WESTERN ATLAS

Core Laboratories

SEDIMENTOLOGY AND PETROLOGY
of a
CONVENTIONAL CORE (2,645.0 - 2,705.4 FEET)
ANADARKO PETROLEUM CORPORATION
THOMPSON F - 1H WELL, HUGOTON FIELD
KRIDER MEMBER, NOLANS LIMESTONE
ODELL SHALE
WINFIELD LIMESTONE
SEWARD COUNTY, KANSAS

RESERVOIR GEOLOGY
FILE NO.: 194240

Prepared for
ANADARKO PETROLEUM CORPORATION

Prepared by
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November, 1994

WESTERN ATLAS

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November 8, 1994

Anadarko Petroleum Corporation
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Houston, Texas 77060

Attention: Mr. Ray Sorenson

Subject: Sedimentology and Petrography Study
Operator: Anadarko Petroleum Corporation
Well: Thompson F - 1H
Location: Hugoton Field
Seward County, Kansas
Formations: Krider Member: Nolans Limestone; Odell Shale.; Winfield Limestone
Age: Permian Wolfcampian

Dallas Reservoir Geology File No.: 194240

Dear Mr. Sorenson:

This report presents the results of a detailed description of 60.4 feet of conventional core (2,645.0 - 2,705.4 feet) from the above referenced well. The core was described in detail, and an interpretation was made of the depositional environments. Five samples were selected for geological characterization using thin section petrography and scanning electron microscopy. X-ray diffraction (XRD) was performed on three samples. The reservoir potential of each lithofacies was evaluated.

Two copies of this report and an accompanying core description have been delivered to your offices in Houston, Texas. It has been our pleasure to perform this study for you. If you have any questions, or if we can be of any further service, please do not hesitate to call.

Sincerely,
CORE LABORATORIES
Reservoir Geology

Jerry S. Kier
Senior Project Coordinator

PROJECT REVIEW

Jerry S. Kier
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Computer Drafting

Malcolm Jones
X-ray Diffraction Analysis

Mark Smesny
Thin Section Preparation

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TABLE OF CONTENTS

SUMMARY

- A total of 60.4 feet (2,645.0 - 2,705.4 feet) of conventional core taken through three Lower Permian (Wolfcampian) formations of the Chase Group in the Anadarko Petroleum Thompson F - 1H Well, Hugoton Field, were described in detail. A total of 7 samples were examined geologically to aid in understanding rock texture, mineralogy, diagenesis, and porosity preservation and/or development. Core depth +7.5 feet is equal to log depth (well depth).

- The Krider Member of the Nolans Limestone is dolostone with grainstone, packstone, wackestone, and mudstone textures. The framework components in the grainstones and packstones are mainly oncoids and pelecypods, with lesser amounts of peloids and echinoderms. The wackestones and mudstones contain abundant peloids and pelecypods. Anhydrite nodules are common throughout the Krider Member. These nodules formed mainly as replacement of grains and matrix. The environment of deposition for the Krider Member is interpreted to be a restricted, shallow lagoon. The abundance of intercrystalline and grain-moldic pores indicates good to excellent reservoir rock characteristics.

- The Odell Shale is comprised of matrix-rich dolomitic shales and argillaceous dolostones. Red beds with caliche soil horizons are identified. Overall, the Odell Shale shows decreasing marine influence from its base upward to 2,678.1 feet, with depositional environments changing from shallow lagoon to continental supratidal/coastal plain. Above this, marine influence increases. The fine-grained, matrix-rich rocks of the Odell Shale are judged to be poor reservoir rocks.

- The Winfield Limestone is dolostone with grainstone to packstone textures. Skeletal fragments, mainly echinoderms and pelecypods, and intraclasts are common. A shoal or bar deposited in an open marine environment is suggested for the depositional environment. Both intercrystalline and grain-moldic pores are abundant. These rocks are judged to have good to excellent reservoir rock characteristics.

- An overall marine regressive sequence is defined from the base of the cored Winfield Limestone interval (2,705.4 feet) to a depth of 2,678.1 feet in the Odell Shale. Depositional environments change from open marine, to shallow lagoon, to supratidal/coastal plain. Sediments above this depth show increasing marine influence, from tidal flats to restricted lagoon, and record the onset of a marine transgression.

INTRODUCTION

The Kansas Hugoton Field is located in southwestern Kansas. It was discovered in 1922, and is part of the large Hugoton Field that extends through the Oklahoma panhandle to the Texas panhandle. Most of the Hugoton Field development followed World War II, and it is now the largest gas field in North America. The rocks are mainly shallow marine to supratidal dolostones and evaporites interbedded with continental siltstone and shale redbeds.

A total of 60.4 feet of conventional core taken through three Lower Permian (Wolfcampian) formations of the Chase Group in the Anadarko Petroleum Thompson F - 1H Well, Hugoton Field, were described in detail. A total of 7 samples were examined geologically to aid in understanding rock texture, mineralogy, diagenesis, and porosity preservation and/or development. The cored intervals and examined samples are presented in Table 1.

Table 1

Formation/Member	Cored Interval (feet)	Samples Examined (feet)
Krider Limestone	2,645.0 - 2,674.1	2,646.0, 2,647.8. 2,660.8, 2,665.7
Odell Shale	2,674.1 - 2, 697.3	2,682.2, 2,689.4
Winfield Limestone	2,697.3 - 2,705.4	2,700.5

Thin section petrography and scanning electron microscopy (SEM) analysis were performed on all samples except those from the Odell Shale. Samples from 2,665.7, 2,682.2 and 2,689.4 feet were analyzed with X-ray diffraction (XRD) in order to better understand mineralogy.

The goals of this study are as follows:

- Determine the environments of deposition of the described core.
- Determine the effect of depositional environment on reservoir quality.

The sedimentology and petrography discussion in this report is divided into three sections by formation. Carbonate rock types are classified according to a textural system devised by Dunham (1962; Figure 3).

SEDIMENTOLOGY AND PETROGRAPHY

Core depths are used throughout this report unless otherwise stated. Correlation of the wireline gamma ray log with the core gamma ray log reveals that core depth +7.5 feet is equal to the log depth. The sedimentology and petrography of each formation is discussed separately in this section of the report. Rock colors mentioned in the core description are taken from a GSA Rock-Color Chart.

Krider Member: Nolans Limestone

A total of 29.1 feet (2,645.0 - 2,674.1 feet) of core was described through the Krider Member. Samples from 2,646.0, 2,647.8. 2,660.8, 2,665.7 feet were examined geologically. The core is dolostone with grainstone, packstone, wackestone, and mudstone textures. The dolomitization process has obscured textures and made their differentiation difficult. The framework components in the grainstones and packstones are mainly oncoids (Plate 5) and pelecypods (Plate 1), with lesser amounts of peloids and echinoderms. The wackestones and mudstones contain abundant peloids and pelecypods. Contacts between depositional units are generally scoured. Compaction seams, along which insoluble residues have collected, are common. Microstylolites are less common.

Anhydrite nodules are common throughout the Krider Member. These nodules formed mainly as replacement of grains and matrix (Plates 1, 3, and 5). As such, they formed in the subsurface after sediment burial and dolomitization. However, anhydrite nodules in the sample from 2.665.7 (Plate 7) feet are clearly displacive, formed near the sediment/water interface, under hypersaline conditions. Some of these anhydrite nodules have been partially to totally replaced by chalcedony. Chalcedony replacement of anhydrite appears to be most common between 2,661 - 2,665.8 feet.

The sample from 2,667.5 feet was analyzed with XRD (Table 2). It is composed mainly of dolomite and a minor amount of quartz. Clay minerals account for only one percent of the bulk sample. Halite was detected in the sample from 2,667.5 feet (Plate 8). It is judged to be a natural cement and not a precipitate that formed from pore waters as the core dried. The presence of halite in the cored interval between 2,662 - 2,669 may account for the lowered log resistivity detected between 2,668 - 2,677 feet.

The environment of deposition for the Krider Member is interpreted to be a restricted, shallow lagoon. The paucity of echinoderms, as well as displacive anhydrite and depositional halite at the base of the interval, suggest periodic hypersalinity. The Krider Member marks the beginning of a marine transgression over the more continental rocks of the Odell Shale (Figure 1).

The original limestone has been replaced by fine- to medium-crystalline, subhedral to euhedral dolomite (Plates 1 and 2). This has resulted in the formation of abundant intercrystalline pores (Plates 1 and 6). Dissolution of skeletal particles, especially pelecypods, has resulted in the formation of secondary, grain-moldic pores (Plates 1 and 2). Some of these pores may have been solution enlarged (Plate 3). Average porosity is 12.9 percent (4.3 - 24.0 percent) and average permeability is 4.34 millidarcys (0.005 - 37.1 millidarcys). The range of porosity and permeability values are displayed in Figure 2 and Table 3. Insoluble residue collects along compaction seams and microstylolites. These features are common in the Krider Member and will result in vertical permeability barriers. Overall, the Krider Member of the Nolans Limestone is judged to display good to excellent reservoir rock characteristics.

Odell Shale

A total of 23.2 feet of core (2,674.1 - 2,697.3 feet) were described from the Odell Shale. No samples were selected for thin section petrography or SEM. However, samples from 2,682.2 and 2,689.4 feet were analyzed with XRD (Table 2).

The rocks cored in the interval from 2,674.1 - 2,686.5 feet are shales to dolomitic shales and argillaceous dolomudstones. Color varies from dark gray and light olive gray, to reddish gray. The rocks are laminated to burrowed and bioturbated. Caliche nodules are abundant from 2,682.5 - 2,686.0 feet within the grayish red, dolomitic shale. This represents a subaerially weathered soil horizon. XRD data from a sample at 2,682.2 feet shows it to be an argillaceous dolostone (Table 2) The clay mineral suite is dominated by illite and mixed-layer illite/smectite. Desiccation cracks and a dissolution surface are discernible at 2,678 - 2,679 feet. The interpreted environments of deposition are tidal flat to supratidal/coastal plain (Figure 1).

The interval from 2,686.5 - 2,697.3 feet is interbedded dolomudstone, dolowackestone, and dolomitic shale. Rock color varies from light olive gray to grayish red. Contacts between depositional units are scoured to sharp or bioturbated. The upper portion of the interval (2,686.5 - 2,689 feet) contains desiccation cracks and possible root mottles. Compaction seams and microstylolites are common throughout. Peloids and pelecypods are the only common identified grains, although rare echinoderms are identified in the basal section. XRD data for a sample from 2,689.4 feet (Table 2) indicates that it is a dolomitic shale, with most of the clay mixed-layer illite/smectite and illite.

Overall, the Odell Shale shows decreasing marine influence from its base upward to 2,678.1 feet. The root mottles and desiccation cracks between 2,686.5 - 2,689 feet mark the transition from shallow lagoon to continental supratidal/coastal plain environments. Soil horizons containing caliche are found in the red shales of the continental facies. The contact at 2,678.1 feet displays dissolution features and desiccation cracks suggesting subaerial exposure. This is overlain by dark, laminated shale interpreted to have been deposited in a tidal flat environment. This marks the beginning of a marine transgression that continues through the overlying Krider Member of the Nolans Limestone.

The pore system in the Odell shale consists mainly of micropores within these matrix-rich rocks. Moldic pores, partially filled with solid hydrocarbon, were observed in the peloid, pelecypod dolowackestone between 2,690.2 - 2,693.8 feet. Porosity averages 7.9 percent (3.6 - 14.0 percent) and permeability averages 1.40 millidarcys (0.002 - 5.62 millidarcys). However, these matrix-rich samples are subject to desiccation-related fractures that will result in an increase in permeability in some samples. Therefore, the median permeability of 0.103 millidarcys may be more typical for the interval. These rocks are judged to be poor reservoir rocks.

Winfield Limestone

Core from 2,697.3 - 2,705.4 feet, a total of 8.1 feet, was described from the Winfield Limestone. A sample from 2,700.5 was examined with thin section petrography and SEM (Plates 9 and 10). The core is all dolostone, with grainstone to packstone textures. Skeletal fragments, mainly echinoderms and pelecypods, and intraclasts are common. Oncoids are rare. Microstylolites and compaction seams are common. Insoluble residues that collect along these seams can be considered vertical permeability barriers.

The paucity or lack of depositional matrix indicates that rocks of the cored interval were deposited in relatively high energy conditions. The abundance of echinoderms suggests normal marine salinity. Therefore, a shoal or bar deposited in an open marine environment is suggested for the depositional environment.

Both intercrystalline and grain-moldic pores are evident in the sample examined petrographically (Plate 9). There appears to be some solution enlargement of moldic pores. The elongated to arcuate shape of the moldic pores suggests that pelecypods may have been leached. Anhydrite has unevenly replaced dolomite (Plates 9 and 10). Average porosity for the Winfield Limestone is 12.4 percent (9.0 - 18.3 percent) and average permeability is 3.50 millidarcys (0.264 - 9.15 millidarcys). These rocks are judged to have good to excellent reservoir rock characteristics.

An overall marine regressive sequence is defined from the base of the cored Winfield Limestone interval to a depth of 2,678.1 feet in the Odell Shale. Depositional environments change from open marine, to shallow lagoon, to supratidal/coastal plain. Sediments above this depth show increasing marine influence, from tidal flats to restricted lagoon, and record the onset of a marine transgression.

Table 2

X-ray Diffraction Data

Anadarko Petroleum Corporation
Thompson F - 1H Well

	Whole Rock Composition (weight %)										Relative Clay Abundance (Normalized to 100%)			
Depth, feet	Quartz	K feldspar	Plagioclase	Calcite	Dolomite	Siderite	Pyrite	Anhydrite	Gypsum	*Total Clays*	Illite	Kaolinite	Chlorite	Illite/ Smectite
2,667.5	4	0	1	Tr	93	0	Tr	Tr	1	*1*	64	36	0	0
2,682.2	18	0	6	0	64	0	0	0	0	*12*	65	0	11	24
2,689.4	27	0	12	0	24	0	1	0	0	*36*	28	0	8	64

Percent of smectite in mixed-layer clay is 10%.

Figure 2

Porosity versus Permeability
Anadarko Petroleum Corporation
Thompson F - 1H Well

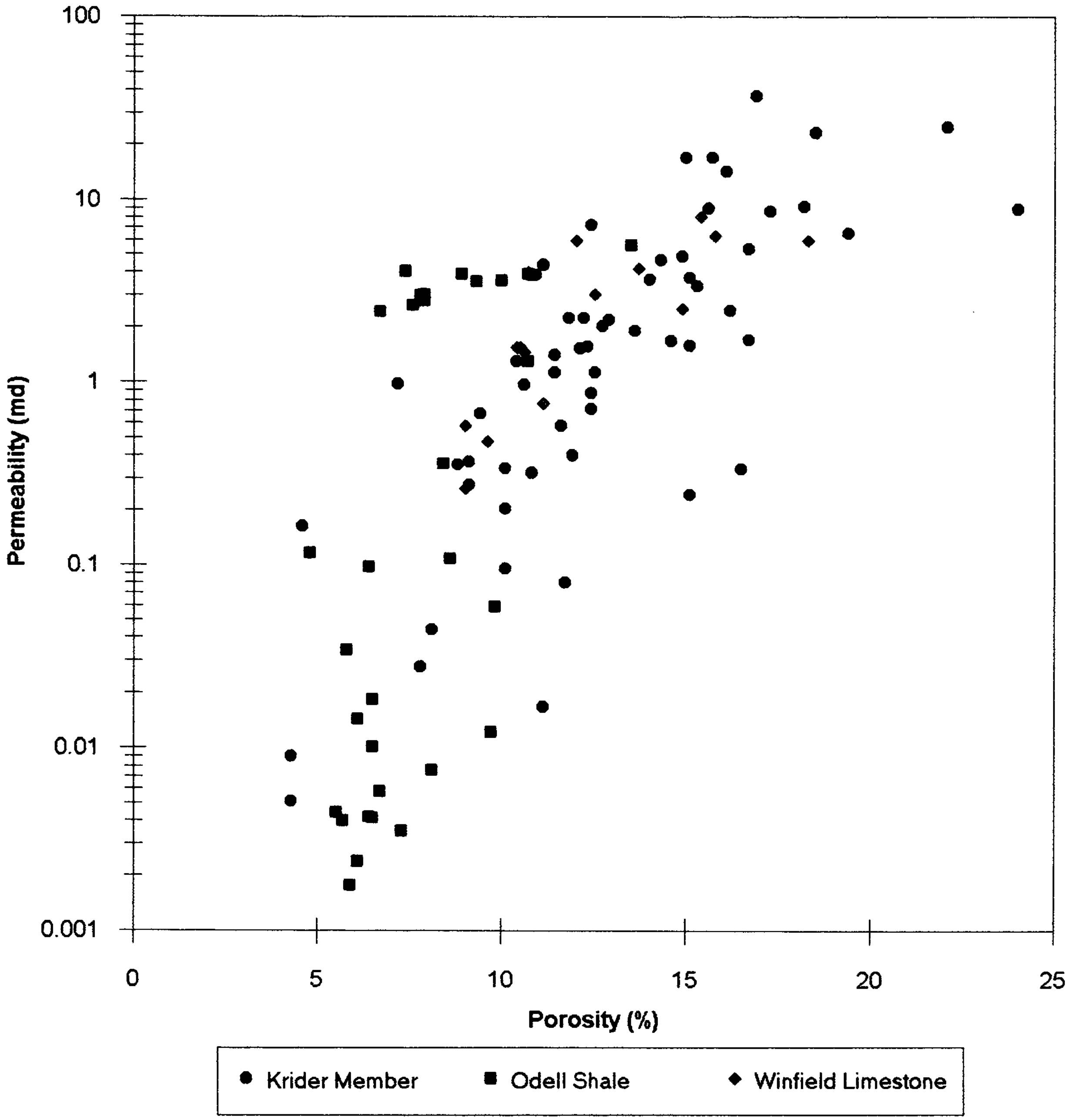

Table 3

Standard Core Analysis Data

Anadarko Petroleum Corporation

Thompson F- 1H Well

Depth (feet)	Porosity (%)	Klinkenberg Permeability (md)	Grain Den. g/cm3
Krider Member: Nolans Limestone			
2,645.3	16.2	2.47	2.84
2,645.8	11.6	0.581	2.83
2,646.3	15.1	1.59	2.83
2,646.8	9.1	0.369	2.84
2,647.3	19.4	6.55	2.82
2,647.8	10.1	0.095	2.83
2,648.3	12.9	2.19	2.84
2,648.8	12.4	0.719	2.82
2,649.3	12.4	0.869	2.83
2,649.8	12.1	1.53	2.84
2,650.3	11.9	0.399	2.83
2,650.8	10.1	0.204	2.84
2,651.3	9.1	0.274	2.83
2,651.8	16.7	1.70	2.83
2,652.3	15.1	3.76	2.84
2,652.8	14.9	4.89	2.84
2,653.3	14.6	1.67	2.84
2,653.8	12.3	1.57	2.85
2,654.3	17.3	8.66	2.85
2,654.8	15.7	17.0	2.85
2,655.3	14.0	3.68	2.84
2,655.8	11.1	4.40	2.83
2,656.3	16.9	37.1	2.84
2,656.8	16.7	5.39	2.84
2,657.3	11.4	1.13	2.83
2,657.8	16.1	14.4	2.84
2,658.3	13.6	1.91	2.83
2,658.8	7.8	0.028	2.82
2,659.3	7.2	0.978	2.83
2,659.8	10.6	0.975	2.83
2,660.3	12.4	7.27	2.84
2,660.8	15.0	17.0	2.84
2,661.3	18.2	9.19	2.79
2,661.8	10.8	0.320	2.80
2,662.3	15.6	8.98	2.83
2,662.8	12.7	2.01	2.83
2,663.3	14.3	4.67	2.83

Table 3

Standard Core Analysis Data

Anadarko Petroleum Corporation

Thompson F- 1H Well

Depth (feet)	Porosity (%)	Klinkenberg Permeability (md)	Grain Den. g/cm3
2,663.8	22.1	25.1	2.73
2,664.2	24.0	8.88	2.65
2,664.7	11.4	1.40	2.83
2,665.3	8.1	0.044	2.83
2,665.7	16.5	0.335	2.72
2,666.2	4.6	0.164	2.80
2,666.8	10.4	1.30	2.84
2,667.3	11.7	0.080	2.79
2,667.8	10.9	3.86	2.84
2,668.3	11.8	2.25	2.83
2,668.8	10.1	0.339	2.84
2,669.3	15.1	0.241	2.85
2,669.8	15.3	3.38	2.84
2,670.3	9.4	0.672	2.84
2,670.8	18.5	23.4	2.83
2,671.3	4.3	0.009	2.86
2,671.8	12.5	1.13	2.84
2,672.3	8.8	0.357	2.84
2,672.8	12.2	2.24	2.85
2,673.3	11.1	0.017	2.84
2,673.8	4.3	0.005	2.84
Average	12.9	4.34	2.83
Median	12.4	1.58	2.84
Minimum	4.3	0.005	2.65
Maximum	24.0	37.1	2.86
Number	58	58	58
		Odell Shale	
2,674.3	5.5	0.004	2.76
2,674.8	6.5	0.004	2.75
2,675.3	8.4	0.360	2.71
2,675.8	6.1	0.014	2.78
2,676.3	14.0		2.67
2,678.4	8.1	0.008	2.79
2,678.7	4.3	<.001	2.81
2,679.4	7.6	2.65	2.78
2,679.8	6.7	2.44	2.78

Table 3

Standard Core Analysis Data

Anadarko Petroleum Corporation

Thompson F- 1H Well

Depth (feet)	Porosity (%)	Klinkenberg Permeability (md)	Grain Den. g/cm3
2,680.2			2.68
2,680.7	7.8	3.01	2.74
2,681.3	7.9	2.82	2.81
2,681.8	10.0	3.62	2.76
2,682.3	9.3	3.58	2.76
2,682.7			2.72
2,683.2	11.7		2.71
2,683.8	8.1		2.71
2,684.3	10.7	3.92	2.63
2,684.6	10.8	3.89	2.71
2,685.2	7.9	3.05	2.79
2,685.8	7.9		2.58
2,686.4	12.4		2.70
2,686.7	5.8	0.034	2.83
2,687.3	7.3	0.004	2.83
2,687.8	6.4	0.004	2.81
2,688.3	8.9	3.92	2.76
2,688.8	7.4	4.07	2.75
2,689.4	7.9		2.77
2,689.8	7.4		2.78
2,690.3	3.6	<.001	2.82
2,690.8	6.5	0.018	2.83
2,691.3	10.7	1.29	2.84
2,691.8	5.7	0.004	2.83
2,692.3	8.6	0.109	2.83
2,692.8	6.1	0.002	2.83
2,693.3	9.8	0.059	2.84
2,693.8	6.5	0.010	2.82
2,694.4	9.7	0.012	2.83
2,694.8	6.7	0.006	2.83
2,695.3	4.8	0.117	2.84
2,695.8	5.9	0.002	2.84
2,696.3	6.4	0.098	2.84
2,696.3	3.6	<.001	2.84
2,697.2	13.5	5.62	2.83
Average	7.9	1.40	2.78
Median	7.7	0.103	2.79
Minimum	3.6	0.002	2.58

Table 3

Standard Core Analysis Data

Anadarko Petroleum Corporation

Thompson F- 1H Well

Depth (feet)	Porosity (%)	Klinkenberg Permeability (md)	Grain Den. g/cm3
Maximum	14.0	5.62	2.84
Number	42	32	44
	Winfield Limestone		
2,697.8	13.7	4.22	2.84
2,698.2	10.6	1.46	2.83
2,698.2	10.7	4.03	2.84
2,699.3	9.0	0.581	2.86
2,699.8	9.6	0.479	2.85
2,700.3	10.4	1.54	2.86
2,700.8	11.1	0.764	2.87
2,701.3	9.0	0.264	2.85
2,701.8	10.5	1.54	2.85
2,702.3	12.0	5.97	2.84
2,702.8	15.4	8.13	2.84
2,703.3	18.3	5.97	2.84
2,703.8	15.6	9.15	2.84
2,704.3	14.9	2.51	2.85
2,704.8	15.8	6.33	2.84
2,705.3	12.5	3.04	2.83
Average	12.4	3.50	2.85
Median	11.6	2.77	2.84
Minimum	9.0	0.264	2.83
Maximum	18.3	9.15	2.87
Number	16	16	16

FIGURE 3.

DUNHAM CLASSIFICATION OF LIMESTONES
(DUNHAM, 1962)

<table>
<tr><td colspan="5">RECOGNIZABLE DEPOSITIONAL TEXTURE</td><td rowspan="5">UNRECOGNIZABLE DEPOSITIONAL TEXTURE</td></tr>
<tr><td colspan="4">PARTICULATE SEDIMENT</td><td rowspan="4">ORGANICALLY
BOUND
SEDIMENT</td></tr>
<tr><td colspan="2">CONTAINS MUD
MUD < 62.5 m</td><td colspan="2">MUD - FREE
(< 5 %)</td></tr>
<tr><td colspan="2">MUD - SUPPORTED</td><td colspan="2">GRAIN - SUPPORTED</td></tr>
<tr><td>< 10 %
GRAINS</td><td colspan="3">> 10 % GRAINS</td></tr>
<tr><td>M
MUDSTONE</td><td>W
WACKESTONE</td><td>P
PACKSTONE</td><td>G
GRAINSTONE</td><td>B
BOUNDSTONE</td><td>RX - LS
RECRYSTALLIZED
LIMESTONE</td></tr>
</table>

ANALYTICAL PROCEDURES

Core Description

The slabbed core was described at a scale of one inch of description equals two feet of core. A binocular microscope, dilute hydrochloric acid, and a grain-size comparator were utilized. Grain variations are displayed as a "weathering profile" on the core descriptions that accompany this report. Reported colors are keyed from A GSA Rock-Color Chart.

Thin Sections

Thin sections were prepared from samples by first impregnating them with epoxy to augment cohesion and to prevent loss of material during grinding. Blue dye was added to the epoxy to highlight the pore spaces. Each sample was mounted on a frosted glass slide and then cut and ground in water to an approximate thickness of 30 microns. The thin sections were stained with Alizarin Red-S to differentiate calcite from dolomite. The thin sections were analyzed using standard petrographic techniques.

Scanning Electron Microscopy (SEM)

Each sample was mounted on an aluminum stub with a carbon-based paste so that a freshly broken surface was exposed. The samples were coated with gold-palladium (Au-Pd) alloy using a Polaron Coating Unit. The SEM photomicrographs are secondary electron images taken with a Polaroid camera attached to an ISI-SX-40 Scanning Electron Microscope operating at 20 kv. Qualitative elemental data on selected minerals observed during the SEM study were obtained through the use of an interfaced Tracor Northern 5400 Energy Dispersive Spectroscope equipped with a Si (Li) detector. Recognition of any authigenic clays was based on the criteria proposed in Wilson and Pittman (1977).

X-ray Diffraction Analysis (XRD)

Samples selected for XRD were dried and cleaned of any obvious contaminants. The sample is weighed and then placed in a sonic cell disrupter. The resultant slurry is placed in a centrifuge to fractionate the sample at 4 microns. The suspended <4 micron fraction is decanted and saved. The >4 micron fraction is dried and weighed to determine the percent of clay- and silt-sized material. The suspended <4 micron sample is suctioned onto a pure silver substrate to orient the clay mineral particles. The <4 micron sample mount is run in an air-dried state, then treated with ethylene glycol vapor for 24 hours and run again. The >4 micron fraction is milled and run on a Phillips APD 3600 diffractometer. The diffractograms are then analyzed for mineral content using a profile-fitting algorithm. The integrated areas from the profile-fitting algorithm are entered into a spreadsheet which contains the correction coefficients for numerous minerals. These coefficients were obtained according to the adiabatic method outlined by Chung (1974). Tabular data are reported in weight percent format in Table 2.

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Anadarko Petroleum
Thompson F-1H Well
Seward County, Kansas
Lithology: Dolostone
Texture: Packstone/Grainstone
Porosity: 11.6 percent
Permeability: 0.581 md

File: 194240

PLATE 1

Thin Section Photomicrographs
Sample Depth: 2,646.0 Feet
Krider Member

A

The texture in this sample has been obscured by dolomitization. It appears to contain only a minor amount of recrystallized matrix, and is therefore classified as a packstone/grainstone. Peloids (D1 and A11) and pelecypods (E9 and H4) are the most common framework components. Most of the pelecypods have been leached resulting in the formation of moldic pores. The pore system (blue) is comprised of a combination of moldic and intercrystalline pores. Anhydrite (white) is a common replacive cement. Note the small dolomite crystals within the nodule in the upper left. The black rim around the large moldic pore in the center of the photomicrograph is solid hydrocarbon. (31X, Transmitted light)

B

Solid hydrocarbon (black) lines a moldic pore derived from a leached pelecypod. Intercrystalline pores (H11 and J12-12.5) are also visible. The light colored dolomite crystals (C1 and G13) are cement, whereas the darker, inclusion-rich dolomite is matrix and/or peloids (A4 and H15). (125X, Transmitted light)

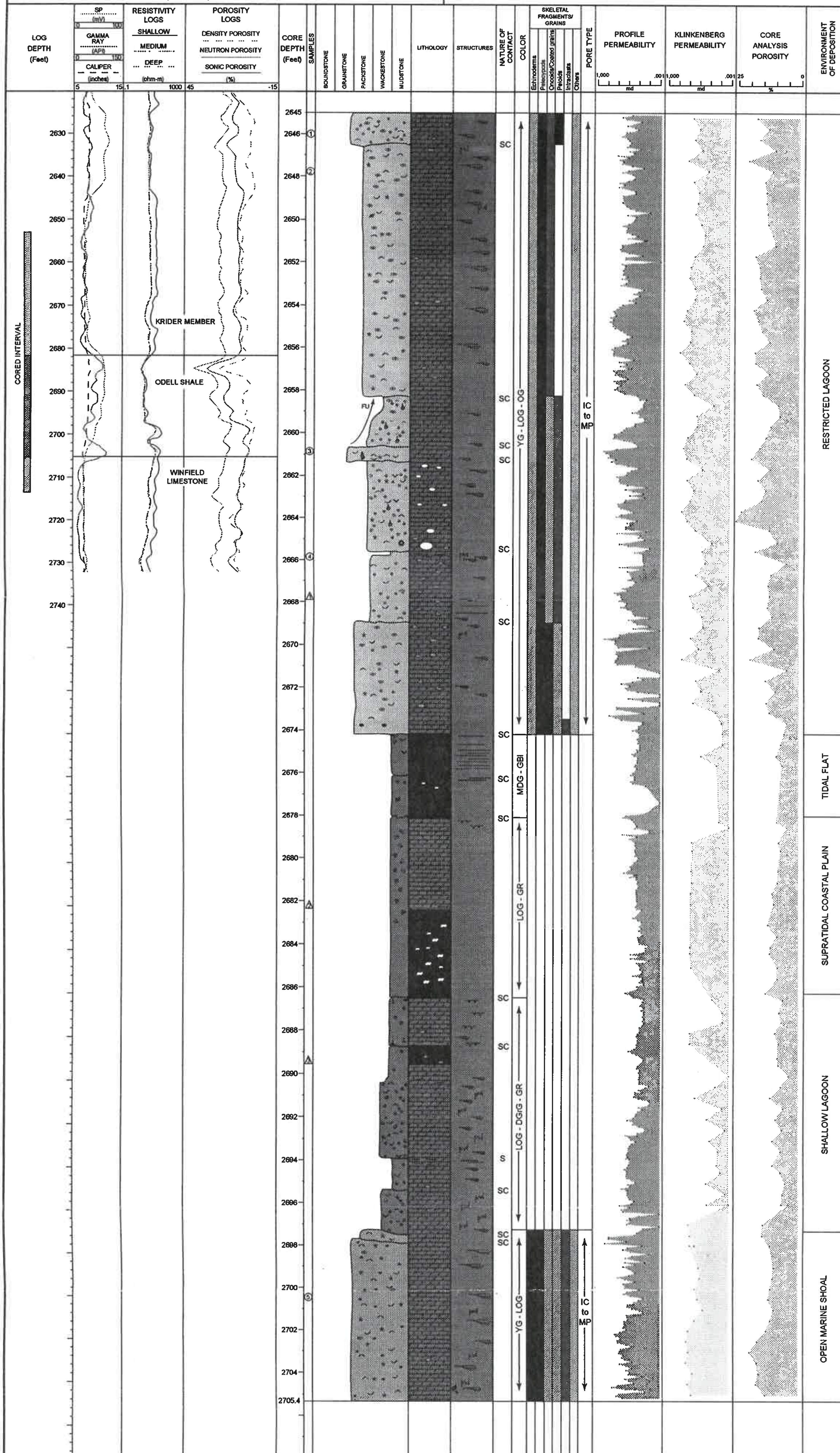
20-33-33W
15-175-21410

WESTERN ATLAS
Core Laboratories

Figure 1

Well: Thompson F - 1H
Company: Anadarko Petroleum Corp.
Field/Location: Hugoton; Seward County, Kansas
Formations: Krider Member: Nolans Limestone, Odell Shale, Winfield Limestone

LITHOLOGIC LOG



REMARKS

Core depth + 7.5 feet = Log depth

KRIDER MEMBER: NOLANS LIMESTONE

2,645.0 - 2,674.1 feet: Dolostone; grainstone, packstone, wackestone, and mudstone textures; yellowish gray, light olive gray to olive gray; contacts between depositional units generally scoured; common solution compaction seams; microstylolites less common; anhydrite nodules throughout; chalcedony replacement of dolomite 2,661.0 - 2,665.8 feet; grainstones and packstones contain abundant oncoids and pelecypods, less common peloids and echinoderms; wackestones and mudstones contain abundant peloids and pelecypods; bryozoan at 2,649.8 feet; sponge at 2665.4 feet; primary sedimentary structures obscured by dolomitization; bioturbation occasionally evident; intercrystalline and grain-moldic pores common in grainstones and packstones.

ODELL SHALE

2,674.1 - 2,678.1 feet: Shale and dolomitic shale, medium dark gray to grayish black; laminated to massive; burrows above 2,676 feet; small nodules, possibly anhydrite, at 2,676.7 feet.

2,678.1 - 2,686.5 feet: Shale to dolomitic shale and argillaceous dolomudstone; light olive gray to grayish red; caliche from 2,682.5 - 2,686.0 feet; dissolution features and desiccation cracks along upper contact of interval; bioturbated 2,679 - 2,682.5 feet.

2,686.5 - 2,697.3 feet: Dolostone, argillaceous dolostone, and dolomitic shale; light olive gray, dark greenish gray to grayish red; dolostone has wackestone to mudstone texture; microstylolites and solution compaction seams throughout; peloids and pelecypods common; rare echinoderms; solid hydrocarbon in moldic pores 2,690 - 2,693 feet; interval possibly bioturbated; possible root mottles from 2,687 - 2,689 feet.

WINFIELD LIMESTONE

2,697.3 - 2,705.4 feet: Dolostone, skeletal intraclast packstone to grainstone; yellowish gray to light olive gray; echinoderms and pelecypods common, oncoids less common; intraclasts mainly mudstone; microstylolites and compaction seams throughout; small open fracture 2,703.5 feet; grain-moldic and intercrystalline pores throughout.

Lithology
Dolostone
Argillaceous Dolostone
Shale
Dolomitic Shale

Color
YG Yellow Gray
OG Olive Gray
MDG Medium to Dark Gray
GR Gray Red
GBl Gray Black
LOG Light Olive Gray
OGrG Olive Green Gray

Nature of Contact
SC Scoured
S Sharp
Erosional (Scour) Contact
Sharp (Flat) Contact

Porosity Type
MP Moldic Porosity
IC Intercrystalline Porosity

Relative Scale
Abundant
Common
Rare

Parallel Bedding
Planar Cross-Bedding
Trough Cross-Bedding
Ripples
Wavy Bedding
M Massive
Convolute Bedding
Fluid Escape Structure
Flame Structure

Microfault
Microstylolite
Pressure Solution "Wispy" Laminae
Fracture o/c
o = open
c = closed
Desiccation Cracks
Root Structures
Rip-up Clasts/Intraclast

Symbols
Bioturbation
Vertical Burrow
Horizontal Burrow
Undiff. Fossil
Undiff. Pelecypod
Undiff. Gastropod
Bryozoan
Echinoderm
Sponge
Oncoid/coated grain
Peloid
Argillaceous
Calcitic
Dolomitic
Pyrite
Anhydrite
XRD Sample Marker
Thin Section/SEM Sample Marker
Nodule
Caliche
FU Fining Upward

Geology: J. S. Kier
Computer Drafting: C. McElmoyl
November, 1994

Anadarko Petroleum
Thompson F-1H Well
Seward County, Kansas
Lithology: Dolostone
Texture: Packstone/Grainstone
Porosity: 11.6 percent
Permeability: 0.581 md

File: 194240

PLATE 1

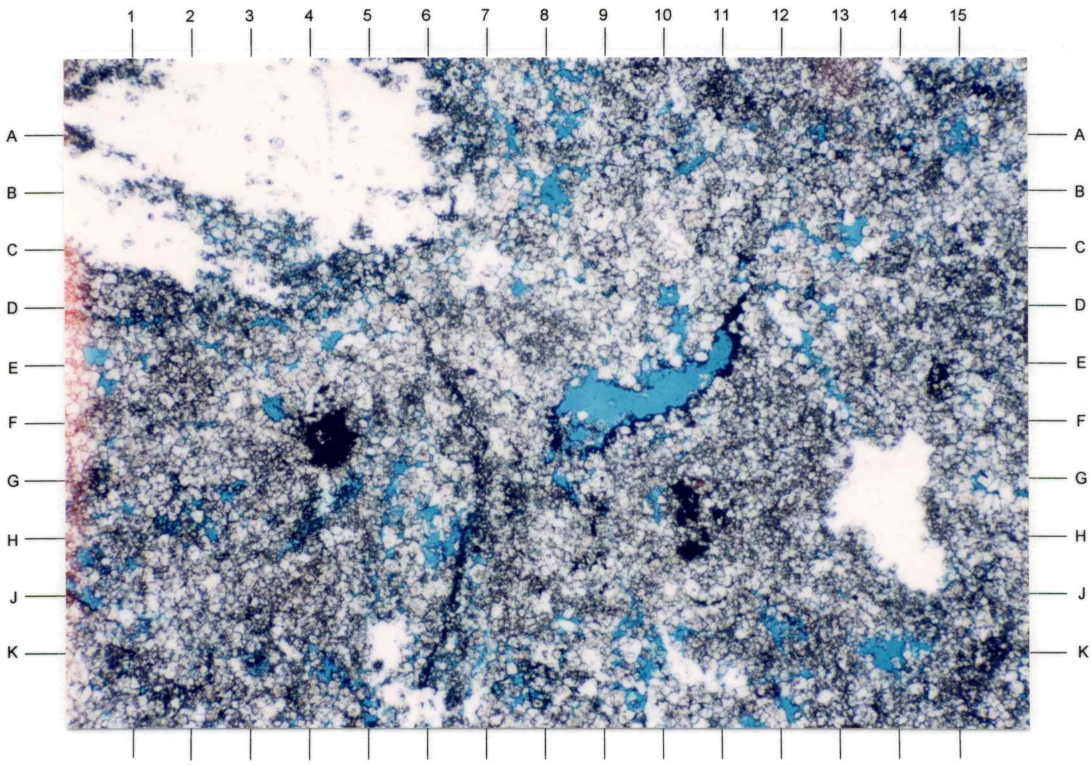
Thin Section Photomicrographs
Sample Depth: 2,646.0 Feet
Krider Member

A

The texture in this sample has been obscured by dolomitization. It appears to contain only a minor amount of recrystallized matrix, and is therefore classified as a packstone/grainstone. Peloids (D1 and A11) and pelecypods (E9 and H4) are the most common framework components. Most of the pelecypods have been leached resulting in the formation of moldic pores. The pore system (blue) is comprised of a combination of moldic and intercrystalline pores. Anhydrite (white) is a common replacive cement. Note the small dolomite crystals within the nodule in the upper left. The black rim around the large moldic pore in the center of the photomicrograph is solid hydrocarbon. (31X, Transmitted light)

B

Solid hydrocarbon (black) lines a moldic pore derived from a leached pelecypod. Intercrystalline pores (H11 and J12-12.5) are also visible. The light colored dolomite crystals (C1 and G13) are cement, whereas the darker, inclusion-rich dolomite is matrix and/or peloids (A4 and H15). (125X, Transmitted light)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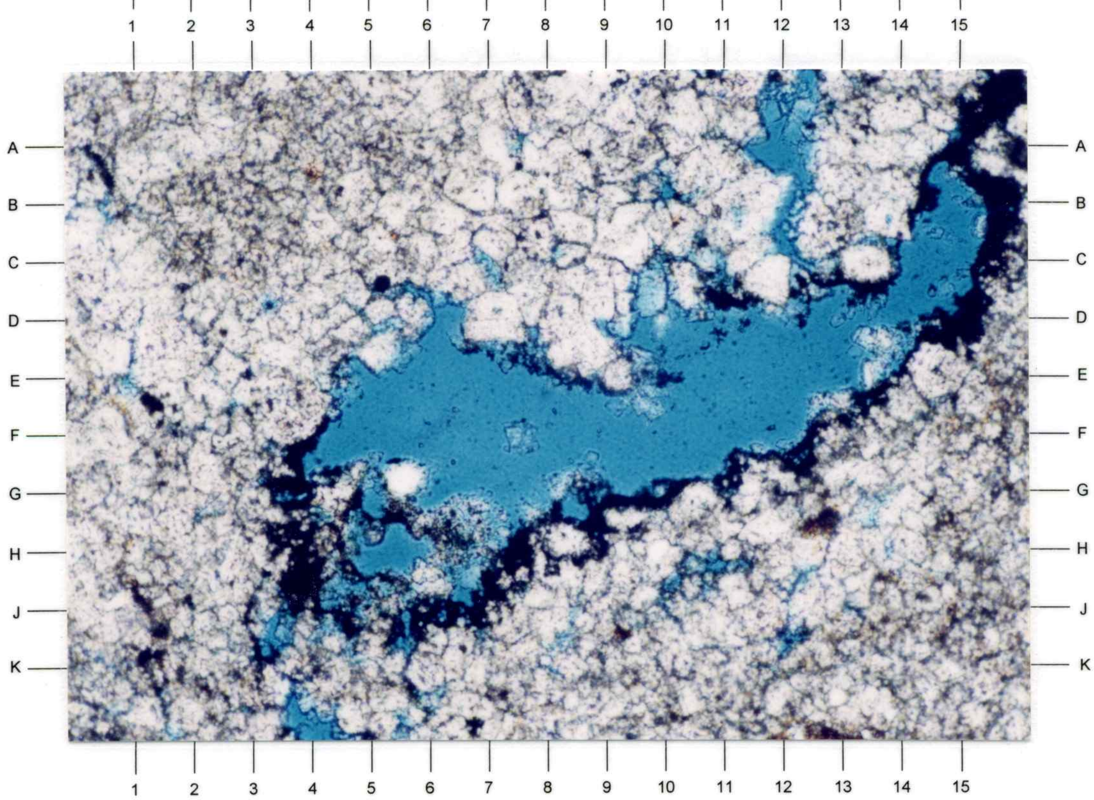
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B

Anadarko Petroleum **File: 194240**
Thompson F-1H Well
Seward County, Kansas
Lithology: Dolostone
Texture: Packstone/Grainstone
Porosity: 11.6 percent
Permeability: 0.581 md

PLATE 2

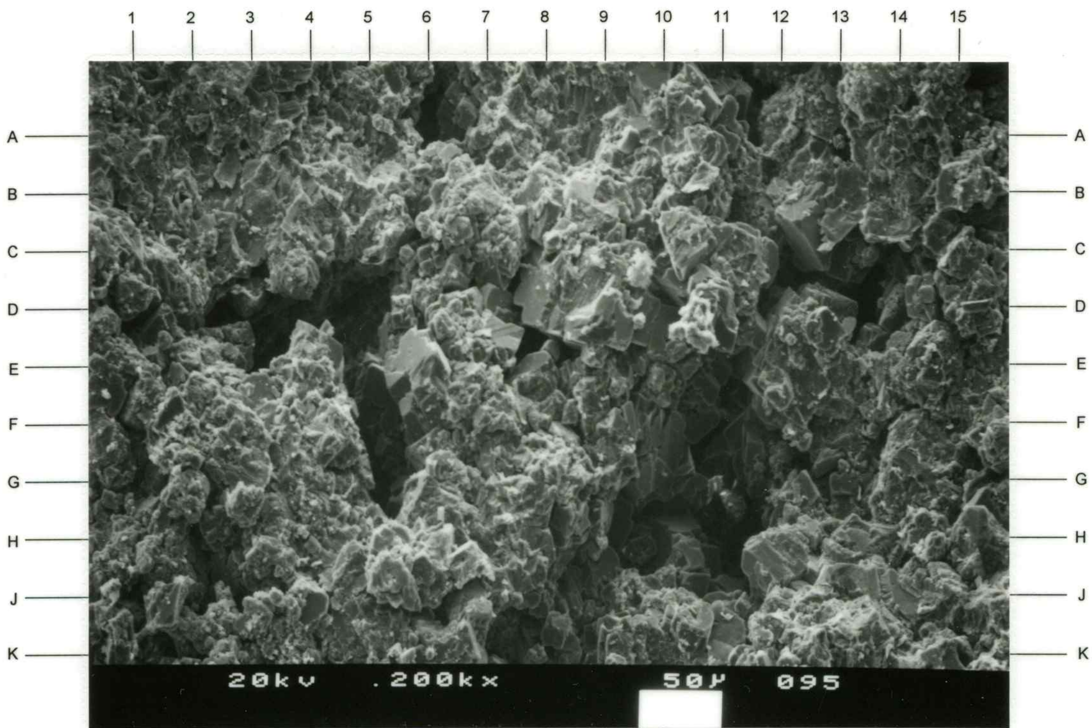
SEM Photomicrographs
Sample Depth: 2,646.0 Feet
Krider Member

A

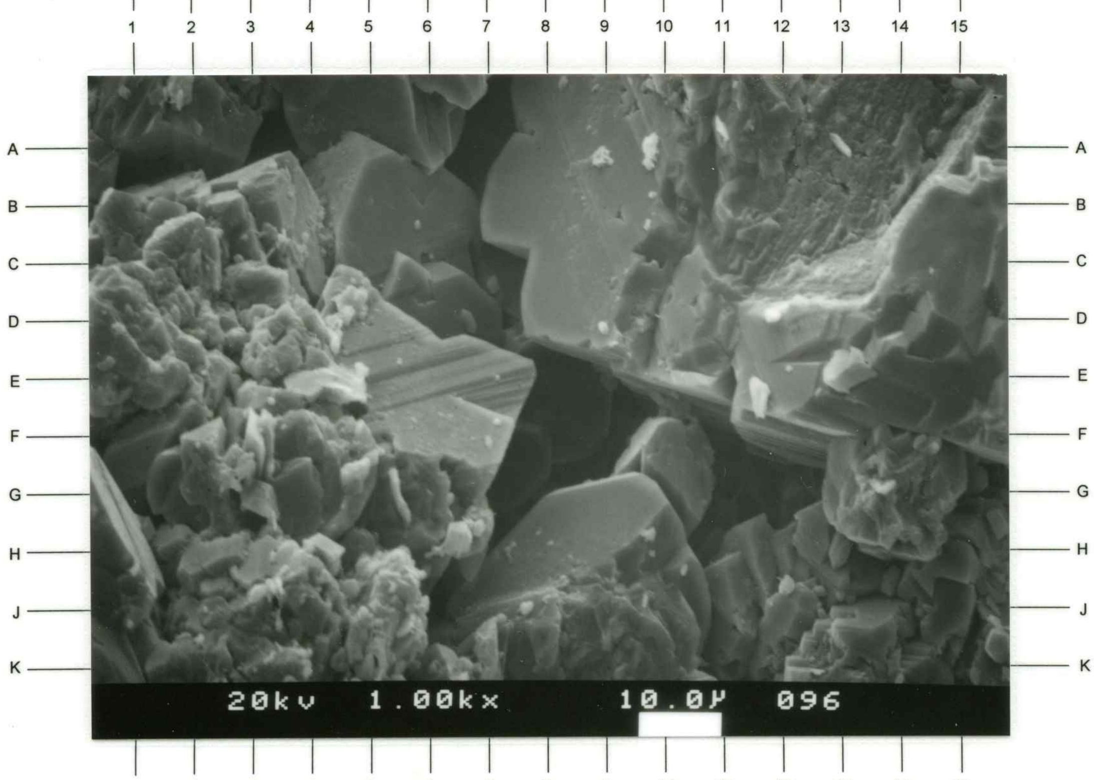
This dolostone contains anhydrite and possibly siderite. Porosity is mostly well developed and interconnected intercrystalline pores (D1, C-D13.5, H11) and grain-moldic pores (D3 - G5). Some authigenic illite clay is also seen in intercrystalline areas. Some dissolution of the cements and constituents has occurred. Quartz and feldspars (mostly likely plagioclase) are seen occasionally. (200X)

B

This high magnification image is centered around the area at E8 in Plate 2A. Dolomite crystals (B9, E6, H8) partially fill a moldic pore (F9). (1000X)



A



B

Anadarko Petroleum
Thompson F-1H Well
Seward County, Kansas
Lithology: Dolostone
Texture: Packstone/Wackestone
Porosity: 10.1 percent
Permeability: 0.095 md

File: 194240

PLATE 3

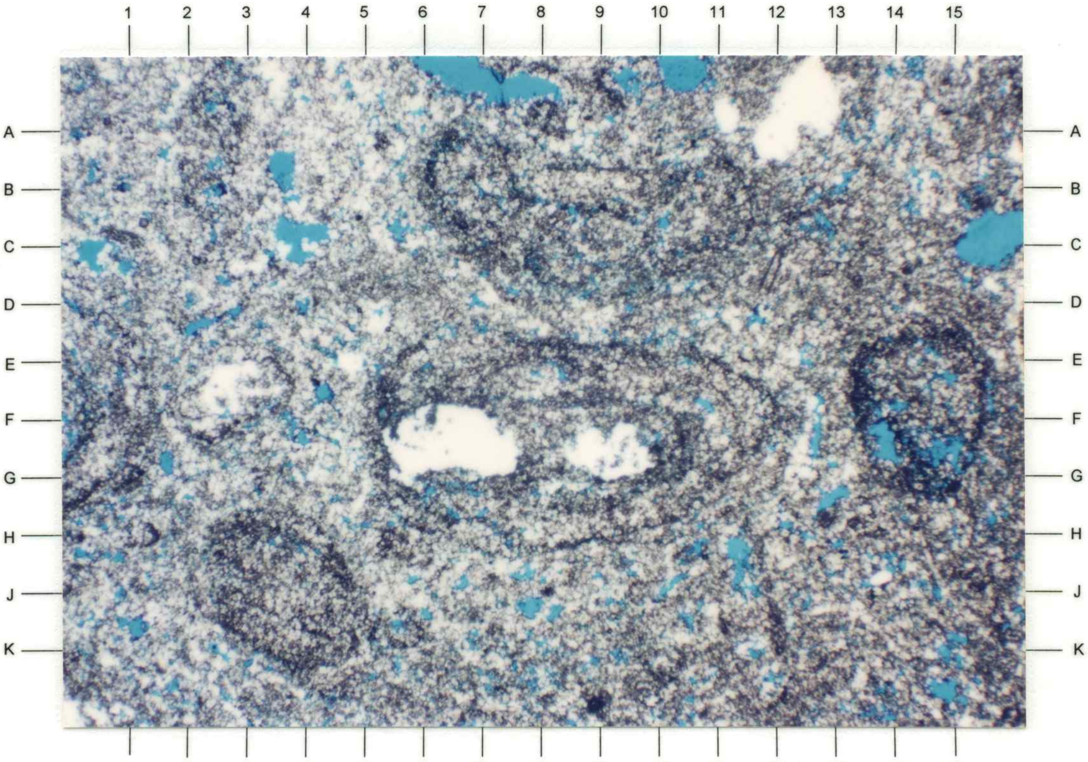
Thin Section Photomicrographs
Sample Depth: 2,647.8 Feet
Krider Member

A

This dolostone sample displays both packstone and wackestone textures. The irregularly laminated, ovoid grains (B-C8, F14, and F7) are oncoids, probably of algal origin. The center of one of the oncoids has been replaced by anhydrite (F6 and F9). The elongated moldic pores (A7, D2, and F12.5) result from the dissolution of pelecypods. Small, intercrystalline pores are common. (16X, Transmitted light)

B

A patch of replacive anhydrite (white) is highlighted in this view that is centered around F6 in photomicrograph A. Within the anhydrite are remnant dolomite crystals (dark) that were not replaced. Faint, organic-rich laminae (B1-3) of the oncoid are discernible. The pores (blue) are intercrystalline. (125X, Transmitted light)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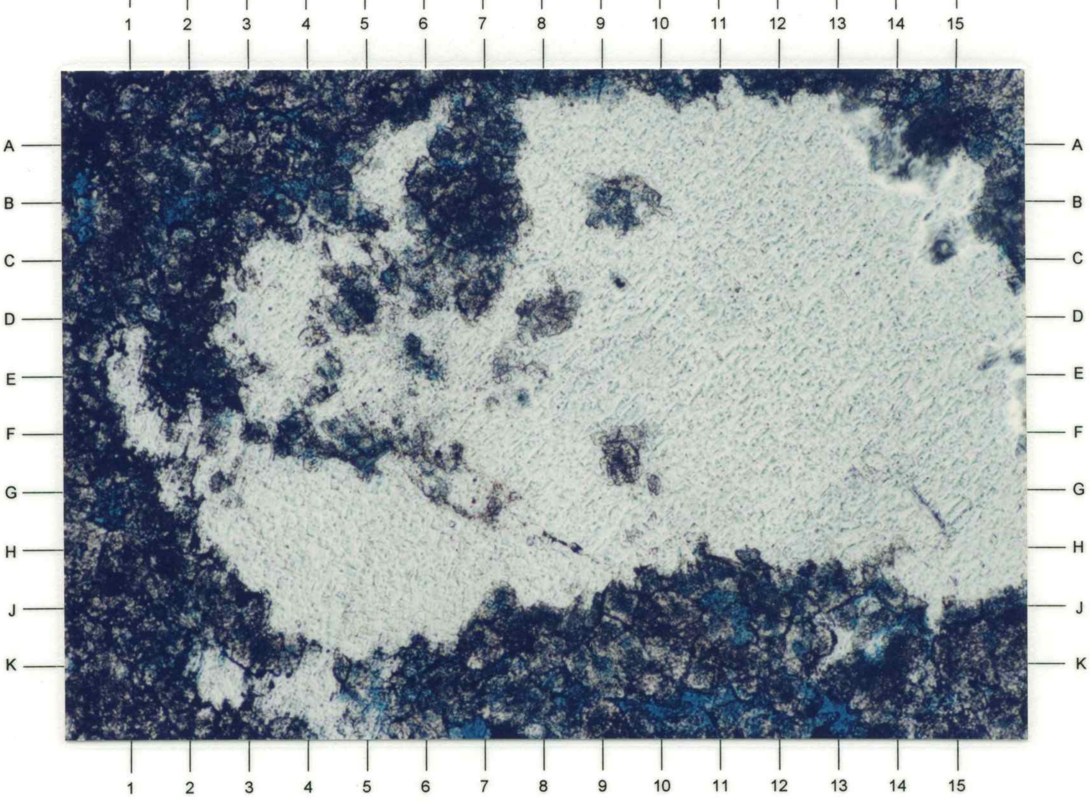
A B C D E F G H J K

A


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A B C D E F G H J K

B

Anadarko Petroleum
Thompson F-1H Well
Seward County, Kansas
Lithology: Dolostone
Texture: Packstone/Wackestone
Porosity: 10.1 percent
Permeability: 0.095 md

File: 194240

PLATE 4

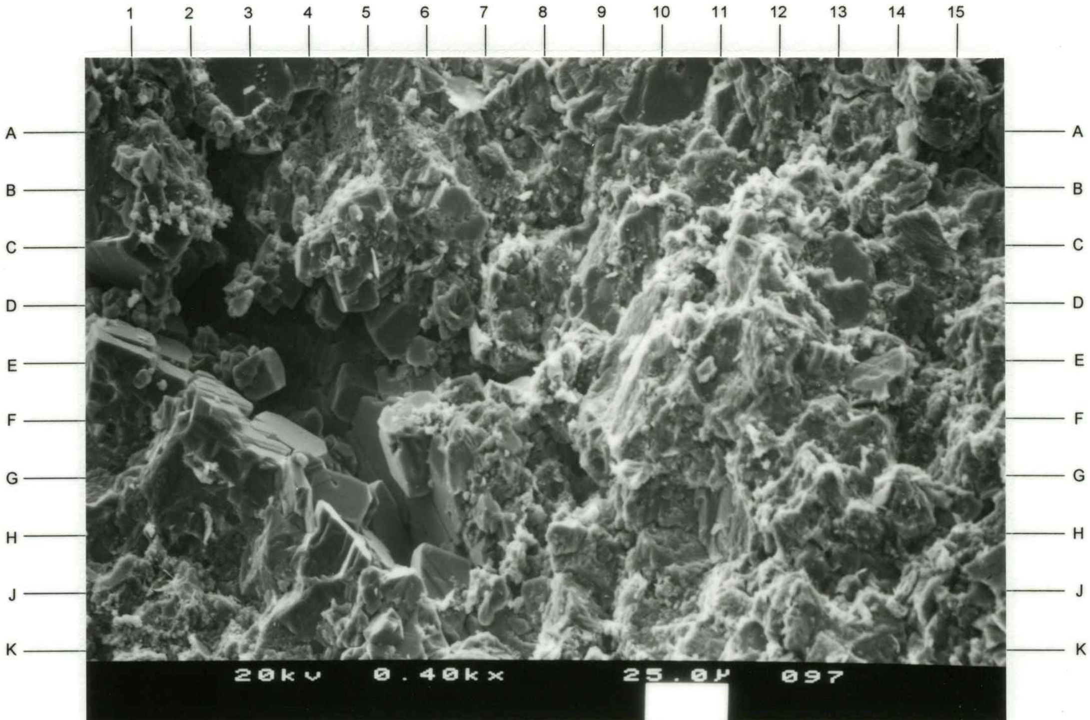
SEM Photomicrographs
Sample Depth: 2,647.8 Feet
Krider Member

A

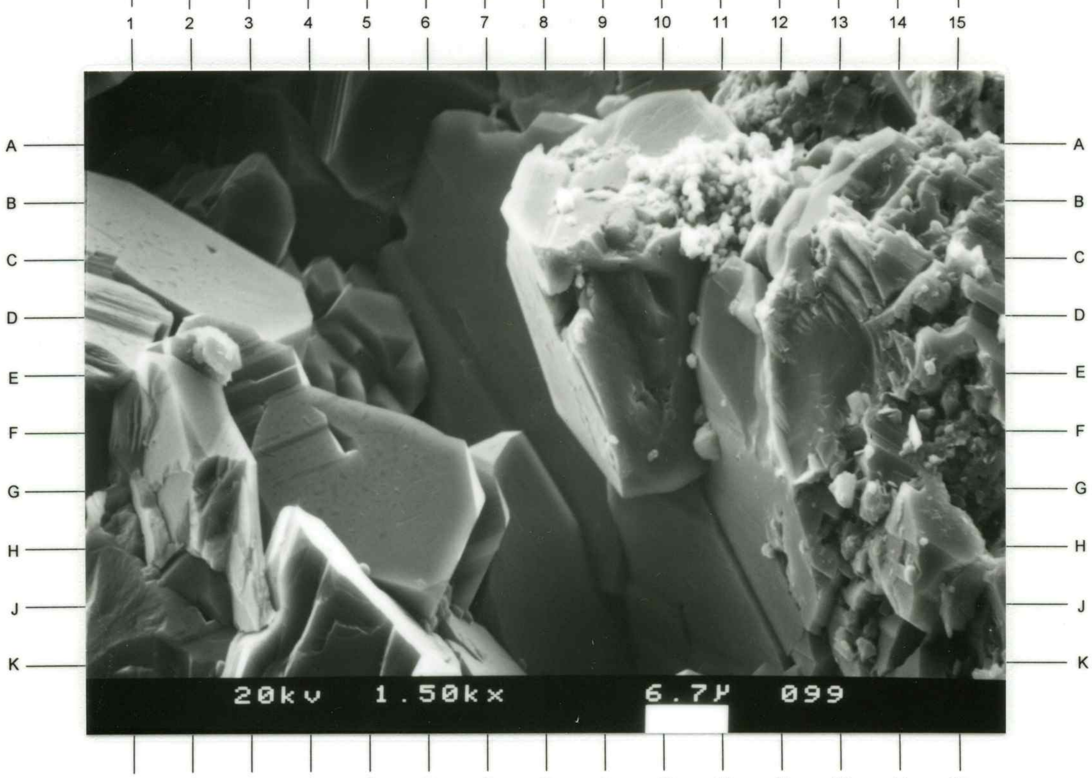
Detrital quartz (H13.5), feldspars (not shown), and occasionally mica (not shown) are observed in this dolostone sample. Large, intercrystalline and moldic pores (D-E4, B2.5) are lined with medium crystalline dolomite. Authigenic illite (B-C2.5) and pyrite (G13-14, F6) are seen. (400X)

B

Centered around the area at G5 in Plate 4A, this image shows the interlocking nature of the dolomite (C2, G5, A10) crystals. These crystals partially fill a pore (E7). Authigenic pyrite (A-B11) is visible in this photomicrograph. (1500X)



A



B

Anadarko Petroleum
Thompson F-1H Well
Seward County, Kansas
Lithology: Dolostone
Texture: Packstone/Grainstone
Porosity: 15.0 percent
Permeability: 17.0 md

File: 194240

PLATE 5

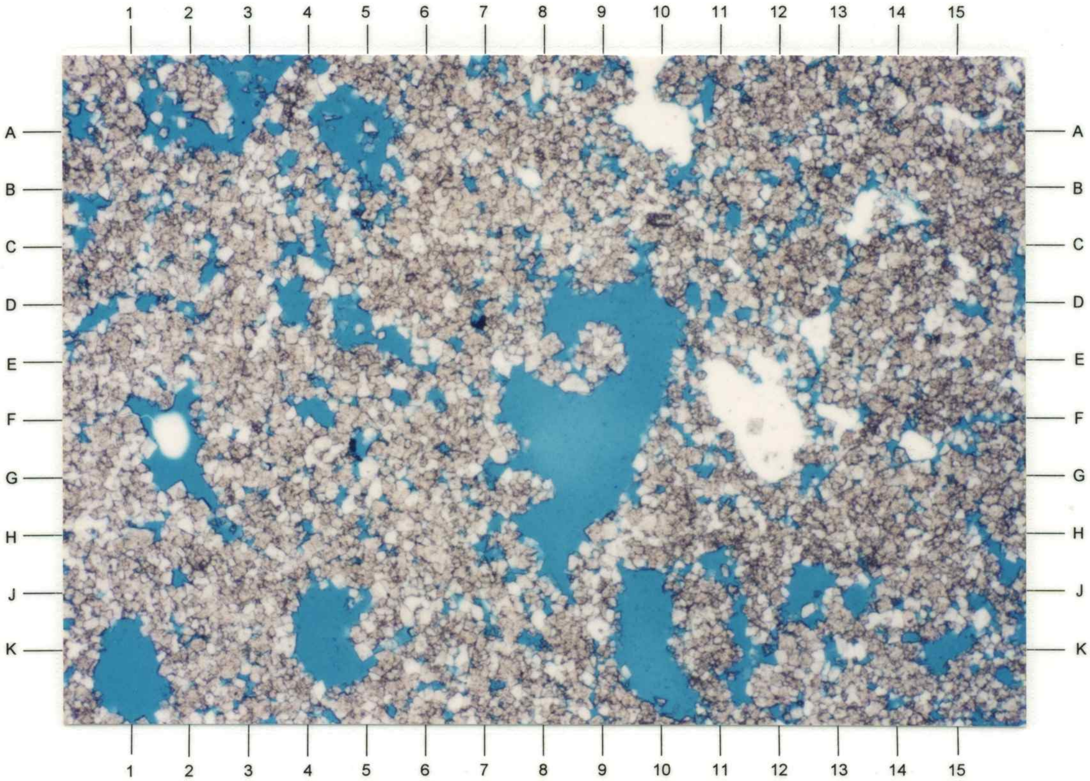
Thin Section Photomicrographs
Sample Depth: 2,660.8 Feet
Krider Member

A

The texture of this dolostone has been largely obscured by dolomitization. However, it appears to be a packstone/grainstone. Large moldic pores and small intercrystalline pores (blue) are common. The elongated moldic pores result from the dissolution of pelecypods (E<1, H-K7-8, and J9). Patches of anhydrite (white) generally contain dolomite remnants that were not replaced. (31X, Transmitted light)

B

Large moldic pores (A6-9 to K1-4) and smaller intercrystalline pores (blue) are featured in this high magnification view of the center of photomicrograph A. The anhydrite nodule (white) contains small remnant dolomite crystals (E12 and H14) as well as larger, euhedral dolomite crystals that have replaced the anhydrite (F14). The circular shape of the dolomite crystals in the upper left suggest a replaced ooid or peloid. (125X, Transmitted light)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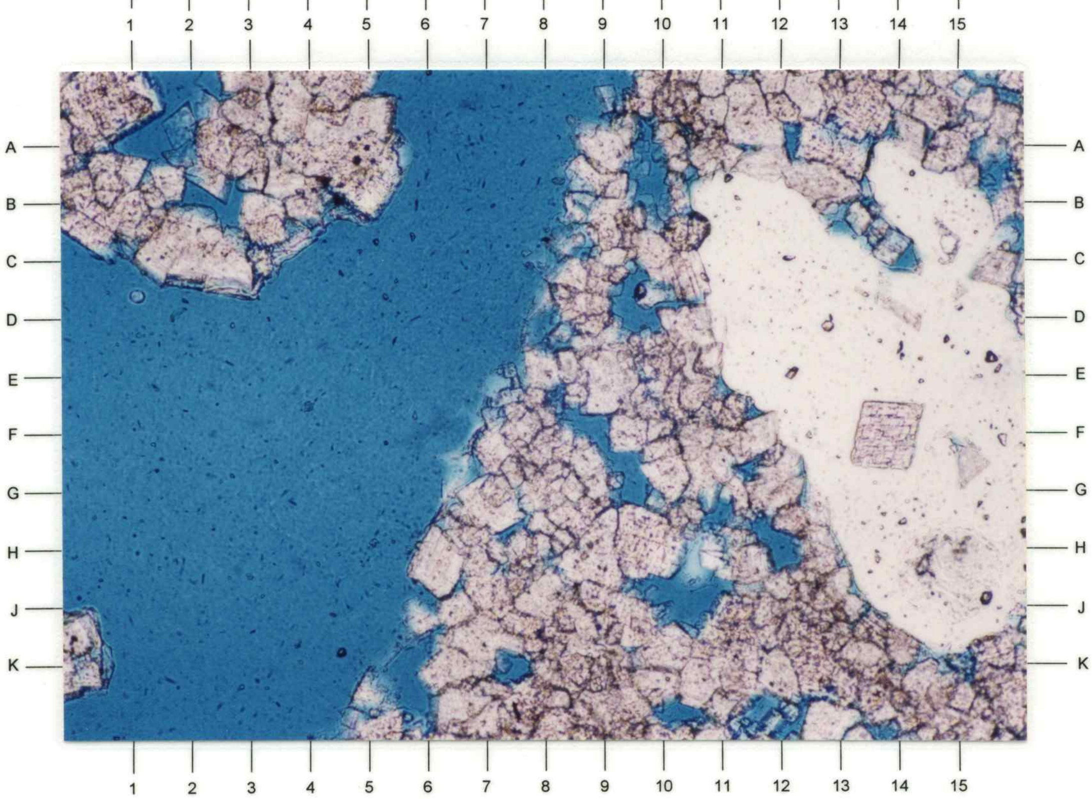
A B C D E F G H J K

A


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A B C D E F G H J K

B

Anadarko Petroleum **File: 194240**
Thompson F-1H Well
Seward County, Kansas
Lithology: Dolostone
Texture: Packstone/Grainstone
Porosity: 15.0 percent
Permeability: 17.0 md

PLATE 6

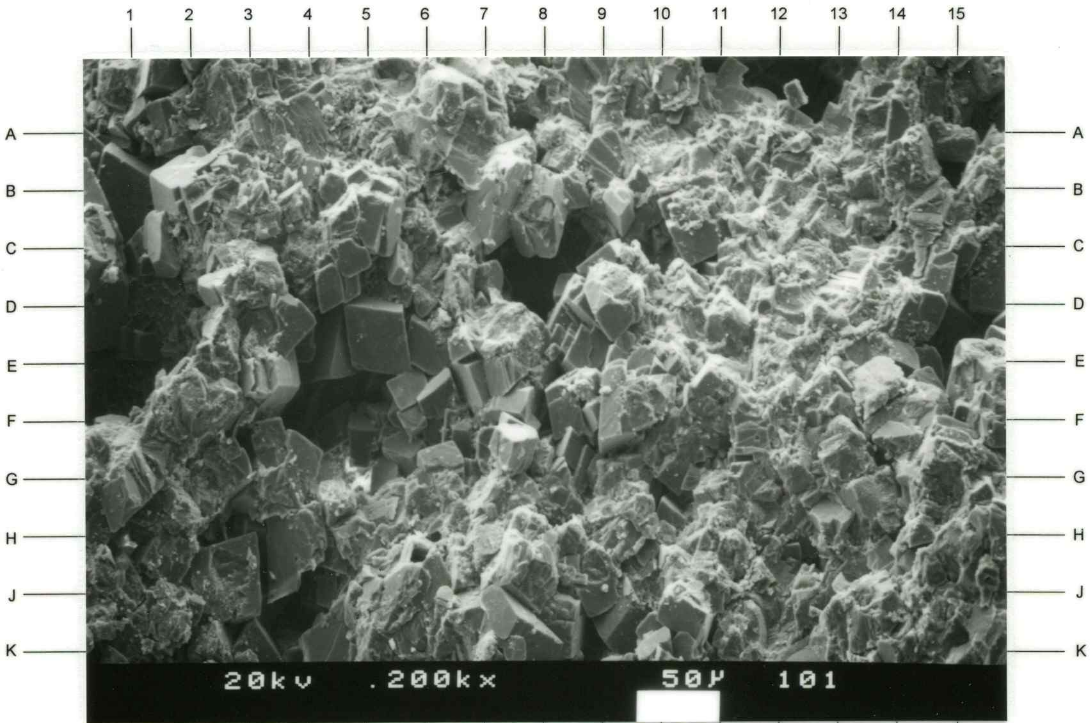
SEM Photomicrographs
Sample Depth: 2,660.8 Feet
Krider Member

A

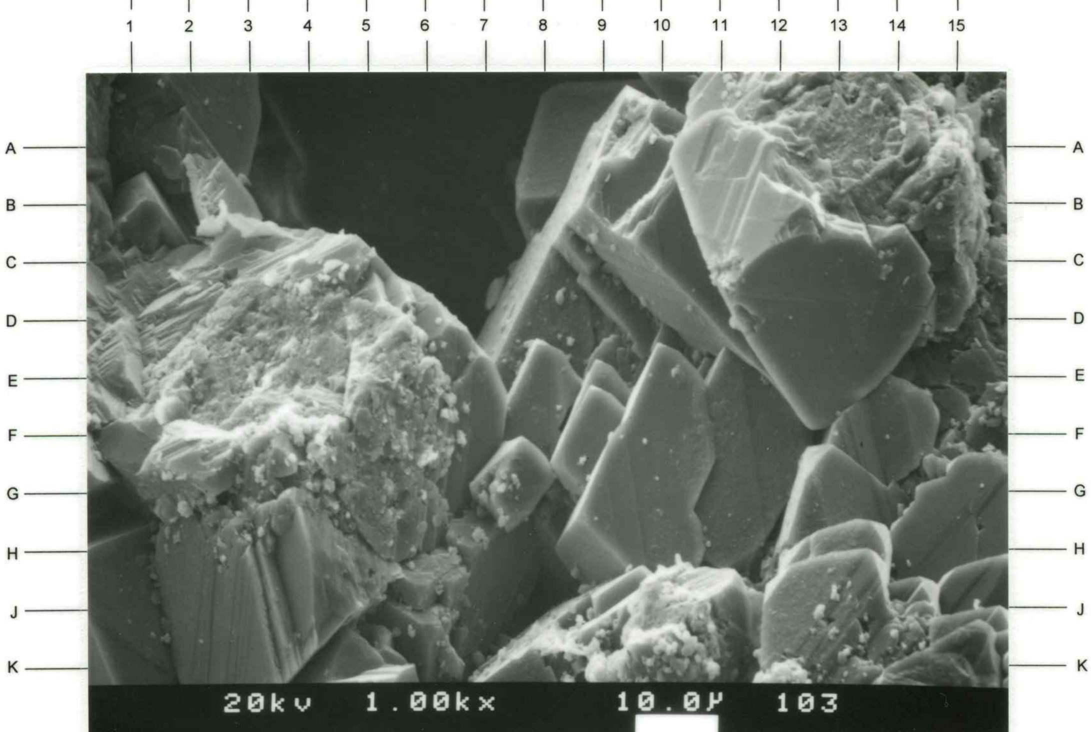
Pores lined with medium crystalline dolomite (B2, D5, E6, and D9) are well developed in this sample. Kaolinite and fossil fragments are not shown, but are observed. Kaolinite is also found in trace amounts. Evidence of dissolution is also seen. (200X)

B

Medium crystalline dolomite has grown around finer crystalline grains (E4, A14). This view is centered around D-E8-9 in Plate 6A. (1000X)



A



B

Anadarko Petroleum
Thompson F-1H Well
Seward County, Kansas
Lithology: Argillaceous Dolostone
Texture: Mudstone
Porosity: 16.7 percent
Permeability: 0.335 md

File: 194240

PLATE 7

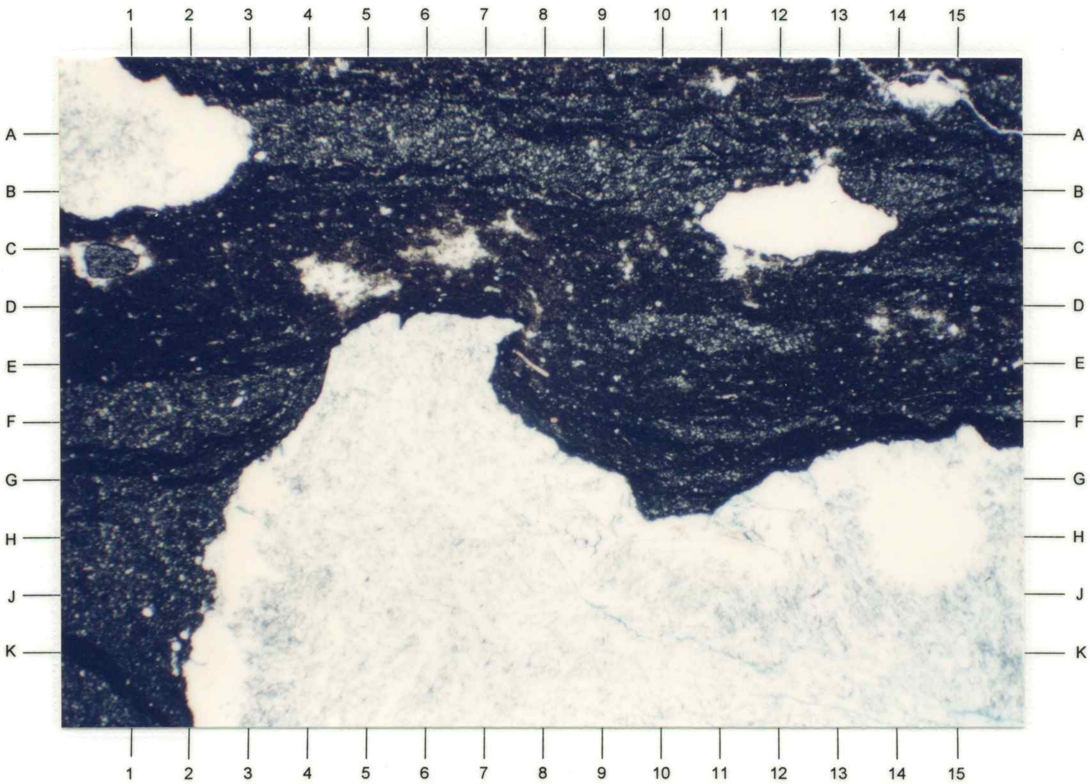
Thin Section Photomicrographs
Sample Depth: 2,665.7 Feet
Krider Member

A

This sample is an argillaceous dolomudstone. Thin, shaly laminae (dark) and lighter colored dolostone (A3-11 and F1-3) are differentiable. Phosphatized skeletal fragments (E7.5-8) are evident. Large, displacive anhydrite nodules (K2-15 to F3-15) and smaller patches of replacive anhydrite (B-C12, C-D4.5, and C6.5) are prominent. The nodule at A-B1-2 is composed of chalcedony that has replaced anhydrite. (16X, Transmitted light)

B

In a more dolomitic area of the sample, argillaceous, finely crystalline dolomite abuts against what is tentatively identified as a dolomitized sponge (white). Patches of chalcedony are discernible within the sponge. The circular to tube-like pores within the sponge were spicules. (16X, Transmitted light)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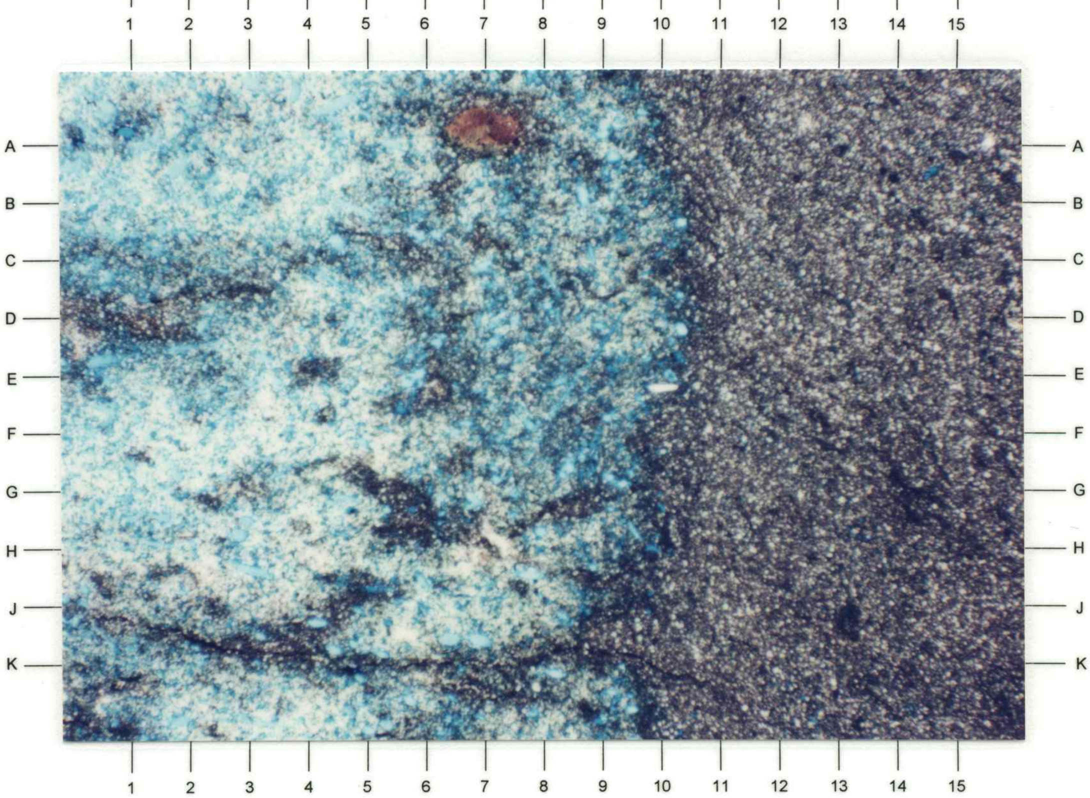
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A B C D E F G H J K

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Anadarko Petroleum **File: 194240**
Thompson F-1H Well
Seward County, Kansas
Lithology: Argillaceous Dolostone
Texture: Mudstone
Porosity: 16.7 percent
Permeability: 0.335 md

PLATE 8

SEM Photomicrographs
Sample Depth: 2,665.7 Feet
Krider Member

A

Halite (A2, F10, A9) and dolomite (K4.5, C-D15) cement this sample. This sample also has anhydrite nodules and clay laminations that are best seen in hand sample. A pelecypod (E1-A6) replaced by dolomite is evident. Some isolated pores are observed in this relatively tight sample. Detrital quartz and potassium feldspars (F-G7.5) occur in trace amounts. (400X)

B

This high magnification photomicrograph, centered around the area at D8 in Plate 8A, exhibits the crystalline nature of the halite cement (G6, C3, H13). This cement is seen throughout the sample. Dolomite can be seen at D10. Kaolinite (not shown) is observed as an authigenic clay in sparse amounts. (2000X)


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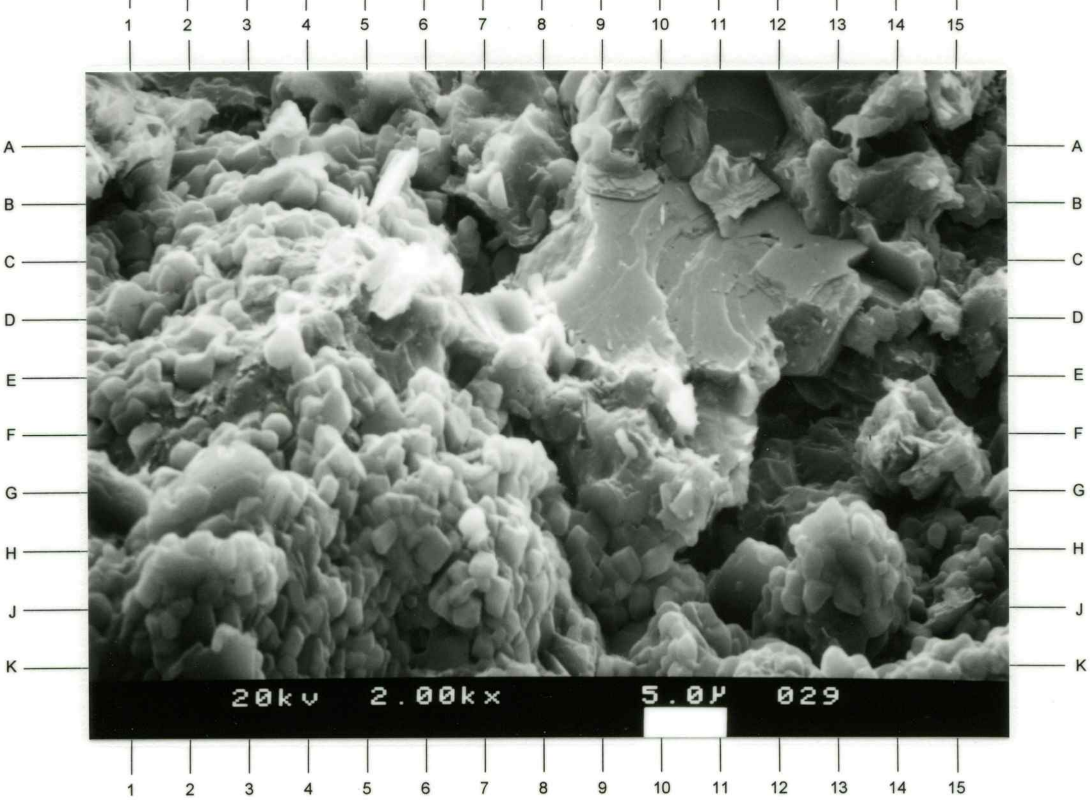
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B

Anadarko Petroleum
Thompson F-1H Well
Seward County, Kansas
Lithology: Dolostone
Texture: Grainstone/Packstone
Porosity: 10.4 percent
Permeability: 1.54 md

File: 194240

PLATE 9

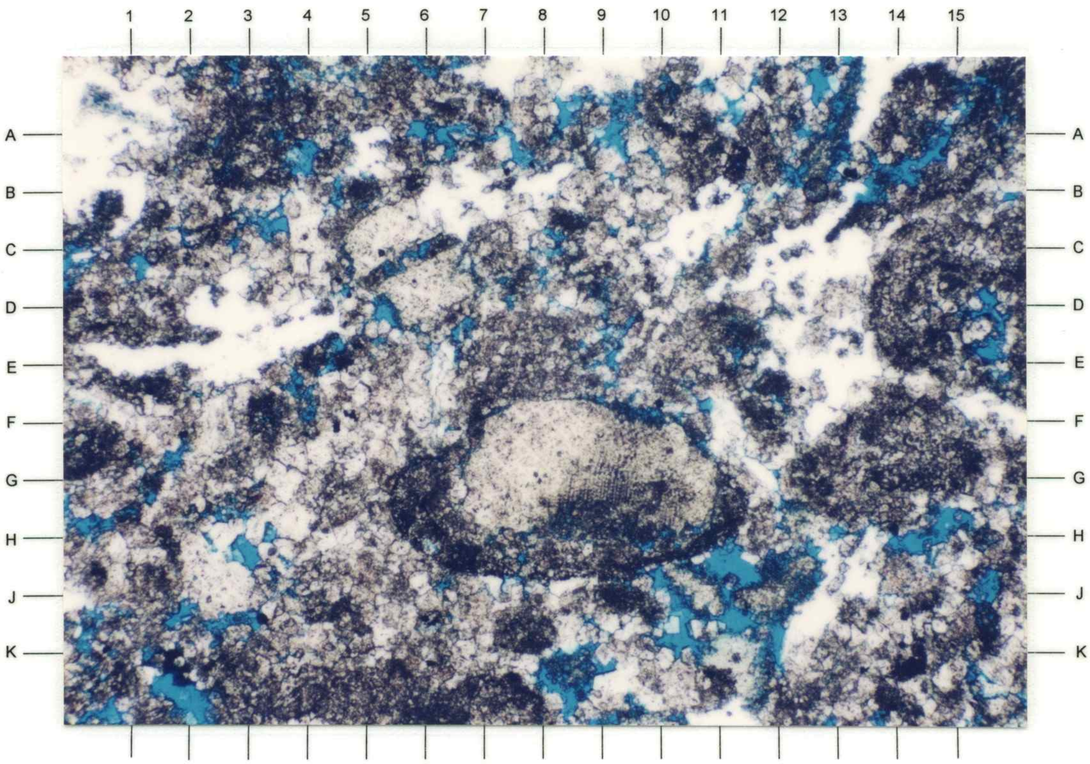
Thin Section Photomicrographs
Sample Depth: 2,700.5 Feet
Winfield Limestone

A

This sample is a pelecypod (A14), echinoderm (G8), intraclast (G14) dolograinstone to dolopackstone. Most of the pelecypods have been dissolved, resulting in elongated moldic pores. Small, intercrystalline pores are differentiable from the large moldic pores. Anhydrite (white) has replaced dolomite and filled pores. (31X, Transmitted light)

B

The microstructure of an echinoderm (H3 - G15) is featured in this view of the of the area surrounding F-G7.5 in photomicrograph A. Intercrystalline pores (blue) are evident. The inclusion-rich dolomite (D5) adjacent to the echinoderm may be recrystallized matrix. (125X, Transmitted light)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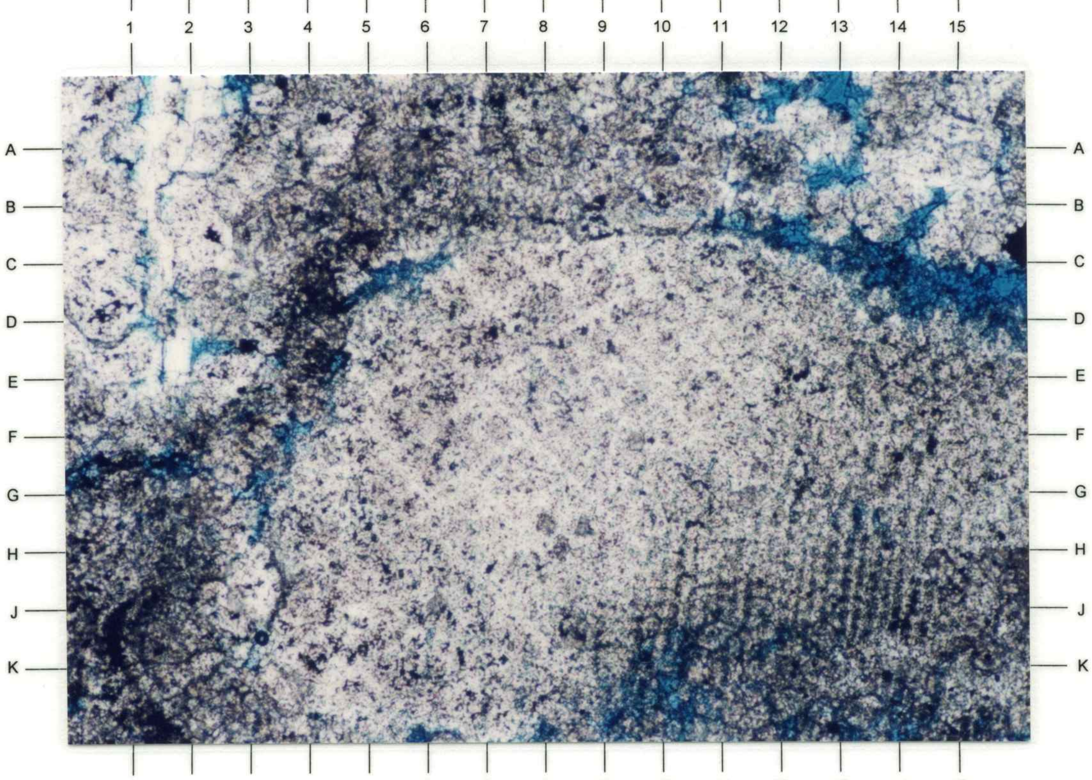
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A B C D E F G H J K

B

Anadarko Petroleum
Thompson F-1H Well
Seward County, Kansas
Lithology: Dolostone
Texture: Grainstone/Packstone
Porosity: 10.4 percent
Permeability: 1.54 md

File: 194240

PLATE 10

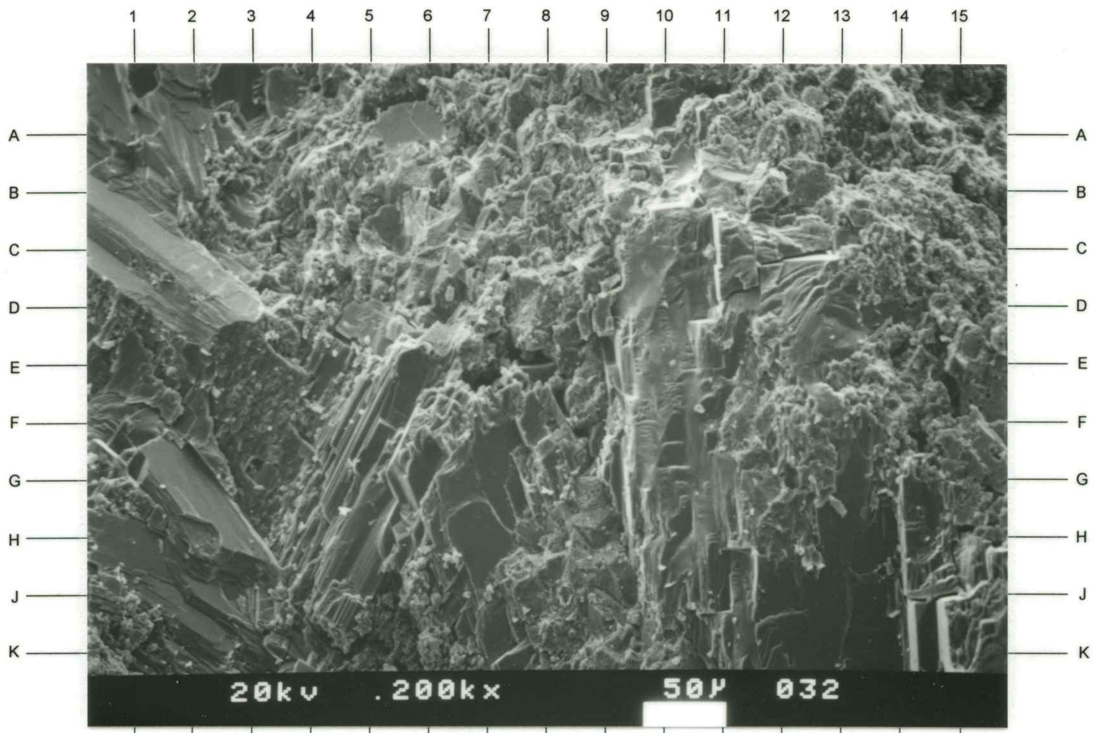
SEM Photomicrographs
Sample Depth: 2,700.5 Feet
Winfield Limestone

A

Anhydrite (E10, J12, D2, G2) occurs throughout the sample. Intercrystalline pores are seen at E8 and E-F7. This area of the sample is well cemented. Authigenic kaolinite occurs in trace amounts. (200X)

B

This high magnification image is centered around the area at E8 in Plate 10A and shows an intercrystalline pore (G9) surrounded by anhydrite (C14, H15, K5). (1000X)



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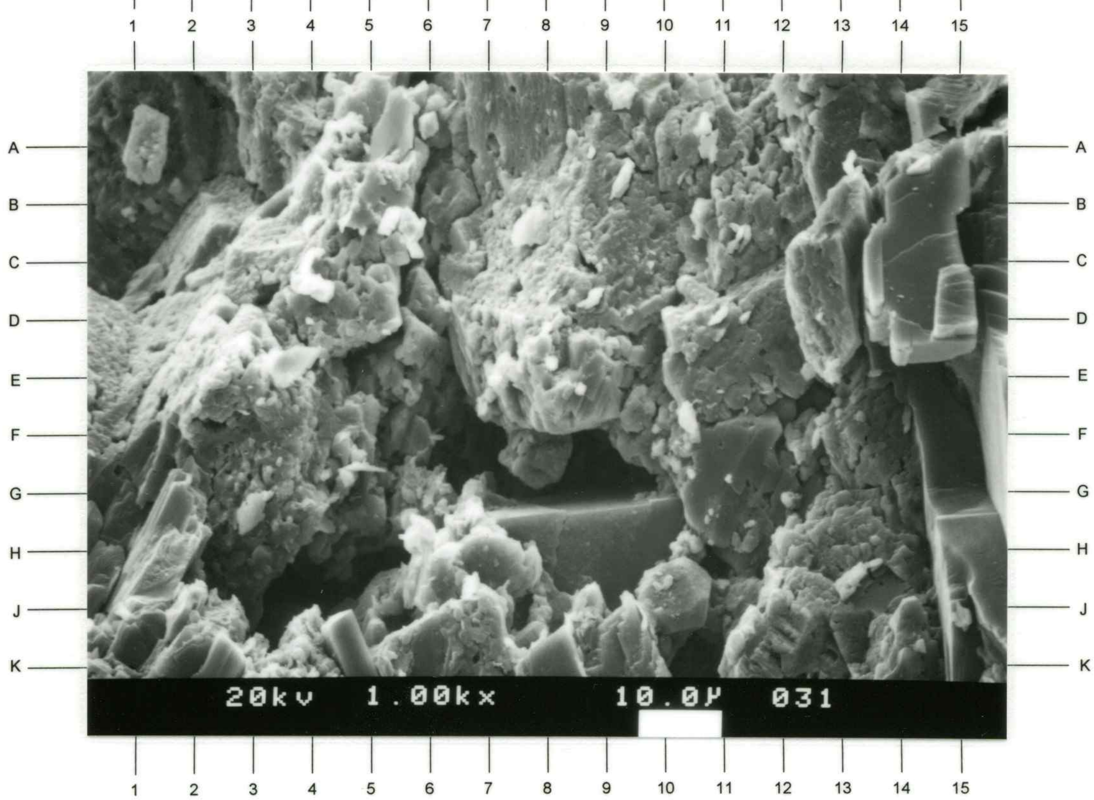

B