calcite	1	Mostly as cement
Muscovite	2	
Biotite	3	Altered - often to chlorite
Opaques	1	
Accessory Minerals		
Zircon	tr	
Garnet	tr	
Anatase	tr	
Carbonaceous Material	tr	
Clay Minerals	21	Matrix and authigenic clay
Illite (XRD)	Mod	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MLX-4973.7
INTERVAL: Mid-Fluvial I

Petrologist: R. Dayvault
Date: August 9, 1983

Rock Type: Siltstone
Mean Grain Size (mm): 0.034
Grain Size Range (mm): 0.008 to 0.09

% Pore Space: None
Sorting (est.): M to W
Angularity (est.): SR

GENERAL DESCRIPTION: Possible cross bedded(?) siltstone with many small lenticular organic particles aligned parallel to bedding. Quartz is dominent followed by plagioclase, K-feldspar, lithics, chert, biotite, muscovite, and opaques. Accessories include garnet, zircon and tourmaline. Rock shows partial recrystallization of clayey matrix.

COMPOSITION	%	COMMENTS
Clay Minerals		
Illite (XRD)	Subd	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Subd	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-4982.2
INTERVAL: Mid-Fluvial I

Petrologist: R. Dayvault
Date: August 9, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.14
Grain Size Range (mm): 0.02 to 0.32

% Pore Space: None
Sorting (est.): P to M
Angularity (est.): SA

GENERAL DESCRIPTION: Fine-grained matrix-support arkose. Clay matrix is partly recrystallized; some has altered to a chloritic material. Good foliation in clay matrix.

COMPOSITION	%	COMMENTS
Quartz	21	
K-Feldspar	11	Argillic alteration
Plagioclase	9	Fairly fresh
Chert	2	
Lithics	6	
Authigenic Minerals		
Calcite	tr	
Muscovite	1	
Biotite	3	
Opaques	1	Some as carbonaceous material with pyrite
Accessory Minerals		
Zircon	tr	
Garnet	tr	
Epidote	tr	
Clay Minerals	47	Partly recrystallized matrix
Illite (XRD)	Dom	Randomly interstratified with montmorillonite
Chlorite (XRD)	Min	
Mixed Layer (XRD)	Subd	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-4988.5
INTERVAL: Mid-Fluvial I

Petrologist: R. Dayvault
Date: August 10, 1983

Rock Type: Lithic Arkose
Mean Grain Size (mm): 0.25
Grain Size Range (mm): 0.09 to 0.52

% Pore Space: None
Sorting (est.): M-W
Angularity (est.): SR

GENERAL DESCRIPTION: Very tight even-grained rock. Grains show long, concave-convex, and slightly sutured boundaries.

COMPOSITION	%	COMMENTS
Quartz	26	Minor overgrowths
K-Feldspar	18	
Plagioclase	24	Much argillic alteration
Chert	4	
Lithics	18	Primarily volcanic and claystones (recrystallized)
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	4	Both as replacement of grains and cement
Muscovite	1	
Biotite	3	
Opaques	tr	
Accessory Minerals		
Garnet	tr	
Zircon	tr	
Clay Minerals	2	Partly recrystallized
Illite (XRD)	Subd	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-4993.7
INTERVAL: Mid-Fluvial I

Petrologist: R. Dayvault
Date: August 9, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.13
Grain Size Range (mm): 0.05 to 0.34

% Pore Space: None
Sorting (est.): M-W
Angularity (est.): SA-SR

GENERAL DESCRIPTION: Another very tight rock with long and concave convex grain contacts.

COMPOSITION	%	COMMENTS
Quartz	23	Good overgrowth
K-Feldspar	18	
Plagioclase	17	
Chert	5	
Lithics	11	Mostly volcanic and plutonic
Authigenic Minerals		
Calcite	2	Mostly as replacement of grains
Muscovite	1	
Biotite	2	
Opaques	1	
Accessory Minerals		
Zircon	tr	
Garnet	tr	
Clay Minerals	20	Matrix
Illite (XRD)	Mod	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MLX-4998.2
INTERVAL: Mid-Fluvial I

Petrologist: R. Dayvault
Date: August 15, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.18
Grain Size Range (mm): 0.06 to 0.42

% Pore Space: None
Sorting (est.): P
Angularity (est.) SA-SR

GENERAL DESCRIPTION: Very tight fine-grained sandstone with several stringers of clay. Organic matter is associated with clayey areas, also pyrite in organics. Increase in clay matrix from last sample.

COMPOSITION	%	COMMENTS
Quartz	21	
K-Feldspar	21	
Plagioclase	5	
Chert	1	
Lithics	3	Plutonic and volcanic
Authigenic Minerals		
Calcite	tr	
Muscovite	2	
Biotite	1	
Opaques	1	
Accessory Minerals		
Zircon	tr	
Garnet	tr	
Anatase	tr	
Carbonaceous Material	tr	Mineralized by pyrite
Clay Minerals	46	Matrix. Some recrystallization
Illite (XRD)	Dom	Randomly interstratified with montmorillonite
Chlorite (XRD)	Subd	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: 5001.2
INTERVAL: Mid-Fluvial I

Petrologist: D. Dayvault
Date: August 8, 1983

Rock Type: Lithic Arkose
Mean Grain Size (mm): 0.11
Grain Size Range (mm): 0.008 to 0.24

% Pore Space: None
Sorting (est.): M
Angularity (est.): SA-SR

GENERAL DESCRIPTION: Tight rock with oriented micas, especially in silty layers. Finer grained fractions have organic stringers with authigenic pyrite. Many grains touching, mostly matrix support. Finer grain size and decreased in clay matrix from last sample.

COMPOSITION	%	COMMENTS
Quartz	31	
K-Feldspar	6	
Plagioclase	10	
Chert	1	
Lithics	9	Low volcanic lithics
Authigenic Minerals		
Calcite	tr	
Muscovite	3	
Biotite	6	
Opaques	1	
Accessory Minerals		
Zircon	tr	
Garnet	tr	
Anatase	tr	
Carbonaceous Material	1	Mineralized by pyrite
Clay Minerals	32	Matrix
Illite (XRD)	Subd	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5006.5
INTERVAL: Mid-Fluvial I

Petrologist: R. Dayvault
Date: August 15, 1983

Rock Type: Lithic Arkose
Mean Grain Size (mm): 0.20
Grain Size Range (mm): 0.08 to 0.40

% Pore Space: None
Sorting (est.): M
Angularity (est.): SA

GENERAL DESCRIPTION: Another very tight rock with concave-convex and long grain boundaries. Sedimentary lithics are full of micas which are chloritized. Organic stringers along bedding with traces of authigenic pyrite. Decrease in amount of clay matrix, increase in grain size from last sample.

COMPOSITION	%	COMMENTS
Quartz	33	Overgrowths common
K-Feldspar	14	
Plagioclase	22	Much argillic alteration
Chert	1	
Lithics	16	Considerable plutonic
Authigenic Minerals		
Silica O. gr.	2	
Calcite	tr	
Muscovite	1	
Biotite	3	Chloritized
Opaques	tr	Pyrite
Accessory Minerals		
Zircon	tr	
Apatite	tr	
Anatase	tr	
Garnet	tr	
Carbonaceous Material	tr	
Clay Minerals	9	Matrix
Illite (XRD)	Min	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5011.8
INTERVAL: Mid-Fluvial I

Petrologist: R. Dayvault
Date: August 17, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.08
Grain Size Range (mm): 0.02 to 0.28

% Pore Space: None
Sorting (est.): M to P
Angularity (est.): SA

GENERAL DESCRIPTION: Rock is fine-grained sandstone with large patches of siltstone to claystone intermixed; vague notion of bedding. Large decrease in average grain size and increase in clay matrix from last sample.

COMPOSITION	%	COMMENTS
Quartz	10	
K-Feldspar	10	
Plagioclase	11	
Chert	1	
Lithics	5	
Authigenic Minerals		
Calcite	tr	As replacement of grains
Muscovite	1	
Biotite	3	
Opaques	1	
Accessory Minerals		
Garnet	tr	
Zircon	tr	
Anatase	tr	
Clay Minerals	58	Matrix
Illite (XRD)	Dom	Randomly interstratified with montmorillonite
Chlorite (XRD)	Mod	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS FORM

SAMPLE NO: MWX 5013.7
INTERVAL: Mid Fluvial I

Petrologist: R. Dayvault
Date: August 18, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.14
Grain Size Range (mm): 0.04 to 0.24

% Pore Space: None
Sorting (est.): M to W
Angularity (est.): SR

GENERAL DESCRIPTION: Fine-grained sandstone, grains slightly interlocked, some thin selvges of clay. Cracked grains observed. This sample is better sorted than last sample. Decrease in clay matrix from last sample.

COMPOSITION	%	COMMENTS
Quartz	38	
K-Feldspar	15	
Plagioclase	26	
Chert	3	
Lithics	5	
Authigenic Minerals		
Silica O.gr.	1	
Calcite	2	Much as replacements of feldspar grains
Muscovite	1	
Biotite	4	Mostly gone to chlorite
Accessory Minerals		
Tourmaline	tr	
Zircon	tr	
Anatase (?)	tr	
Amphibole (Altered)	tr	
Garnet	tr	
Clay Minerals	5	Matrix and some thin authigenic coatings on clasts.
Illite (XRD)	Min	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Min	

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5020.4
INTERVAL: Mid-Fluvial I

Petrologist: R. Dayvault
Date: August 19, 1983

Rock Type: Calcitic Arkose
Mean Grain Size (mm): 0.11
Grain Size Range (mm): 0.02 to 0.22

% Pore Space: None
Sorting (est.): M
Angularity (est.): SR

GENERAL DESCRIPTION: Great amount of calcite cement. Overgrowths of quartz not preserved. Feldspars are being replaced by calcite. A rutilated garnet observed.

COMPOSITION	%	COMMENTS
Quartz	29	
K-Feldspar	10	Some alteration to calcite, some nearly completely replaced
Plagioclase	15	Much alteration to clay and calcite
Chert	2	
Lithics	3	Mostly nondescript, could distinguish a few volcanic and plutonic fragments, some sedimentary
Authigenic Minerals		
Calcite	36	Calcite cement and replacement, no twinning observed
Muscovite	1	
Biotite	3	Altering to chlorite
Opaques	tr	
Accessory Minerals		
Garnet	tr	
Zircon	tr	
Amphibole(?)	tr	
Glauconite	tr	
Clay Minerals	1	Mostly as thin coatings between grains
Illite (XRD)	Mod	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5022.5 | Petrologist: R. Dayvault
INTERVAL: Mid Fluvial I | Date: August 23, 1983

Rock Type: Arkose | % Pore Space: 6
Mean Grain Size (mm): 0.17 | Sorting (est.): M - W
Grain Size Range (mm): 0.05 to 0.30 | Angularity (est.): SR

GENERAL DESCRIPTION: Much void space with thin linings of authigenic clays. Good overgrowths of SiO_2 on quartz grains. Increase in porosity from last sample.

COMPOSITION	%	COMMENTS
Quartz	37	Some rutillated
K-Feldspar	8	Some calcite replacement
Plagioclase	26	Calcite replacement
Chert	3	
Lithics	7	
Authigenic Minerals		
Silica O.gr.	tr	Some silica in voids and silicification of grains
Calcite	tr	
Muscovite	1	
Biotite	1	Good alignment along bedding planes
Opaques	1	
Accessory Minerals		
Garnet	1	
Zircon	tr	
Glauconite	tr	
Voids w/o Clay	4	
Voids w/Clay	2	
Clay Minerals	9	Authigenic
Illite (XRD)	Subd	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5026.8 Petrologist: R. Dayvault
INTERVAL: Mid-Fluvial I Date: August 24, 1983

Rock Type: Arkose % Pore Space: 2
Mean Grain Size (mm): 0.28 Sorting (est.): M
Grain Size Range (mm): 0.06 to 0.52 Angularity (est.): SA

GENERAL DESCRIPTION: Grains show very tight interlocking texture; however, there is pore space - probably secondary. Much silica overgrowths and alteration of grains to carbonate. Decrease in porosity from last sample.

COMPOSITION	%	COMMENTS
Quartz	34	Some rutillated
K-Feldspar	17	Some to carbonate
Plagioclase	21	Argillic alteration
Chert	6	
Lithics	9	Considerable volcanic and plutonic rock fragments
Authigenic Minerals		
Silica O. gr.	4	
Calcite	1	Some twinned
Muscovite	tr	
Biotite	1	
Opaques	1	
Accessory Minerals		
Garnet	tr	One very large grain (≈ .15 mm)
Zircon	tr	
Anatase	tr	In vug with carbonate cement
Voids w/o Clay	2	
Voids w/Clay	tr	
Clay Minerals	4	Authigenic coatings on clasts, trace of matrix
Illite (XRD)	Mod	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5032.7
INTERVAL: Mid-Fluvial I

Petrologist: R. Dayvault
Date: August 24, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.25
Grain Size Range (mm): 0.01 to 0.43

% Pore Space: tr
Sorting (est.): M - W
Angularity (est.): SA

GENERAL DESCRIPTION: Another very tight rock with minor silica and dominant calcite cements. Good overgrowths on quartz. Relatively coarse grained for this sequence. Decrease of porosity from last sample.

COMPOSITION	%	COMMENTS
Quartz	40	Good overgrowths
K-Feldspar	14	
Plagioclase	23	
Chert	3	
Lithics	7	
Authigenic Minerals		
Silica O. gr.	4	Some silica cement also
Calcite	5	Some twinned cement, some replaced grains
Muscovite	tr	
Biotite	2	Altered to chlorite
Opaques	tr	
Accessory Minerals		
Zircon	tr	
Garnet	tr	
Glauconite	tr	
Tourmaline	tr	
Voids w/o Clay	tr	
Clay Minerals	2	Authigenic coatings on clasts
Illite (Assumed)	Mod	Randomly interstratified with montmorillonite
Chlorite (Assumed)	Dom	
Mixed Layer (Assumed)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5033.6
INTERVAL: Mid-Fluvial I

Petrologist: R. Dayvault
Date: August 24, 1983

Rock Type: Calcitic Arkose
Mean Grain Size (mm): 0.30
Grain Size Range (mm): 0.11 to 2.21

% Pore Space: None
Sorting (est.): M
Angularity (est.): SA

GENERAL DESCRIPTION: Medium-grained rock with twinned calcite cement. Rock contains a vein of sparry to fiberous calcite and trails of carbonaceous material containing authigenic pyrite. Rock fragments are mostly sedimentary, few volcanic fragments were seen.

COMPOSITION	%	COMMENTS
Quartz	26	Some silica overgrowths
K-Feldspar	14	
Plagioclase	11	
Chert	tr	
Lithics	13	Several large sedimentary lithics
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	27	Coarse poikilotopic texture - twinning in at least two directions, calcite vein
Muscovite	tr	
Biotite	1	
Opaques	1	
Accessory Minerals		
Garnet	tr	
Zircon	tr	
Carbonaceous Material	1	Stringers mineralized by pyrite
Clay Minerals	5	Matrix in mudstone lenses and clay stringers
Illite (XRD)	Mod	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5035.8
INTERVAL: Mid-Fluvial I

Petrologist: R. Dayvault
Date: August 24, 1983

Rock Type: Calcitic Arkose
Mean Grain Size (mm): 0.11
Grain Size Range (mm): 0.02 to 0.36

% Pore Space: None
Sorting (est.): M
Angularity (est.) SA

GENERAL DESCRIPTION: Fine-grained rock with coarse poikilotopic calcite convex. Calcite twinned. Several silt lenses occur. They do not have carbonate cement. Large decrease in grain size from last sample.

COMPOSITION	%	COMMENTS
Quartz	27	Some overgrowth
K-Feldspar	8	
Plagioclase	8	
Chert	tr	
Lithics	8	
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	36	Coarse poikilotopic areas, twinned, most striae in one direction
Muscovite	tr	
Biotite	3	
Opaques	tr	
Accessory Minerals		
Zircon	1	
Garnet	tr	
Clay Minerals	8	Mostly as matrix in siltstone lenses
Illite (XRD)	Min	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5041.5
INTERVAL: Mid Fluvial I

Petrologist: R. Dayvault
Date: August 26, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.20
Grain Size Range (mm): 0.03 to 0.50

% Pore Space: None
Sorting (est.): M to W
Angularity (est.): SR

GENERAL DESCRIPTION: Very tight rock. Increase in grain size from last sample. This sample contains placer horizions.

COMPOSITION	%	COMMENTS
Quartz	43	
K-Feldspar	12	
Plagioclase	17	Typical argillic alteration
Chert	1	
Lithics	3	Several Plutonic and volcanic, mostly sedimentary
Authigenic Minerals		
Silica O.gr.	tr	
Calcite	1	Some replacement of K-Feldspar and minor cement
Muscovite	1	
Biotite	2	
Opaques	tr	
Accessory Minerals		
Zircon	tr	
Garnet	1	
Monazide	tr	
Clay Minerals	19	Authigenic coatings on clasts with little matrix
Illite (XRD)	Min	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5044.3 Petrologist: Larry Fukui
INTERVAL: Mid Fluvial I Date: August 8, 1983

Rock Type: Arkose % Pore Space: 3
Mean Grain Size (mm): 0.42 Sorting (est.): M
Grain Size Range (mm): 0.06-0.60 Angularity (est.): A-SR

GENERAL DESCRIPTION: Authigenic clay coats detrital components. Increase in grain size from last sample

COMPOSITION	%	COMMENTS
Quartz	35	
K-Feldspar	17	Some dissolution and replacement by calcite
Plagioclase	22	Bent twins observed. Typically sericitized
Chert	1	
Lithics	14	Volcanics, plutonics, and claystones
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	2	Cement. Subpoikilotopic
Muscovite	tr	
Biotite	1	
Opaques	tr	Goethite, occasional pyrite
Accessory Minerals		
Zircon	tr	
Garnet	tr	
Voids w/o Clay	2	
Voids w/Clay	1	
Clay Minerals	6	Authigenic coatings on clasts
Illite (XRD)	Mod	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5048.5
INTERVAL: Mid-Fluvial I

Petrologist: Larry Fukui
Date: August 8, 1983

Rock Type: Lithic Arkose
Mean Grain Size (mm): 0.27
Grain Size Range (mm): 0.06 to 0.61

% Pore Space: 3
Sorting (est.): M-W
Angularity (est.): A-SR

GENERAL DESCRIPTION: Similar texturally to last sample. Decrease in grain size. Increase in lithics with a decrease in feldspars. Less carbonate cement and quartz overgrowths in this sample. Authigenic clay coats clasts.

COMPOSITION	%	COMMENTS
Quartz	33	
K-Feldspar	17	Some dissolution and replacement by calcite
Plagioclase	15	Typically sericitized
Chert	1	
Lithics	24	Volcanics, claystones, and plutonics
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	1	Cement
Muscovite	1	
Biotite	3	
Opaques	tr	Mostly goethite. Some pyrite altering to goethite.
Accessory Minerals		
Zircon	tr	
Voids w/o Clay	2	
Voids w/Clay	1	
Clay Minerals	2	Authigenic coatings on clasts
Illite (Assumed)	Mod	Randomly interstratified with montmorillonite
Chlorite (Assumed)	Dom	
Mixed Layer (Assumed)	Min	Regularly interstratified 1:1 chlorite/illite (?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5050.6
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 9, 1983

Rock Type: Lithic Arkose
Mean Grain Size (mm): 0.35
Grain Size Range (mm): 0.06 to 0.67

% Pore Space: 4
Sorting (est.): M-W
Angularity (est.): SA-SR

GENERAL DESCRIPTION: Similar texturally to last sample; slight increase in grain size. Authigenic clay coats clasts. Less quartz overgrowths observed.

COMPOSITION	%	COMMENTS
Quartz	36	
K-Feldspar	13	Some dissolution and replacement by calcite observed
Plagioclase	18	Some replacement by calcite observed
Chert	1	
Lithics	19	Volcanics, plutonics, and claystones
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	1	Cement
Muscovite	tr	
Biotite	2	Mostly altered to chlorite
Opaques	tr	Occasional pyrite
Accessory Minerals		
Zircon	tr	
Garnet	tr	
Voids w/o Clay	3	
Voids w/Clay	1	
Clay Minerals	7	Authigenic coatings on clasts
Illite (Assumed)	Mod	Randomly interstratified with montmorillonite
Chlorite (Assumed)	Dom	
Mixed Layer (Assumed)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5051.6
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 9, 1983

Rock Type: Lithic Arkose
Mean Grain Size (mm): 0.35
Grain Size Range (mm): 0.10 to 0.62

% Pore Space: 2
Sorting (est.): M
Angularity (est.): A-SR

GENERAL DESCRIPTION: Less well sorted than last three samples. Authigenic clay coating clasts. No quartz overgrowths observed.

COMPOSITION	%	COMMENTS
Quartz	33	
K-Feldspar	13	Some dissolution
Plagioclase	19	Typically sericitized. Some replacement by calcite
Chert	1	
Lithics	22	Volcanics and claystones
Authigenic Minerals		
Calcite	1	Cement
Muscovite	tr	
Biotite	2	
Opaques	tr	Pyrite, some alteration to goethite
Accessory Minerals		
Zircon	tr	
Voids w/o Clay	1	
Voids w/Clay	1	
Clay Minerals	7	Authigenic coatings on clasts
Illite (Assumed)	Mod	Randomly interstratified with montmorillonite
Chlorite (Assumed)	Dom	
Mixed Layer (Assumed)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5052.3 | Petrologist: Larry Fukui
INTERVAL: Mid Fluvial I | Date: August 9, 1983

Rock Type: Lithic Arkose | % Pore Space: 1
Mean Grain Size (mm): 0.42 | Sorting (est.): M
Grain Size Range (mm): 0.13 to 0.73 | Angularity (est.): SA-SR

GENERAL DESCRIPTION: Better sorting than last sample. Authigenic clay coats clasts.

COMPOSITION	%	COMMENTS
Quartz	31	
K-Feldspar	14	Some partial replacement by calcite
Plagioclase	19	Typically sericitized
Chert	2	
Lithics	20	Volcanics, claystones, and plutonics
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	2	Cement
Muscovite	tr	
Biotite	1	Mostly altered to chlorite
Opaques	tr	
Accessory Minerals		
Ziron	tr	
Voids w/o Clay	1	
Voids w/Clay	tr	
Clay Minerals	9	Authigenic coatings on clasts
Illite (Assumed)	Mod	Randomly interstratified with montmorillonite
Chlorite (Assumed)	Dom	
Mixed Layer (Assumed)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5056.5
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 9, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.28
Grain Size Range (mm): 0.07 to 0.44

% Pore Space: 2
Sorting (est.): M-W
Angularity (est.): SA-SR

GENERAL DESCRIPTION: Similar to last sample.

COMPOSITION	%	COMMENTS
Quartz	42	
K-Feldspar	11	Partial dissolution some grains
Plagioclase	22	Typically sericitized
Chert	1	
Lithics	15	Volcanics, plutonics, claystones
Authigenic Minerals		
Silica O. gr.	1	
Calcite	tr	Cement
Muscovite	1	
Biotite	1	
Accessory Minerals		
Garnet	tr	
Zircon	tr	
Voids w/o Clay	1	
Voids w/Clay	1	
Clay Minerals	4	Authigenic clay coats clasts
Illite (Assumed)	Mod	Randomly interstratified with montmorillonite
Chlorite (Assumed)	Dom	
Mixed Layer (Assumed)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5061.7
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 10, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.34
Grain Size Range (mm): 0.17 to 0.47

% Pore Space: 1
Sorting (est.): M-W
Angularity (est.) SA-SR

GENERAL DESCRIPTION: Similar to last sample

COMPOSITION	%	COMMENTS
Quartz	45	
K-Feldspar	12	Some dissolution and replacement by calcite
Plagioclase	20	Some replacement by calcite. Typically sericitized
Chert	1	
Lithics	12	Volcanics, plutonics, and claystones
Authigenic Minerals		
Silica O. gr.	1	
Calcite	1	Cement
Muscovite	1	
Biotite	1	
Opaques	tr	Goethite
Accessory Minerals		
Tourmaline	tr	
Garnet	tr	
Voids w/o Clay	1	
Clay Minerals	5	Authigenic clay coats clasts
Illite (Assumed)	Mod	Randomly interstratified with montmorillonite
Chlorite (Assumed)	Dom	
Mixed Layer (Assumed)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5064.5
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 10, 1983

Rock Type: Lithic Arkose
Mean Grain Size (mm): 0.25
Grain Size Range (mm): 0.13 to 0.48

% Pore Space: 2
Sorting (est.): W
Angularity (est.): SA-SR

GENERAL DESCRIPTION: Finer grain size than last sample

COMPOSITION	%	COMMENTS
Quartz	32	
K-Feldspar	14	Some dissolution and replacement by calcite
Plagioclase	23	Typically sericitized
Chert	1	
Lithics	17	Volcanics, claystones
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	3	Cement. Subpoikilotopic in part
Muscovite	1	
Biotite	1	
Opaques	tr	Goethite and pyrite altering to goethite
Accessory Minerals		
Zircon	tr	
Carbonaceous Material	tr	
Voids w/o Clay	1	
Voids w/Clay	1	
Clay Minerals	6	Thin authigenic coatings on clasts
Illite (XRD)	Mod	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5084.8
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 11, 1983

Rock Type: Lithic Arkose
Mean Grain Size (mm): 0.25
Grain Size Range (mm): 0.04 to 0.43

% Pore Space: tr
Sorting (est.): W
Angularity (est.): SA-SR

GENERAL DESCRIPTION: Less porosity than last sample.

COMPOSITION	%	COMMENTS
Quartz	35	
K-Feldspar	15	Some dissolution and replacement by calcite
Plagioclase	18	Typically sericitized
Chert	1	
Lithics	19	Volcanics, claystones, and plutonics
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	4	Cement
Muscovite	1	
Biotite	2	
Opaques	tr	Goethite
Accessory Minerals		
Zircon	tr	
Carbonaceous Material	tr	
Voids w/Clay	tr	
Clay Minerals	4	Thin authigenic coatings on clasts
Illite (Assumed)	Mod	Randomly interstratified with montmorillonite
Chlorite (Assumed)	Dom	
Mixed layer (Assumed)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5086.9
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 12, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.22
Grain Size Range (mm): 0.10 to 0.47

% Pore Space: Tr
Sorting (est.): M-W
Angularity (est.): SA-SR

GENERAL DESCRIPTION: Texturally similar to last sample. Less lithics than last sample. Note: The percentage of pore space may be greater than reported; impregnation with blue epoxy apparently did not reach the interior of the core plug.

COMPOSITION	%	COMMENTS
Quartz	39	
K-Feldspar	17	Some dissolution and replacement by calcite
Plagioclase	22	Typically sericitized
Chert	1	
Lithics	14	Volcanics, claystones, and plutonics
Authigenic Minerals		
Silica O. gr.	1	
Calcite	2	Cement
Biotite	2	
Opaques	tr	Goethite
Accessory Minerals		
Garnet	tr	
Epidote	tr	
Zircon	tr	
Tourmaline	tr	
Voids w/o Clay	tr	Note: Percentage of pore space may be greater than
Voids w/Clay	tr	A trace; incomplete impregnation with blue epoxy
Clay Minerals	3	Thin authigenic coatings on clasts
Illite (Assumed)	Mod	Randomly interstratified with montmorillonite
Chlorite (Assumed)	Dom	
Mixed Layer (Assumed)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5088.5
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 12, 1983

Rock Type: Lithic Arkose
Mean Grain Size (mm): 0.33
Grain Size Range (mm): 0.17 to 0.55

% Pore Space: 3
Sorting (est.): M-W
Angularity (est.): SA-SR

GENERAL DESCRIPTION: Increase in grain size and porosity from last sample. Authigenic clay coatings on clasts have increased in abundance and thickness.

COMPOSITION	%	COMMENTS
Quartz	34	
K-Feldspar	12	Some dissolution and replacement by calcite
Plagioclase	20	Typically sericitized
Chert	1	
Lithics	18	Volucanics, claystones, and plutonics
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	1	Cement
Muscovite	1	
Biotite	2	
Opaques	tr	Goethite
Accessory Minerals		
Garnet	tr	
Zircon	tr	
Tourmaline	tr	
Voids w/o Clay	2	
Voids w/Clay	1	
Clay Minerals	7	Authigenic clay coats clasts; minor iron-stained matrix
Illite (XRD)	Dom	Randomly interstratified with montmorillonite
Chlorite (XRD)	Subd	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5091.2
INTERVAL: Mid Fluvial I

Petrologist: Larry Fului
Date: August 18, 1983

Rock Type: Calcitic Lithic Arkose
Mean Grain Size (mm): 0.24
Grain Size Range (mm): 0.10 to 0.39

% Pore Space: None
Sorting (est.): W
Angularity (est.): SA-SR

GENERAL DESCRIPTION: Finer grain size than last sample. This sample contains much more calcite cement than the last sample. Some grain outlines (clay) observed: Totally replaced by calcite. Some replacement of silica overgrowths by calcite.

COMPOSITION	%	COMMENTS
Quartz	35	
K-Feldspar	6	Partial dissolution and replacement by calcite
Plagioclase	20	Partial dissolution and replacement by calcite
Chert	1	
Lithics	19	Volcanics, claystones, and plutonics
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	17	Cement. Poikilotopic. Twinned
Muscovite	tr	
Biotite	1	
Accessory Minerals		
Epidote	tr	
Zircon	tr	
Sphene	tr	
Garnet	tr	
Clay Minerals	1	Matrix and coatings on clasts. Iron stained
Illite (XRD)	Min	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5093.8
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 15, 1983

Rock Type: Lithic Arkose
Mean Grain Size (mm): 0.18
Grain Size Range (mm): 0.09 to 0.33

% Pore Space: 2
Sorting (est.): W
Angularity (est.): SA-SR

GENERAL DESCRIPTION: Finer grain size than last sample; this sample contains much less carbonate cement than last sample. Authigenic clay coats clasts.

COMPOSITION	%	COMMENTS
Quartz	46	
K-Feldspar	9	Some dissolution and replacement by calcite
Plagioclase	19	Typically sericitized
Chert	1	
Lithics	15	Volcanics, claystones, and plutonics
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	1	Cement
Goethite	tr	Locally as a cement
Muscovite	tr	
Biotite	2	
Opaques	tr	Goethite with some discrete pyrite
Accessory Minerals		
Zircon	tr	
Tourmaline	tr	
Garnet	tr	
Voids w/o Clay	1	
Voids w/Clay	1	
Clay Minerals	4	Authigenic clay coats clasts
Illite (XRD)	Subd	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5096.2
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 15, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.23
Grain Size Range (mm): 0.10 to 0.36

% Pore Space: 2
Sorting (est.): M-W
Angularity (est.): SA-SR

GENERAL DESCRIPTION: Increase in grain size from last sample. Increase of silica overgrowths on detrital quartz from last sample.

COMPOSITION	%	COMMENTS
Quartz	39	
K-Feldspar	11	Some dissolution and replacement by calcite
Plagioclase	23	Typically sericitized. Occasional replacement by calcite
Chert	1	
Lithics	15	Volcanics, claystones, mudstones, and plutonics
Authigenic Minerals		
Silica O. gr.	2	
Calcite	2	Cement
Barite	tr	Associated with calcite cement
Muscovite	tr	
Biotite	2	
Opaques	tr	Goethite and pyrite
Accessory Minerals		
Zircon	tr	
Anatase	tr	Euhedra in a void replacing a titanium-rich detrital phase
Garnet	tr	
Apatite	tr	
Voids w/o Clay	1	
Voids w/Clay	1	
Clay Minerals	4	Thin authigenic coatings on clasts; minor matrix
Illite (XRD)	Mod	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5098.4
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 16, 1983

Rock Type: Lithic Arkose
Mean Grain Size (mm): 0.35
Grain Size Range (mm): 0.22 to 0.58

% Pore Space: 2
Sorting (est): M-W
Angularity (est.): SA-SR

GENERAL DESCRIPTION: Increase in grain size, amount of calcite cement and clay from last sample

COMPOSITION	%	COMMENTS
Quartz	37	
K-Feldspar	10	Some dissolution and replacement by calcite
Plagioclase	15	Some replacement by calcite. Typically sericitized
Chert	1	
Lithics	22	Volcanics, claystones, plutonics, and mudstones
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	4	Poor stain; calcite peak present on clay X-ray pattern. Poikilotopic cement
Muscovite	tr	
Biotite	1	
Opaques	tr	Goethite and pyrite
Accessory Minerals		
Anatase	tr	Detrital
Garnet	tr	
Zircon	tr	
Voids w/o Clay	2	
Voids w/Clay	tr	
Clay Minerals	7	Matrix and authigenic coatings on clasts
Illite (XRD)	Mod	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5102.3
INTERVAL: Mid-Fluvial I

Petrologist: Larry Fukui
Date: August 16, 1983

Rock Type: Sandy Claystone

% Pore Space: None
Sorting (est.): M
Angularity (est.): A-SR

GENERAL DESCRIPTION: This is a massive sandy claystone with floating detrital grains of quartz (silt-to medium sand-sized), plagioclase, K-feldspar, lithics, chert, micas, goethite, and zircon. Some randomly oriented stringers of carbonaceous material containing pyrite are observed. Sample contains 68 volume percent clay. Most clasts are floating in the clay matrix. The clay matrix is partially recrystalized.

COMPOSITION	%	COMMENTS
Clay Minerals		
Illite (XRD)	Mod	Illite and randomly interstratified illite-montmorillonite
Chlorite (XRD)	Dom	Chlorite and randomly interstratified chlorite-montmorillonite
Mixed Layer (XRD)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5129.5 | Petrologist: Larry Fukui
INTERVAL: Mid Fluvial I | Date: August 16, 1983

Rock Type: Lithic Arkose | % Pore Space: 2
Mean Grain Size (mm): 0.25 | Sorting (est.): W
Grain Size Range (mm): 0.12 to 0.44 | Angularity (est.): SA-SR

GENERAL DESCRIPTION: Finer grain size than 5098.4; otherwise similar.

COMPOSITION	%	COMMENTS
Quartz	38	
K-Feldspar	11	Some replacement by calcite
Plagioclase	17	Typically sericitized
Chert	1	
Lithics	19	Volcanics and claystones
Authigenic Minerals		
Silica O. gr.	1	
Calcite	2	Cement
Muscovite	1	
Biotite	3	
Opaques	tr	Goethite and pyrite
Accessary Minerals		
Zircon	tr	
Epidote	tr	
Garnet	tr	
Anatase	tr	Lines void; replacing a titanium-rich detrital phase
Glauconite/ celadonite	tr	
Voids w/o Clay	tr	
Voids w/Clay	2	
Clay Minerals	5	Authigenic coatings on clasts and minor matrix
Illite (XRD)	Subd	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5131.5
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 16, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.17
Grain Size Range (mm): 0.07 to 0.37

% Pore Space: tr
Sorting (est.): W
Angularity (est.) SA

GENERAL DESCRIPTION: Finer grain size than last sample; otherwise smiliar.

COMPOSITION	%	COMMENTS
Quartz	44	
K-Feldspar	9	Some replacement by calcite
Plagioclase	22	Typically sericitized. Some replacement by calcite
Chert	tr	
Lithics	13	Volcanics and claystones
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	2	Cement. Twinned
Muscovite	1	
Biotite	1	
Opaques	tr	Detrital goethite. Pyrite filling a pore
Accessory Minerals		
Zircon	tr	
Glauconite	tr	
Anatase	tr	Euhedra replacing a titanium-bearing phase
Carbonaceous Material	tr	
Voids w/Clay	tr	
Clay Minerals	7	Matrix and thin authigenic coatings on clasts
Illite (XRD)	Dom	Randomly interstratified with montmorillonite
Chlorite (XRD)	Mod	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5133.7
INTERVAL: Mid-Fluvial I

Petrologist: Larry Fukui
Date: August 17, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.12
Grain Size Range (mm): 0.06 to 0.21

% Pore Space: None
Sorting (est.): M-W
Angularity (est.): A-SR

GENERAL DESCRIPTION: Large increase in clay matrix, decrease in grain size, increase in carbonaceous matrix from last sample. Bedding is somewhat contorted.

COMPOSITION	%	COMMENTS
Quartz	34	
K-Feldspar	9	
Plagioclase	11	Typically sericitized
Chert	1	
Lithics	8	Claystones and volcanics
Authigenic Minerals		
Calcite	1	Cement
Muscovite	1	
Biotite	3	
Opaques	tr	Goethite. Carbonaceous material contains pyrite
Accessory Minerals		
Garnet	tr	
Zircon	tr	
Apatite	tr	
Anatase	tr	Detrital
Tourmaline	tr	
Rutile	tr	
Carbonaceous Material	3	Forms braided laminae. Defines bedding.
Clay Minerals	28	Matrix; iron-stained, slightly recrystallized
Illite (XRD)	Dom	Randomly interstratified with montmorillonite
Chlorite (XRD)	Subd	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5143.6
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 18, 1983

Rock Type: Claystone

% Pore Space: None
Sorting (est.): P (Bimodal)
Angularity (est.): A

GENERAL DESCRIPTION: This sample is a claystone consisting of clay matrix (77 volume percent), detrital quartz (silt-to medium sand-sized), plagioclase, K-feldspar, lithics, opaques (goethite), and chert. The sample contains lenses and stringers of carbonaceous material parallel to bedding. The sample also contains trace amounts of sparitic carbonate which may be detrital.

COMPOSITION	%	COMMENTS
Clay Minerals		
Illite (XRD)	Dom	Randomly interstratified with montmorillonite
Chlorite (XRD)	Min	
Mixed Layer (XRD)	Subd	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5144.1
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 18, 1983

Rock Type: Sandy Claystone

% Pore Space: None
Sorting (est.): Bimodal
Angularity (est.): A-SA

GENERAL DESCRIPTION: This sample is a sandy claystone consisting of an iron-stained clay matrix (56 volume percent), detrital quartz (silt-to medium sand-sized), plagioclase, K-feldspar, lithics, biotite, chert, muscovite, opaques (goethite and pyrite) and zircon. This sample contains trace amounts of carbonate and carbonaceous material.

COMPOSITION	%	COMMENTS
Clay Minerals		
Illite (XRD)	Dom	Randomly interstratified with montmorillonite
Chlorite (XRD)	Min	
Mixed Layer (XRD)	Subd	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5146.5
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 18, 1983

Rock Type: Calcitic Arkose
Mean Grain Size (mm): 0.29
Grain Size Range (mm): 0.09 to 0.59

% Pore Space: None
Sorting (est.): M-W
Angularity (est.): SA-SR

GENERAL DESCRIPTION: Large increase in grain size and calcite cement from MWX-5133.7. This sample does not contain clay matrix, 5133.7 contains 28 volume percent matrix. Calcite cement in this sample is fine-grained. Calcite in sample MWX 5091.2 is medium-to coarse-grained, poikilotopic.

COMPOSITION	%	COMMENTS
Quartz	35	
K-Feldspar	9	Some replacement by calcite
Plagioclase	19	Typically sericitized. Some replacement by calcite
Chert	tr	
Lithics	8	Volcanics, claystones, and plutonics
Authigenic Minerals		
Silica O. gr.	tr	Some grains exhibit two generations of overgrowths
Calcite	30	Cement
Muscovite	tr	
Biotite	tr	
Opaques	tr	Goethite and pyrite
Accessory Minerals		
Garnet	tr	
Anatase	tr	Replacing a titanium-rich phase
Apatite	tr	
Zircon	tr	
Clay Minerals	tr	Authigenic coatings on clasts
Illite (XRD)	Subd	Randomly interstratified with montmorillonite
Chlorite (XRD)	Min	
Mixed Layer (XRD)	Dom	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5149.5
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 19, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.31
Grain Size Range (mm): 0.17 to 0.68

% Pore Space: 3
Sorting (est.): M
Angularity (est.): A-SR

GENERAL DESCRIPTION: Authigenic clay coats clasts. Increase in porosity. Slight increase in clast size from last sample. Some K-feldspar grains have more dissolution than former samples. This secondary porosity contains authigenic clay. Some pores contain authigenic quartz crystals.

COMPOSITION	%	COMMENTS
Quartz	41	
K-feldspar	11	Some dissolution and replacement by calcite
Plagioclase	14	Typically sericitized
Chert	tr	
Lithics	13	Volcanics, claystones, plutonics, sparitic carbonate
Authigenic Minerals		
Silica O. gr.	1	
Calcite	2	Cement
Muscovite	1	
Biotite	2	
Opaques	1	Goethite
Accessory Minerals		
Garnet	tr	
Zircon	tr	
Anatase	tr	Replacing a titanium-rich phase
Voids w/o Clay	2	
Voids w/Clay	1	
Clay Minerals	11	Authigenic coatings on clasts
Illite (XRD)	Mod	Randomly interstratified with montmorillonite
Chlorite (XRD)	Mod	
Mixed Layer (XRD)	Dom	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5153.5
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 24, 1983

Rock Type: Lithic Arkose
Mean Grain Size (mm): 0.45
Grain Size Range (mm): 0.09 to 0.66

% Pore Space: 4
Sorting (est.): M-W
Angularity (est.) SA-SR

GENERAL DESCRIPTION: Large increase in grain size. Increase in porosity.

COMPOSITION	%	COMMENTS
Quartz	44	
K-Feldspar	13	Some dissolution and replacement by calcite
Plagioclase	9	Typically sericitized
Chert	2	
Lithics	18	Volcanics, claystones, plutonics, and sandstones
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	2	Cement
Biotite	tr	
Opaques	tr	Goethite
Accessory Minerals		
Garnet	tr	
Anatase	tr	Replacing a formal detrital titanium-rich phase
Voids w/o Clay	3	
Voids w/Clay	1	
Clay Minerals	9	Authigenic coatings on clasts
Illite (XRD)	Subd	Randomly interstratified with montmorillonite
Chlorite (XRD)	Subd	
Mixed Layer (XRD)	Dom	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5168.5
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 24, 1983

Rock Type: Calcitic Siltstone

% Pore Space: None
Sorting (est.): W
Angularity (est.): A-SA

GENERAL DESCRIPTION: The sample is a siltstone consisting of silt-to fine sand-sized quartz, plagioclase, K-feldspar, lithics, chert, biotite, muscovite, goethite, and zircon. The sample contains approximately 40 volume percent poikilotopic calcite cement. Thin authigenic clay coatings are observed on clasts. The sample also contains minor to trace amounts of clay matrix. Point contacts and floating grains are common, long contacts are less common.

COMPOSITION	%	COMMENTS
Clay Minerals		
Illite (XRD)	Mod	Illite and randomly interstratified illite-montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5189.1 | Petrologist: Larry Fukui
INTERVAL: Mid-Fluvial I | Date: August 29, 1983

Rock Type: Calcitic Feldspathic Litharenite | % Pore Space: None
Mean Grain Size (mm): 0.09 | Sorting (est.): W
Grain Size Range (mm): 0.02 to 0.18 | Angularity (est.): A-SR

GENERAL DESCRIPTION: Coarser grain size than last sample (much finer than 5153.5). Calcite cement is finer-grained and not poikilotopic as in the last sample. Note: This sample may contain more feldspars than reported; due to fine clast size, some feldspar may have been misidentified as quartz. This sample contains stringers and laminae of carbonaceous material.

COMPOSITION	%	COMMENTS
Quartz	35	
K-Feldspar	4	Some replacement by calcite
Plagioclase	4	
Chert	3	
Lithics	11	Claystones, micritic carbonate and unidentifiable
Authigenic Minerals		
Calcite	32	Fine-grained cement. Twinned
Muscovite	tr	
Biotite	1	
Opaques	tr	Pyrite and goethite
Accessory Minerals		
Anatase	tr	Detrital
Zircon	tr	
Garnet	tr	
Carbonaceous Material	tr	Braided stringers forming laminae parallel to bedding
Clay Minerals	9	Matrix and thin authigenic coatings on clasts
Illite (Assumed)	Min	Illite and randomly interstratified illite-montmorillonite
Chlorite (Assumed)	Dom	
Mixed Layer (Assumed)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5196.4 Petrologist: Larry Fukui
INTERVAL: Mid Fluvial I Date: August 25, 1983

Rock Type: Calcitic Feldspathic Litharenite % Pore Space: None
Mean Grain Size (mm): 0.18 Sorting (est.): W-M
Grain Size Range (mm): 0.09 to 0.32 Angularity (est.): SA-SR

GENERAL DESCRIPTION: Coarser grain size than last sample. Calcite cement is coarse-grained, poikilotopic again. Increase in clay matrix and claystone lithics.

COMPOSITION	%	COMMENTS
Quartz	36	
K-Feldspar	5	Most grains partially replaced by calcite
Plagioclase	12	Some replacement by calcite. Typically sericitized
Chert	1	
Lithics	21	Claystones >> volcanics, plutonics
Authigenic Minerals		
Silica O. gr.	1	
Calcite	11	Poikilotopic cement
Muscovite	tr	
Biotite	1	
Opaques	tr	Goethite
Accessory Minerals		
Zircon	tr	
Tourmaline	tr	
Altered Mafic (?)	tr	Chlorite pseudomorph after amphibole (?)
Garnet	tr	
Anatase	tr	Replacing a former titanium-rich detrital phase
Carbonaceous Material	tr	Contains pyrite
Clay Minerals	13	Matrix and thin authigenic coatings on clasts
Illite (XRD)	Min	Illite and randomly interstratified illite-montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5199.1
INTERVAL: Mid Fluvial

Petrologist: Larry Fukui
Date: August 25, 1983

Rock Type: Sandy Claystone

% Pore Space: None
Sorting (est.): M-W
Angularity (est.): A-SA

GENERAL DESCRIPTION: The sandy claystone consists of iron-stained clay matrix (56 vol. %) containing detrital grains (silt-to medium sand-sized) quartz, plagioclase, K-feldspar, lithics, biotite, chert, opaques (goethite), muscovite, zircon, tourmaline, glauconite/celadonite, and carbonaceous material (containing pyrite). Floating grains and point contacts are common, long contacts are less common.

COMPOSITION	%	COMMENTS
Clay Minerals		
Illite (XRD)	Mod	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5220.2
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 25, 1983

Rock Type: Claystone

% Pore Space: None
Sorting (est.): M
Angularity (est.): A-SA

GENERAL DESCRIPTION: The claystone consists of iron-strained clay matrix (71 vol. %) with detrital grains (silt-to coarse sand-sized) of quartz, plagioclase, K-feldspar, biotite, muscovite, opaques (goethite and pyrite), and zircon. Stringers and grains of carbonaceous material are mineralized by pyrite. Floating grains and point contacts are common.

COMPOSITION	%	COMMENTS
Clay Minerals		
Illite (XRD)	Mod	Illite and randomly interstratified illite-montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5234.5
INTERVAL: Mid Fluvial I

Petrologist: Larry Fukui
Date: August 25, 1983

Rock Type: Mudstone

% Pore Space: None
Sorting (est.): W
Angularity (est.): SA

GENERAL DESCRIPTION: The mudstone consists of iron-stained clay matrix (49 vol. %) with predominately silt-sized detrital grains of quartz, feldspars, micas, and opaques (goethite). This sample contains trace amounts of very fine-grained sparitic carbonate (no calcite stain is observed). Thin stringers of carbonaceous material mineralized by pyrite are observed. Laminae of claystone are observed. Floating detrital grains are common, point contacts are less common.

COMPOSITION	%	COMMENTS
Clay Minerals		
Illite (XRD)	Codom	Randomly interstratified with montmorillonite
Chlorite (XRD)	Codom	
Mixed Layer (XRD)	Codom	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5248.7
INTERVAL: Mid Fluvial I

PETROLOGIST: Larry Fukui
Date: August 26, 1983

Rock Type: Arkose
Mean Grain Size (mm): 0.09
Grain Size Range (mm): 0.02 to 0.20

% Pore Space: None
Sorting (est.): M-P (Bimodal)
Angularity (est.): A-SA

GENERAL DESCRIPTION: Increase of detrital silt and sand from last three samples. This sample exhibits claystone and sandstone layers.

COMPOSITION	%	COMMENTS
Quartz	36	
K-Feldspar	5	Some replacement by calcite
Plagioclase	7	Typically sericitized
Chert	tr	
Lithics	5	Claystones >> volcanics
Authigenic Minerals		
Calcite	2	Cement
Muscovite	tr	
Biotite	2	
Opaques	tr	Pyrite. Detrital goethite
Accessory Minerals		
Zircon	tr	
Anatase	1	Detrital
Garnet	tr	
Carbonaceous Material	1	Mineralized by pyrite
Clay Minerals	40	Matrix
Illite (XRD)	Mod	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5259.7
INTERVAL: Mid-Fluvial I

Petrologist: Larry Fukui
Date: August 26, 1983

Rock Type: Mudstone

% Pore Space: None
Sorting (est.): M (Bimodal)
Angularity (est.) A

GENERAL DESCRIPTION: The sample consists of two lithologies: siltstone containing approximately equal amounts of calcite cement and clay matrix and claystone with only trace amounts of calcite. The siltstone contains silt-to fine sand-sized quartz, plagioclase, K-feldspar, chert, biotite, muscovite, tourmaline, opaques (goethite), and carbonaceous material. The claystone contains a similar detrital assemblage. Grain size ranges from silt-to fine sand-sized. The claystone also contains lenses of fine sand sized detritus in a clay matrix.

COMPOSITION	%	COMMENTS
Clay Minerals		
Illite (XRD)	Mod	Illite and randomly interstratified illite-montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5268.5
INTERVAL: Mid-Fluvial I

Petrologist: Larry Fukui
Date: August 26, 1983

Rock Type: Lithic Arkose
Mean Grain Size (mm): 0.11
Grain Size Range (mm): 0.03 to 0.25

% Pore Space: None
Sorting (est.): M (Bimodal)
Angularity (est.): SA-SR

GENERAL DESCRIPTION: The detrital grains in this sample have a bimodal distribution. Both clay matrix and structurally controlled authigenic clay are present in this sample.

COMPOSITION	%	COMMENTS
Quartz	44	
K-Feldspar	6	Some replacement by calcite
Plagioclase	9	Typically sericitized
Chert	2	
Lithics	11	Claystones, carbonates, and volcanics
Authigenic Minerals		
Silica O. gr.	1	
Calcite	1	Cement
Muscovite	tr	
Biotite	1	
Opaques	1	Goethite, occasionally associated with authigenic anatase
Accessory Minerals		
Zircon	tr	
Tourmaline	tr	
Monazite (?)	tr	Rimmed by hematite/goethite
Clay Minerals	23	Matrix and authigenic, both iron-stained. Authigenic clay is coarsely crystalline and appears to be structurally controlled (along a fracture ?). Authigenic clay constitutes 10 vol. % of the clay minerals.
Illite (XRD)	tr	Illite and randomly interstratified illite-montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	tr	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5270.5
INTERVAL: Mid-Fluvial I

Petrologist: Larry Fukui
Date: August 29, 1983

Rock Type: Feldspathic Litharenite
Mean Grain Size (mm): 0.16
Grain Size Range (mm): 0.07 to 0.25

% Pore Space: tr
Sorting (est.): W
Angularity (est.): SA-SR

GENERAL DESCRIPTION: This sample contains placer horizions. Some micro-porosity associated with clay matrix.

COMPOSITIONS	%	COMMENTS
Quartz	48	
K-Feldspar	6	Some replacement by calcite
Plagioclase	5	Some replacement by calcite. Typically sericitized
Chert	3	
Lithics	20	Claystones and volcanics
Authigenic Minerals		
Silica O. gr.	3	
Calcite	2	Cement. Rarely twinned
Muscovite	tr	
Biotite	tr	
Opaques	4	Predominately goethite; trace pyrite
Accessory Minerals		
Zircon	tr	
Tourmaline	tr	
Garnet	tr	
Anatase	tr	Detrital and replacing titatium-rich detrital phases
Apatite	tr	
Voids w/Clay	tr	
Clay Minerals	9	Matrix
Illite (Assumed)	Min	Randomly interstratified with montmorillonite
Chlorite (Assumed)	Dom	
Mixed Layer (Assumed)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5271.6 | Petrologist: Larry Fukui
INTERVAL: Mid-Fluvial I | Date: August 30, 1983

Rock Type: Calcitic Litharenite | % Pore Space: 1
Mean Grain Size (mm): 0.23 | Sorting (est.): M-W
Grain Size Range (mm): 0.09 to 0.47 | Angularity (est.): SA-SR

GENERAL DESCRIPTION: This sample has a coarser grain-size, poorer sorting, an increase in chert, an increase in calcite cement, and a decrease in clay matrix from the last sample.

COMPOSITION	%	COMMENTS
Quartz	45	
K-Feldspar	5	Most grains partially replaced by calcite
Plagioclase	5	Typically sericitized
Chert	8	
Lithics	17	Claystones, volcanics, and plutonics
Authigenic Minerals		
Silica O. gr.	2	
Calcite	11	Poikilotopic cement. Totally replaces some clasts. Twinned
Muscovite	tr	
Biotite	1	
Opaques	tr	Goethite. Trace of pyrite
Accessory Minerals		
Zircon	tr	
Voids w/Clay	1	
Clay Minerals	5	Matrix
Illite (XRD)	Min	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Min	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5272.5
INTERVAL: Mid-Fluvial I

Petrologist: Larry Fukui
Date: August 31, 1983

Rock Type: Claystone

% Pore Space: None
Sorting (est.): Bimodal
Angularity (est.): A-SR

GENERAL DESCRIPTION: This claystone consists of clay matrix (71 vol. %), calcite cement, silt-to medium sand-sized quartz, lithics, plagioclase, chert, K-feldspar, micas, opaques (goethite), zircon, and tourmaline. Sparitic and micritic carbonates are the predominant lithc type. Some of the sparite lithics do not exhibit calcite staining; adjacent grains are well stained. These unstained grains may be dolomite; bulk rock X-ray diffraction confirms the presence of dolomite. A carbonate fossil is also observed. Claystone and volcanic lithics are also present. K-feldspar exhibits some replacement by calcite. Thin stringers of carbonaceous material are mineralized by pyrite. Predominately floating detrital grains. Weight percent dolomite in carbonate fraction = 25.50.

COMPOSITION	%	COMMENTS
Clay Minerals		
Illite (XRD)	Codom	Randomly interstratified with montmorillonite
Chlorite (XRD)	Codom	
Mixed Layer (XRD)	Codom	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5287.3
INTERVAL: Mid-Fluvial I

Petrologist: Larry Fukui
Date: September 1, 1983

Rock Type: Claystone

% Pore Space: None
Sorting (est.): Bimodal
Angularity (est.): A-SR

This claystone contains more clay matrix (87 vol. %), less detrital grains, a finer grain size of detrital grains (silt-to fine sand-sized), and a decrease in lithics (especially carbonates) than the last sample. This claystone consists of clay matrix, detrital quartz, K-feldspar, plagioclase, chert, micas, opaques (goethite and pyrite), lithics (claystones, volcanics, and a few sparitic carbonates), anatase, and zircon. This sample contains substantially less carbonaceous material than the last sample. This carbonaceous material is disseminated and mineralized by pyrite. Predominately floating detrital grains. The clay matrix is partially recrystallized.

COMPOSITION	%	COMMENTS
Clay Minerals		
Illite (XRD)	Subd	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Subd	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5294.5 | Petrologist: Larry Fukui
INERVAL: Mid-Fluvial I | Date: September 1, 1983

Rock Type: Calcitic Feldspathic Litharenite | % Pore Space: None
Mean Grain Size (mm): 0.09 | Sorting (est.): W
Grain Size Range (mm): 0.02 to 0.17 | Angularity (est.): A-SR

GENERAL DESCRIPTION: This sample is finely laminated with laminations defined by stringers and laminae of clay and carbonaceous material. This sample is finer-grained and contains more calcite cement than sample 5271.6. Weight percent dolomite in carbonate fraction = 7.73.

COMPOSITION	%	COMMENTS
Quartz	37	
K-Feldspar	3	Some replacement by calcite; Note that some K-feldspar grains may be totally replaced by calcite
Plagioclase	8	Some replacement by calcite
Chert	1	
Lithics	12	Carbonates (calcite > dolomite), claystones, and volcanics
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	29	Twinned cement
Muscovite	1	
Biotite	1	
Opaques	1	
Accessory Minerals		
Epidote	tr	
Tourmaline	tr	
Anatase	tr	Detrital
Carbonaceous Material	1	Mineralized by pyrite
Clay Minerals	5	Matrix
Illite (XRD)	Mod	Illite and randomly interstratified illite-montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5287.3
INTERVAL: Mid-Fluvial I

Petrologist: Larry Fukui
Date: September 1, 1983

Rock Type: Claystone

% Pore Space: None
Sorting (est.): Bimodal
Angularity (est.): A-SR

This claystone contains more clay matrix (87 vol. %), less detrital grains, a finer grain size of detrital grains (silt-to fine sand-sized), and a decrease in lithics (especially carbonates) than the last sample. This claystone consists of clay matrix, detrital quartz, K-feldspar, plagioclase, chert, micas, opaques (goethite and pyrite), lithics (claystones, volcanics, and a few sparitic carbonates), anatase, and zircon. This sample contains substantially less carbonaceous material than the last sample. This carbonaceous material is disseminated and mineralized by pyrite. Predominately floating detrital grains. The clay matrix is partially recrystallized.

COMPOSITION	%	COMMENTS
Clay Minerals		
Illite (XRD)	Subd	Randomly interstratified with montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Subd	Regularly interstratified 1:1 chlorite/illite(?)

MULTI-WELL PETROGRAPHIC ANALYSIS

SAMPLE NO: MWX-5294.5
INERVAL: Mid-Fluvial I

Petrologist: Larry Fukui
Date: September 1, 1983

Rock Type: Calcitic Feldspathic Litharenite
Mean Grain Size (mm): 0.09
Grain Size Range (mm): 0.02 to 0.17

% Pore Space: None
Sorting (est.): W
Angularity (est.): A-SR

GENERAL DESCRIPTION: This sample is finely laminated with laminations defined by stringers and laminae of clay and carbonaceous material. This sample is finer-grained and contains more calcite cement than sample 5271.6. Weight percent dolomite in carbonate fraction = 7.73.

COMPOSITION	%	COMMENTS
Quartz	37	
K-Feldspar	3	Some replacement by calcite; Note that some K-feldspar grains may be totally replaced by calcite
Plagioclase	8	Some replacement by calcite
Chert	1	
Lithics	12	Carbonates (calcite > dolomite), claystones, and volcanics
Authigenic Minerals		
Silica O. gr.	tr	
Calcite	29	Twinned cement
Muscovite	1	
Biotite	1	
Opaques	1	
Accessory Minerals		
Epidote	tr	
Tourmaline	tr	
Anatase	tr	Detrital
Carbonaceous Material	1	Mineralized by pyrite
Clay Minerals	5	Matrix
Illite (XRD)	Mod	Illite and randomly interstratified illite-montmorillonite
Chlorite (XRD)	Dom	
Mixed Layer (XRD)	Mod	Regularly interstratified 1:1 chlorite/illite(?)