

24-32-39W
15-189-21539

**GEOLOGICAL ANALYSIS
OF CONVENTIONAL CORE (2700-2884.5 FT)
FROM THE
ANADARKO PETROLEUM CORPORATION
YOUNGREN K NO. 3A WELL
PANOMA (COUNCIL GROVE) FIELD
STEVENS COUNTY, KANSAS**

Prepared
for
Anadarko Petroleum Corporation
Houston, Texas

RSH 2810

CONFIDENTIAL
June, 1993

SUMMARY

1. A total of 184.5 feet of conventional core from the Anadarko Petroleum Corporation Youngren K No. 3A Well, located in Stevens County, Kansas were examined in detail.
2. Four principal lithofacies were delineated, each associated with a specific depositional environment.

<u>Depositional Environment</u>	<u>Lithologic Characteristics</u>	<u>% of Cored Interval</u>	<u>Porosity Range (%) (Average)</u>	<u>Permeability Range (md) (Average)</u>	<u>Estimated Reservoir Potential</u>
Open Marine Shelf	Dark gray to grayish-brown, calcareous shale to argillaceous limestone. Minor siltstone. Horizontal to wavy laminations.	20%	11.0-4.0 (7.6)	27.2-0.002 (2.4)	Poor
Shoal Flank	Yellowish-brown limestone. Mudstone, wackestone and some packstone. Locally shaly. Nodular bedding may reflect bioturbation. Diverse fossil assemblage.	8%	14.0-2.4 (7.6)	5.82-0.015 (1.2)	Poor to Fair
Shoal	Mostly grayish-pink limestones. Packstone to packstone/grainstone textures. Diverse fossil assemblage, plus coated grains and peloids.	24%	23.0-1.7 (9.1)	47.6-0.001 (4.0)	Poor to Very Good
Paleosol	Dark reddish-brown, silty claystones. Caliche nodules common. Root structures, locally silty and calcareous.	48%	12.1-1.6 (7.7)	35.7-0.002 (2.9)	Poor

3. The open marine shelf, shoal flank and shoal facies are the product of sedimentation in related, laterally adjacent depositional environments. Collectively, these facies form shoaling-upward sequences that record the gradual evolution of higher energy conditions. Specifically, the open marine shelf facies are the deepest water, lowest energy marine deposits, while the shoal flank facies reflects sedimentation under somewhat higher energy conditions, and the carbonate sand shoal deposits are the product of shallow

water, high-energy sedimentation. These related depositional environments can exist along both coastal beaches and offshore bar buildups in strike-oriented facies belts. The fourth facies, the paleosol deposits, record sedimentation during relative low stands in sea level. These oxidized ancient soil horizons contain caliche nodules and root structures are indicative of subaerial sedimentation.

4. **The shoal facies is the principal reservoir target in these deposits.** The cyclic sedimentation patterns reflected in these strata have produced **multiple, stacked prospective reservoir horizons.** Most of the shoal deposits are "clean" limestones, they may be discriminated through gamma-ray log cutoffs. By generating net isopach maps of "clean" carbonate deposits in this area, it may be possible to maximize the thickness of the principal reservoir facies (specifically the shoal deposits), and concomitantly minimize non-prospective paleosol and open marine shelf deposits.
5. Although most of the strata in the cored interval have rather low permeability, **local fracture development in the shoal facies** yields rocks with enhanced reservoir potential. These fractures, combined with interparticle, intraparticle and moldic macropores, can form grainstones and packstones with good to very good reservoir potential. Microporosity in the shoal facies could lead to high immobile water saturations, and thus complicate pay delineation. Most of the porosity measured in the paleosol and open marine facies is in the form of ineffective microporosity. These deposits are judged to have poor reservoir potential. The shoal flank deposits generally have only poor to fair reservoir potential, reflecting detrital micrite matrix and a pore system dominated by isolated macropores and microporosity.
6. Overall, efforts should be made to identify areas with relatively thick accumulations of the grainstone/packstone carbonate sand shoal deposits. These carbonate sand shoal accumulations probably formed in elongate sand

bodies that roughly paralleled depositional strike. Facies migration (i.e. progradation) of the bars may have resulted in broad distribution of these deposits, in sheet-like sand bodies. By maximizing the thickness of carbonate sand shoal deposits and minimizing open marine shelf and paleosol facies, pay thickness may be optimized.

GEOLOGICAL ANALYSIS
OF CONVENTIONAL CORE (2700–2884.5 FEET) FROM THE
ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL
PANOMA (COUNCIL GROVE) FIELD, STEVENS COUNTY, KANSAS

INTRODUCTION

This report, prepared for Anadarko Petroleum Corporation, presents the results and conclusions obtained from geological analysis of 184.5 feet (2700–2884.5 feet) of conventional core from the Anadarko Petroleum Corporation Youngren K No. 3A Well, located in Stevens County, Kansas.

The objectives of this study were to 1) describe the conventional core and delineate lithofacies, 2) interpret depositional environments, 3) evaluate pore system properties, and 4) assess the reservoir potential of these strata.

In order to meet these objectives, the following analytical program was utilized:

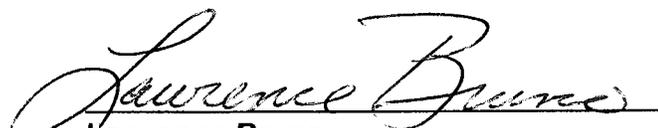
- The conventional core was slabbed into one-third and two-third sections. The core was photographed, in color, to provide a permanent, easily accessible record of cored interval. Core photographs are presented in Figure 3. Individual core pieces were photographed at higher magnification to show representative lithologies and/or specific rock features. These close core photographs are presented in Figure 4.
- The core was described in detail, and lithologies, depositional textures, sedimentary structures and visible pore types were delineated. This core description is displayed in Figure 2.
- Eleven samples were selected for detailed analysis through thin section petrography (TS) and scanning electron microscopy (SEM). These samples are:

<u>Depth</u>	<u>TS</u>	<u>SEM</u>	<u>Figure #</u>
2710.4	*	*	8
2743.5	*	*	9
2799.4	*	*	10
2807.6	*	*	11
2823.5	*	*	12
2828.5	*	*	13
2845.5	*	*	14
2861.5	*	*	15
2873.6	*	*	16
2877.8	*	*	17
2879.6	*	*	18

-- The specimens selected for thin section analysis were impregnated with blue-dyed epoxy to highlight pore space. The thin sections were then ground to 30 microns and stained with Alizarin Red-S, which aids in differentiating calcite from other carbonate minerals. Thin section analysis provides data on mineralogy, texture, pore system properties and diagenesis. Thin section photomicrographs are presented in Figures 8 through 18. Whole thin sections of selected samples are provided in Figures 5, 6, and 7.

-- SEM analysis, which was conducted on freshly broken rock surfaces, was utilized to identify pore system properties and the types and modes of occurrence of pore-filling constituents. SEM photomicrographs accompany the thin section photomicrographs in Figures 8 through 18.

Reservoirs' Job Number RSH 2810 was assigned to this study. Any communications regarding this report should refer to this Job Number. Three copies of this study have been forwarded to Mr. Donpaul Henderson, Anadarko Petroleum Corporation, Houston, Texas. Additional copies of this report may be obtained for reproduction costs. All data, interpretations, and other matters related to this study are considered highly confidential and the sole property of Anadarko Petroleum Corporation, Houston, Texas.


 Lawrence Bruno
 Manager of General Projects
 RESERVOIRS, INC.

GEOLOGICAL ANALYSIS

This section of the report presents the results of geological analyses performed on 184.5 feet (2700–2884.5 feet) of conventional core from the Anadarko Petroleum Corporation Youngren K No. 3A Well, located in Stevens County, Kansas.

Core Description and Interpretations

Examination of the conventional core reveals four (4) principal lithofacies, each associated with a specific depositional environment. These lithofacies are:

<u>Depositional Environment</u>	<u>Lithologic Characteristics</u>	<u>% of Cored Interval</u>	<u>Porosity Range (%) (Average)</u>	<u>Permeability Range (md) (Average)</u>	<u>Estimated Reservoir Potential</u>
Open Marine Shelf	Dark gray to grayish-brown, calcareous shale to argillaceous limestone. Minor siltstone. Horizontal to wavy laminations.	20%	11.0–4.0 (7.6)	27.2–0.002 (2.4)	Poor
Shoal Flank	Yellowish-brown limestone. Mudstone, wackestone and some packstone. Locally shaly. Nodular bedding may reflect bioturbation. Diverse fossil assemblage.	8%	14.0–2.4 (7.6)	5.82–0.015 (1.2)	Poor to Fair
Shoal	Mostly grayish-pink limestones. Packstone to packstone/grainstone textures. Diverse fossil assemblage, plus coated grains and peloids.	24%	23.0–1.7 (9.1)	47.6–0.001 (4.0)	Poor to Very Good
Paleosol	Dark reddish-brown, silty claystones. Caliche nodules common. Root structures, locally silty and calcareous.	48%	12.1–1.6 (7.7)	35.7–0.002 (2.9)	Poor

Open Marine Shelf Facies:

Description:

The **open marine shelf** facies consists of dark gray and dark grayish-brown calcareous shale and argillaceous limestone (Figure 4,B). In places, the shale/argillaceous limestone grades to siltstone and very fine-grained sandstone (such

as near the top of the cored interval (Figure 4,A). Thin, wavy to horizontal laminations can be distinguished, and there is some indication of bioturbation. Fossil debris is rather widely scattered throughout this lithofacies. Benthonic foraminifera (including fusulinids), brachiopod fragments, echinoderm fragments, bryozoans and ostracodes were identified.

Six principal units of the open marine shelf facies can be delineated (Figure 2). These units range in thickness from 0.75 feet to 21 feet:

2700–2706.5 feet (6.5')
2744.75–2749.5 feet (4.75')
2752–2754 feet (2')
2755–2776 feet (21')
2778–2779.5 feet (1.5')
2809.5–2810.25 feet (0.75')

Collectively, these fine-grained deposits account for roughly 20% of the strata in the cored interval. In many cases, the open marine facies grades upward into shoal or shoal flank deposits, forming shoaling-upward sequences (Figure 2).

Interpretation:

The abundance of matrix material indicates that these strata accumulated in a low-energy environment. The faunal assemblage and bioturbation are consistent with sedimentation in an open marine setting. Combining these observations, these deposits are interpreted as **open marine shelf** accumulations.

Pore System Properties:

Routine core analysis measurements from the open marine shelf facies show porosity values ranging from 11.0% to 4.0% (average of 7.6%), and permeability values ranging from 27.2 md to 0.002 md (average of 2.4 md) (Crossplot 1). **Visible pore space is uncommon**; the terrigenous mud and carbonate mud that account for the bulk of this lithofacies, yield rocks with very little macropore space. Some intraparticle pore space is present in fossil fragments. In addition, most of the measured pore volume is in the form of microporosity in the matrix. This microporosity will be largely ineffective.

Based on the observed pore structure in this rock, the average permeability value is considered to be too high. The average permeability value is skewed toward the high end by measurements through core plugs with induced fractures. No clearly defined natural fractures were observed in this lithofacies. Overall, the abundance of detrital matrix and the general lack of macropore space indicate that the open marine shale facies has poor reservoir potential.

Shoal Flank Facies:

Description:

The shoal flank facies consists of pale, yellowish–brown limestone. Mudstone and wackestone textures predominate (Figure 4,H), with some packstone also identified. A minor amount of matrix–selective dolomitization was recognized (Figure 16). Where this lithofacies grades into adjacent open marine shelf deposits, the limestones can be rather argillaceous. Some wavy laminations are present, but the facies typically has a nodular appearance that reflects bioturbation.

Five main shoal flank units were identified in the core (Figure 2):

2801.25–2806 feet (4.75') -
2826.5–2830 feet (3.5')
2870–2871 feet (1')
2872.5–2877 feet (3.5')
2882–2884.5 feet (2.5')

This lithofacies accounts for roughly 8% of the cored strata.

Skeletal fragments and peloids are the main grain types in the shoal flank facies (Figure 13). A diverse faunal assemblage was observed, including: fusulinids, brachiopods, ostracodes, sponge spicules, echinoderms, bryozoans, phylloid algae, *Tubiphytes* and gastropods. Scattered silica nodules were identified; many of these nodules contain concentrations of siliceous sponge spicules.

Interpretation:

The depositional textures and the diverse faunal assemblage are judged to indicate that these strata were deposited in a **shoal flank setting**. That is, these mudstones, wackestones and packstones accumulated peripheral to higher energy carbonate sand shoal deposits, in a somewhat lower energy environment. **The shoal flank deposits can be thought of as a transitional phase between the open marine shelf and shoal environments.**

Pore System Properties:

Visible pore space is uncommon in most of the shoal flank deposits, reflecting an abundance of detrital micrite, and various amounts of terrigenous clay matrix. Routine core analysis measurements from the shoal flank facies show porosity values ranging from 14.0% to 2.4% (average of 7.6%), and permeability values ranging from 5.82 md to 0.015 md (average of 1.2 md) (Crossplot 2). The higher range of porosity values in the shoal flank deposits occur in association with wackestone to packstone textures that have some intraparticle (Figures 16,B), moldic and scattered interparticle pores. The matrix material is microporous. **Throughout most of this lithofacies, a large portion of the measured pore volume is in the form of microporosity (Figure 13).** Overall, the general paucity of interconnected macropore space yields rocks with typically low porosity and permeability, and only poor to fair reservoir potential.

Shoal Facies:

Description:

The shoal deposits are mostly grayish–pink, grain–supported limestones, ranging from packstone to grainstone (Figure 4,D,G and I). **Fossils and peloids** are the main framework constituents. Oncoids, miliolid foraminifera, fusulinids and other foraminifera, phylloid algae, echinoderms, brachiopod fragments, gastropods, ostracodes, bryozoans, *Tubiphytes* and scattered coral fragments were observed (Figures 8 through 12). In addition, ooids and grains encrusted with foraminifera are common. Detrital quartz sand is locally admixed into the shoal deposits, particularly near the top of the cored interval (Figure 8).

Bedding features are generally lacking, and most of the strata in the shoal facies can be described as massive. There is some imbrication of skeletal grains that may reflect subtle cross-stratification. Horizontal stylolites are relatively common, and some patchy silicification is apparent.

The packstones and grainstones occur in beds that range in thickness from one foot to seven feet (Figure 2). These intervals are:

2706.5–2711.5 feet (5')
2741–2744.75 feet (3.75')
2749–2752 feet (2.5')
2754–2755 feet (1')
2776–2778 feet (2')
2797.5–2801.25 feet (3.75')
2806–2809.5 feet (3.5')
2819.5–2826.5 feet (7')
2844–2848 feet (4')
2860–2863.5 feet (3.5')
2864–2865 feet (1')
2871–2872.5 feet (1.5')
2877–2882 feet (5')

Collectively, these shoal deposits account for nearly 24% of the cored strata. Some of the shoal beds have sharp bases and sharp tops. But, in several cases, the grainstones and packstones of the shoal facies "cap" shoaling-upward sequences that grade from open shelf facies at the base, through shoal flank wackestones, and eventually into shoal deposits. Paleosol deposits overly the shoal grainstones/packstones in many cases (Figure 4,C and F).

Interpretation:

The packstone and grainstone textures in these deposits are consistent with sediment accumulation in a moderate to high-energy, subtidal environment, such as carbonate sand shoal. The diverse faunal assemblage and admixed ooids and oncoids also suggest a shallow water, high-energy, shoal environment. In this environment, wave and tidal action remove matrix material, and typically form strike-oriented grainstone and packstone sand bodies.

Pore System Properties:

Routine core analysis measurements from the shoal facies show porosity values ranging from 23.0% to 1.7% (average of 9.1%), and permeability values ranging from 47.6 md to 0.001 md (average of 4.0 md) (Crossplot 3). The packstones and grainstones that predominate in the shoal facies have pore systems that consist of a combination of 1) interparticle pores, 2) intraparticle pores (Figures 14 and 15) and 3) microporosity (Figure 17). The microporosity occurs within micritized framework grains, and within the admixed detrital micrite matrix. In addition to these pore types, **natural fractures** are locally present (Figures 7 and 18). Where primary interparticle pore space has been preserved, porosity values can exceed 10%, and permeability values may be in excess of 1 md. The highest permeability values occur where natural fractures are present. Nearly all of the permeability values in the shoal facies that are in excess of 10 md are associated with natural fractures (Figures 5 and 7). By comparison, some of the grainstones and packstones show rather extensive calcite cementation and/or contain carbonate matrix. In these rocks, visible pore space is uncommon and a large portion of the measured pore volume is in the form of rather ineffective microporosity. Patchy anhydrite and silica replacement were observed, and these locally reduced both porosity and permeability (Figure 6). **Overall, the shoal facies is judged to have rather variable reservoir potential, ranging from poor to very good. The best potential occurs in grainstones and packstones that have both interparticle pores and natural fractures.**

Paleosol Facies:

Description:

Paleosol deposits account for nearly 50% of the cored interval (Figure 2). Dark, reddish-brown, calcareous to silty claystones and siltstones predominate (Figure 4, C, E and F). Most of this lithofacies is rather featureless, although caliche nodules and root mottles were identified. In addition some silica nodules are apparent. Throughout most of the cored interval, the paleosol facies overlies shoal deposits, with the exception of one case where paleosol deposits directly overly shoal flank facies. Paleosol deposits were identified in the following intervals:

2711.5–2713 feet (1.5')
2713–2714 feet (28')
2779.5–2797.5 feet (18 ')
2810.25–2819.5 feet (9.25')
2830–2844 feet (14')
2848–2860 feet (12')
2863.5–2864 feet (0.5')
2865–2870 feet (5')

Interpretation:

The oxidized (reddish–brown) color, abundance of terrigenous mud, lack of marine indicators, and root structures all suggest that these claystones and siltstones were deposited as soil horizons or **paleosols**. These paleosols are the product of extended periods of subaerial exposure during relative low stands in sea level. Paleosol horizons develop, in part, due to dissolution of exposed carbonate strata and the associated concentration of insoluble clay minerals and terrigenous sand. Many feet of dissolved carbonate rock may be required to produce only a few inches of concentrated insoluble residue. Therefore, these paleosols may be associated with the loss of many tens of feet of carbonate rock from the stratigraphic record.

Pore System Properties:

Routine core analysis measurements are somewhat sparsely distributed throughout the paleosol facies, and porosity and permeability measurements were not made in each of the paleosol units. Porosity measurements range from 12.1% to 1.6% (average of 7.6%), and permeability values range from 35.7 md to 0.002 md (average of 2.9 md) (Crossplot 4). Most of the measured pore volume is in the form of **microporosity** within the terrigenous matrix. This microporosity is considered to be rather ineffective. A trace amount of intercrystalline pore space occurs in some of the caliche nodules. **The wide range in permeability values is interpreted to reflect the presence of induced fractures. Overall, the general lack of effective pore space and the low natural permeability indicate that the paleosol facies has poor reservoir potential.**

EXPLORATION/DEVELOPMENT MODEL

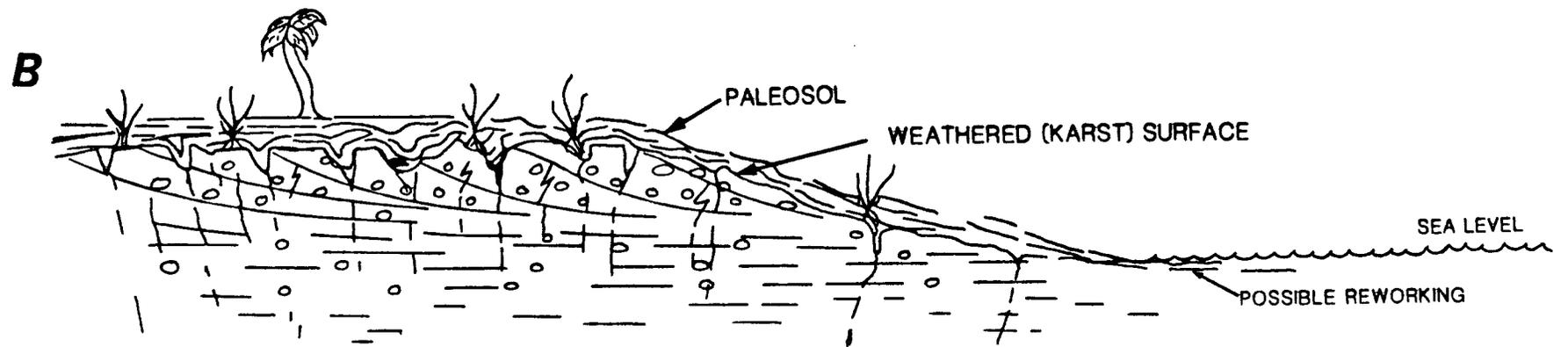
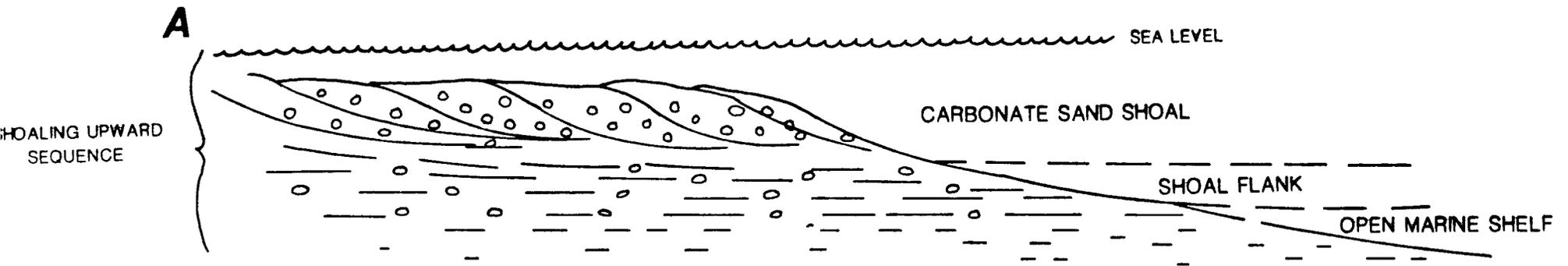
This section of the report provides a synthesis of the observations and conclusions obtained from geological analysis of conventional core from the Anadarko Youngren K No. 3A Well, Stevens County, Kansas. Four (4) principal lithofacies were identified in the cored interval. These are:

**Open Marine Shelf Facies
Shoal Flank Facies
Shoal Facies
Paleosol Facies**

The open marine shelf, shoal flank and shoal facies are the product of sedimentation in related, laterally adjacent depositional environments (Diagram 1,A). Collectively, these facies form shoaling-upward sequences that record the gradual evolution of higher energy conditions. Specifically, the open marine shelf facies are the deepest water, lowest energy marine deposits, while the shoal flank facies reflects sedimentation under somewhat higher energy conditions, and the carbonate sand shoal deposits are the product of shallow water, high-energy sedimentation. These related depositional environments can exist along coastal beaches and offshore bar build-ups in strike-oriented facies belts. The fourth facies, the paleosol deposits, record sedimentation during relative low stands in sea level (Diagram 1,B). The brick-red (oxidized) color, caliche nodules, and root structures identified in the paleosol deposits are all indicative of subaerial sedimentation. Paleosols, in part, reflect the accumulation of insoluble residue due to surface weathering of exposed carbonate rocks. Many feet of dissolved carbonate strata may be required to form only a few inches of paleosol deposits.

As many as 13 shoaling-upward sequences can be delineated in the cored interval (Figure 2). Paleosols cap many of the shoaling-upward cycles and are, in turn, overlain by open marine shelf deposits that reflect reinundation or flooding of the exposed terrain. The shoal facies is the principal reservoir target in these deposits. The cyclic sedimentation patterns reflected in these strata have produced

DIAGRAM 1
IDEALIZED DEPOSITIONAL MODEL

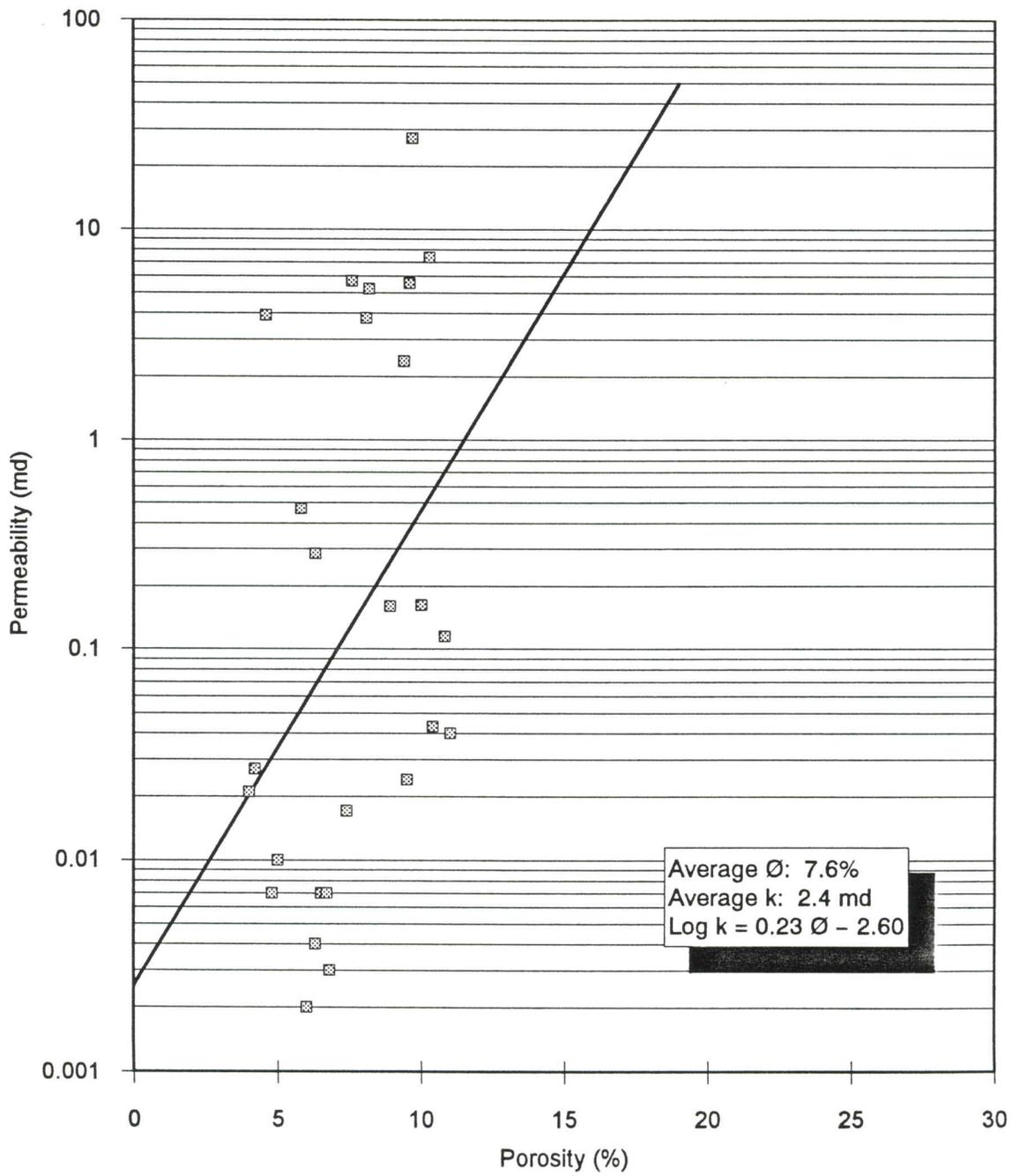


multiple, stacked, prospective reservoir horizons. Most of the shoal deposits are "clean" limestones, they may be discriminated through gamma-ray log cutoffs. By generating net isopach maps of "clean" carbonate deposits in this stratigraphic interval, it may be possible to maximize the thickness of the principal prospective reservoir facies (specifically the shoal deposits), and concomitantly minimize non-prospective paleosol and open marine shelf deposits.

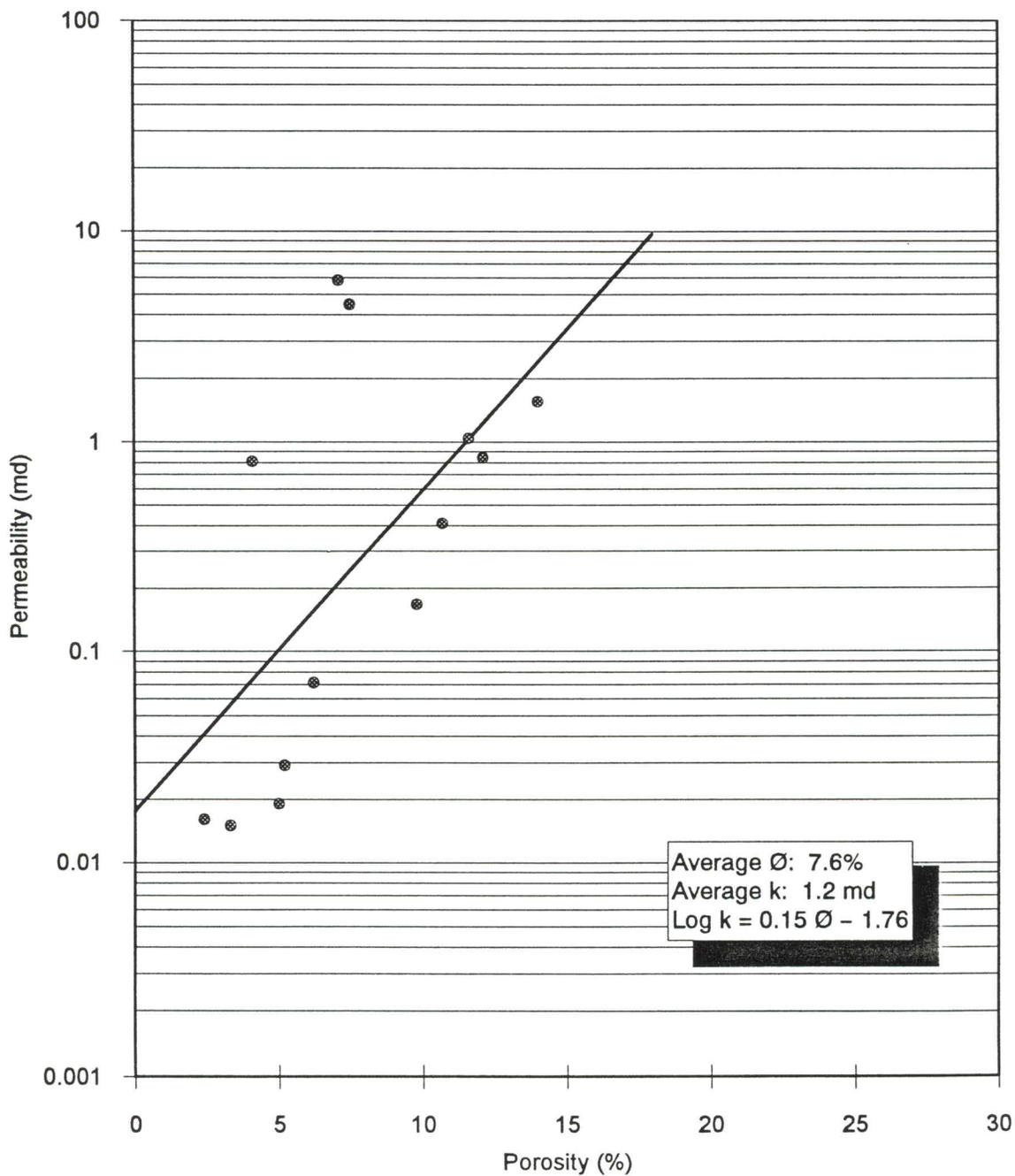
Although most of the strata in the cored interval have rather low permeability, local fracture development in the shoal facies yields rocks with enhanced reservoir potential. The fractures could have developed during subaerial exposure of the shoal deposits (Diagram 1,B). These fractures, combined with interparticle, intraparticle and moldic macropores can form rocks with good to very good reservoir potential (Figures 7, 12 and 18). In addition to the macropores in the shoal facies, microporous grains and matrix are common. This microporosity may be associated with high immobile water saturations that could make it difficult to delineate pay from resistivity log response. Laboratory measured electrical properties could allow for improved log evaluation of these deposits. Most of the porosity measured in the paleosol facies and open marine shelf facies is in the form of ineffective microporosity. These deposits are judged to have poor reservoir potential.

In summary, efforts should be made to identify areas with relatively thick accumulations of the grainstone/packstone, carbonate sand shoal deposits. These carbonate sand shoal accumulations probably formed elongate sand bodies that roughly paralleled depositional strike. Facies migration (i.e., progradation) of these bars may have resulted in broad distribution of these deposits, in sheet-like sand bodies. By maximizing the thickness of the shoal deposits and minimizing open marine shelf and paleosol facies, it may be possible to optimize pay thickness.

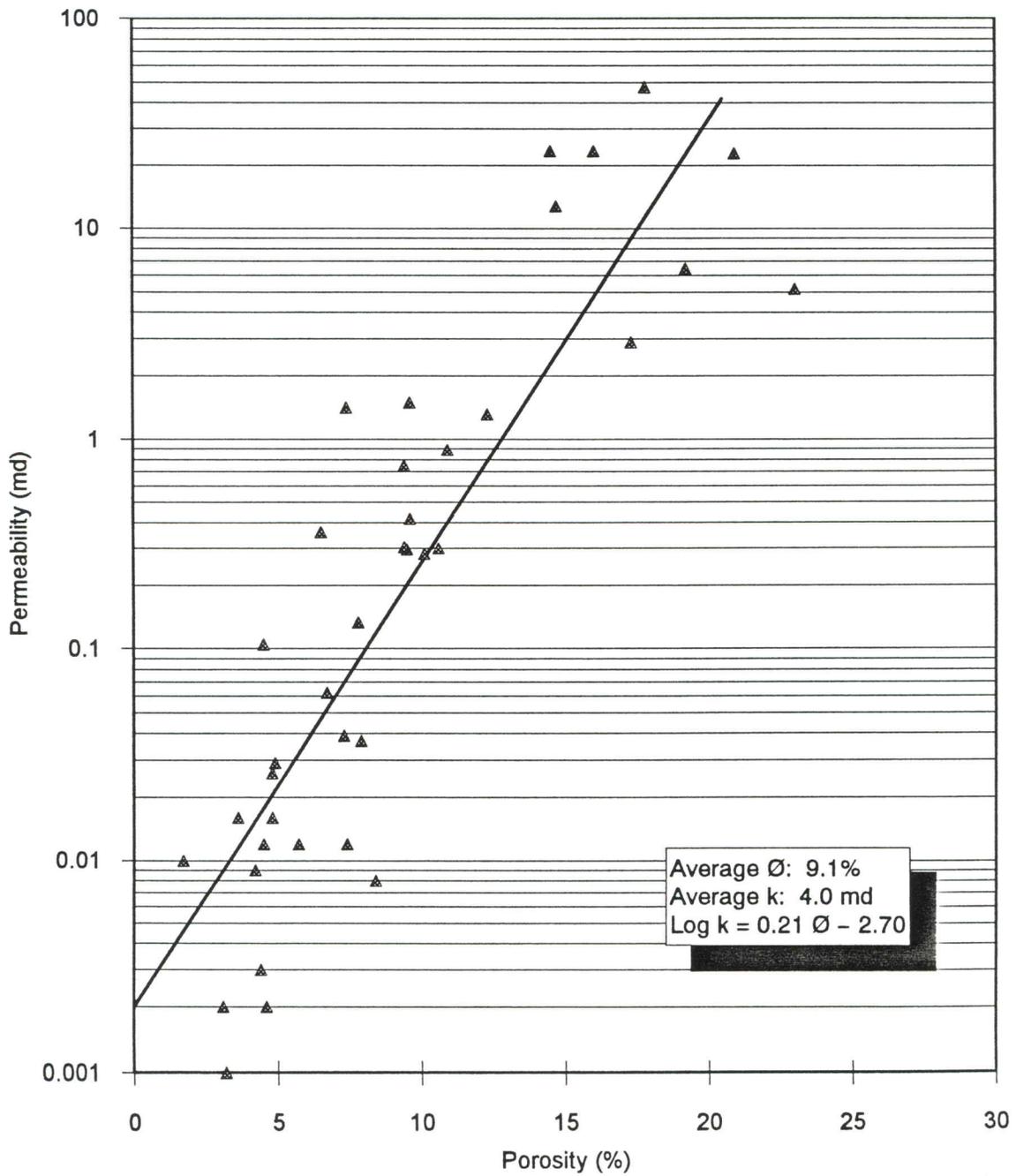
CROSSPLOT 1
POROSITY vs. PERMEABILITY
YOUNGREN K NO. 3A WELL
OPEN MARINE SHELF FACIES



CROSSPLOT 2
POROSITY vs. PERMEABILITY
YOUNGREN K NO. 3A WELL
SHOAL FLANK FACIES



CROSSPLOT 3
POROSITY vs. PERMEABILITY
YOUNGREN K NO. 3A WELL
SHOAL FACIES



CROSSPLOT 4
POROSITY vs. PERMEABILITY
YOUNGREN K NO. 3A WELL
PALEOSOL FACIES

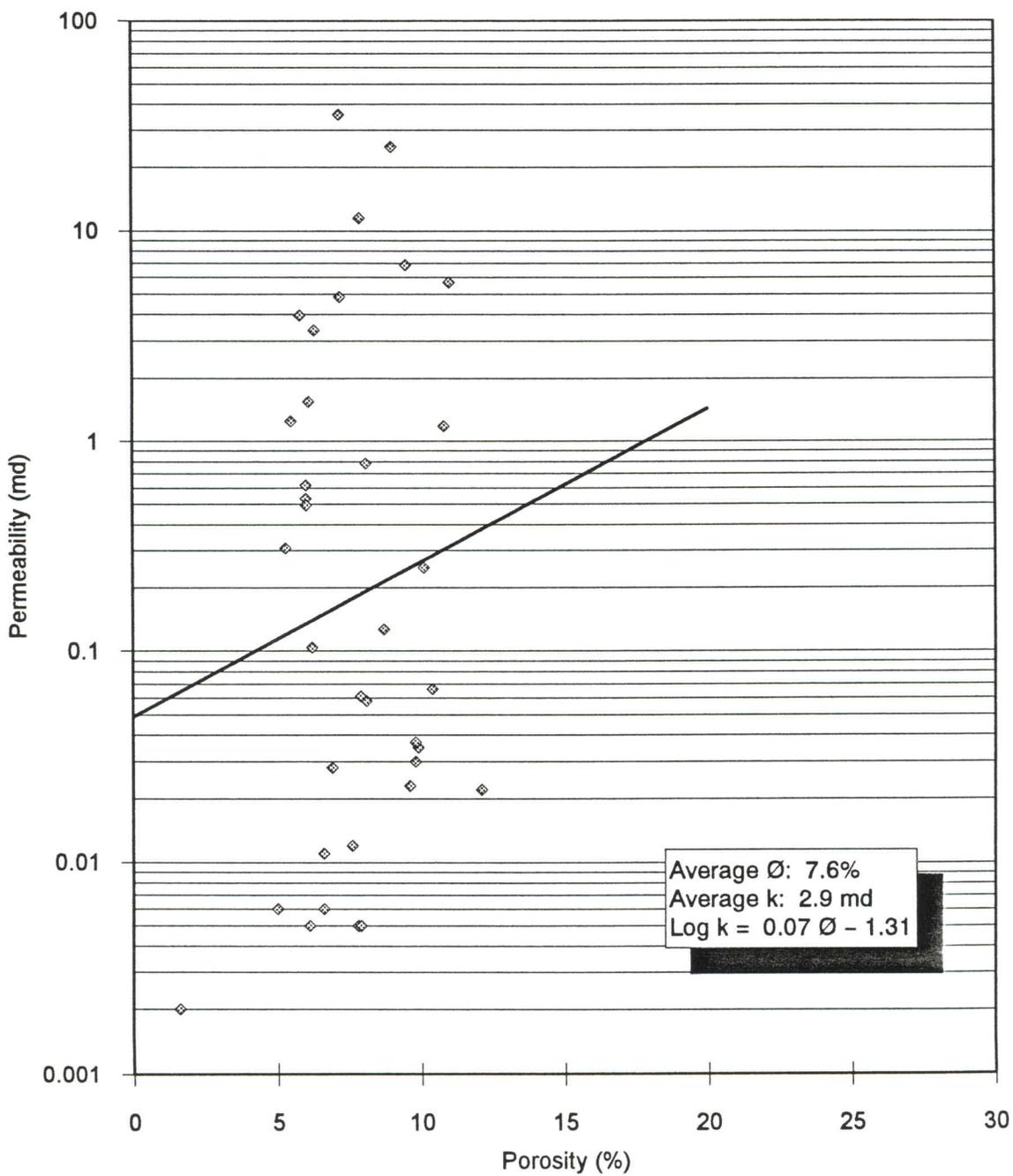


FIGURE 1
CORE TO LOG CORRELATION
ANADARKO YOUNGREN K NO. 3A

LOG DEPTH=CORE DEPTH -8 FEET

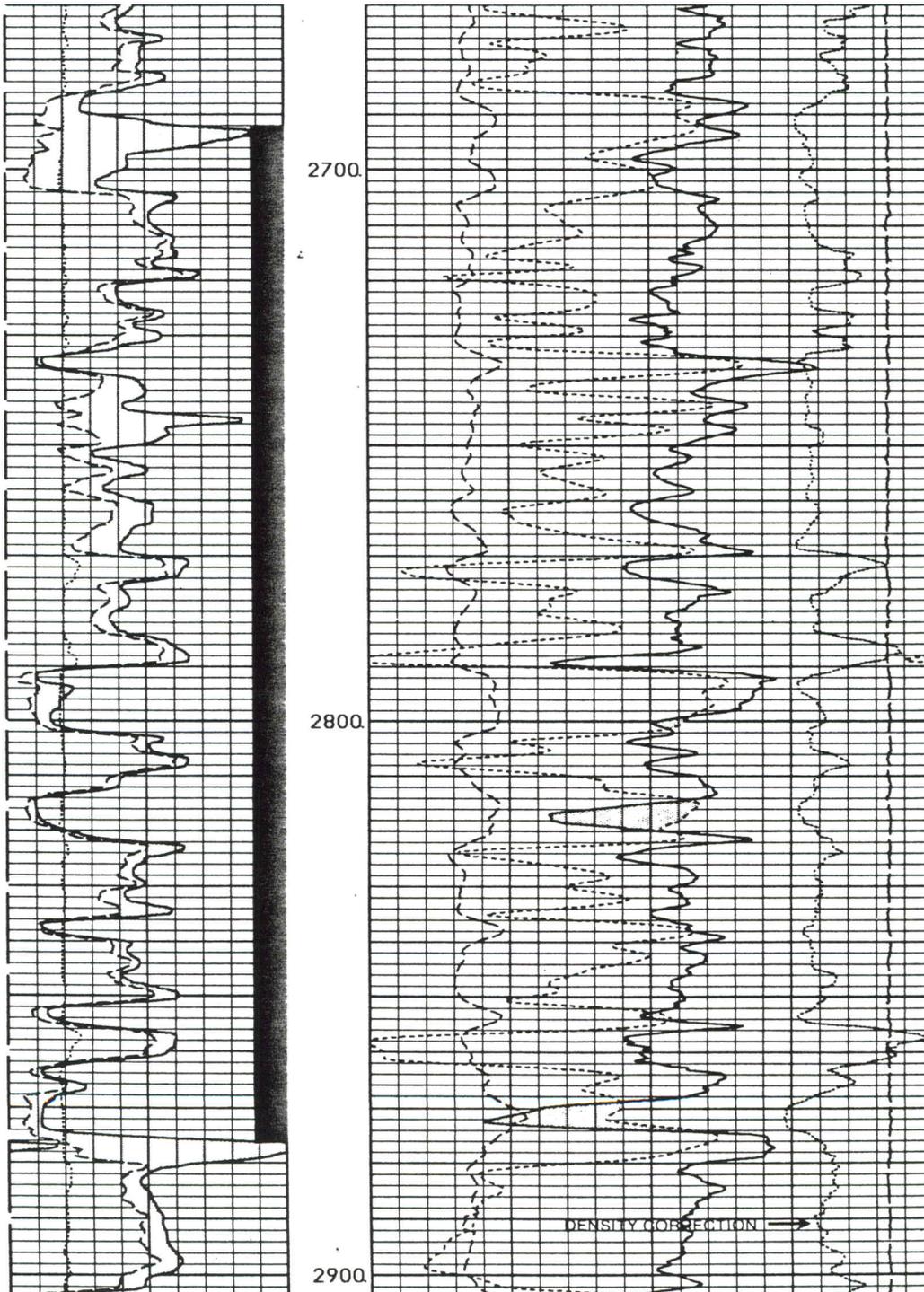


FIGURE 2
CORE DESCRIPTION AND DEPOSITIONAL ENVIRONMENTS
ANADARKO YOUNGREN K NO. 3A
STEVENS COUNTY, KANSAS

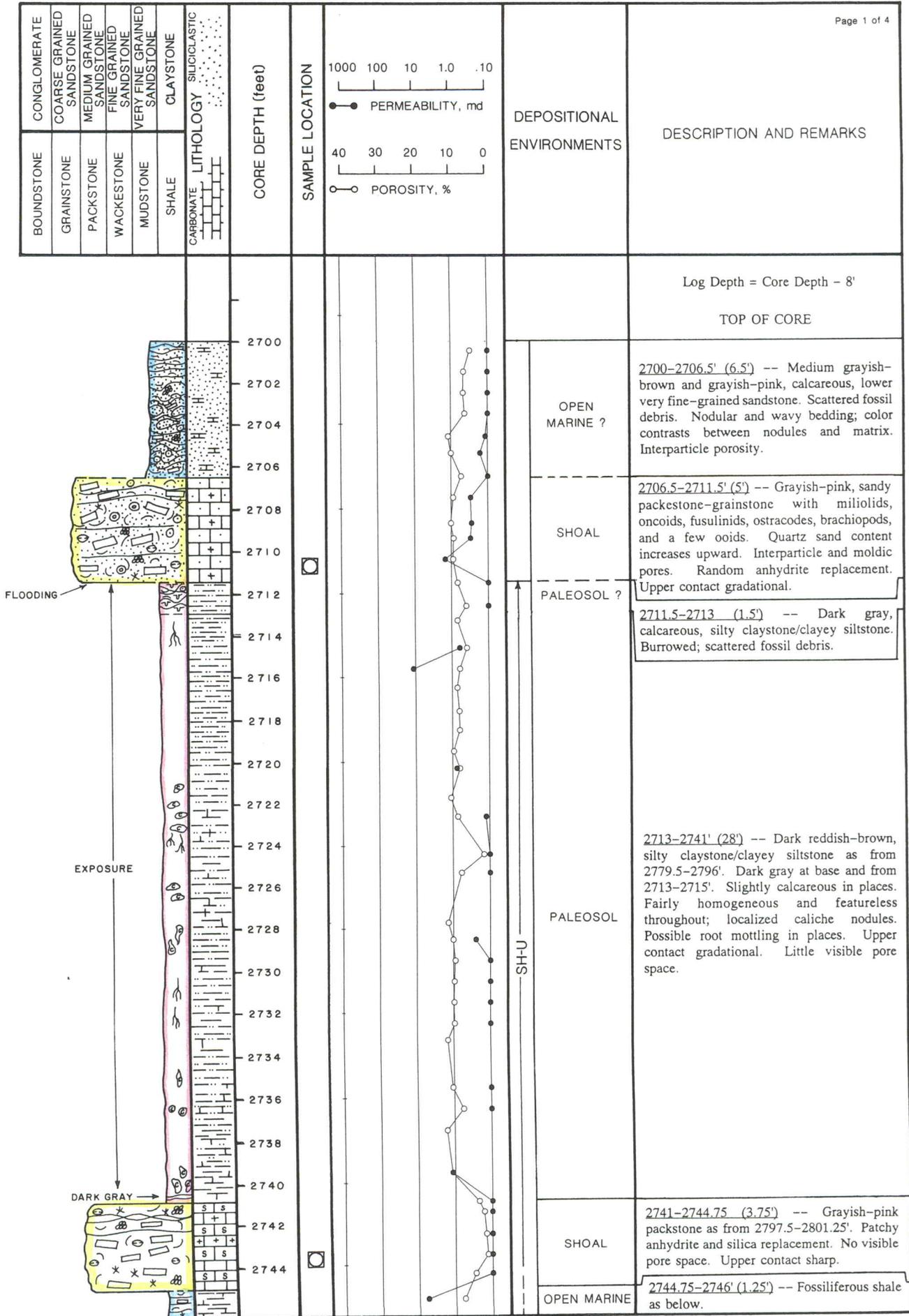


FIGURE 2 CONTINUED
ANADARKO YOUNGREN K NO. 3A

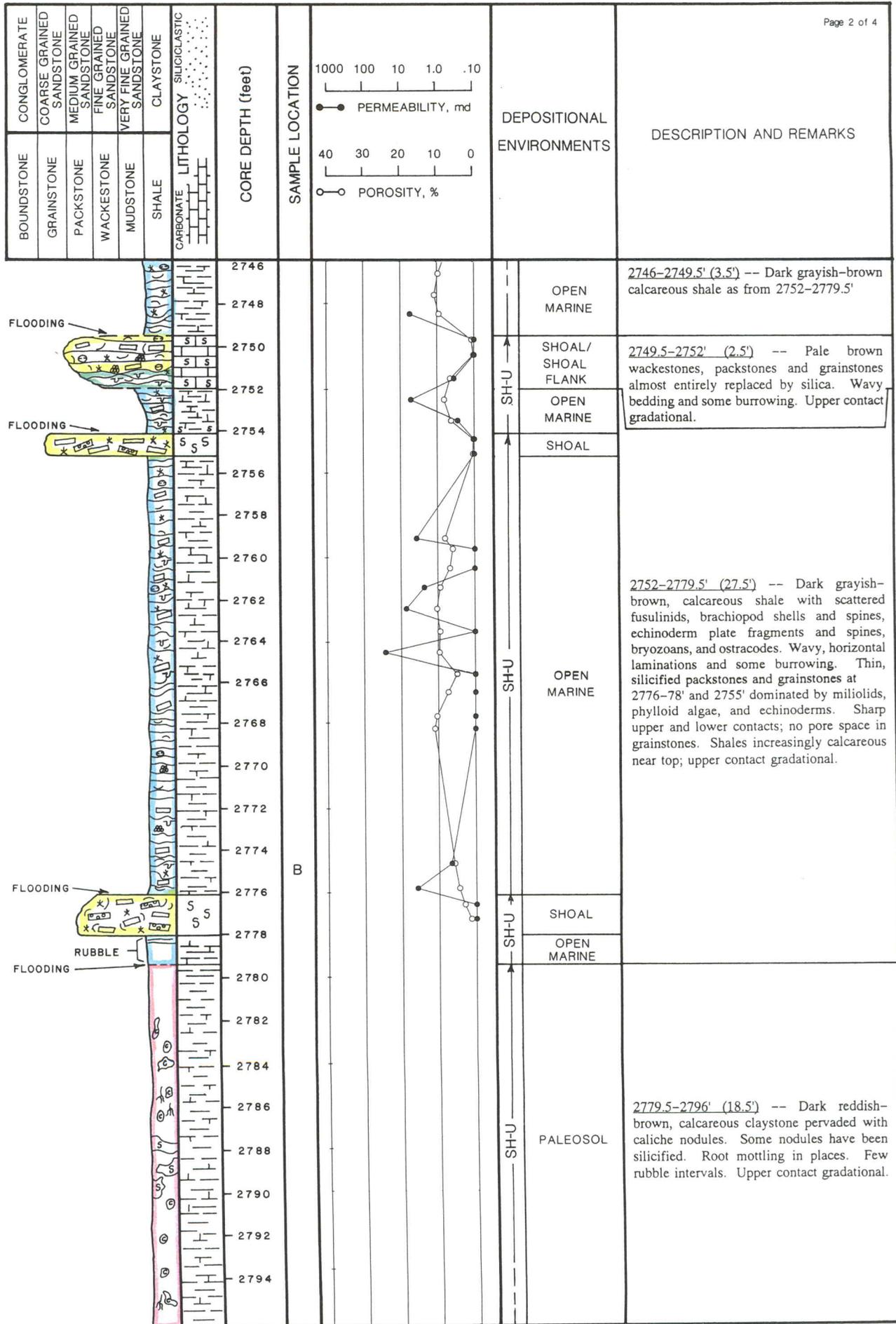


FIGURE 2 CONTINUED
ANADARKO YOUNGREN K NO. 3A

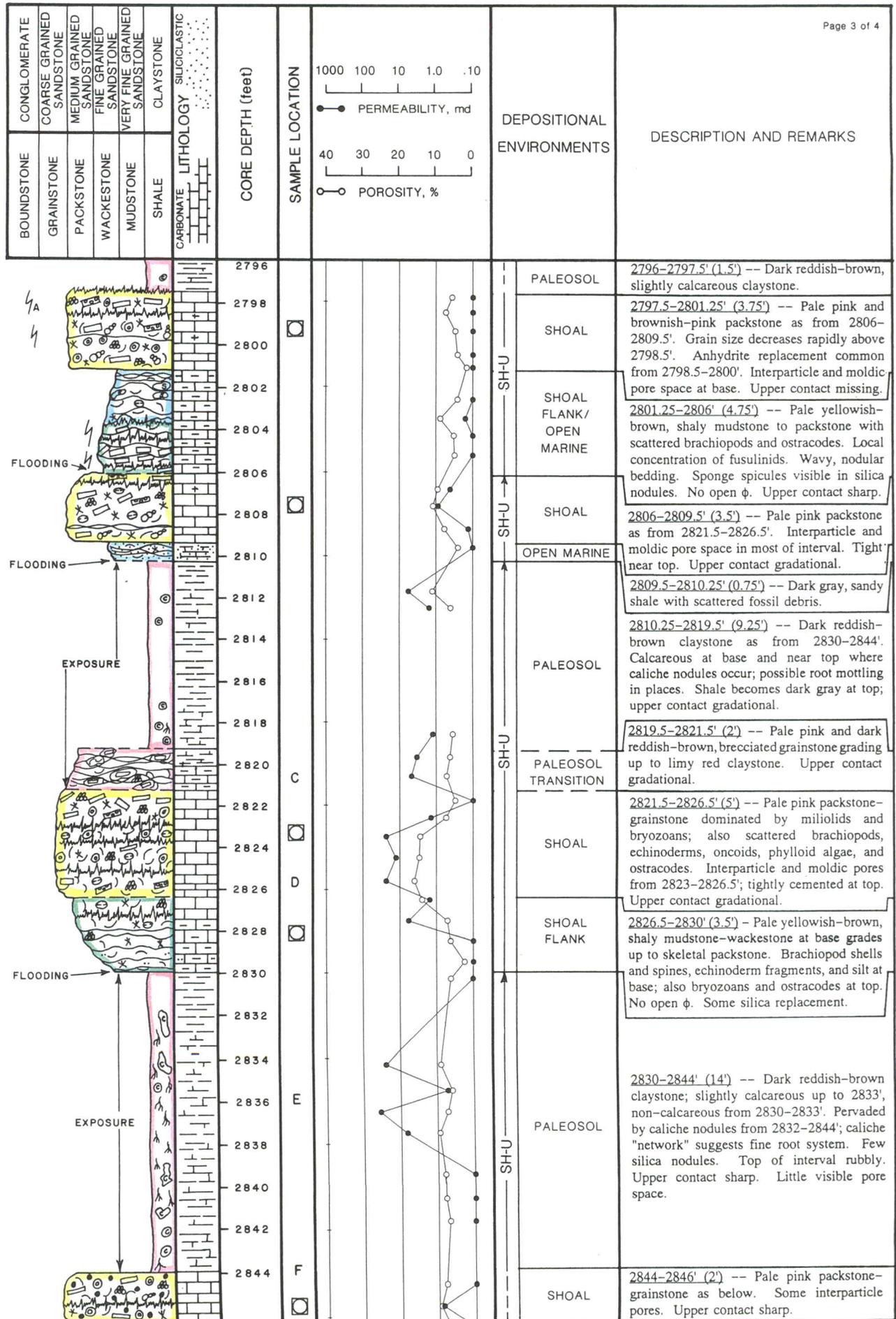


FIGURE 2 CONTINUED
ANADARKO YOUNGREN K NO. 3A

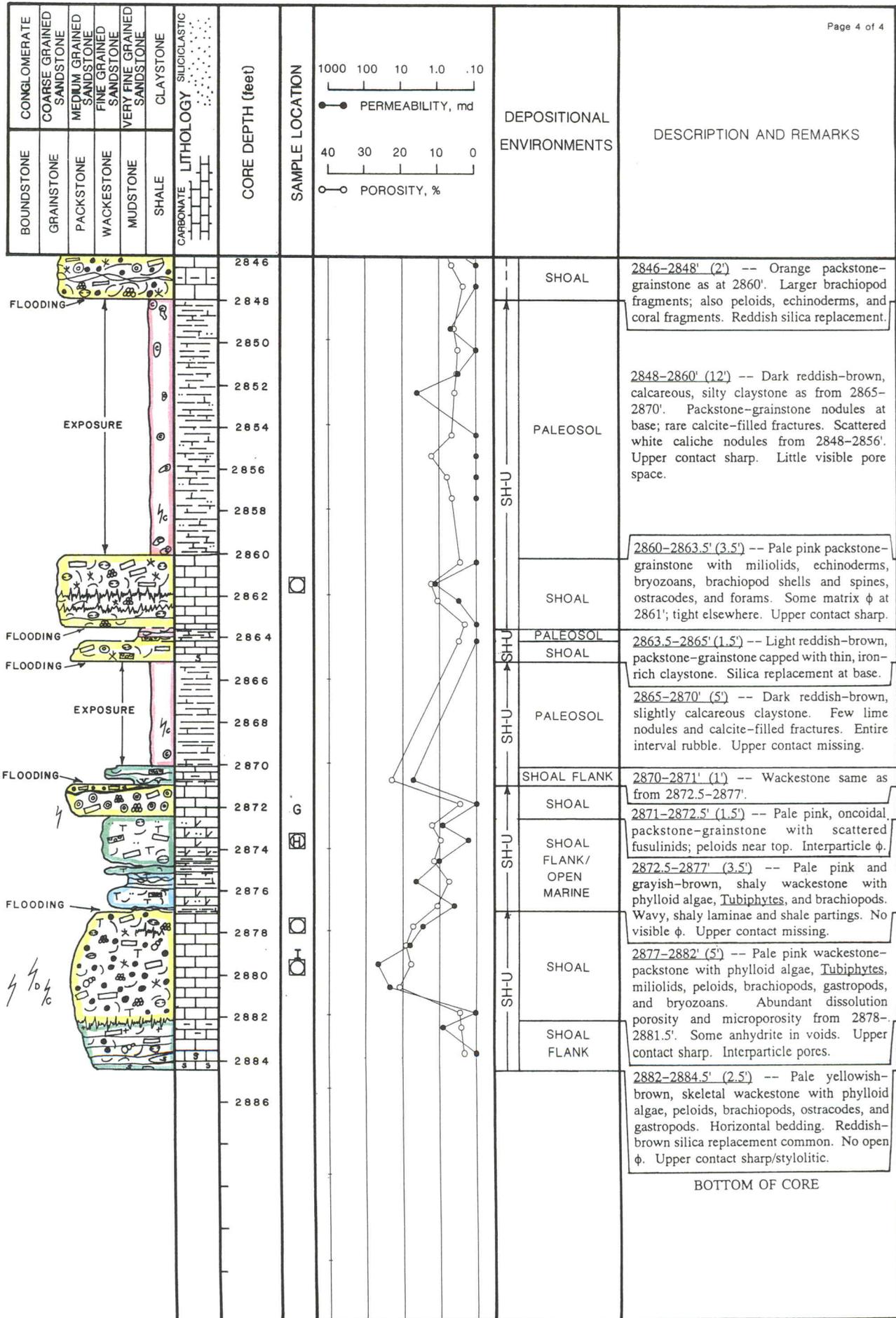
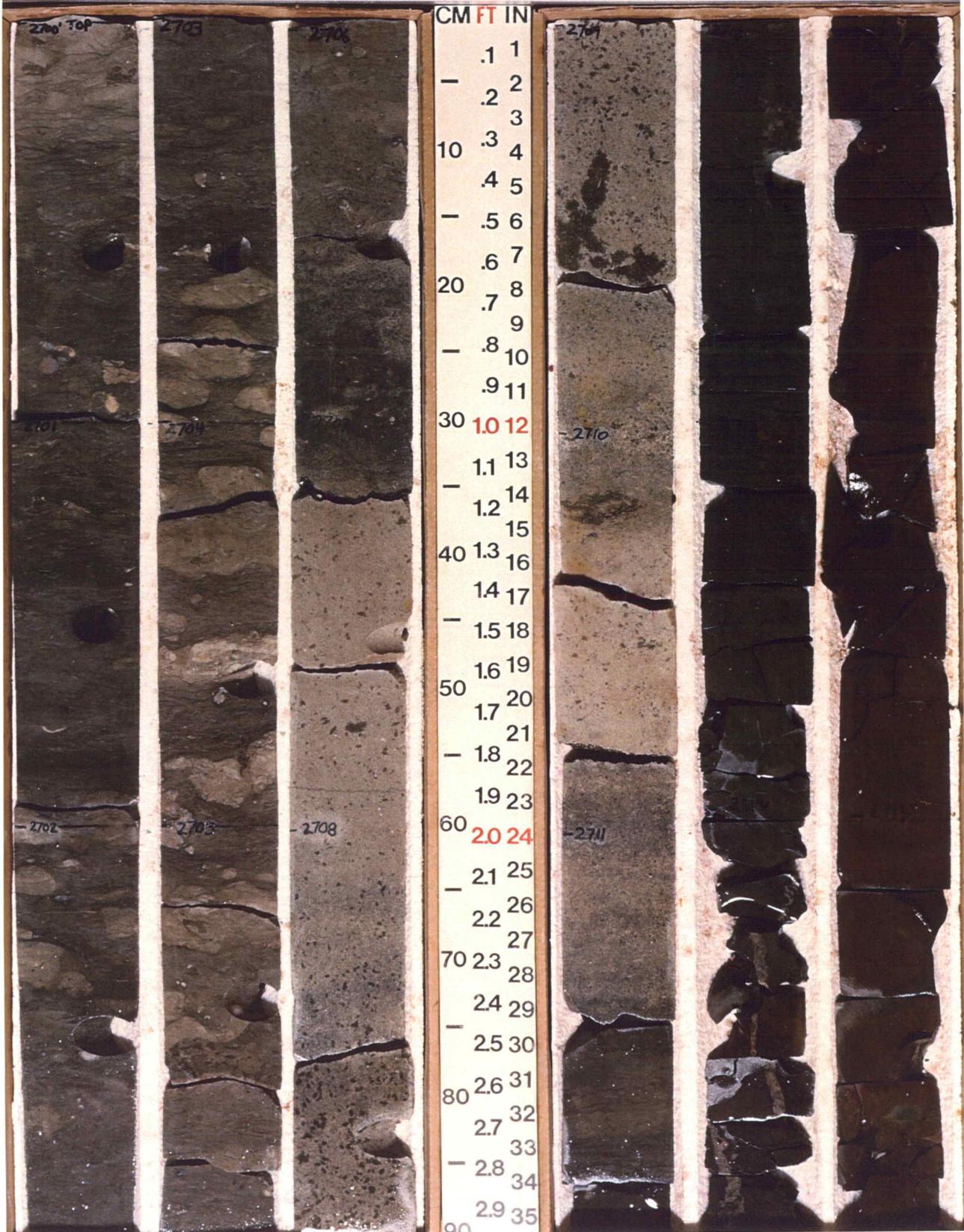


FIGURE 3
CONTINUOUS CORE PHOTOGRAPHS
ANADARKO YOUNGREN K NO. 3A

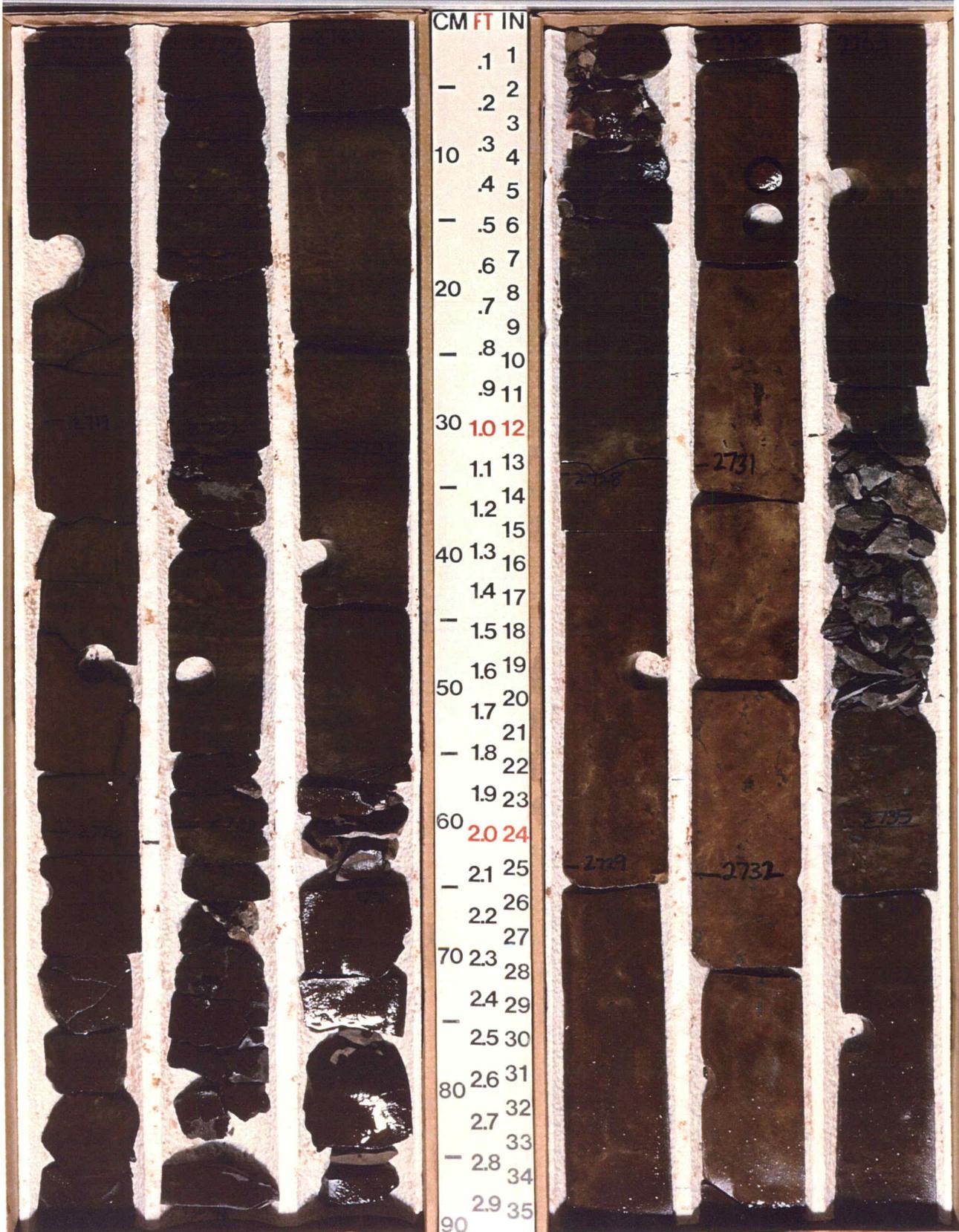
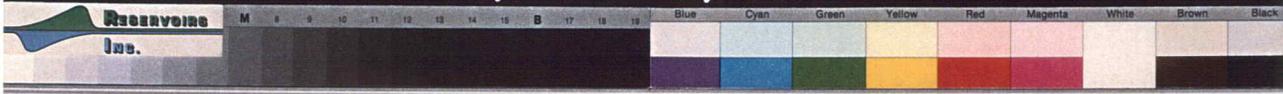
Core Depths

2770'-2884.4'

ANADARKO PETROLEUM CORPORATION
 YOUNGREN K NO. 3A
 PANOMA (COUNCIL GROVE) FIELD
 STEVENS COUNTY, KANSAS
 2,700.0 - 2,718.0



ANADARKO PETROLEUM CORPORATION
 YOUNGREN K NO. 3A
 PANOMA (COUNCIL GROVE) FIELD
 STEVENS COUNTY, KANSAS
 2,718.0 - 2,736.0



CM	FT	IN
.1		1
—	.2	2
		3
10	.3	4
	.4	5
—	.5	6
	.6	7
20	.7	8
	.8	9
—	.9	10
		11
30	1.0	12
	1.1	13
—	1.2	14
		15
40	1.3	16
	1.4	17
—	1.5	18
	1.6	19
50	1.7	20
	1.8	21
—	1.9	22
		23
60	2.0	24
	2.1	25
—	2.2	26
		27
70	2.3	28
	2.4	29
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	2.6	31
80	2.7	32
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	2.9	35
90		

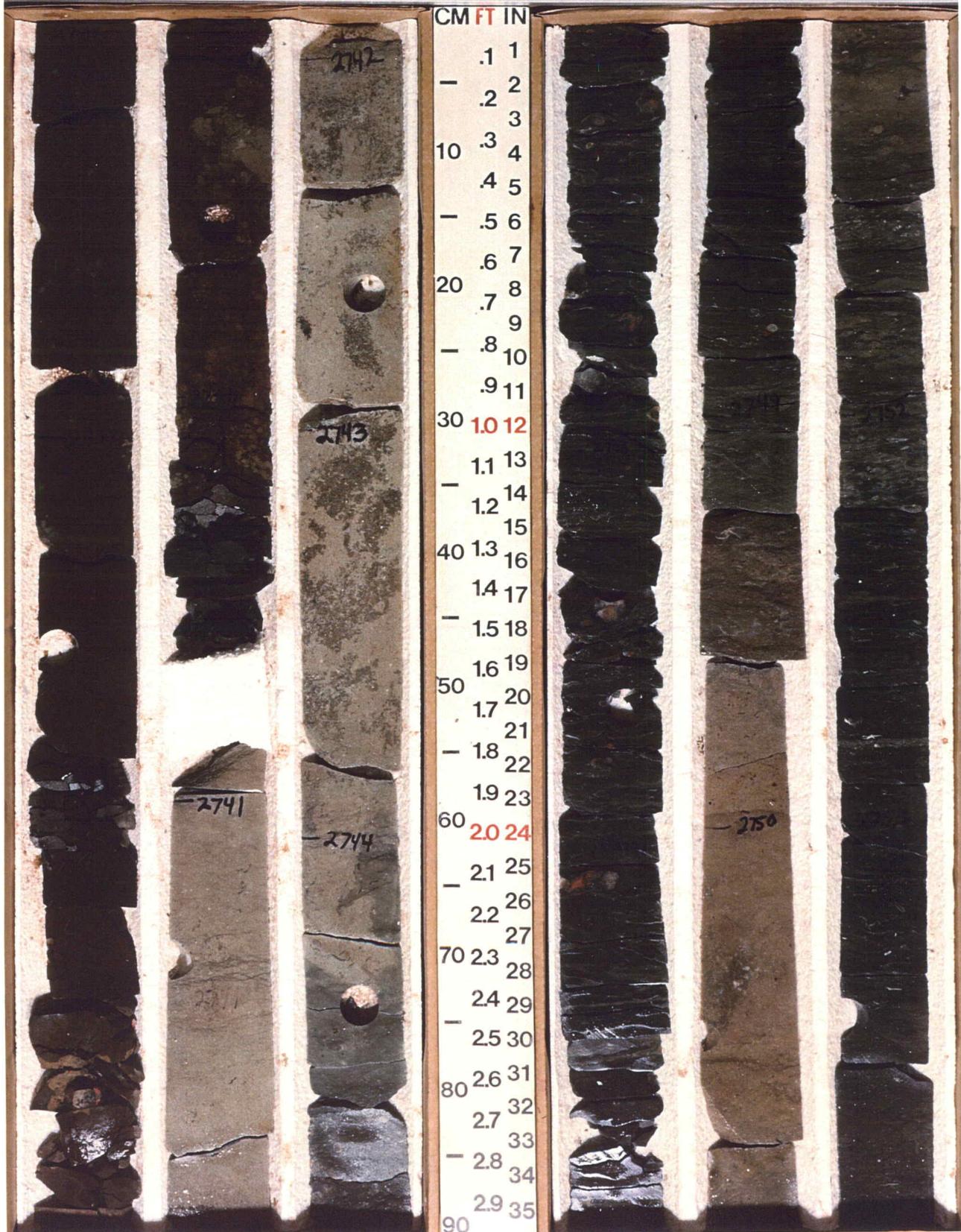
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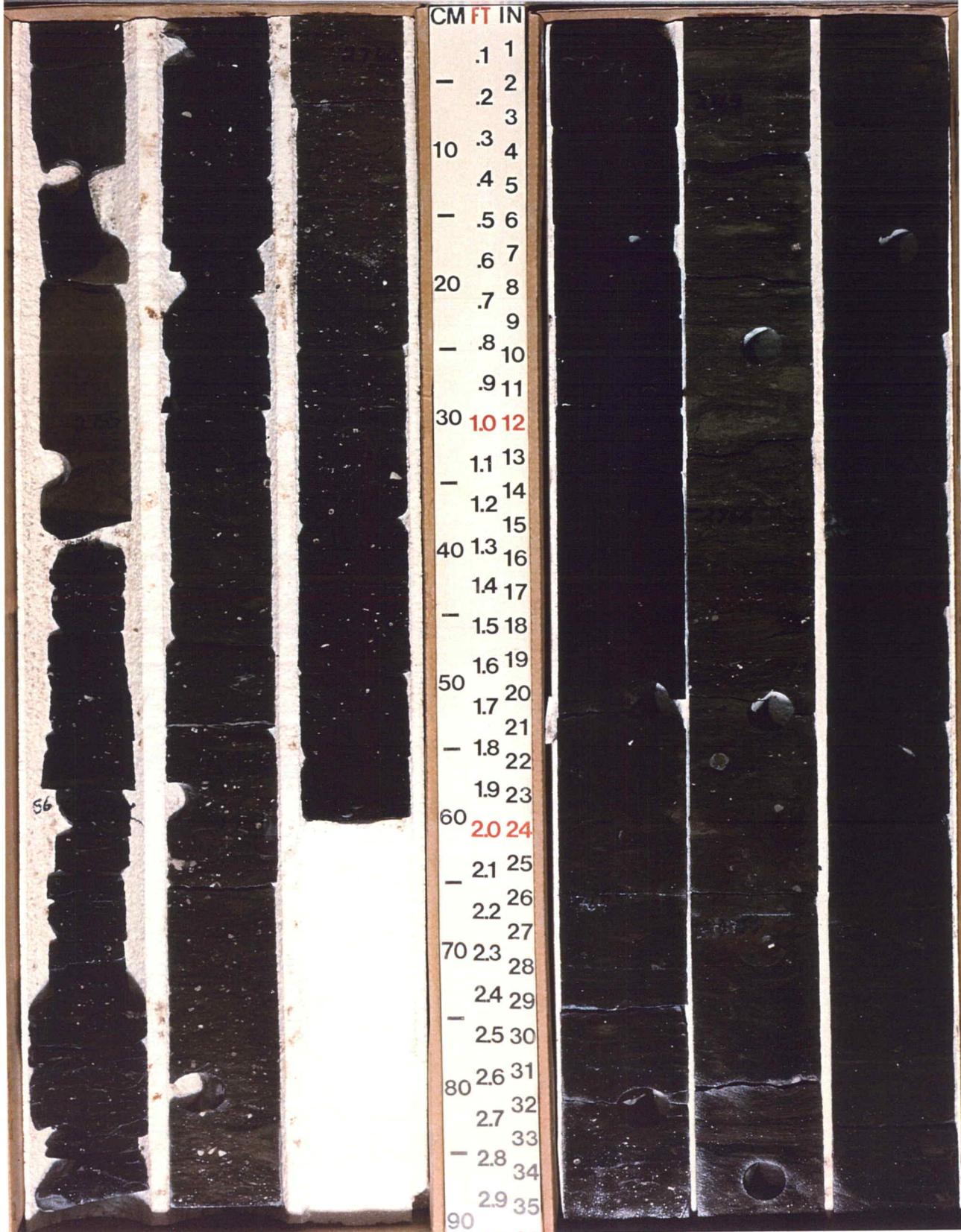
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2735

ANADARKO PETROLEUM CORPORATION
 YOUNGREN K NO. 3A
 PANOMA (COUNCIL GROVE) FIELD
 STEVENS COUNTY, KANSAS
 2,736.0 - 2,754.0



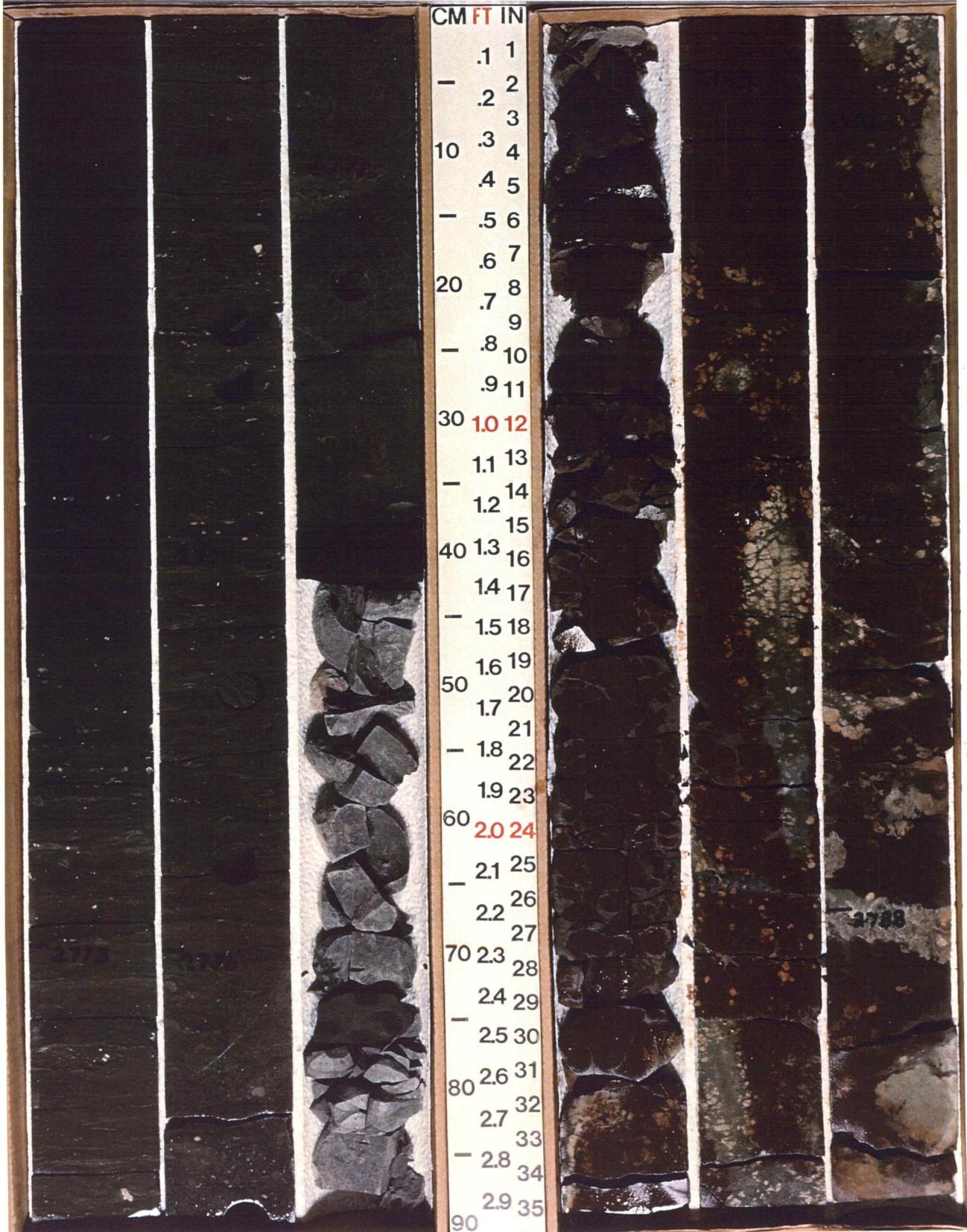
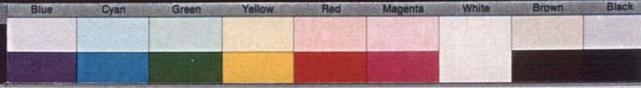
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YOUNGREN K NO. 3A
PANOMA (COUNCIL GROVE) FIELD
STEVENS COUNTY, KANSAS
2,754.0 - 2,770.8



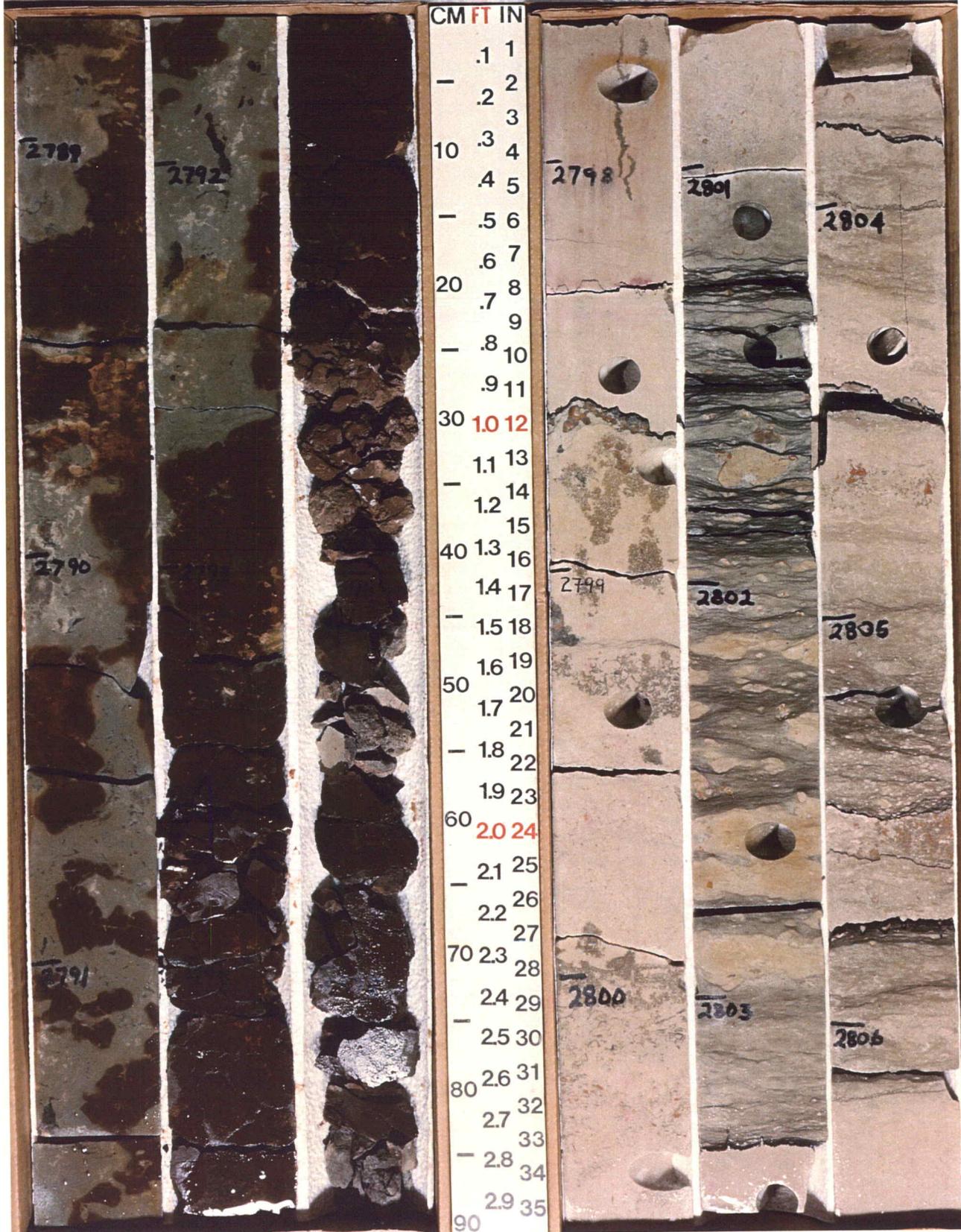
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YOUNGREN K NO. 3A
PANOMA (COUNCIL GROVE) FIELD
STEVENS COUNTY, KANSAS
2,770.8 - 2,788.7



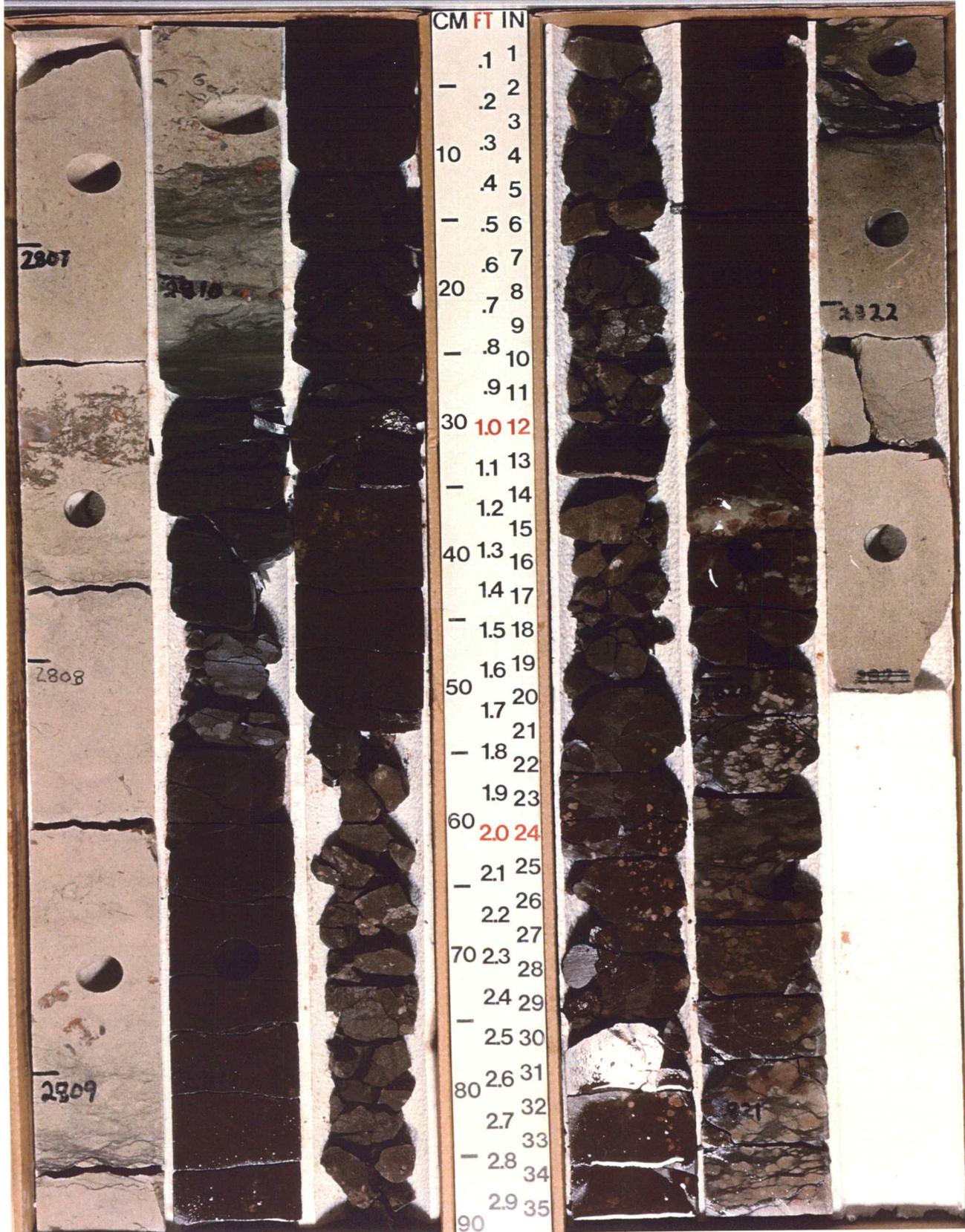
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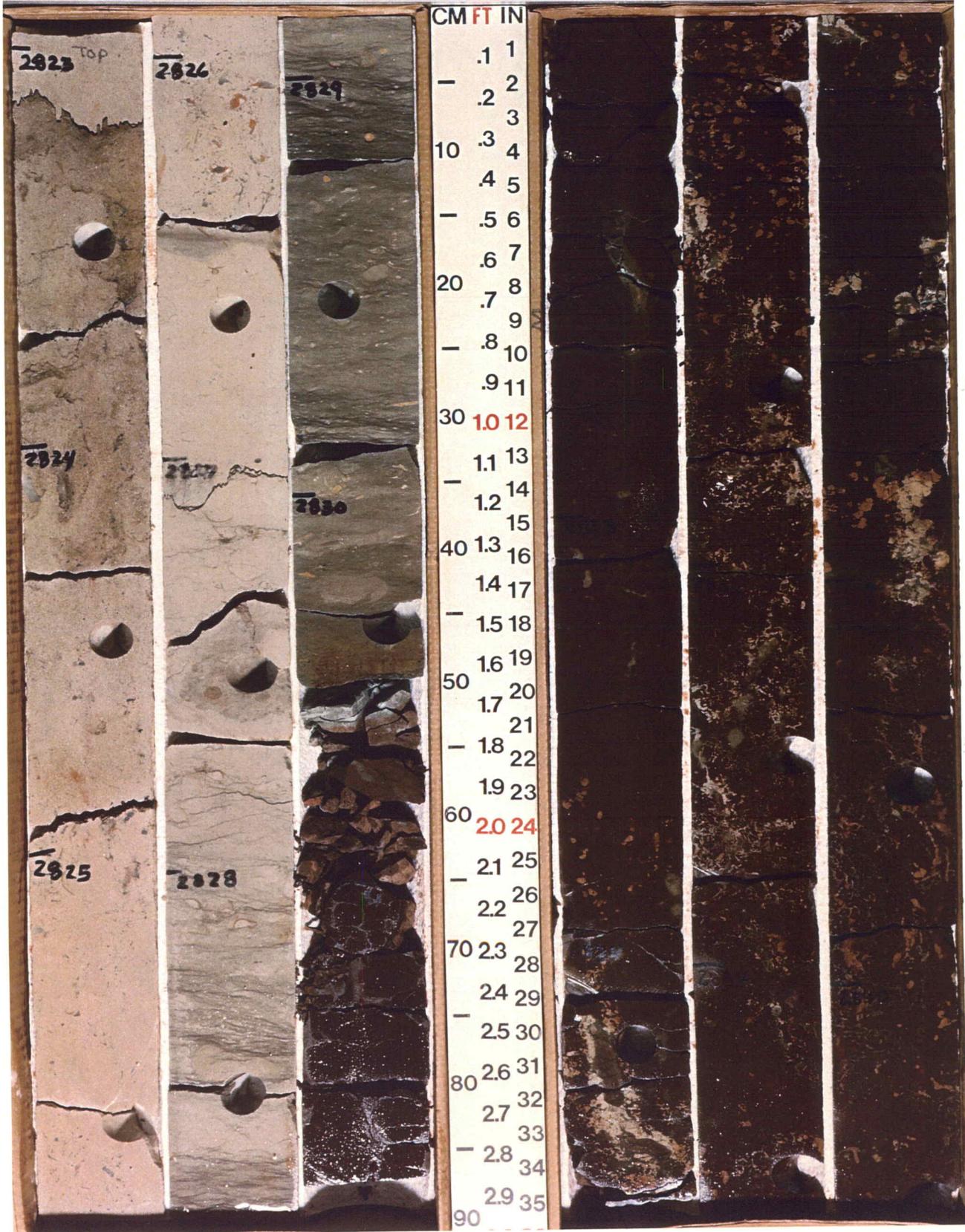
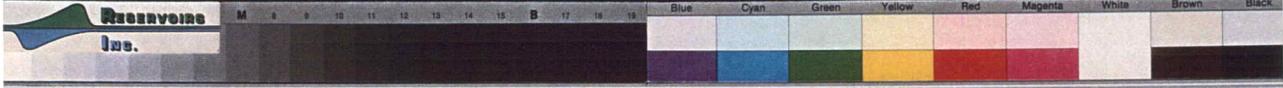
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 PANOMA (COUNCIL GROVE) FIELD
 STEVENS COUNTY, KANSAS
 2,788.7 - 2,806.5



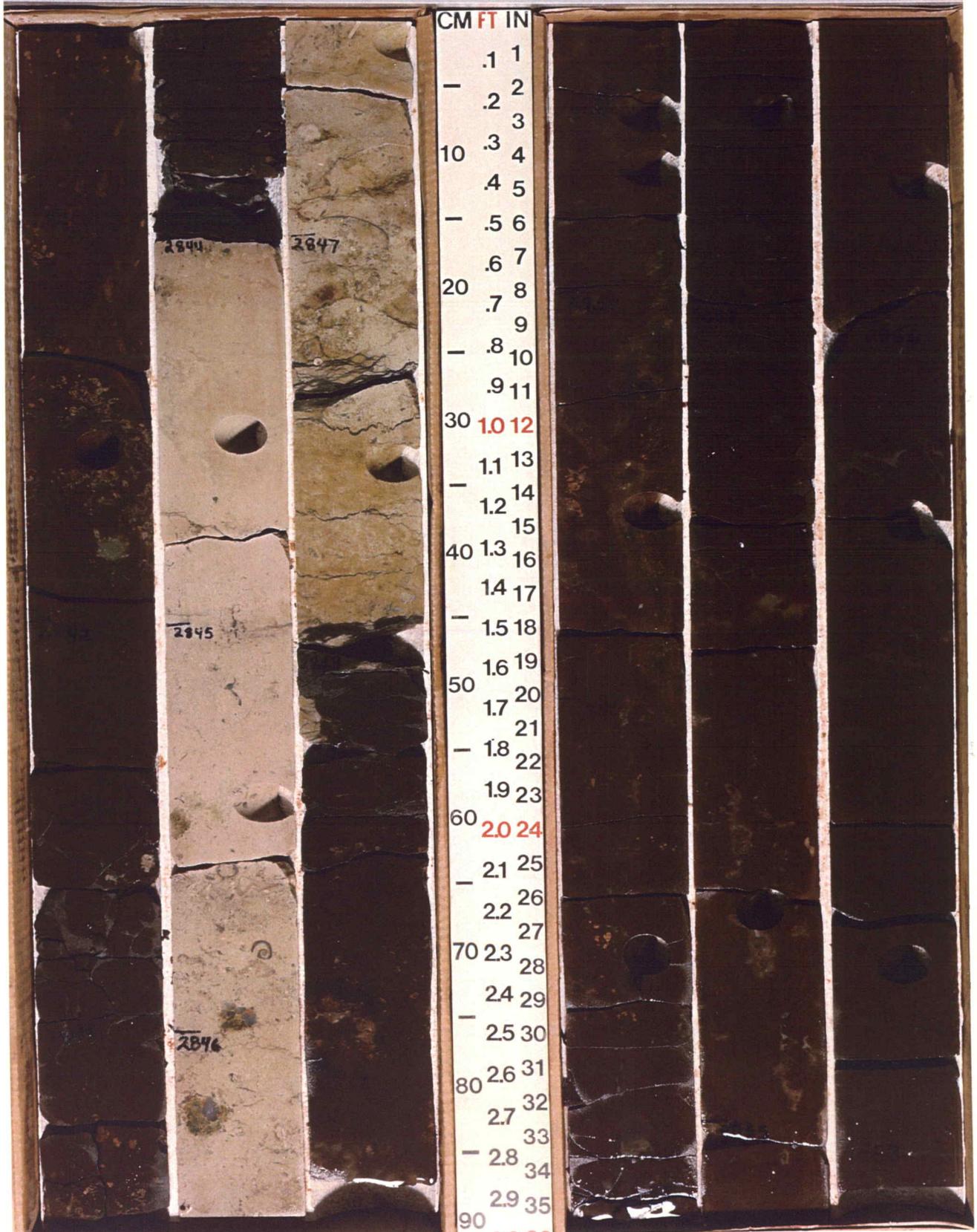
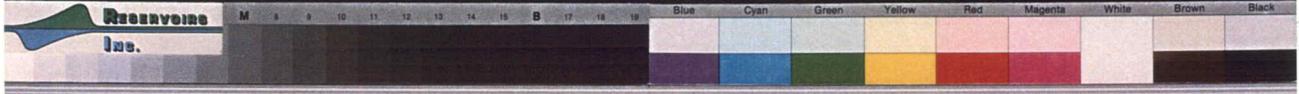
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 PANOMA (COUNCIL GROVE) FIELD
 STEVENS COUNTY, KANSAS
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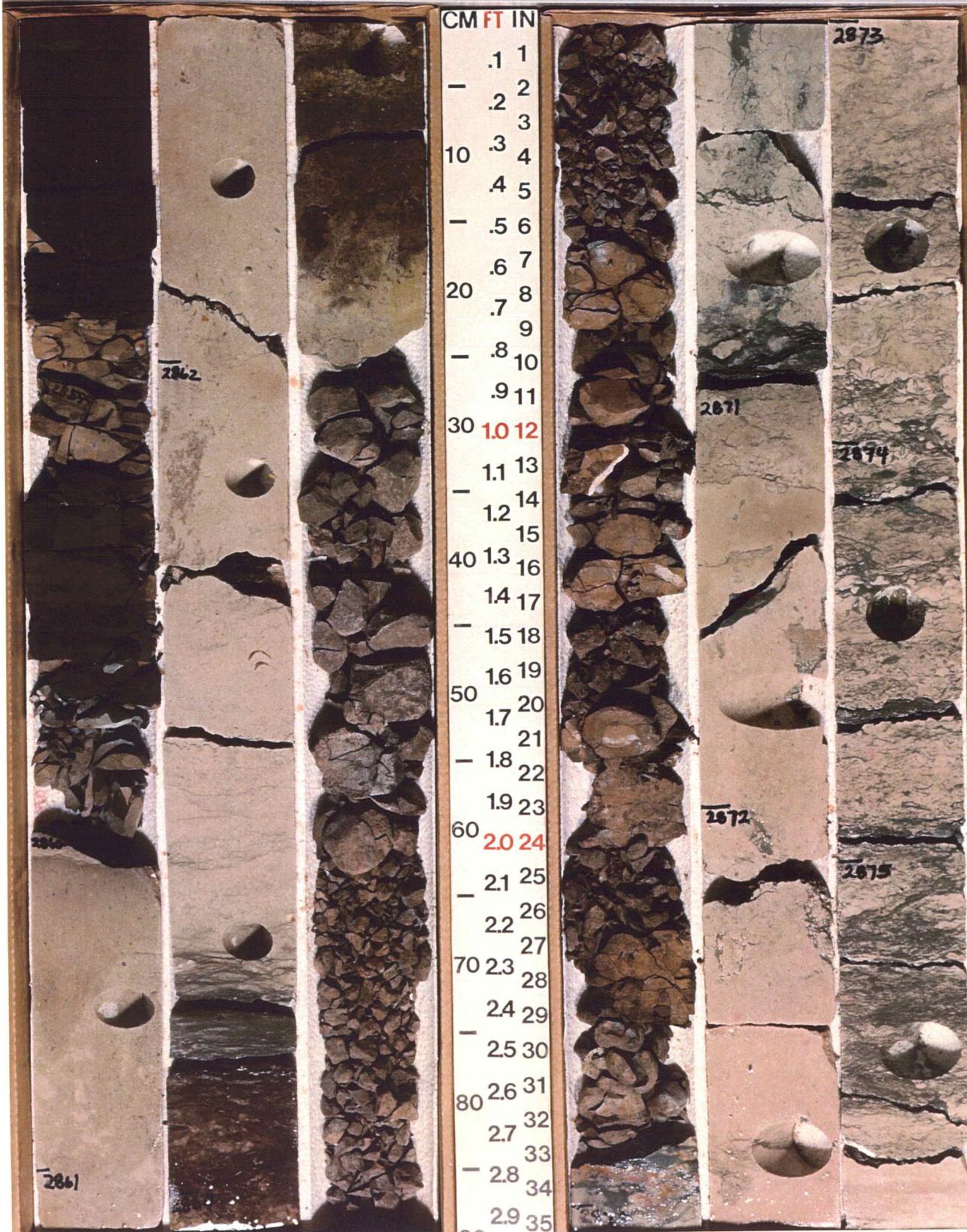
ANADARKO PETROLEUM CORPORATION
 YOUNGREN K NO. 3A
 PANOMA (COUNCIL GROVE) FIELD
 STEVENS COUNTY, KANSAS
 2,822.9 - 2,840.5



ANADARKO PETROLEUM CORPORATION
YOUNGREN K NO. 3A
PANOMA (COUNCIL GROVE) FIELD
STEVENS COUNTY, KANSAS
2,840.5 - 2,858.1



ANADARKO PETROLEUM CORPORATION
 YOUNGREN K NO. 3A
 PANOMA (COUNCIL GROVE) FIELD
 STEVENS COUNTY, KANSAS
 2,858.1 - 2,876.0



ANADARKO PETROLEUM CORPORATION
 YOUNGREN K NO. 3A
 PANOMA (COUNCIL GROVE) FIELD
 STEVENS COUNTY, KANSAS
 2,876.0 - 2,884.4



CM FT IN
 .1 1
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 30 1.0 12
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 1.6 19
 50 1.7 20
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 — 1.8 22
 1.9 23
 60 2.0 24
 2.1 25
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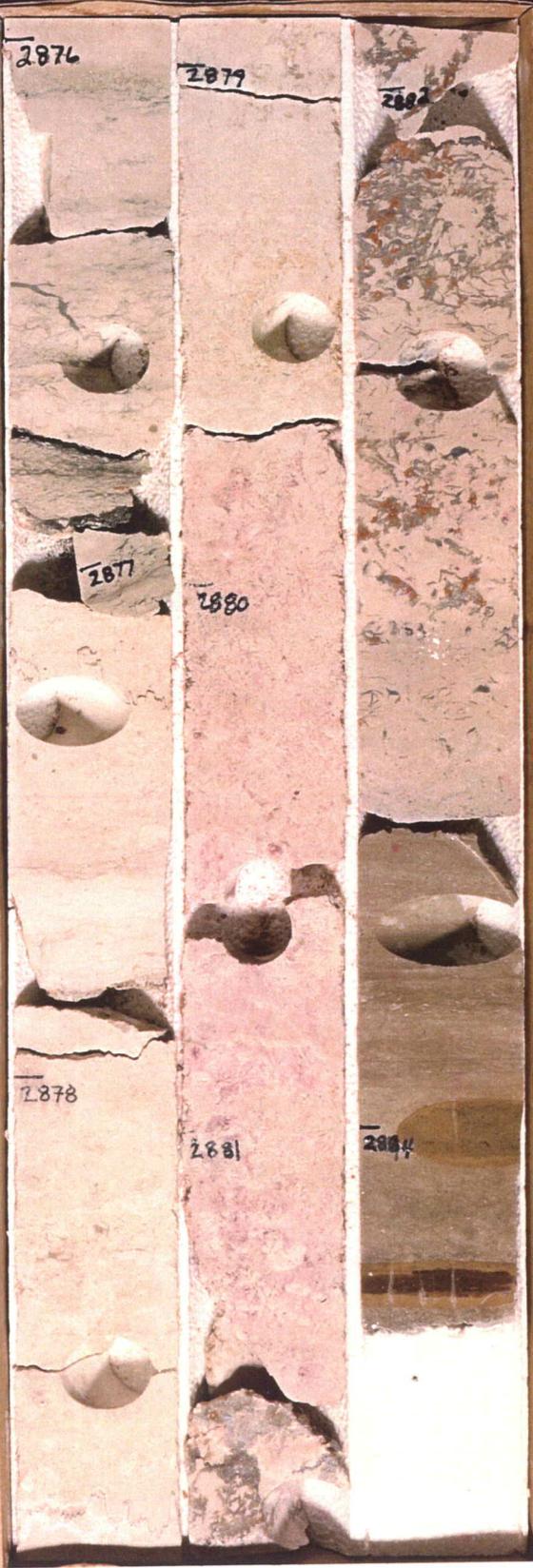


FIGURE 4

CLOSE CORE PHOTOGRAPHS

ANADARKO YOUNGREN K NO. 3A

- A. Depth: 2704' Depositional Facies: Open Marine Shelf

This sample rock is an argillaceous, lower very fine-grained sandstone, with pink, lime mudstone-wackestone "nodules". These "nodules" are probably large burrows. Note the scattered fine-grained marine skeletal debris.

- B. Depth: 2775' Depositional Facies: Open Marine Shelf

This dark brown, calcareous shale is well indurated and has horizontal bedding. The subrounded, light pink grains are fusulinids. Thin, elongate brachiopod shells can also be seen along bedding planes. The marine fossils and the matrix-rich texture are indicative of low energy, subtidal sedimentation in a shelf environment.

- C. Depth: 2821' Depositional Facies: Paleosol Transition

This rock occurs between well indurated limestones and an overlying brick-red paleosol. Brecciated rock such as this commonly underlies ancient soil horizons, and reflects surface weathering and meteoric diagenesis. This sample shows the transition between the host rock limestone and the paleosol.

- D. Depth: 2825.8' Depositional Facies: Shoal

Moderately to well sorted packstone-grainstone such as this predominate in the shoal deposits. Miliolids, bryozoans, and other skeletal fragments are present. Interparticle and moldic pore space occurs in this rock. Routine core analysis measurements from this sample depth show porosity at 16.0% and permeability at 23.4 md.

- E. Depth: 2835.9' Depositional Facies: Paleosol

Root mottling is indicated by the fine network of white caliche nodules in this paleosol. These structures are common attributes of terra rossa soils.

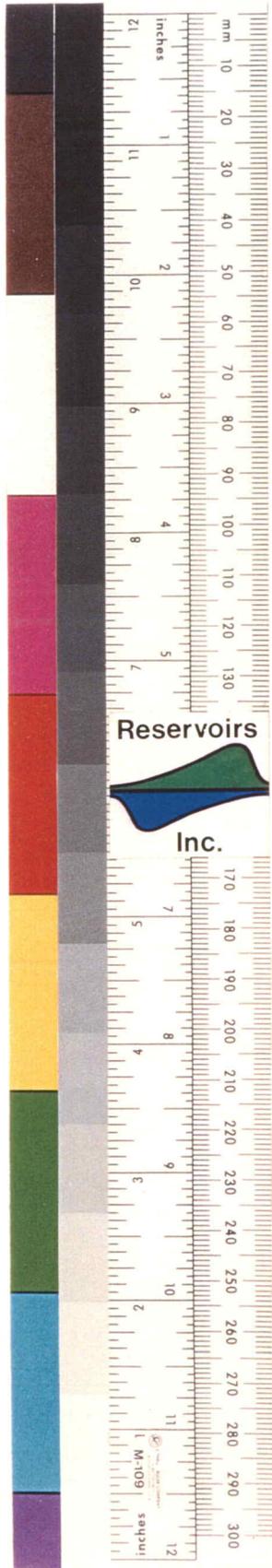
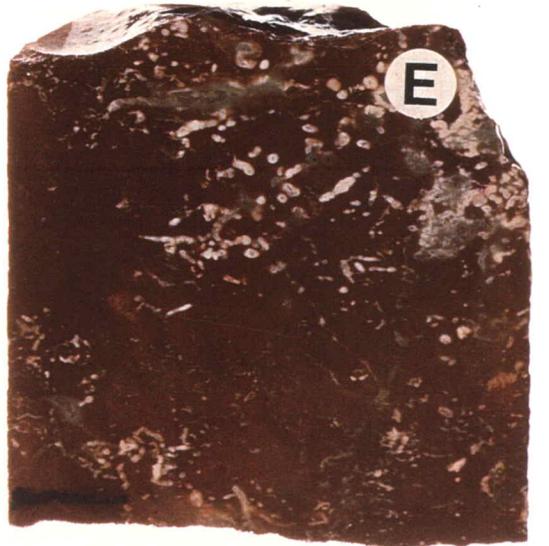
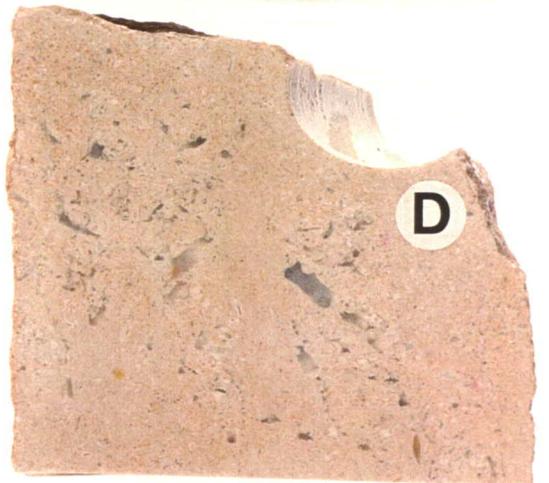
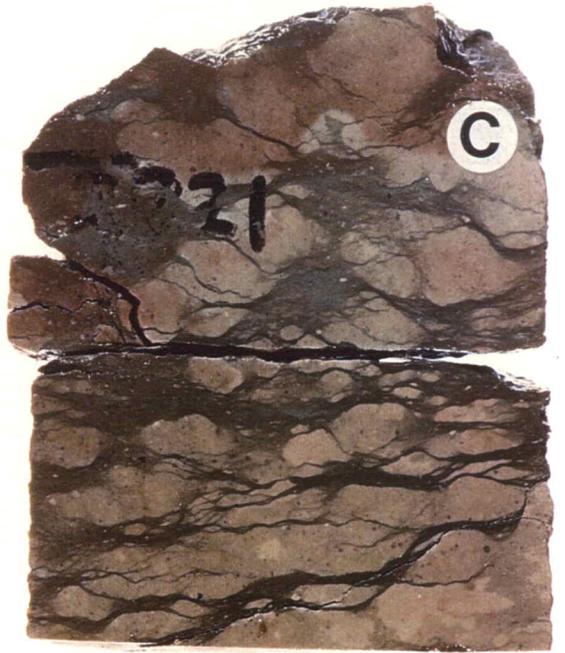
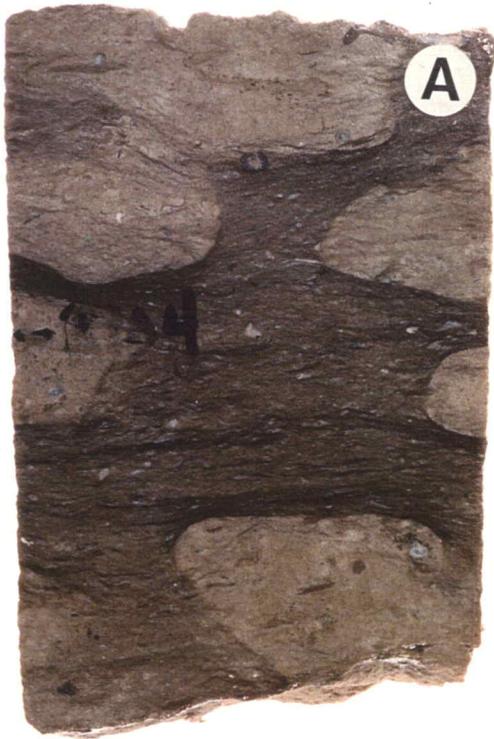


FIGURE 4 (CONTINUED)
CLOSE CORE PHOTOGRAPHS
ANADARKO YOUNGREN K NO. 3A

- F. Depth: 2844' Depositional Facies: Shoal/Paleosol contact

Although the paleosol (red) deposits are poorly preserved, it appears that the contact with the underlying shoal deposits is quite sharp. Compare this to Figure 4,C where the strata along the contact are more gradational.

- G. Depth: 2872.3' Depositional Facies: Shoal

Coarse-grained ooids and oncoids are visible in this packstone-grainstone. The depositional texture and assortment of framework grains are consistent with sedimentation in a high-energy, carbonate sand shoal.

- H. Depth: 2873.75' Depositional Facies: Shoal Flank

Bioturbated wackestone textures, with brachiopod shells and phylloid algae characterizes the shoal flank facies. Fusulinids are also present. Detrital micrite accounts for a large part of the rock.

- I. Depth: 2879.2' Depositional Facies: Shoal

This sample comes from the most porous and permeable interval in the core. The rock is a packstone to grainstone with abundant interparticle pores and natural fractures. There are also dissolution pores and intraparticle pores. The elongate natural fractures apparently account for most of the measured permeability (see Figure 18).

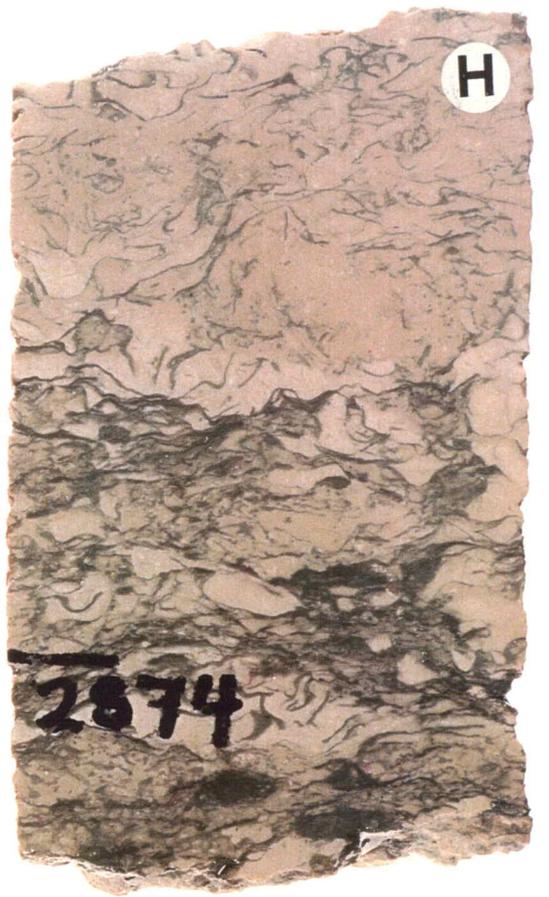
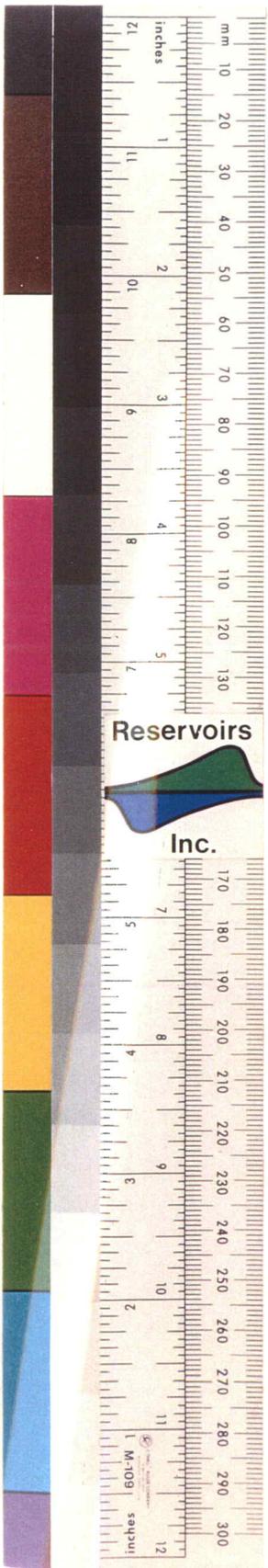


FIGURE 5

WHOLE THIN SECTION PHOTOGRAPH

ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL

Depth: 2,823.5 feet

Shoal Facies

Porosity: 14.5%

Permeability: 23.4 md

In addition to the interparticle and intraparticle macropores that are rather homogeneously distributed throughout this rock, close examination reveals thin vertical fractures that have been only partially infilled with calcite. These fractures are best observed along the left quarter and right quarter of the photograph (see also Figure 12). Most of the permeability probably reflects fluid flow through these natural fractures and remnant interparticle pores. Some dissolution porosity may also contribute to the effective pore network. Calcite cement (light pink patches) and anhydrite cement (white patches) have acted to reduce total pore volume. The anhydrite has also replaced some of the original calcitic grains. The space between the black bar at the base of the photograph equals 1 mm.

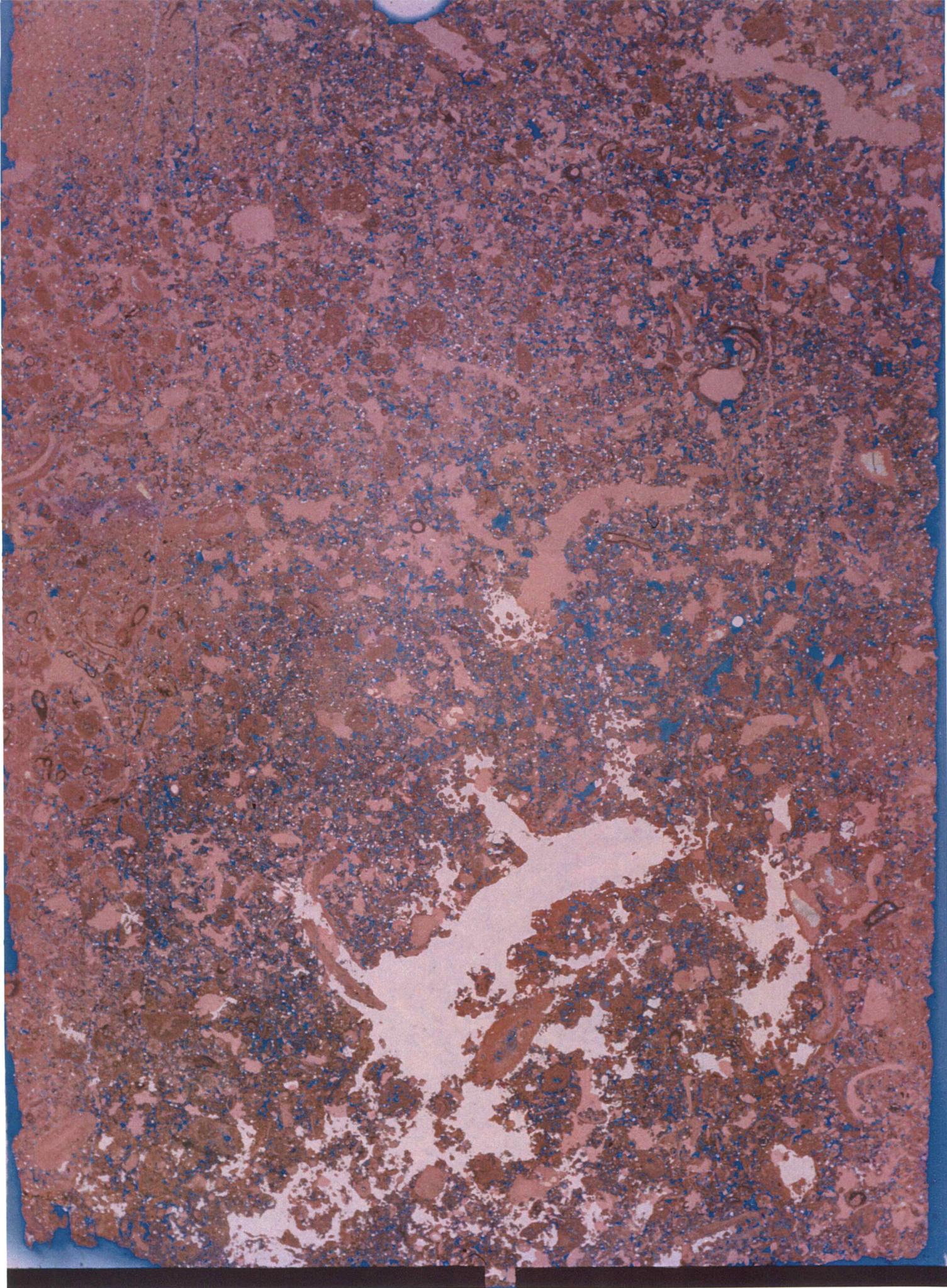


FIGURE 6

WHOLE THIN SECTION PHOTOGRAPH

ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL

Depth: 2,845.5 feet

Shoal Facies

Porosity: 9.4%

Permeability: 0.751 md

Note the large patches of anhydrite (white areas). This anhydrite occurs both as a replacement product and as a patchy cement. Although some interparticle pore space has been preserved between the framework grains of this rock, the low measured permeability suggests that overall, the remnant network of primary pores is poorly interconnected. Note the faint blue cast throughout the finer grained parts of this sample. This reflects the presence of microporosity (see also Figure 14). The horizontal fracture that crosscuts the sample is an artifact of sample handling, and not part of the natural rock fabric. The space between the bars at the base of the photograph equals 1 mm.

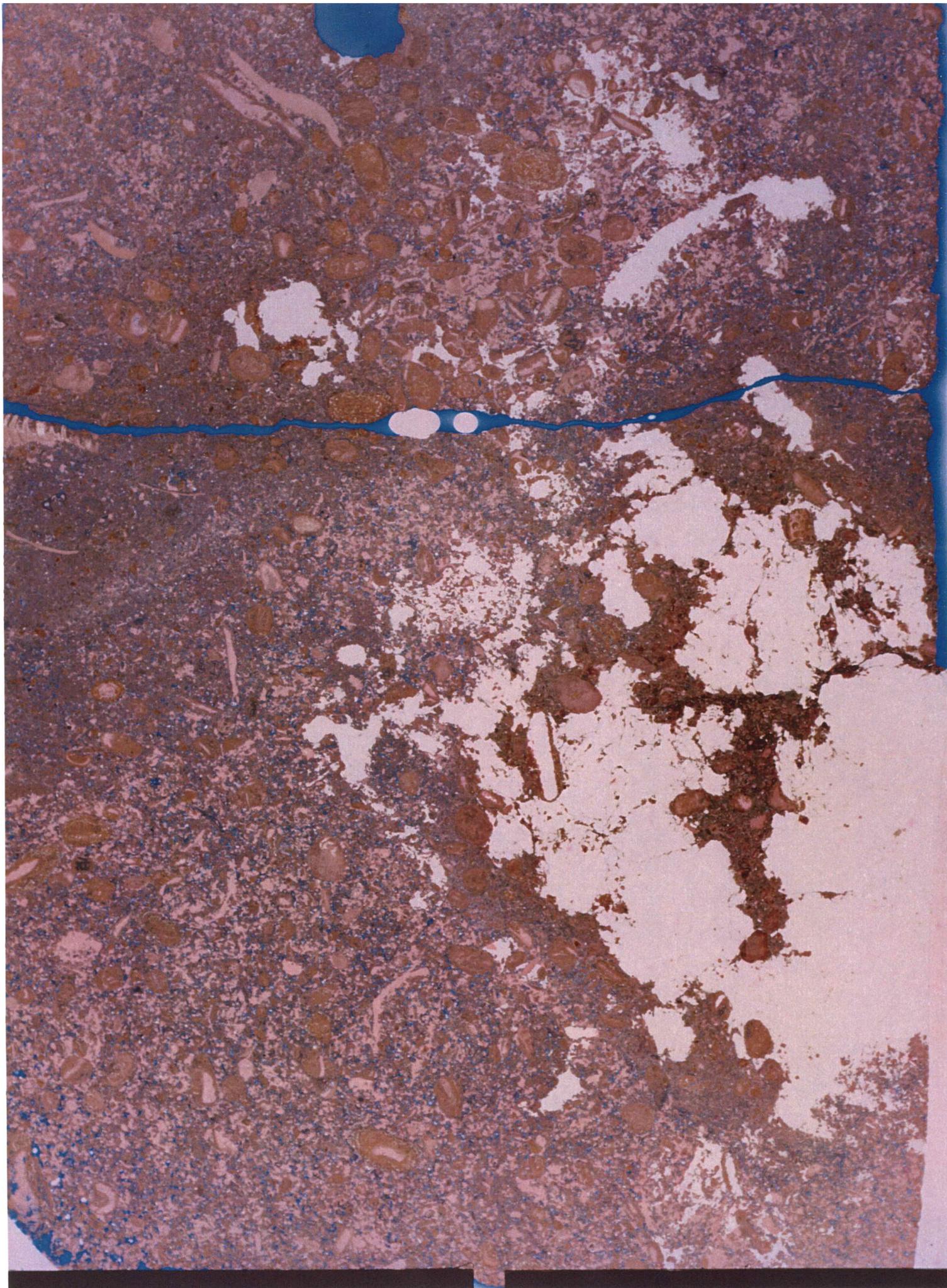


FIGURE 7

WHOLE THIN SECTION PHOTOGRAPH

ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL

Depth: 2,879.6 feet

Shoal Facies

Porosity: 17.8%

Permeability: 47.6 md

Although there are patches with preserved interparticle pore space (such as near the center of this photograph), the small fractures that occur throughout this rock probably account for most of the effective pore network. The rather high measured permeability indicates that these fractures allow fluid flow through the rock. Baroque dolomite cement (most of the white) and a subordinate amount of calcite (stained pink) cement have partially occluded some of these fractures. The space between the black bars at the base of the photograph equals 1 mm.



FIGURE 8

ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL

Depth: 2,710.4 feet

Shoal Facies

Porosity: 9.6%

Permeability: 0.305 md

The pore system in this limestone consists of a combination of interparticle (IP) pores, intraparticle pores (within fossil fragments), and microporosity within micritic grains. In view D, note that many of the grains consist of very finely crystalline calcite, and that subtle recrystallization has led to the development of intragranular microporosity. Calcite cement (C) is present as a pore-filling constituent. The calcite cement occurs, 1) as thin rims of bladed calcite crystals (black arrows) around grain perimeters, 2) as coarse blocky calcite spar (such as shown in view D), and 3) as syntaxial overgrowths around echinoderm (E) fragments. The framework constituents in this rock include: benthonic foraminifera (mostly miliolids (M)), encrusting foraminifera, ostracodes (OS), bryozoans (BR), calcareous algae, oncoids, ooids, gastropods and brachiopods. The diverse faunal assemblage is suggestive of sedimentation in relatively shallow water. Miliolids can sometimes indicate sedimentation under restricted conditions (i.e. associated with a lagoon setting). Minor amounts of replacive anhydrite were observed, and fine-grained quartz (Q) sand/silt is also scattered throughout the rock. This siliciclastic component may also be an indication of sedimentation near a lagoon environment, where terrestrial siliciclastic sediments and marine carbonate grains become admixed.

A – 32X, Thin Section

B – 128X, Thin Section

C – 200X, SEM

D – 500X, SEM

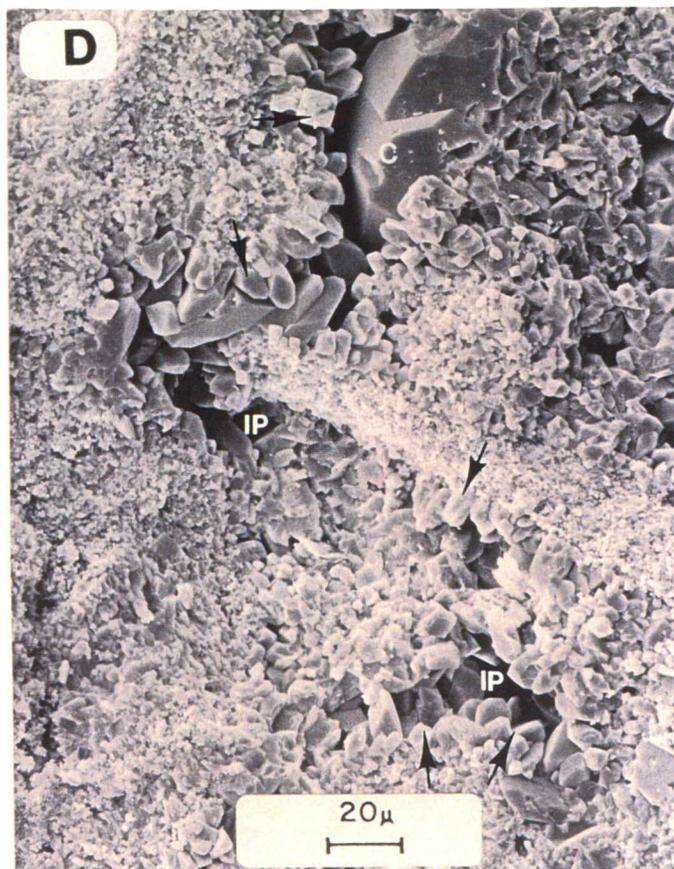
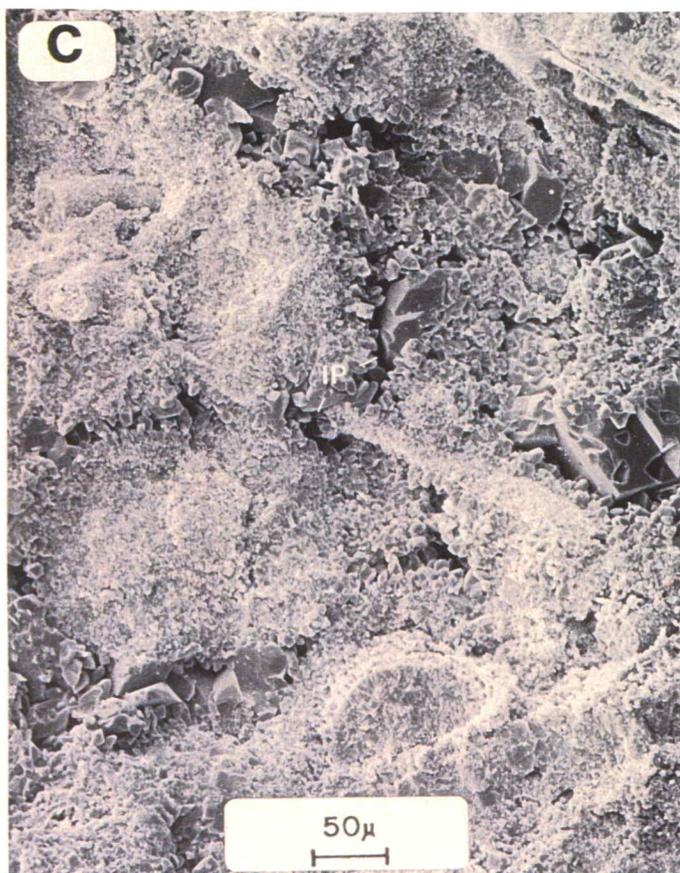
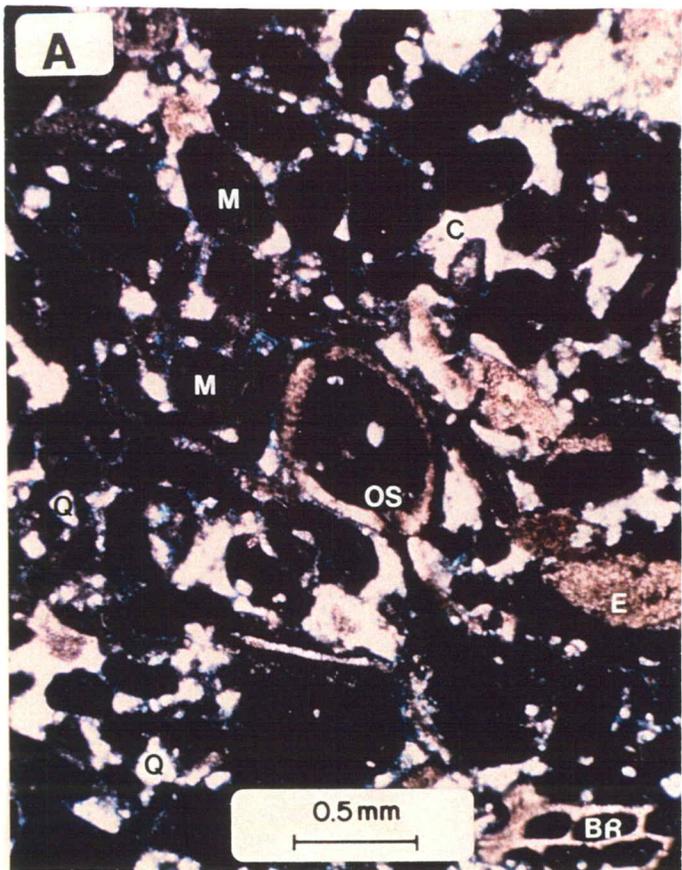


FIGURE 9

ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL

Depth: 2,743.5 feet

Shoal Facies

Porosity: 1.2%

Permeability: <0.001 md

Throughout these photomicrographs, note the general absence of visible macropore space. Close examination of the SEM sample reveals that the matrix contains traces of microporosity (right half of view D). Rocks with this type of pore structure typically have very poor reservoir potential. The sample has a packstone texture; that is, the rock is grain-supported, but contains detrital micrite between the framework particles. A rather wide variety of skeletal constituents are apparent, including: bryozoans (BR), brachiopods (B), miliolid foraminifera, ostracodes and echinoderms. In view B, several forms of diagenetic replacement can be distinguished. Replacive silica (S), dolomite (D), and anhydrite (A) are apparent. X-ray diffraction could be used to quantify the relative proportions of these diagenetic mineral phases.

A – 32X, Thin Section

B – 128X, Thin Section

C – 350X, SEM

D – 1500X, SEM

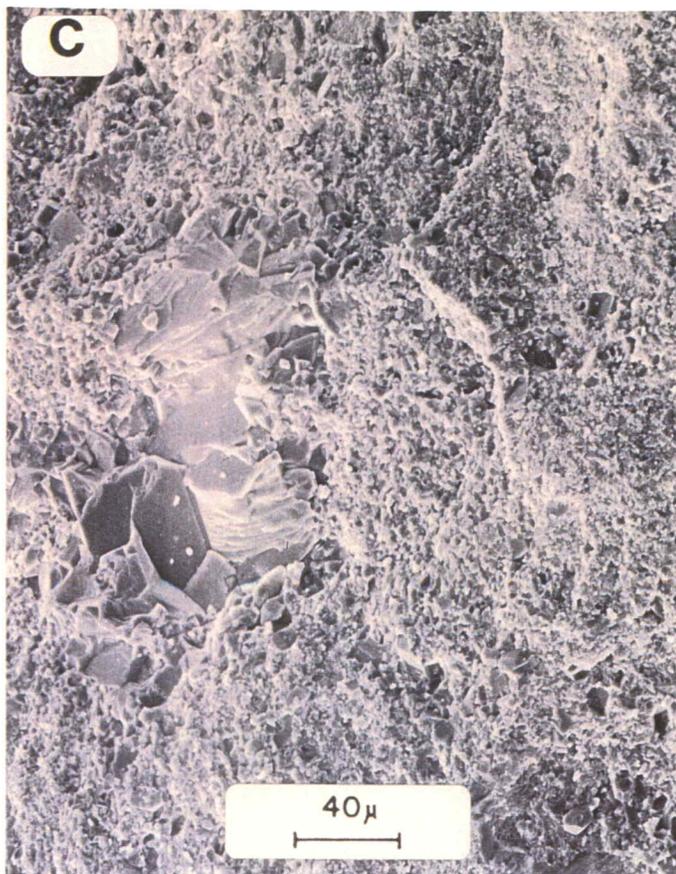
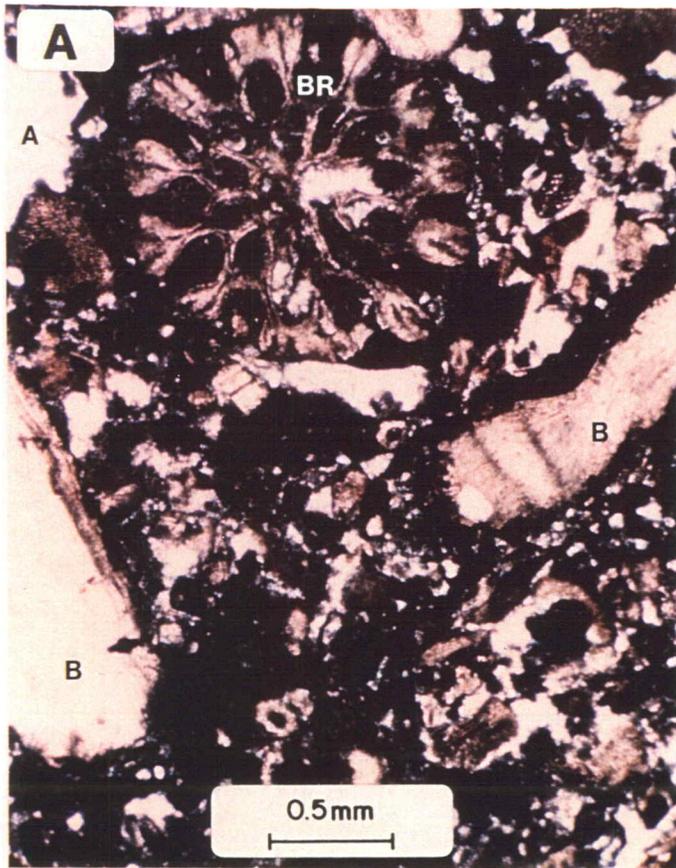


FIGURE 10

ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL

Depth: 2,799.4 feet

Shoal Facies

Porosity: 4.8%

Permeability: 0.026 md

Although most of this sample has a packstone texture, small areas of matrix-free grainstone can be delineated (view B). In these matrix-poor areas, interparticle pores can be distinguished. Carbonate grain types in this rock include: benthonic foraminifera, oncoids (ON), phylloid algae (PH), brachiopods (B), gastropods, echinoderms and bryozoans. Quartz (Q) grains are scattered throughout the rock. Note that there is some intragranular pore space within the miliolid (M) foraminifera. The SEM photomicrographs show how some of these intraparticle macropores are rather isolated from one another. Rocks with this type of pore structure typically have low permeability. In addition to the micritic matrix, calcite (C) cement also plays an important role in porosity reduction. Overall, the pore system in this sample consists of poorly interconnected interparticle and intraparticle pores, and rather ineffective microporosity within micritic framework grains and matrix.

A - 32X, Thin Section

B - 128X, Thin Section

C - 200X, SEM

D - 500X, SEM

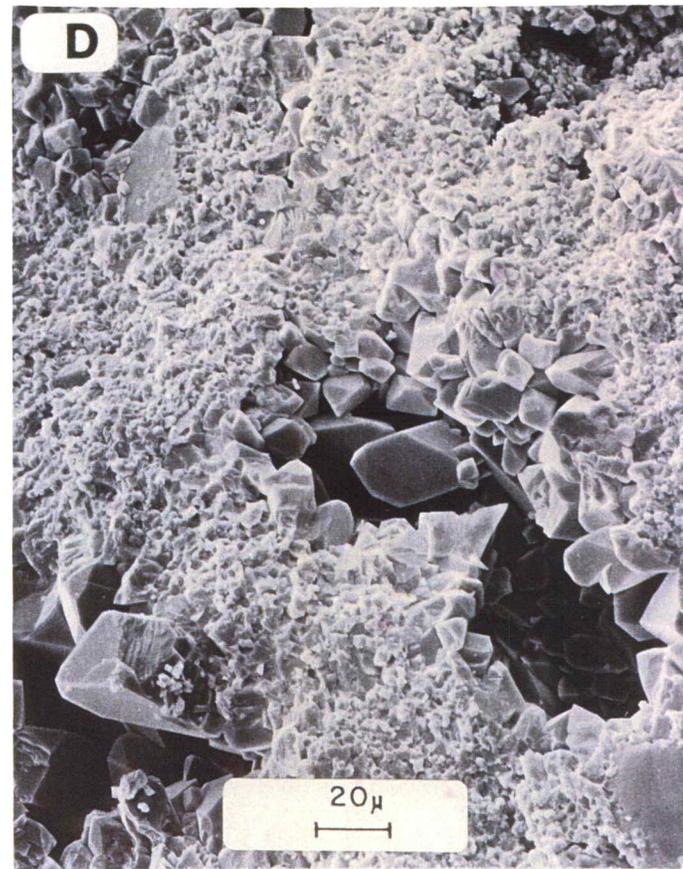
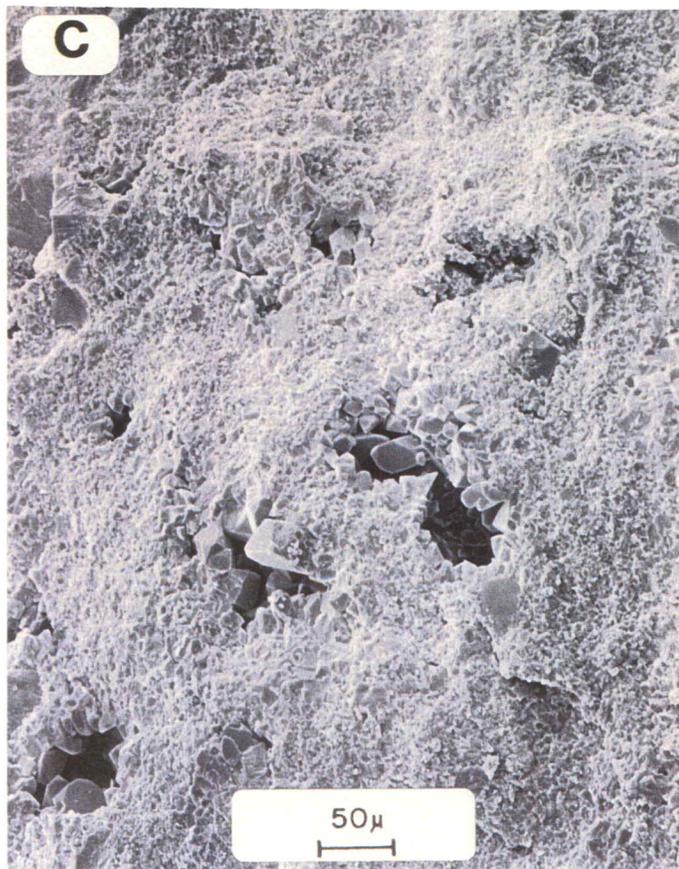
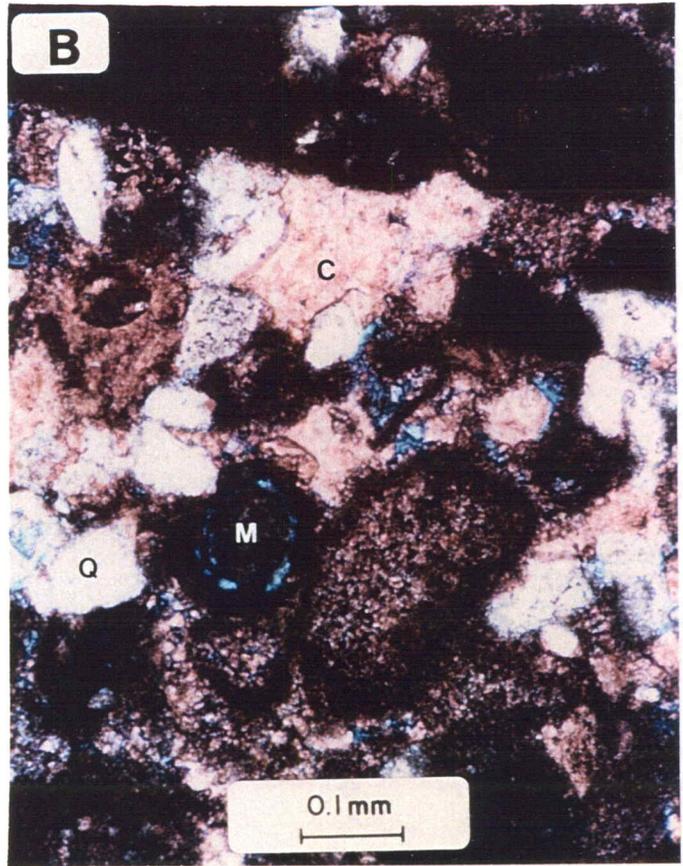
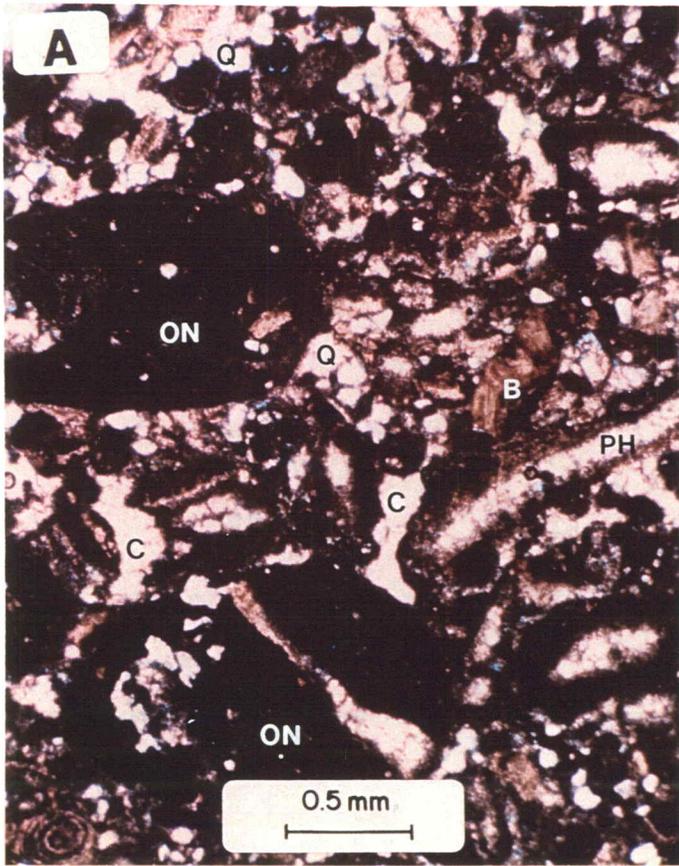


FIGURE 11

ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL

Depth: 2,807.6 feet

Shoal Facies

Porosity: 10.9%

Permeability: 0.891 md

This rock is a packstone with a wide variety of skeletal constituents including: brachiopods (B), phylloid algae (PH), ostracodes (OS) and several varieties of foraminifera (F). Detrital micrite is present between most of the framework grains, although some scattered interparticle pores can be distinguished. Intraparticle pores (such as shown in the foraminifera near the center of view B) and biomoldic pores (such as within the partially leached phylloid algal fragment in view A) account for most of the macroporosity in this rock. The arrows in view B point to small pores of uncertain origin. These could be remnant intergranular pores, or reflect subtle pinpoint dissolution vugs. In view C, note how these relatively large intraparticle and moldic pores 1) are isolated from one another by the microporous matrix, and 2) have been partially infilled with very finely crystalline calcite cement. The low permeability reflects the general lack of interconnection among macropores. A close-up view of the matrix (view D) reveals that the micrite has been partially neomorphosed, yielding very minute pores between the micrite-sized crystals. The rhombs near the top of view D are small dolomite (D) crystals.

A – 32X, Thin Section

B – 128X, Thin Section

C – 500X, SEM

D – 1500X, SEM

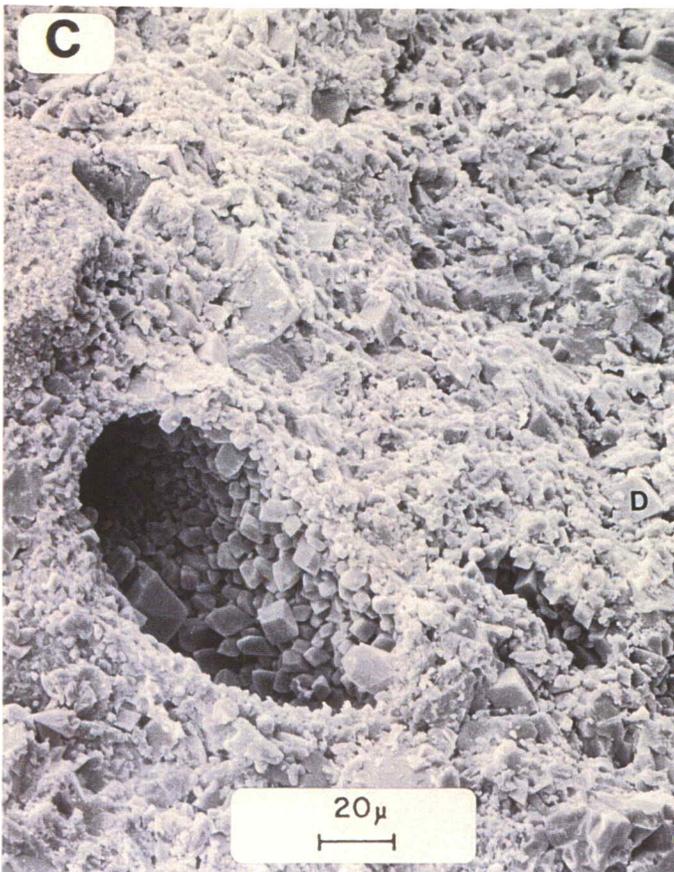
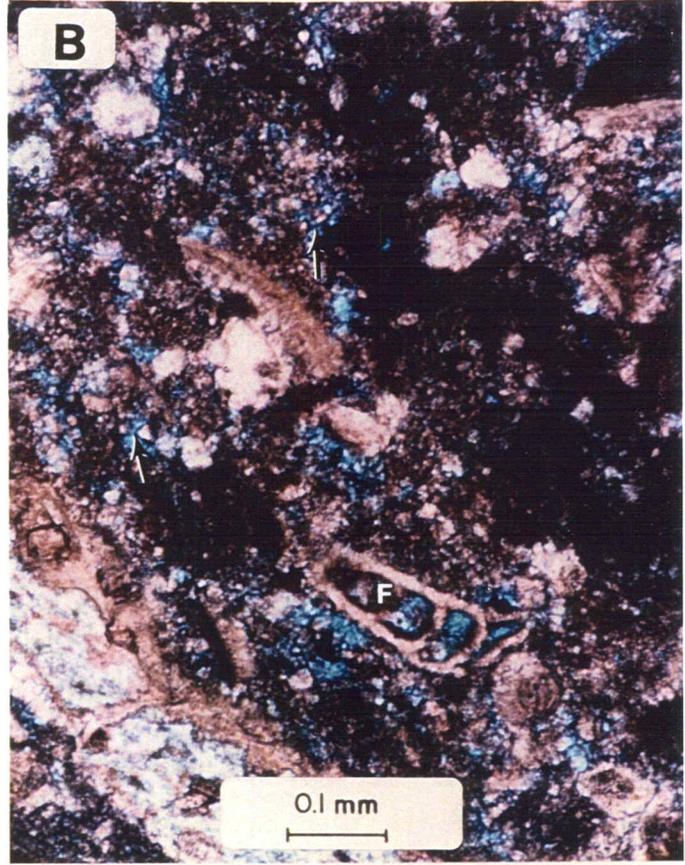
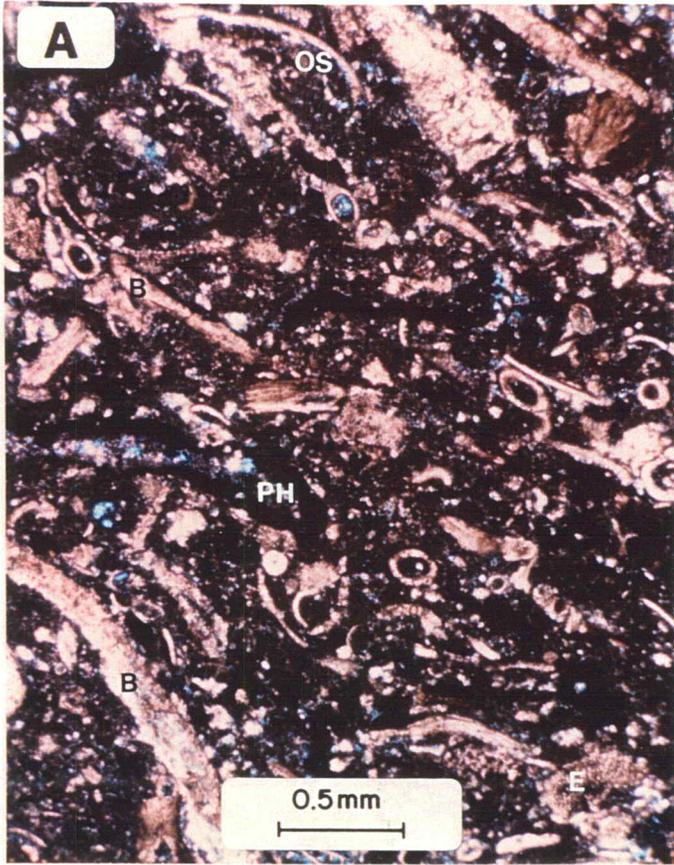


FIGURE 12

ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL

Depth: 2,823.5 feet

Shoal Facies

Porosity: 14.5%

Permeability: 23.4 md

The pore system in this grainstone/packstone consists of a combination of interparticle (IP) pores, intraparticle (white arrows) pores, fracture pores (view A) and microporosity within the micritic grains (view D). There is also some moldic pore space where framework grains, and perhaps some matrix material, have been leached. Calcite (C and stained pink) cement has partially occluded interparticle, intraparticle and fracture pores. In addition, anhydrite cement has also partially infilled fractures and other pores. There has also been some anhydrite replacement of grains and matrix. Rocks with this type of pore structure can have rather high permeability, with fluid flow primarily occurring through fractures and interparticle pores.

A – 32X, Thin Section

B – 128X, Thin Section

C – 200X, SEM

D – 2000X, SEM

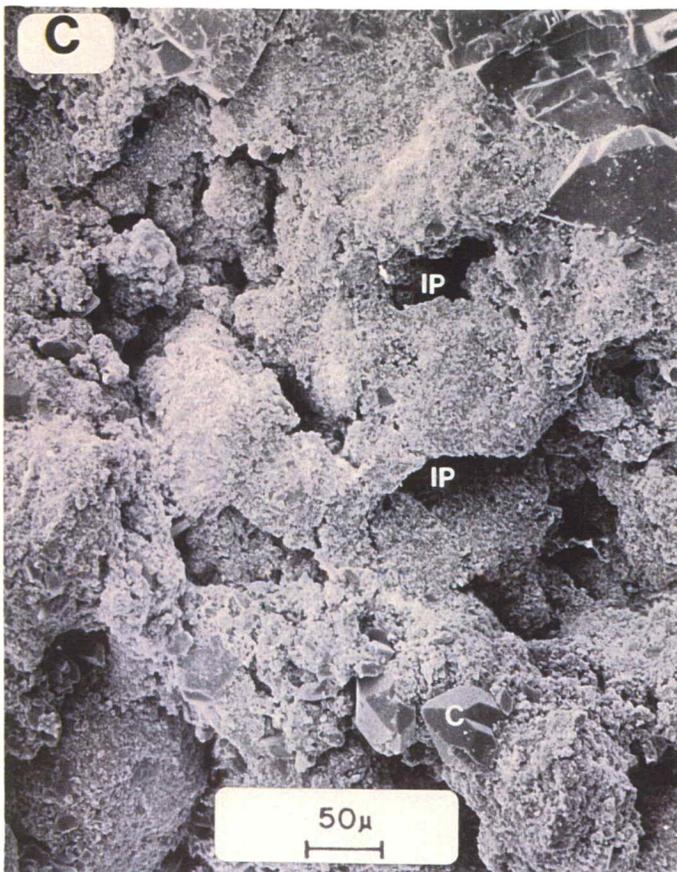
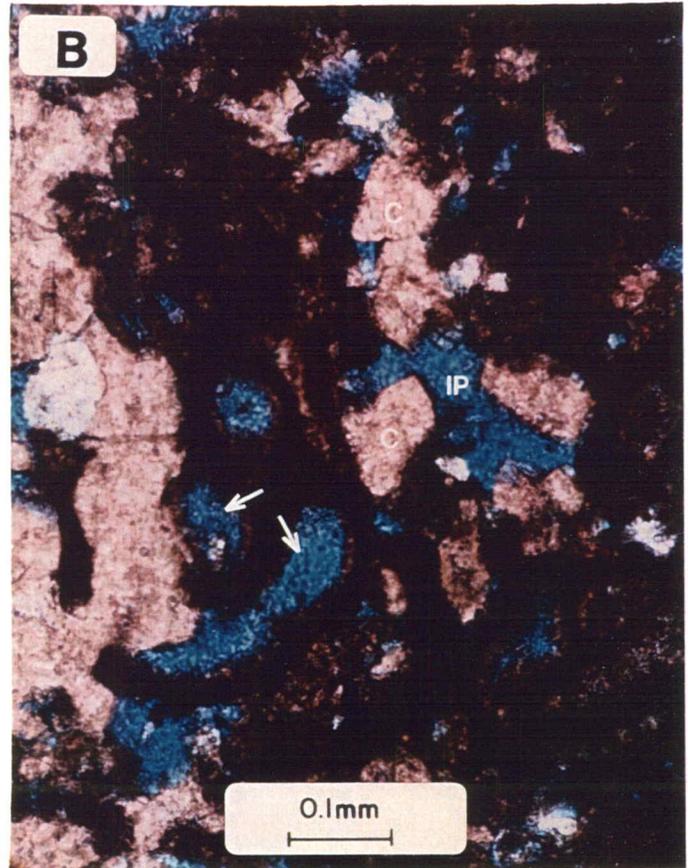
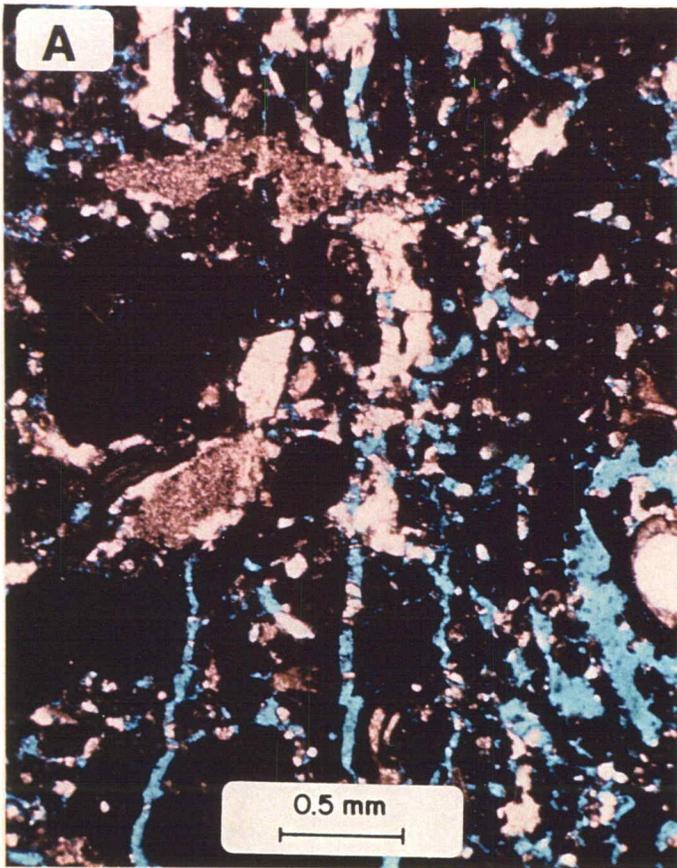


FIGURE 13

ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL

Depth: 2,828.5 feet

Shoal Flank Facies

Porosity: 6.2%

Permeability: 0.071 md

Most of the visible macropore space in this rock is in the form of intraparticle pores within fossil fragments (white arrows). In views C and D, the intraparticle pores are a foraminifera (F). In addition to these scattered, poorly interconnected macropores, the micritic matrix of this rock also contains an abundance of microporosity. Rocks with this type of pore structure typically have low permeability and poor reservoir potential. Quartz sand grains (most of the white particles in views A and B) are scattered throughout this rock.

A – 32X, Thin Section

B – 128X, Thin Section

C – 200X, SEM

D – 750X, SEM

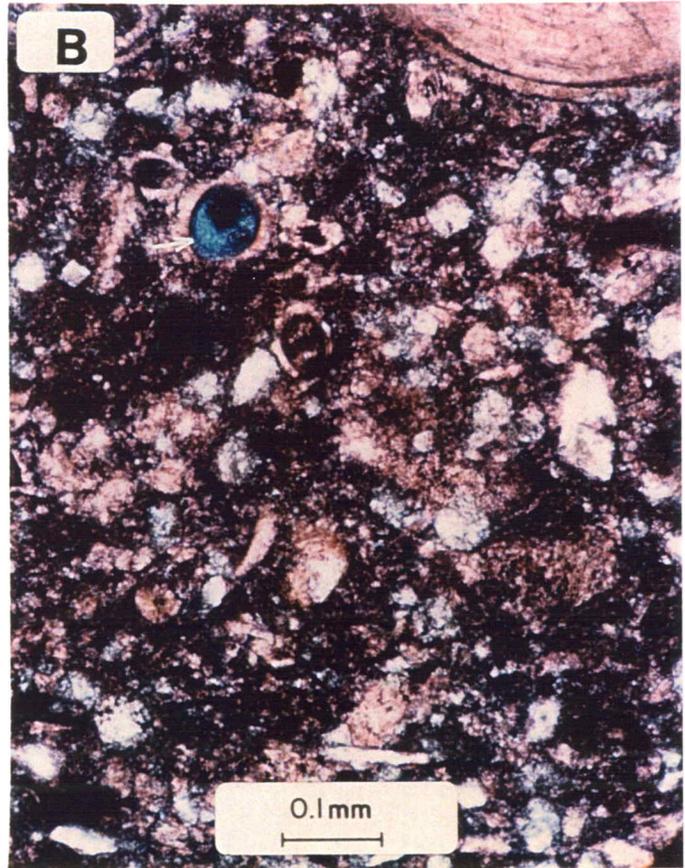
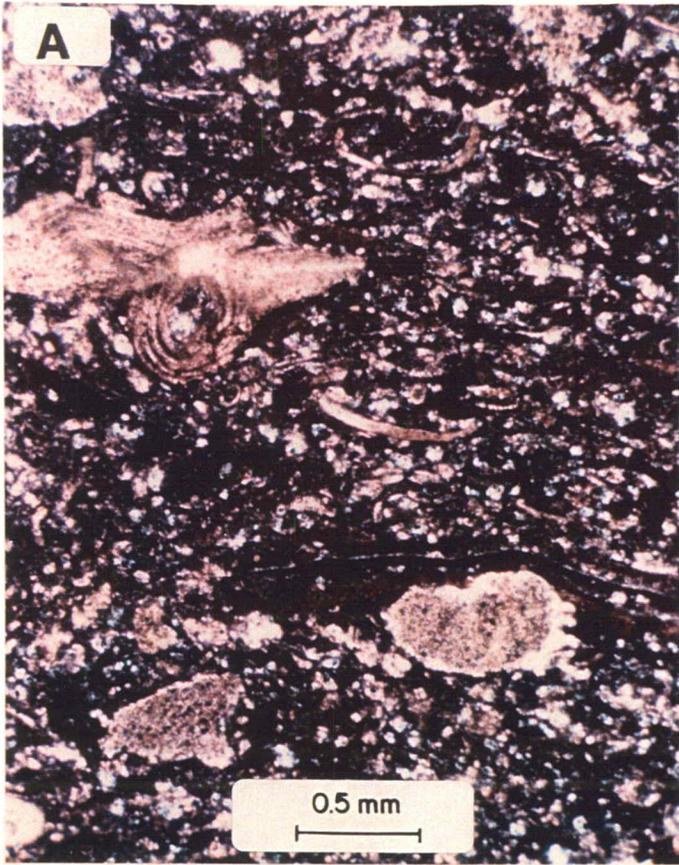


FIGURE 14

ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL

Depth: 2,845.5 feet

Shoal Facies

Porosity: 9.4%

Permeability: 0.751 md

The depositional texture of this rock ranges from packstone to grainstone. In parts of the sample, detrital micrite has infilled the interparticle areas. View B highlights a part of the sample where detrital micrite is less abundant, and where interparticle pores (IP) are relatively common. In addition to the interparticle macropores, many of the micritic framework grains are microporous (views C and D). Furthermore, intraparticle pores are present within skeletal grains, and there may have been some partial grain dissolution. Patchy anhydrite replacement (not shown here) is apparent (see Figure 6). Peloids, extensively micritized benthonic foraminifera, oncoids, ostracodes, bryozoans, phylloid algae and brachiopods were identified in this sample.

A – 32X, Thin Section

B – 128X, Thin Section

C – 200X, SEM

D – 2500X, SEM

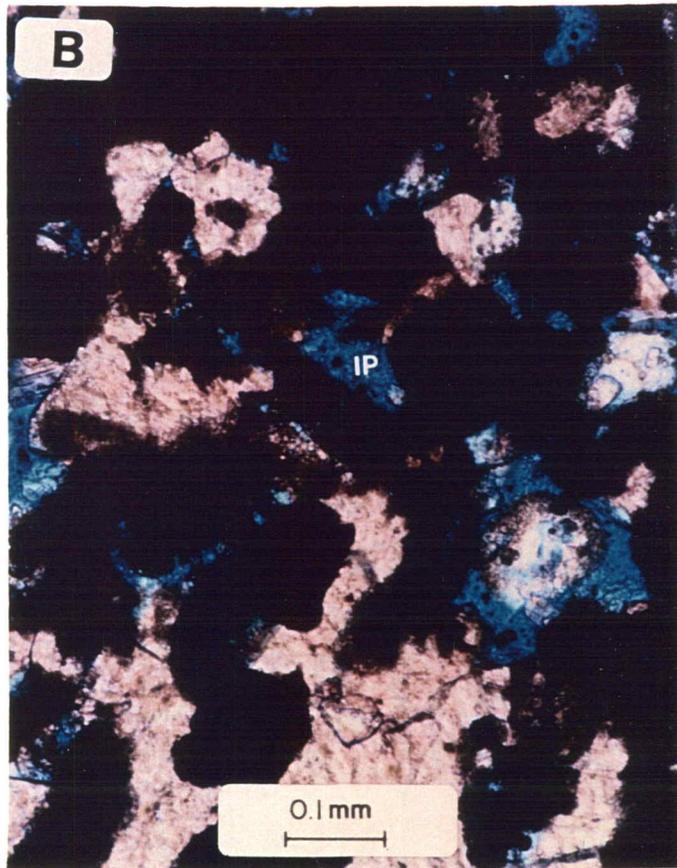
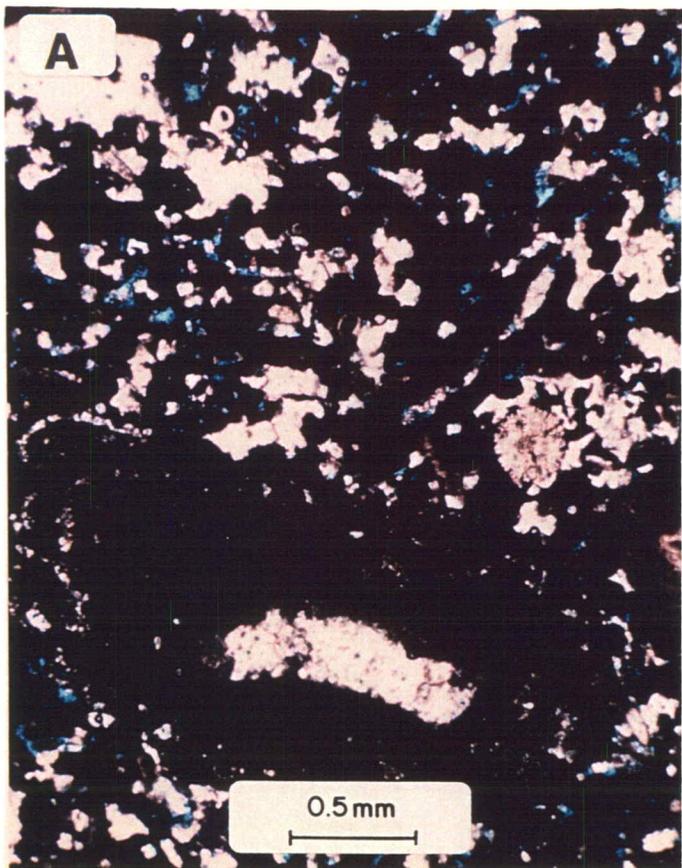


FIGURE 15

ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL

Depth: 2,861.5 feet

Shoal Facies

Porosity: 12.3%

Permeability: 1.32 md

A wide assortment of skeletal fragments, including: bryozoans, benthonic foraminifera, ostracodes, echinoderms and brachiopods, are present in this skeletal-peloid grainstone/packstone. Parts of the sample have interparticle pore space, while other parts, where detrital micrite is more common, have less macropore space. In addition to the interparticle pores, less well interconnected intraparticle pores (white arrows in view B and black arrows in views C and D) are common in the skeletal grains. Furthermore, many of the micritic grains contain microporosity. The depositional texture and allochemical constituents in this sample suggest sediment accumulation in a shallow water environment, under moderate energy conditions.

A – 32X, Thin Section

B – 128X, Thin Section

C – 200X, SEM

D – 1000X, SEM

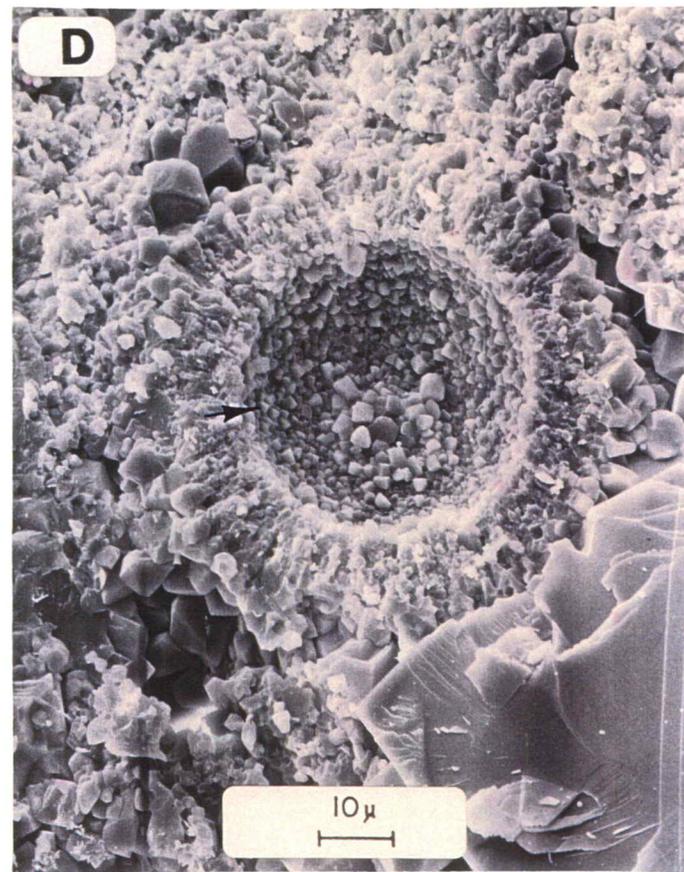
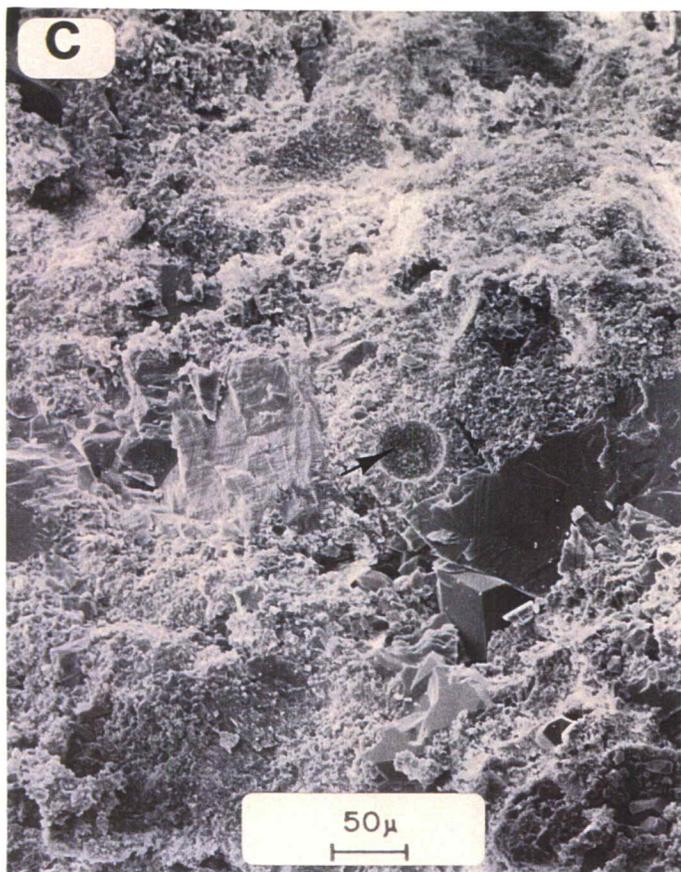
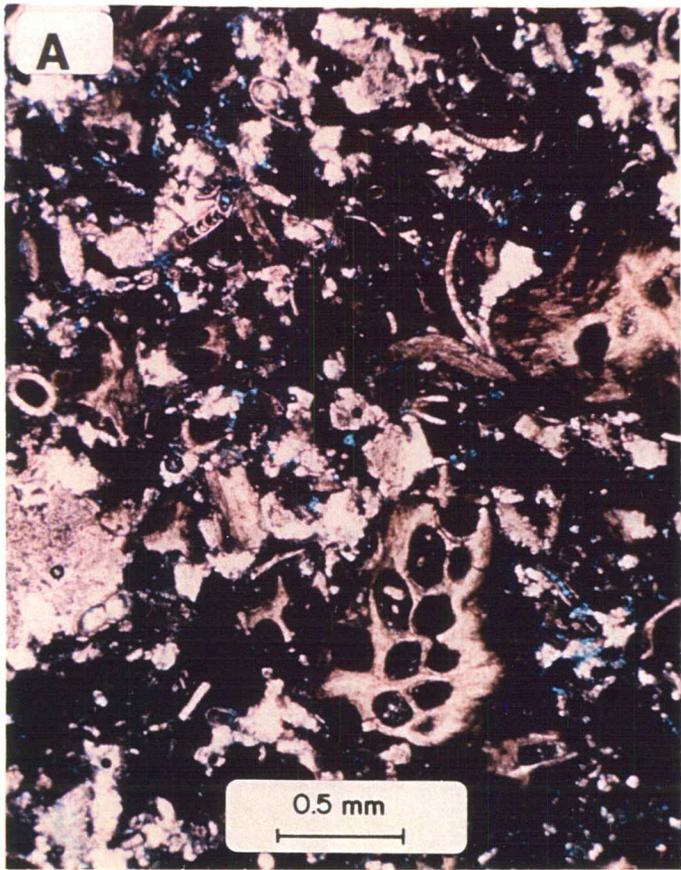


FIGURE 16

ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL

Depth: 2,873.6 feet

Shoal Flank Facies

Porosity: 9.8%

Permeability: 0.167 md

This rock is a calcareous dolostone to dolomitic limestone. Most of the white areas shown in views A and B are dolomite. These dolomite (D) crystals can also be distinguished in the SEM photomicrographs. It appears that dolomitization may have been "matrix selective". That is, many of the carbonate grains are still composed of calcite, while the micrite matrix have been altered to dolomite. Visible pore space is relatively uncommon, although some intragranular pores are present within fossil fragments (view B), and microporosity can be distinguished within the altered matrix (views C and D). Some detrital clay (black arrows in view D) is admixed into the partially dolomitized matrix.

A – 32X, Thin Section

B – 128X, Thin Section

C – 200X, SEM

D – 1500X, SEM

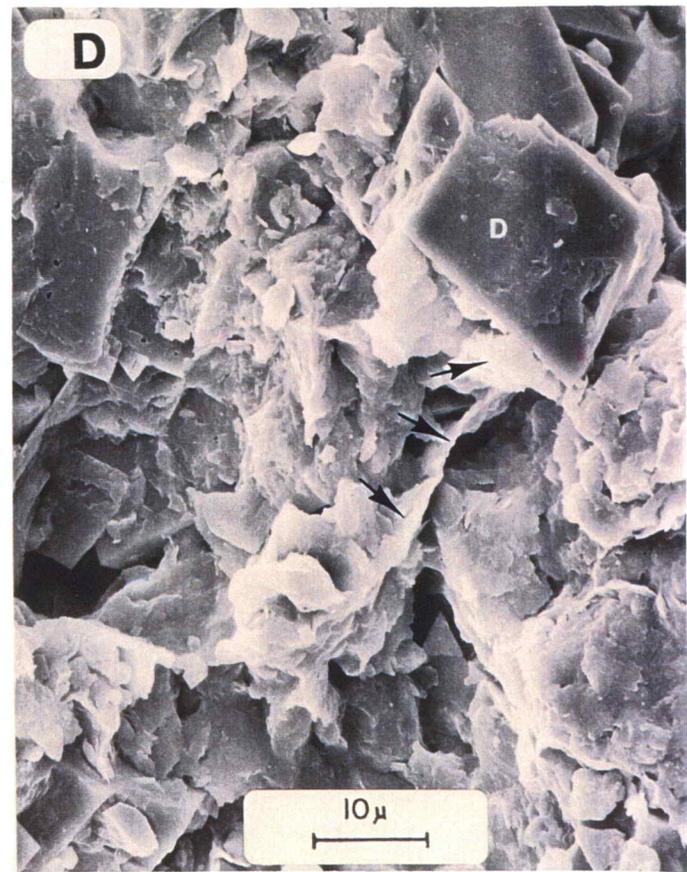
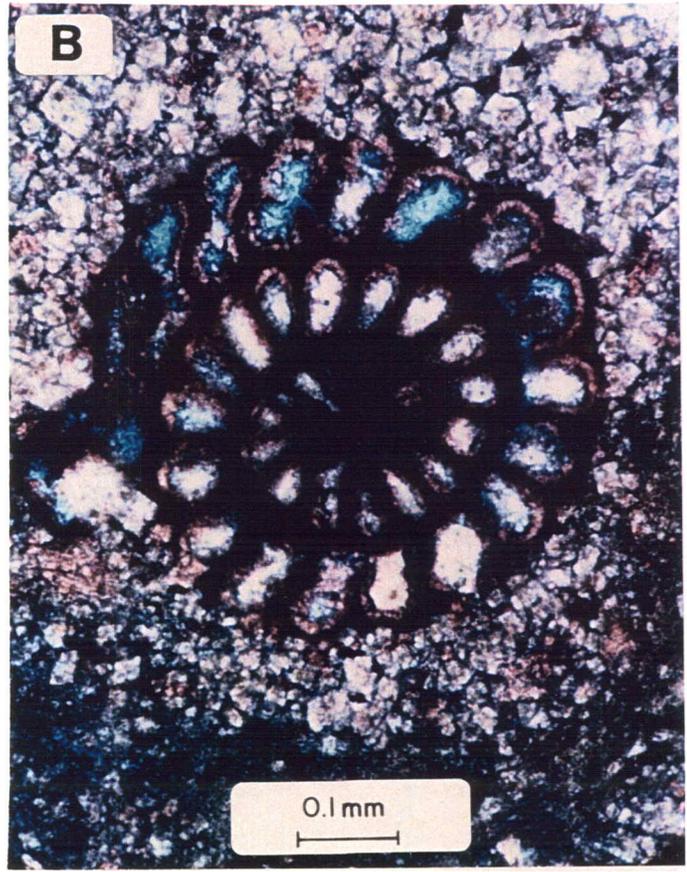


FIGURE 17

ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL

Depth: 2,877.8 feet

Shoal to Shoal Flank Facies

Porosity: 10.7%

Permeability: 0.408 md

This rock has a packstone texture, although both wackestone and grainstone textures can be distinguished in parts of the sample. Detrital micrite is common throughout most of the rock. Where detrital micrite is less abundant, small interparticle pores are present between the framework grains (view B). Most of the macropore space is in the form of small interparticle pores, and within framework grains (i.e., intraparticle pores). In addition, there is an abundance of microporosity within both the matrix and in micritic grains. Specifically, microporous peloids (small dark grains) and micritic *Tubiphytes* (T) (a type of calcareous algae), contain micropores. The SEM photomicrographs reveal a neomorphosed fabric in the matrix, and the associated microporosity. A few small partially filled fractures (not shown here) were identified. Overall, the pore system in this rock yields rather low permeability and poor reservoir potential.

A – 32X, Thin Section

B – 128X, Thin Section

C – 200X, SEM

D – 1500X, SEM

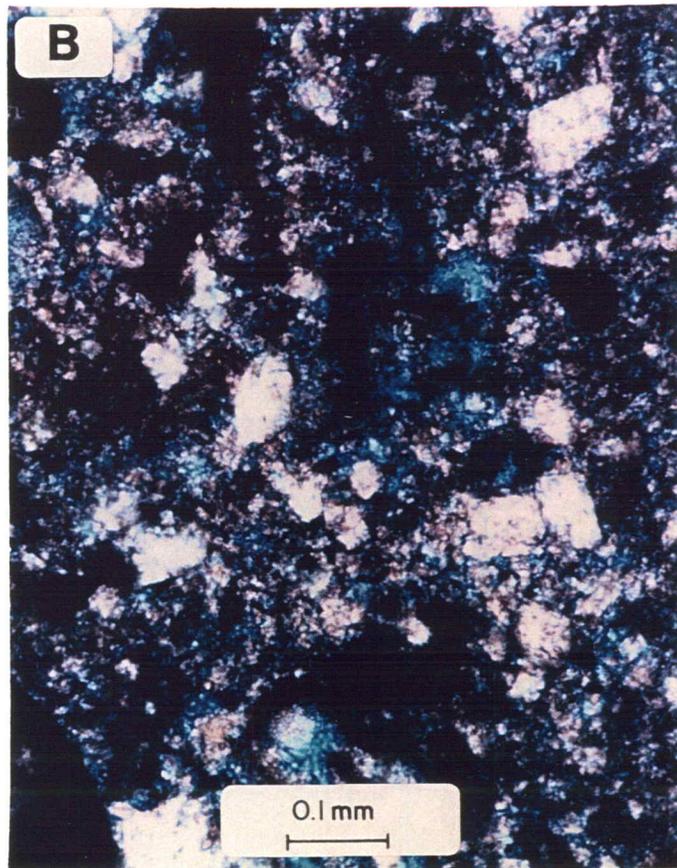
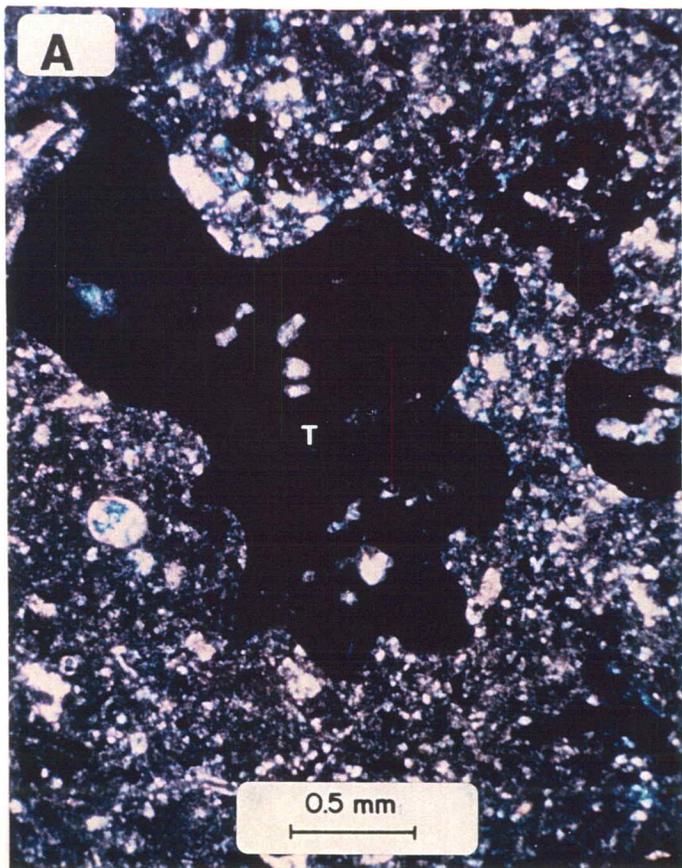


FIGURE 18

ANADARKO PETROLEUM CORPORATION YOUNGREN K NO. 3A WELL

Depth: 2,879.6 feet

Shoal Facies

Porosity: 17.8%

Permeability: 47.6 md

The texture and fabric of this rock suggests relatively early lithification and fracturing, perhaps in response to subaerial exposure (?). Subsequently, the fractures were infilled with a combination of baroque dolomite (large white crystals in views A and B) and calcite cements. In the SEM photomicrographs, note that most of the pore space occurs between the large fracture-filling crystals. In addition to the fracture pores, patches with preserved interparticle pore space are also visible. Furthermore, the matrix and micritic grains possess microporosity. Although the fractures have been partially occluded by dolomite and calcite cements, many remain open. These fractures account for most of the permeability in this rock.

A – 32X, Thin Section

B – 128X, Thin Section

C – 25X, SEM

D – 100X, SEM

