

X-RAY DIFFRACTION AND SEM ANALYSIS

OF

MORROW SANDSTONES, CLARK COUNTY (KANSAS)

Patton 1-3
SEC 3-30S-25W

By

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Report Prepared

for

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March 15, 1983

INTRODUCTION

Three sandstone samples were received from Mr. David Doyle, Murfin Drilling Company, with the request of the examination of these sandstones with x-ray diffraction and scanning electron microscopy. The sandstones were from Murfin's Well Patton 1-3 and they are designated by us according to their depths:

<u>Our sample designation</u>	<u>Sample depth (feet)</u>	<u>% porosity</u>	<u>Permeability</u>
C8-1	5318	13.7	15md
C8-2	5321	15.1	38
C8-3	5324	16.6	88.9

The porosity and permeability measurements were obtained from Mr. Doyle. This report describes the results of the x-ray diffraction and electron microscopic analysis on the samples. These results were already transmitted to Mr. Doyle over the phone on March 11, 1983.

X-RAY DIFFRACTION ANALYSIS

X-ray diffraction analysis has been first carried out on the bulk finely ground sample. Subsequently the clay-size fractions (-4 microns) were separated and oriented clay films were prepared. These clay slides were x-rayed in air-dried state and after saturation with ethylene glycol. The results of the x-ray diffraction analysis are given in Table 1 for the bulk samples and in Table 2 for their clay-sized fractions.

Figure # 13

Sample # Patton Well 1-3/5324'

Magnification: 3,000X

Film # A3002

Description:

A higher magnification image of the pore space between the quartz and chert grains in the above figure.



Figure # 14

Sample # Patton Well 1-3/5324'

Magnification: 5,000X

Film # A3032

Description:

Aggregates of pyrite octahedra and surrounding quartz overgrowth faces. Authigenic pyrite occurs in appreciable quantities (4%) in this sandstone.



Figure # 11

Sample # Patton Well 1-3/5324'

Magnification: 5,000X

Film # A3043

Description:

A close view of authigenic chlorites which are surrounded by extensive quartz overgrowth forms.



Figure # 12

Sample # Patton Well 1-3/5324'

Magnification: 800X

Film # A3001

Description:

Two sand grains (quartz and chert) next to each other; quartz is fully covered by overgrowth faces whereas chert is extensively coated with chlorites.



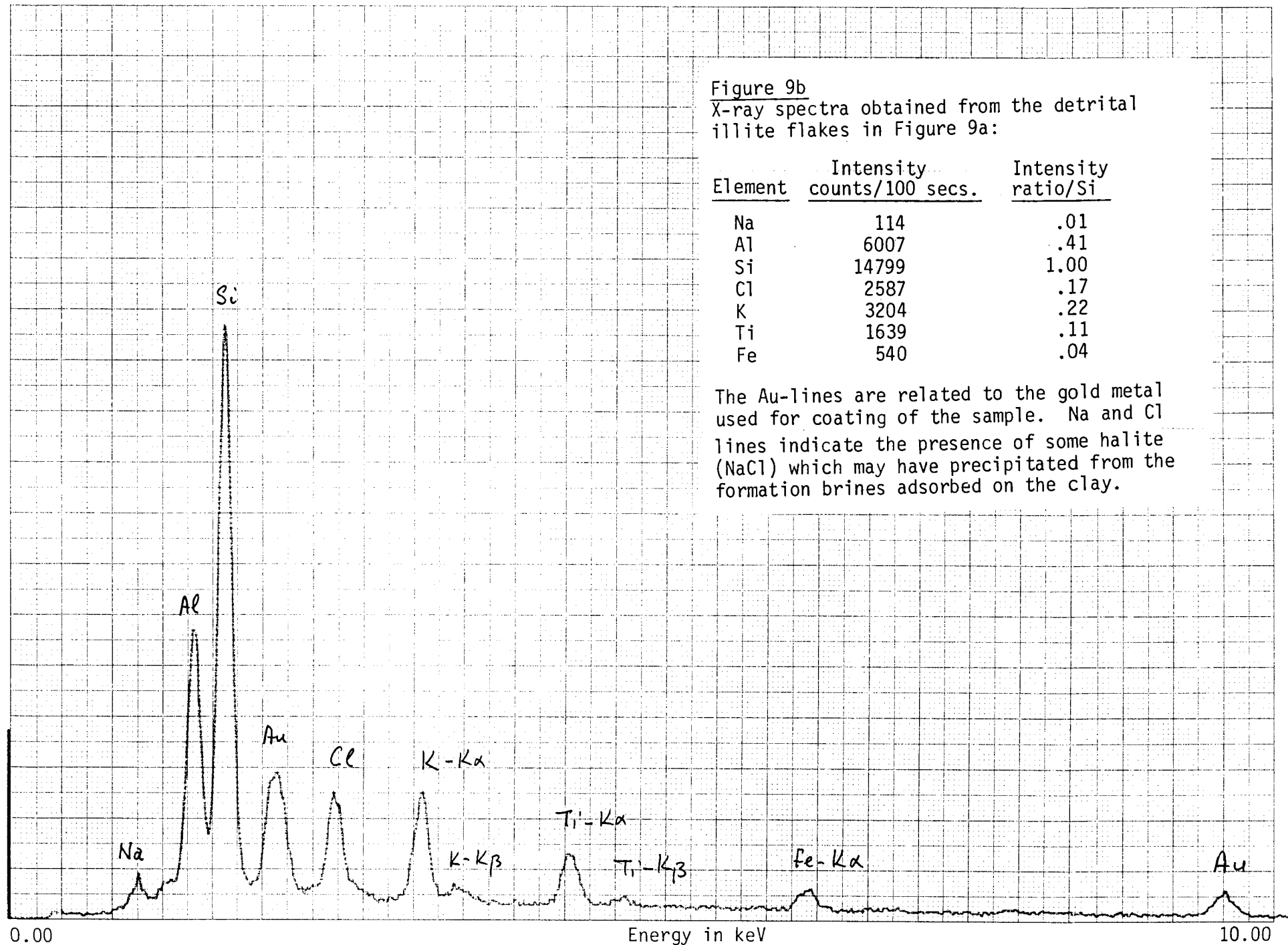


Figure 9b

X-ray spectra obtained from the detrital illite flakes in Figure 9a:

Element	Intensity counts/100 secs.	Intensity ratio/Si
Na	114	.01
Al	6007	.41
Si	14799	1.00
Cl	2587	.17
K	3204	.22
Ti	1639	.11
Fe	540	.04

The Au-lines are related to the gold metal used for coating of the sample. Na and Cl lines indicate the presence of some halite (NaCl) which may have precipitated from the formation brines adsorbed on the clay.

Figure # 9a

Sample # Patton Well 1-3/5321'

Magnification: 5,000X

Film # A2001

Description:

A close view of detrital illite with a laminar texture which is squeezed between the sand grains.



Figure # 10

Sample # Patton Well 103/5324'

Magnification: 300X

Film # A3040

Description:

A general view of the sandstones with the primary grains ranging in size from 80 to 150 microns. Extensive quartz overgrowths and some clay coatings are developed. Some chert grains (lower right) are also visible with microquartz crystals.



Project designation: MURFIN'S Patton Well 1-3
Sample #/Depth: Sandstone/5324 ft.

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GENERAL FEATURES OF ROCK FRAMEWORK AND PORES:

An extremely fine-grained sandstone with extensive quartz overgrowths and authigenic chlorite coatings. Quartz is the major detrital component. Minor amounts of chert is also found along with authigenic pyrite (Figure 14).

AUTHIGENIC MINERALS (morphology, chemistry, and mode of occurrence):

Secondary silica (mostly as quartz overgrowths and some microquartz), iron-rich chlorites, and pyrite are the major authigenic minerals that formed as the products of the diagenesis. Typical quartz overgrowths are shown in Figures 10-13. Chlorite occur as blades which are often surrounded by silica overgrowths (Figure 11). Chert grains are extensively covered by authigenic chlorites and microquartz (Figures 12 and 13). Pyrite develop octahedral forms and such pyrite aggregates are displayed in Figure 14.

EFFECTS OF AUTHIGENIC MINERALS ON RESERVOIR QUALITY:

Secondary silica (especially quartz overgrowth faces) and authigenic chlorites as pore-linings decrease the pore diameters, and thus reduce both porosity and permeability in the reservoir.

FLUID SENSITIVITY OF THE ROCK:

Authigenic iron-rich chlorites make the reservoir extremely sensitive to the injection of acids. If proper chelating agents are not used, the acidization may cause severe formation damages due to the precipitation of iron hydroxides.

Figure # 7

Sample # Patton Well 1-3/5321'

Magnification: 800X

Film # A2013

Description:

Authigenic clay minerals (kaolinite, chlorite, and illite), and secondary silica in the sandstone.



Figure # 8

Sample # Patton Well 1-3/5321'

Magnification: 4,000X

Film # A2014

Description:

A close view of authigenic illite/smectite mixed-layers which occur only in minor amounts in the sandstone.



Figure # 5

Sample # Patton Well 1-3/5321'

Magnification: 500X

Film # A2048

Description:

A general view of the sandstone: fine-grained quartz is heavily coated with authigenic chlorite. The primary quartz grains are extensively covered by overgrowth faces.



Figure # 6

Sample # Patton Well 1-3/5321'

Magnification: 4,000X

Film # A2049

Description:

A close view of the clays in the sandstone: bladed authigenic chlorite with some illite fibers occur as attached to the quartz grains. Booklets of authigenic kaolinite fill the pores (on the right section of the figure).



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GENERAL FEATURES OF ROCK FRAMEWORK AND PORES:

Extremely fine-grained sandstone in which quartz grains of 80-100 microns are the only framework grains and feldspars are totally destroyed (Figure 5). Primary intergranular pores are extensively lined with authigenic clays and secondary silica.

AUTHIGENIC MINERALS (morphology, chemistry, and mode of occurrence):

Secondary silica predominantly as overgrowths with some microquartz, and authigenic clay minerals are the diagenetic products in the sandstone. The authigenic clays consist primarily of kaolinite and chlorite, and of smaller amounts of illite (Figures 6 and 7). Authigenic chlorites are iron-rich and they occur as pore-linings. Authigenic kaolinites consist of vermicular stacks of hexagonal platelets and they develop as pore-fillings. Illites occur in minor amounts as authigenic fibers associated with chlorite platelets (Figure 6). More commonly, illites consist of detrital clay laminae which are squeezed between sand grains (Figure 9a). The x-ray spectra obtained from these illites given in Figure 9b confirm their identification.

EFFECTS OF AUTHIGENIC MINERALS ON RESERVOIR QUALITY:

Secondary silica precipitations (especially as overgrowths) and grain coatings of authigenic chlorites adversely affect both the intergranular porosity and the permeability. Furthermore authigenic kaolinites occur as pore-fillings and may interrupt the pore connections.

FLUID SENSITIVITY OF THE ROCK:

The sandstone is extremely acid sensitive due to iron-rich chlorites. The loosely attached kaolinite platelets are very susceptible to cause migration of fines in the reservoir. To a minor extent illite and illite/smectite mixed-layer may give rise to some swelling problems.

Figure # 3

Sample # Patton Well 1-3/5318'

Magnification: 1000X

Film # A1000

Description:

Authigenic chlorite coatings and microquartz crystals growing on the primary grains of the sandstone.



Figure # 4

Sample # Patton Well 1-3/5318'

Magnification: 6,000X

Film # A1012

Description:

A magnified view of the syntaxial growth of quartz engulfing the chlorite platelets that have precipitated earlier.



Intensity
counts/100 secs.

Figure 2b
X-ray spectra obtained from the chlorite
blades in Figure 2a:

Element	Intensity counts/100 secs.	Intensity ratio/Si
Al	1832	.19
Si	9541	1.00
Fe	3099	.32
K	340	.04
Mg	276	.03

The Au-lines belong to the gold metal used
for the coating of the sample.

The above spectra indicate an iron-rich
variety of chlorite.

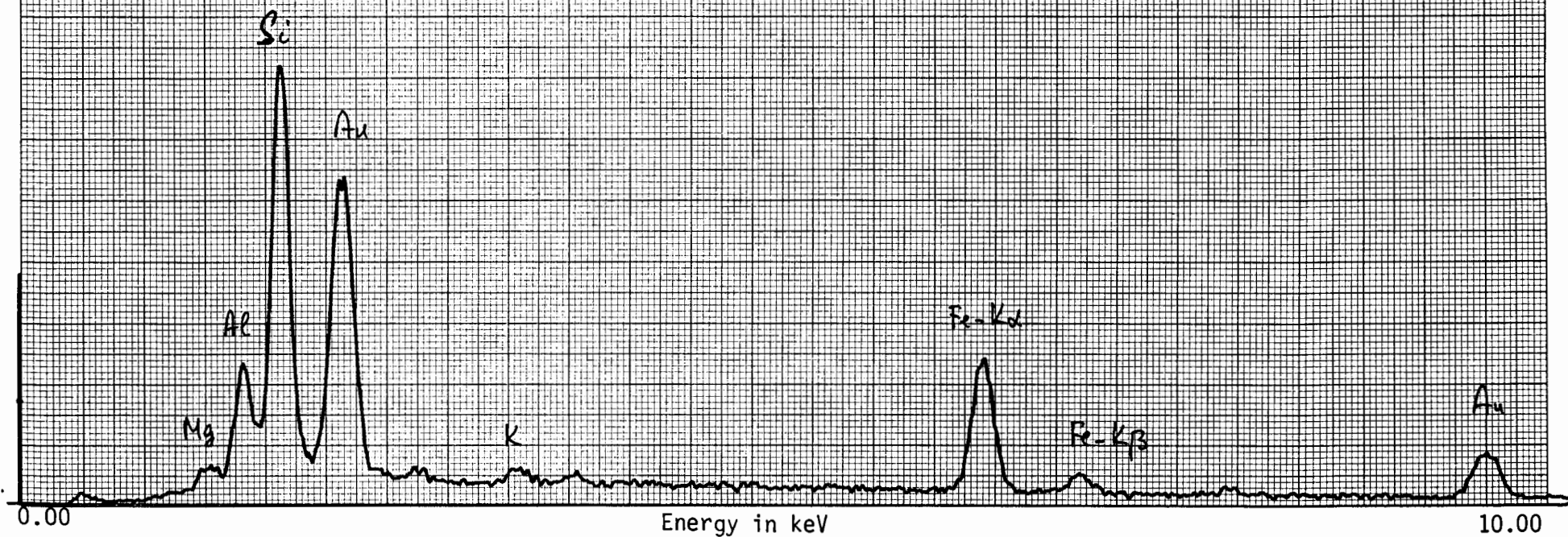


Figure # 1.

Sample # Patton Well 1-3/5318'

Magnification: 500X

Film # A1010

Description:

A fine-grained sandstone consisting of quartz with overgrowths and clay coatings. An unstable grain (possibly a feldspar) is mostly dissolved. Intergranular (primary) pores are well connected to each other.



Figure # 2a

Sample # Patton Well 1-3/5318'

Magnification: 6,000X

Film # A1011

Description:

A close view of the clays coating the quartz grains in the above figure. The platelets are authigenic chlorites which are edge-wise attached to sand grains. A few micro-quartz grains are also seen as equant crystals at the center of the figure.



Project designation: MURFIN'S Patton Well 1-3
Sample #/Depth: Sandstone/5318 ft.

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GENERAL FEATURES OF ROCK FRAMEWORK AND PORES:

A very fine-grained sandstone with the grain size ranging from 50 to 100 microns. Quartz is the only detrital mineral and feldspars are totally destroyed (Figure 1) which generates secondary pores. Primary intergranular pores are narrowed by authigenic minerals.

AUTHIGENIC MINERALS (morphology, chemistry, and mode of occurrence):

Chlorites and secondary silica are the major authigenic minerals in the sandstone. Chlorites occur as platelets which are edge-wise attached to the sand grains. They are iron-rich variety of chlorite as indicated by EDAXS analysis (Figure 2b). Typical authigenic chlorites are shown as grain coatings in Figures 2a and 3. Secondary silica precipitates most commonly as overgrowth faces (Figures 1 and 4) and sometimes as microquartz (ranging in size from 2 to 10 microns). The latter seems to precipitate at the same time as chlorite. The overgrowths continue to develop and engulf the previously formed chlorites (Figure 4).

EFFECTS OF AUTHIGENIC MINERALS ON RESERVOIR QUALITY:

Authigenic iron-rich chlorites and secondary silica (especially the large overgrowth faces occlude considerably the porosity by narrowing the pore spaces. This will decrease both porosity and effective permeability of the reservoir rock.

FLUID SENSITIVITY OF THE ROCK:

The extensive pore-linings of chlorite make the reservoir extremely acid sensitive. Acidizing should be done with the addition of chelating agents so that a possible iron hydroxide precipitation will be avoided. These iron oxides are gelatinous and can cause severe formation damage.

APPENDIX. Tables and Figures

- b) iron-rich chlorites precipitate as bladed crystals lining the pores by coating the quartz grains.
 - c) authigenic kaolinites occur as pore-fillings in the sandstone.
 - d) authigenic pyrites are found in appreciable quantities (4%) in the sandstone from 5321 feet.
 - e) minor amounts of illite, and illite/smectite mixed-layers also occur as authigenic mineral in the sandstone but illites are mainly detrital in origin.
- 3) These diagenetic minerals (especially secondary silica and clay minerals) decrease the pore spaces and the permeability of the sandstones. The major potential reservoir problems are related to:
- a) extreme acid sensitivity due to iron-rich chlorites unless proper chelating additives are used.
 - b) migration of fines due to loose kaolinite platelets and illite fibers. This requires the addition of clay stabilizers in the injected fluids.
 - c) possible water sensitivity due to the swelling of illite/smectite mixed-layers in the formation. This is however a minor problem because of low content of the swelling clays. Nonetheless a KCl or similar salt solution should be added to the fluids during drilling and completion.

Quartz (including chert and microquartz) make up about 80% of the samples. Feldspars occur only in trace quantities and dolomite is found only in one sandstone from 5324 feet. The latter sample contains also considerable amounts (4%) of pyrite. The clay minerals are present in large quantities in these sandstones and they make up about 20% of the samples. Chlorite (an iron-rich variety) is the major clay mineral in the reservoir. Illite occurs in trace amounts in sandstones from 5318 and 5324 feet but in larger quantities (4%) in the sandstone from 5321 feet. The latter sandstone contains also significant amounts (9%) of kaolinite. The only swelling-type clay mineral is found in sample from 5321 feet and it is composed of an illite/smectite mixed-layer. The characteristic features of these clay minerals and their effects on the reservoir quality are described in the following section.

SEM EXAMINATION OF THE MORROW SANDSTONES

The sandstones have been examined with scanning electron microscopy (SEM) and energy-dispersive analysis of x-ray spectra (EDAXS). The results for the individual samples have been described in the following pages. A brief summary of these results is given in the following:

- 1) The sandstones are extremely fine-grained with the grain size ranging from 50-150 microns. Quartz is the major framework (detrital) mineral with some chert grains. Feldspars are mostly dissolved, generating some secondary porosity in the rock.
- 2) Diagenetic reactions in the sandstone involve:
 - a) extensive precipitation of silica predominately as over-growth faces with some microquartz.