

# **Depositional Facies of Grayburg/San Andres Dolomite Reservoirs, Central Basin Platform, Permian Basin\***

**R.A. Garber<sup>1</sup> and P.M. Harris<sup>2</sup>**

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## **Abstract and Contents**

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A comparison of depositional facies within widespread dolostone reservoirs in the Grayburg / San Andres Formations (Permian, Guadalupian) along the eastern edge of the Central Basin Platform of the Permian Basin, Texas, shows remarkable similarity in the overall generalized vertical sequence, particularly in the occurrence of porous shoal grainstones. Data presented in this pilot study are from wells in the Grayburg reservoir of McElroy field and the San Andres reservoir of Waddell and Goldsmith fields. Reservoirs in all three fields occur mainly in the middle part of an upward-shallowing carbonate-shelf sequence that is 250 to 300 ft thick. The sequence consists of (1) basal open-shelf, bioturbated dolowackestones/dolopackstones; (2) middle shallow-water shelf fusulinid dolowackestones overlain by nonskeletal shoal dolopackstones/dolograinstones; and (3) upper variable intertidal-supratidal deposits.

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# **Geologic and Engineering Approaches in Evaluation of San Andres/Grayburg Hydrocarbon Reservoirs—Permian Basin**

**D. G. Bebout and P. M. Harris**  
Editors

**Bureau of Economic Geology • W. L. Fisher, Director**  
**The University of Texas at Austin • Austin, Texas 78713**



**1990**



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## Abstract

A comparison of depositional facies within widespread dolostone reservoirs in the Grayburg/San Andres Formations (Permian, Guadalupian) along the eastern edge of the Central Basin Platform of the Permian Basin, Texas, shows remarkable similarity in the overall generalized vertical sequence, particularly in the occurrence of porous shoal grainstones. Data presented in this pilot study are from wells in the Grayburg reservoir of McElroy field and the San Andres reservoir of Waddell and Goldsmith fields. Reservoirs in all three fields occur mainly in the middle part of an upward-shallowing carbonate-shelf sequence that is 250 to 300 ft thick. The sequence consists of (1) basal open-shelf, bioturbated dolowackestones/dolopackstones; (2) middle shallow-water shelf fusulinid dolowackestones overlain by nonskeletal shoal dolopackstones/dolograinstones; and (3) upper variable intertidal-supratidal deposits.

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## Introduction

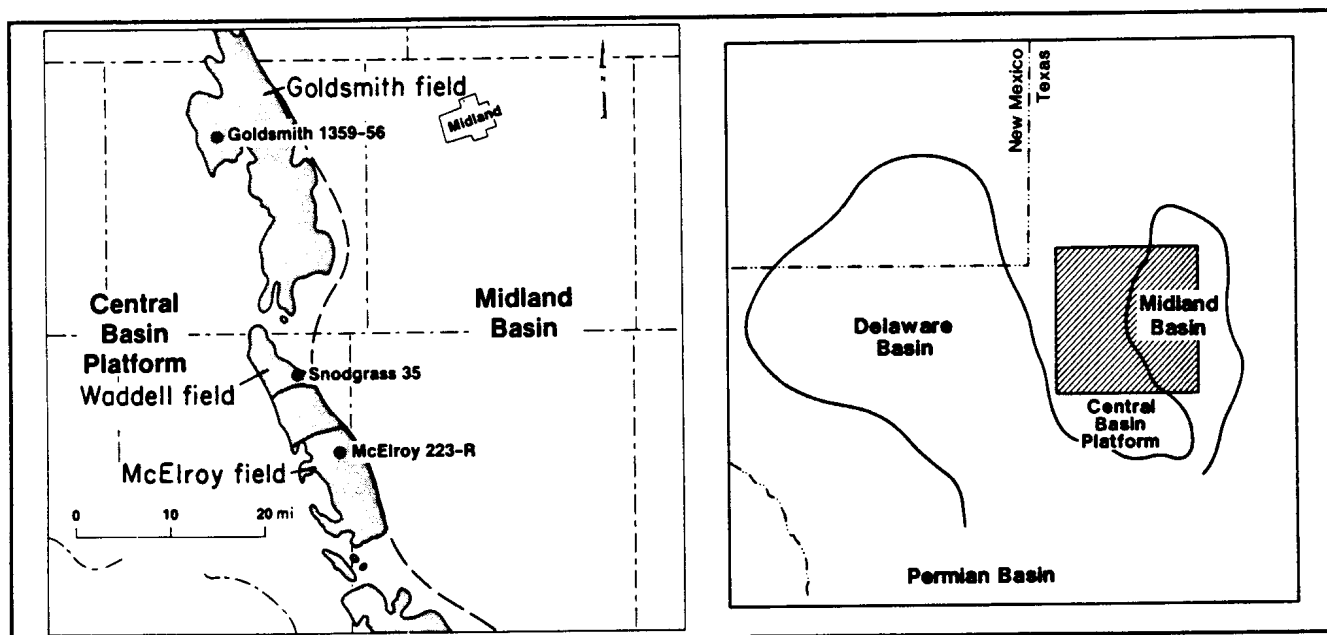
Porous dolostones of the Grayburg/San Andres Formations (Permian, Guadalupian) form major hydrocarbon reservoirs along the eastern edge of the Central Basin Platform of the Permian Basin. Although Galloway and others (1983) and Ward and others (1986) described the regional geologic setting of these dolostones and summarized examples of field studies, a comparison of the facies and porosity types among fields lying along the trend, as revealed by detailed study of conventional cores, has not been presented. This paper is an initial analysis of the Grayburg/San Andres interval from three fields and a comparison with published data from additional fields.

The complexity of Grayburg/San Andres dolostone reservoir intervals on the Central Basin Platform has previously been demonstrated within the following fields located from south to north along a 105-mi portion of the eastern edge of the Central Basin Platform: (1) Yates field (Donoghue and Gupton,

1957; Craig and others, 1986); (2) McElroy field (Longacre, 1980, 1983; Harris and others, 1984; Walker and Harris, 1986); (3) Dune field (Bebout, 1986; Bebout and others, 1987); (4) Foster field (Young and Vaughn, 1957); and (5) Means field (George and Stiles, 1978, 1986). A comparison of the lithological descriptions and depositional models of these fields and others described in Bebout and Harris (1986) shows that although substantial local variation exists, the overall, more generalized vertical sequence and particularly the occurrence of porous shoal grainstones are strikingly similar. It is this apparent regional similarity that has prompted our pilot core study to investigate the vertical sequence and to compare facies and porosity types among fields.

## Regional Study

Data presented in this study come from three wells (fig. 1): the Gulf Oil J. T. McElroy Cons. 223-R, located in the Grayburg reservoir of McElroy field



**FIGURE 1. Regional and detailed location maps of cores discussed in this paper. Three fields producing from the Grayburg/San Andres Formations in this portion of the Permian Basin are shown on the map at right. The Gulf Oil J. T. McElroy Cons. No. 223-R well was drilled in January 1983 in McElroy field, Crane County (Sec. 203, Blk. F, 350 ft FNL and 984 ft FEL, CCSD & RGNG Railroad Survey). The Gulf Oil E. N. Snodgrass (Tract A) No. 35 well was completed in August 1983 in Waddell field, Crane County (Sec. 1, Blk. 25 PSL, 1650 ft FNL and 2200 ft FEL Surveys). The Gulf Oil C. A. Goldsmith and others 1359-56 well was drilled in November 1981 in Goldsmith field, Ector County (Sec. 15, Blk. 44, T-1-S, 100 ft FSL and 100 ft FWL, T & P Survey).**

in Crane County; the Gulf Oil E. N. Snodgrass No. 35 from the San Andres reservoir of Waddell field in Crane County; and the Gulf Oil C. A. Goldsmith and others 1359-56 from the San Andres reservoir of Goldsmith field in Ector County. Interpretations of depositional environment and general discussions are strengthened by multiwell core studies in McElroy and Waddell fields and ongoing studies in all three fields.

The reservoir-bearing dolostones in all three fields occur as part of an upward-shallowing carbonate sequence that is 250 to 300 ft thick. The generalized sequence that constitutes the Grayburg/San Andres interval in the wells consists of three basic parts (fig. 2): (1) a basal open-shelf unit (outer ramp) of bioturbated, subtidal dolowackestones/dolopackstones that are varyingly skeletal and peloidal; (2) a middle shallow shelf unit (inner ramp) of subtidal fusulinid dolowackestones overlain by subtidal-intertidal, nonskeletal shoal dolopackstones/dolograinstones; and (3) an upper unit of intertidal-supratidal (nearshore and coastline) dolomudstones toolograinstones, quartz siltstones and fine sand-

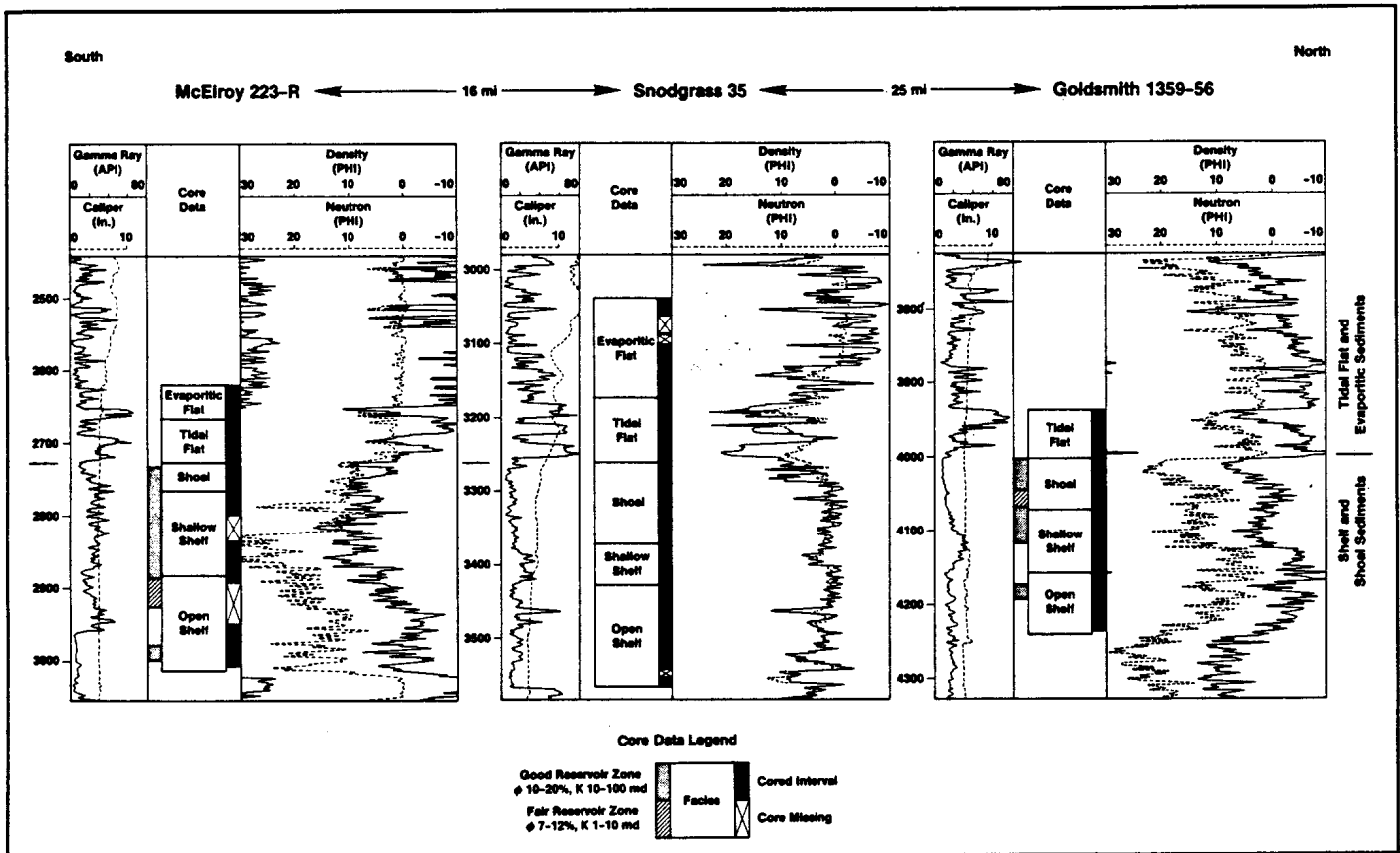
stones, and evaporites that grades upward into the more clastic and evaporitic deposits of the Queen Formation. Reservoir zones occur predominantly in the middle unit of the sequence.

## McElroy 223-R

Cores from the McElroy 223-R well contain rock types representative of all three depositional units of the Grayburg interval as well as the lower portion of the overlying Queen Formation. Longacre (1980) divided the Grayburg/San Andres and lower Queen sections into 11 depositional facies during detailed core studies of the North McElroy Unit, but Harris and others (1984) and Walker and Harris (1986) subsequently proposed a more generalized facies subdivision within the McElroy field. It is this more generalized facies scheme that is used here because the scale of the units is such that they are correlative by both core and log methods.

The McElroy 223-R well is situated on the crest of an asymmetric anticline that dips gently to the west and steeply to the east into the Midland Basin

## Grayburg/San Andres Facies

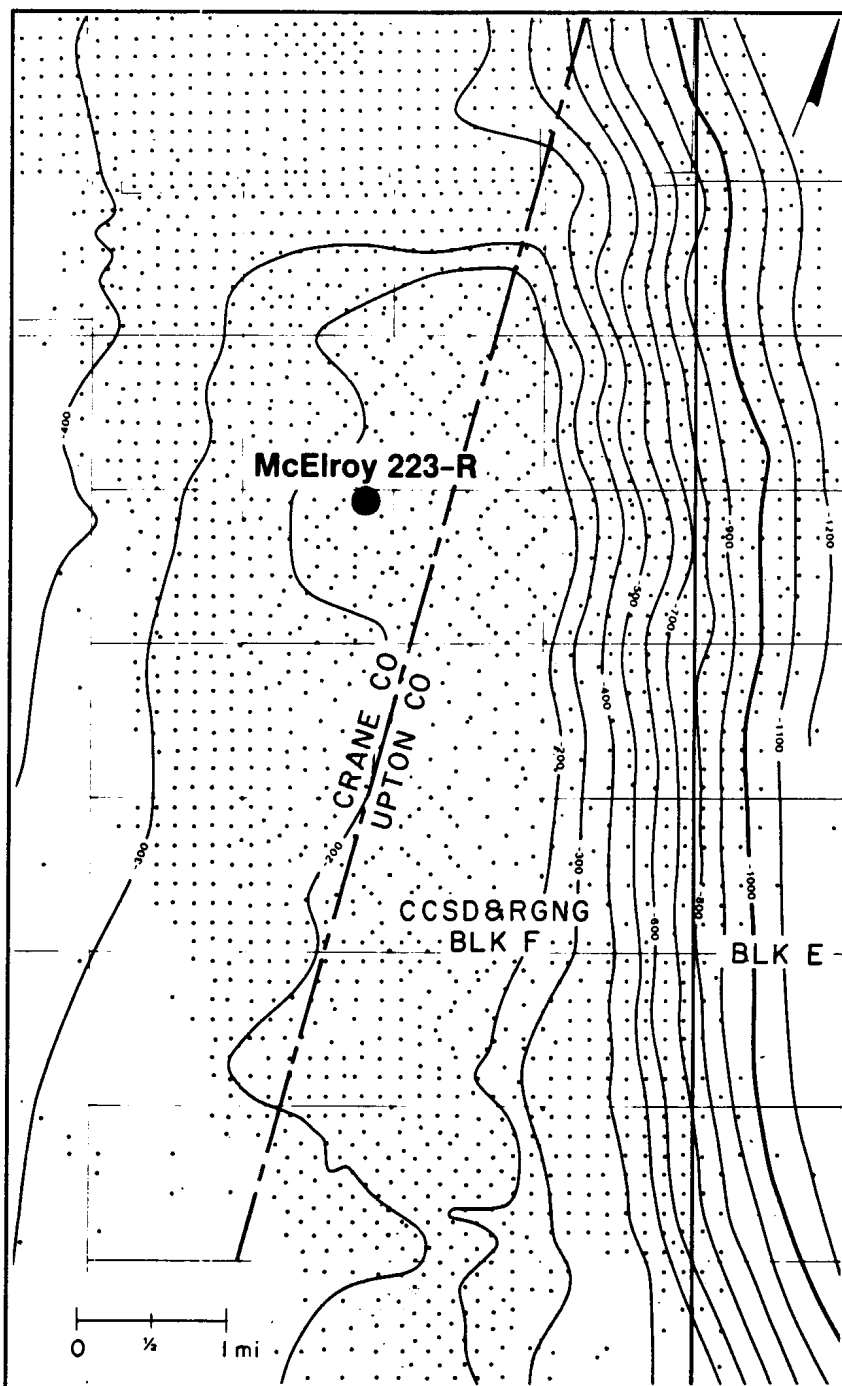


**FIGURE 2.** Wireline logs and core data from the McElroy 223-R, Snodgrass 35, and Goldsmith 1359-56 wells. The wells occur along a 41-mi portion of the eastern edge of the Central Basin Platform (see fig. 1). More detailed descriptions of the lithologies and the porosity-permeability plots for each core are in figures 4, 6, and 8. The datum for figure 2 is a lithological boundary that separates shelf and shoal sediments below (the lower and middle depositional units of the Grayburg or San Andres as described in the text) from tidal-flat and evaporitic deposits above (the upper depositional unit of the Grayburg or San Andres). Note that the porous and permeable section is best developed in shoal and shallow (water) shelf sediments in the McElroy 223-R and Goldsmith 1359-56 cores, but the Snodgrass 35 core lacks a reservoir zone owing to low permeability.

(fig. 3). The Queen/Grayburg contact occurs in the McElroy 223-R well at 2,723 ft. Open-shelf facies at the base of the cored section are predominantly skeletal (fusulinid-rich) and peloidal dolopackstones/dolograinstones (fig. 4 and plate 1A). The interval is extensively bioturbated; fusulinids and minor echinoderm fragments are scattered throughout. Porosity types, in order of importance, are intercrystalline, moldic, microfracture, and fenestral. With only a few exceptions, plug analyses show porosities to be 4 percent or less because molds, microfractures, and fenestral pores are filled with anhydrite, gypsum, or dolomite cements (plate 1B).

The overlying shallow shelf and shoal deposits are burrowed fusulinid and echinoderm dolowackestones and pelletal dolopackstones/dolograin-

stones (plates 1C and 2A and 2B). Vague cross-lamination is present in the grainstones, and in addition to peloids, ooids and rounded skeletal grains are present. Intercrystalline and moldic porosities are most common, and although many of the moldic pores are filled with anhydrite, the measured porosity values are between 10 and 20 percent, and permeabilities are in the tens of millidarcys with exceptional values exceeding 100 md. Dead hydrocarbon fills fusulinid molds within the shallow shelf dolostones (plate 1D). The tidal-flat and evaporitic-flat facies at the top of the core are the most variable vertically and consist of dolomudstones to sandy dolopackstones, siltstones, and nodular anhydrites (plate 2C and 2D). The dolopackstones are cross-laminated mixtures of ooids, rounded skeletal



**FIGURE 3. Structure map, top of Grayburg Formation, McElroy field. Sea level is datum, and contour interval is 100 ft. Dots indicate well control. Present-day structure is an asymmetric anticline with a steeply dipping east limb and more gently dipping west limb.**

## Grayburg/San Andres Facies

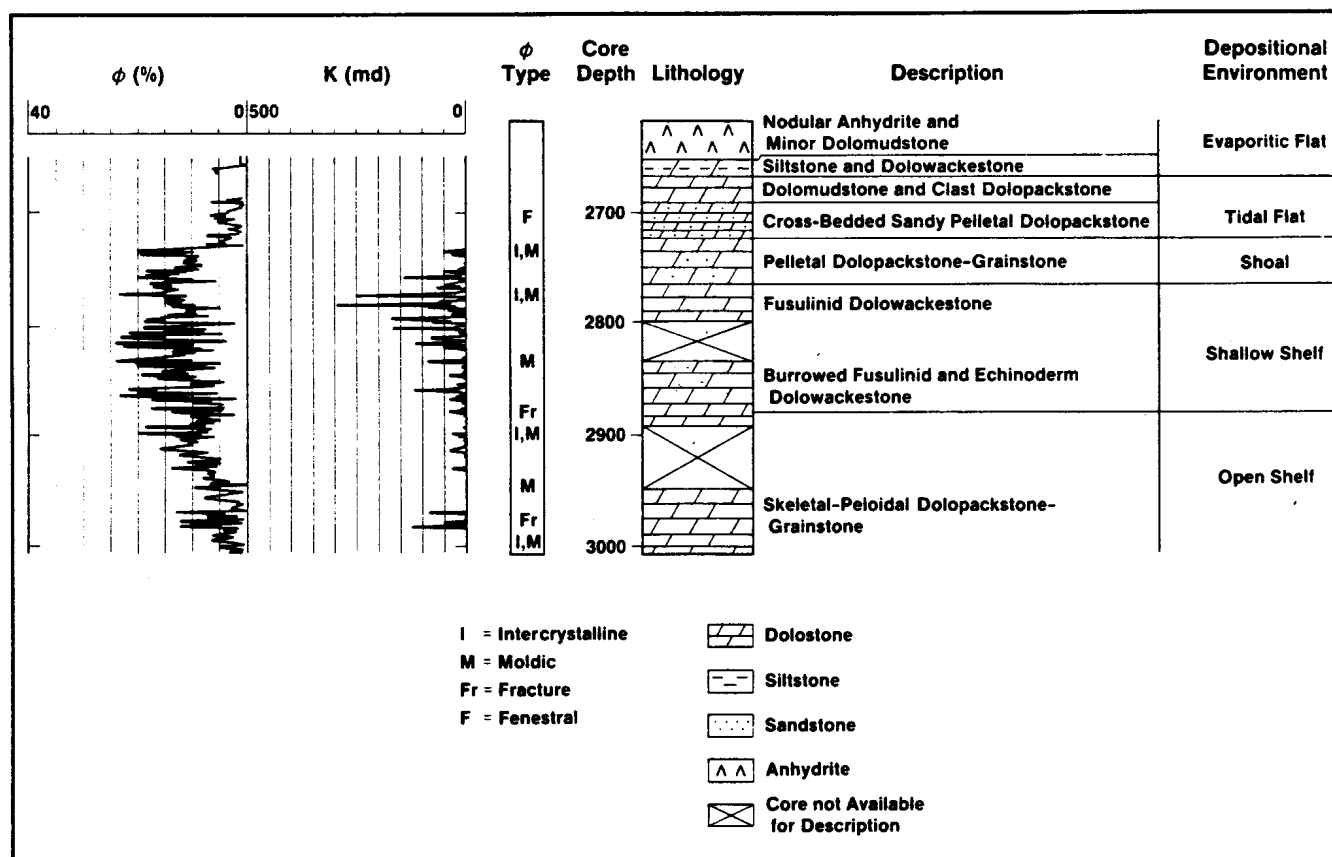


FIGURE 4. Lithology of the Grayburg and Queen Formations, McElroy 223-R cores. Shelf and shoal dolostones change upward into tidal-flat strata that are more variable in lithology. Porosity and permeability determined by plug analysis are plotted, and the porosity type as determined by core and thin-section analysis is shown. The porous-permeable zone is quite thick (approximately 200 ft) and is best developed in the shoal and immediately underlying shallow-shelf intervals.

fragments, and clasts. Measured porosities are generally 3 percent or less for the dolostones and up to 6 percent for the siliciclastic-rich beds; much of the pore space, including a few intervals with fenestral porosity, has been plugged by anhydrite.

## Snodgrass 35

Galloway and others (1983) presented a structure map and log cross section of Waddell field, illustrating a very heterogeneous reservoir. Cores from the Snodgrass 35 well, which is located off the main anticlinal structure (fig. 5), contain a suite of San Andres facies, discussed in the following paragraph, similar to that of the Grayburg Formation of the McElroy 223-R well and also to that seen elsewhere in the Waddell field, determined during other in-house

core studies. The Snodgrass 35 cores differ, however, in that permeability is not well developed and cementation by anhydrite is exceptionally common even in the shoal dolopackstones/dolograinstones (fig. 6).

Log top for the San Andres Formation in the Snodgrass 35 well is 3,255 ft. Open-shelf facies at the base of the Snodgrass 35 cores are burrowed peloidal dolowackestones/dolopackstones with minor fusulinids, pisolites, ooids, and quartz silt (fig. 6, plate 3A and 3B). Measured porosities are 5 percent or less, except toward the base of the core, where intercrystalline and leached fusulinid moldic pores produce porosities of nearly 10 percent. The overlying shallow shelf and shoal interval contains burrowed peloidal dolowackestones/dolopackstones (plate 3C and 3D) grading upward into ooid and pisolite dolopackstones/dolograinstones and peloidal dolopackstones (plate 4A and 4B). The carbonate

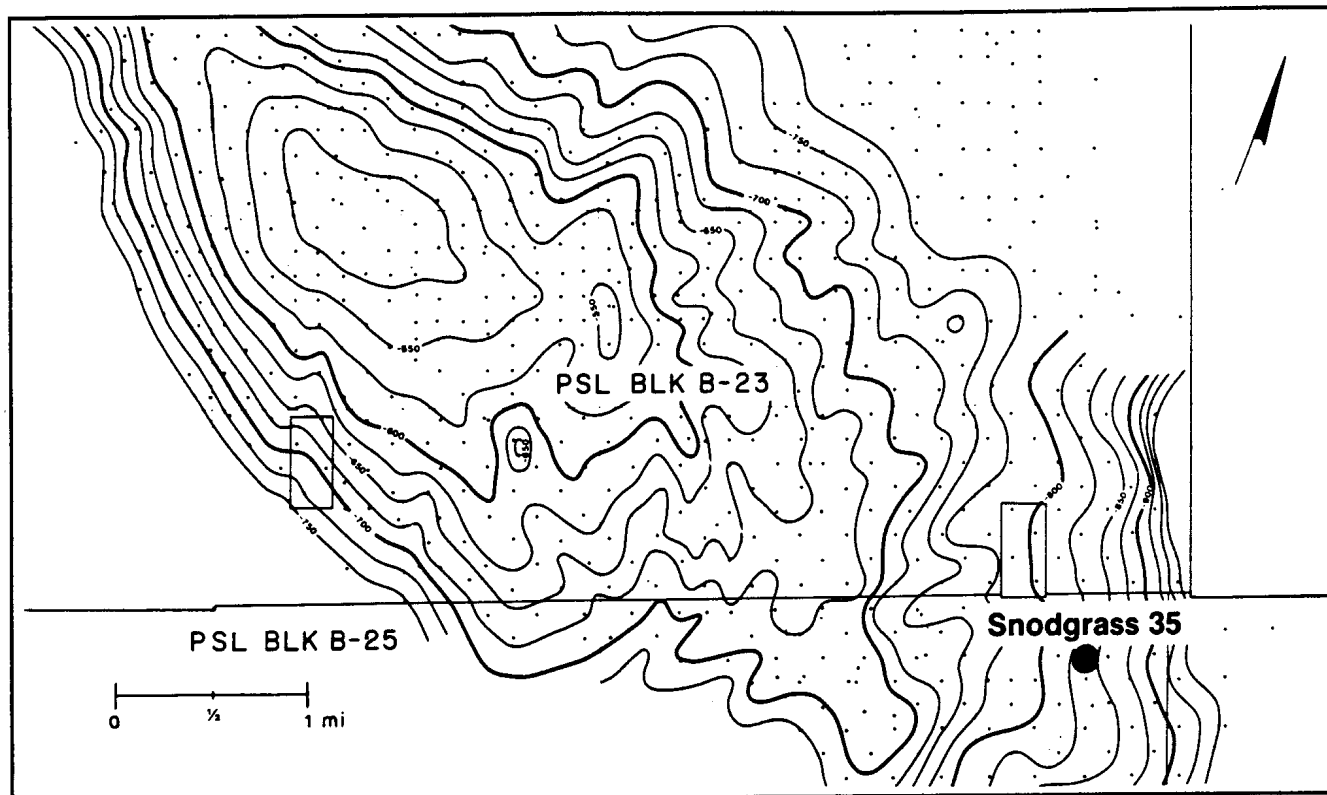


FIGURE 5. Structure map, top of San Andres Formation, Waddell field. Sea level is datum, and the contour interval is 25 ft. Dots indicate well control. Note the off-structure location of the Snodgrass 35 well.

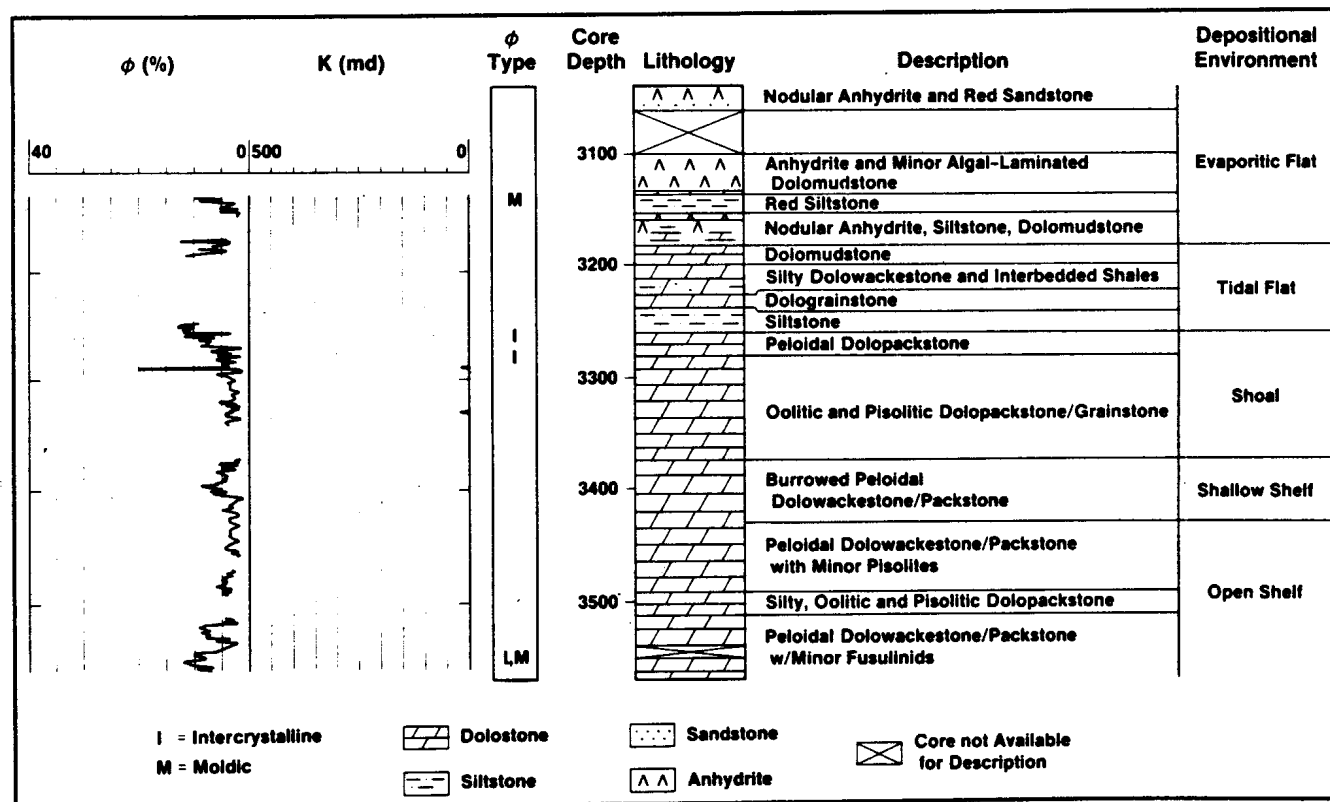


FIGURE 6. Lithology and porosity data, San Andres Formation, Snodgrass 35 cores. The shoal unit is better developed and the open-shelf interval is more variable in the Snodgrass 35 core than in the McElroy 223-R or Goldsmith 1359-56 cores. The Snodgrass 35 cores offer the best view of the capping tidal-flat and evaporitic-flat sediments. Porosity is developed in a few thin streaks but is not accompanied by any permeability.

## Grayburg/San Andres Facies

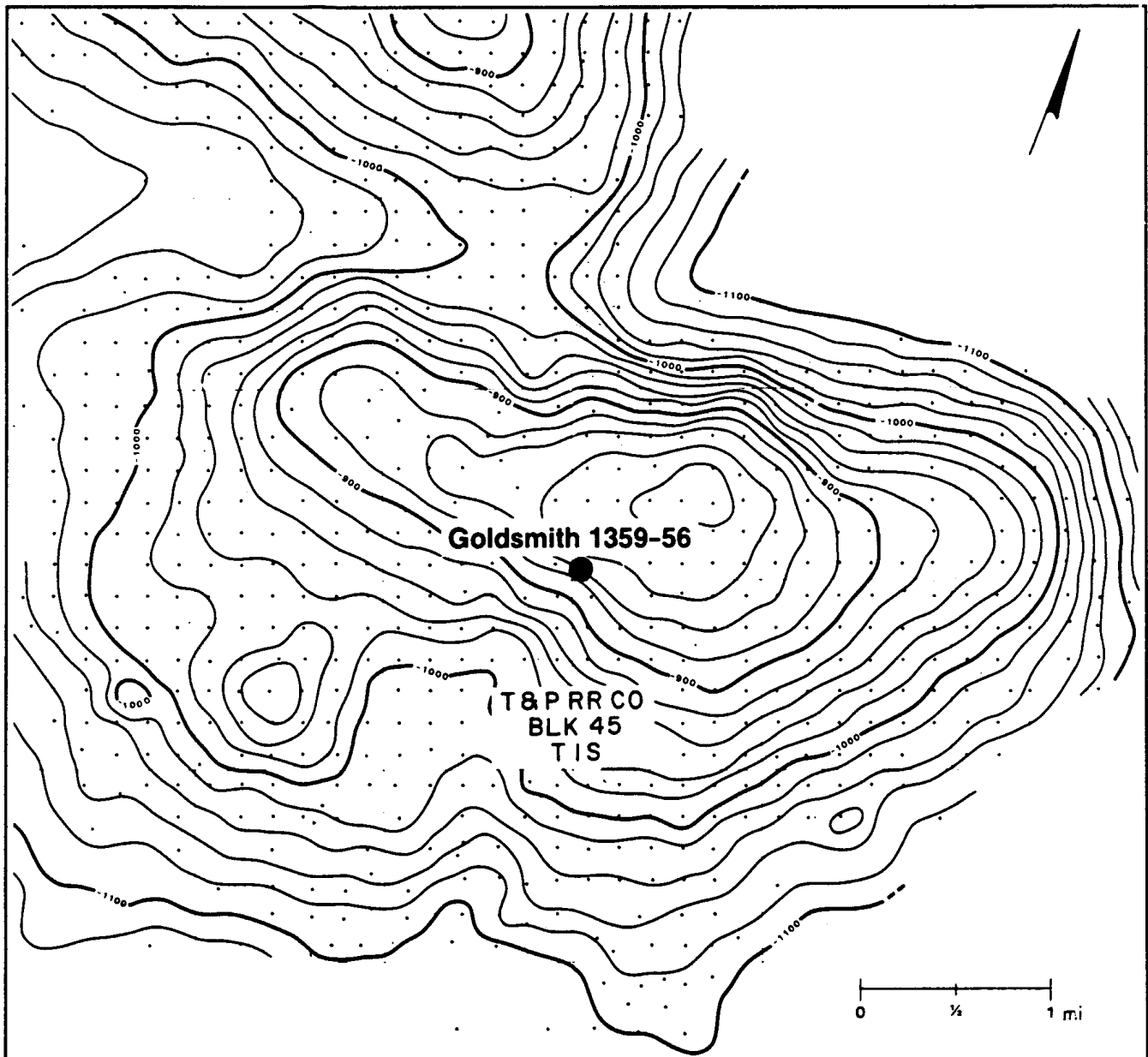


FIGURE 7. Structure map, top of porosity zone, San Andres Formation, Goldsmith field. Datum is sea level, contour interval is 20 ft. Dots indicate well control.

sands accumulated in an extremely shallow water, periodically exposed setting, as suggested by the occurrence of pisolites, algal and cement crusts, solution veins, and probable tepee structures. Porosity is about 5 percent for most of the unit but increases toward the top to approximately 11 percent. The tidal-flat and evaporitic-flat deposits in the upper portions of the core consist of nodular anhydrites with interbedded siltstones and silty dolowackestones/dolomudstones with intercrystalline and minor fenestral porosities of about 10 percent (plate 4C and 4D).

## Goldsmith 1359-56

The Goldsmith 1359-56 well is located near the crest of the structure (fig. 7) in Goldsmith field. Log top for the Grayburg/San Andres interval is at 3,742 ft. Cores contain a sequence of facies similar to that observed in the other fields. Burrowed fusulinid dolowackestones/dolopackstones of open-shelf and shallow-water shelf origin occur at the base of the sequence (fig. 8 and plate 5). Measured porosities are approximately 15 percent where both moldic and intercrystalline pores occur and only 5 percent where

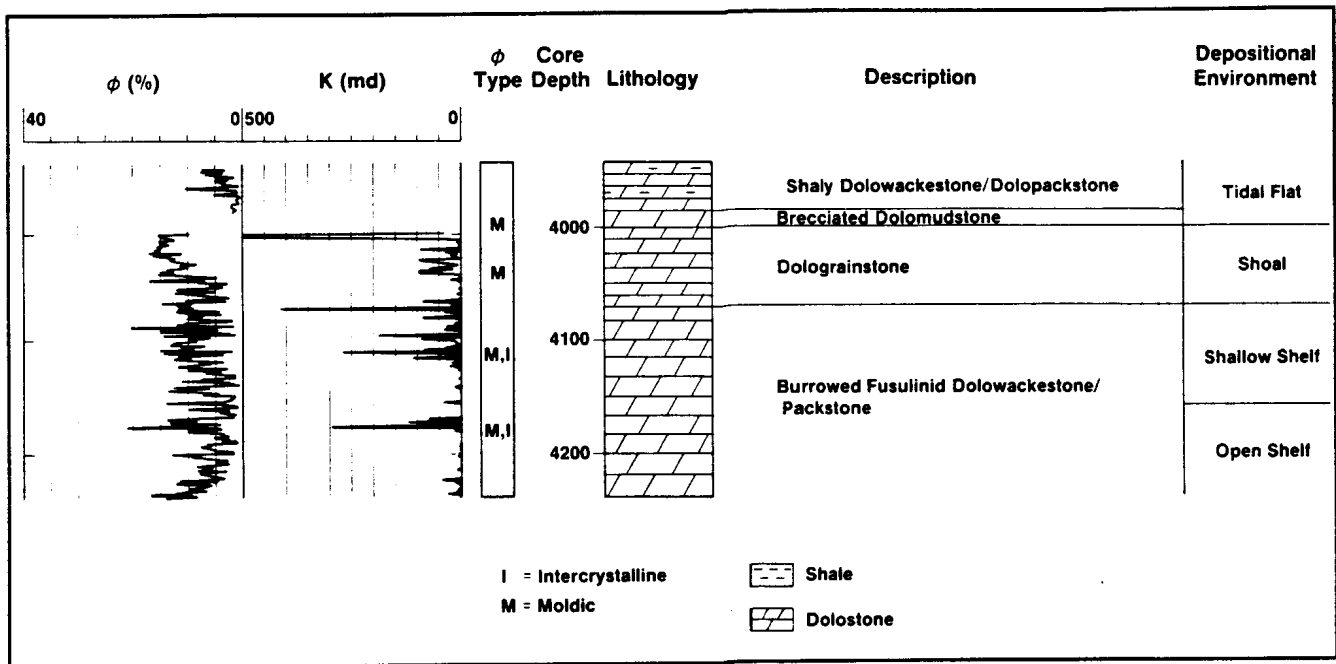


FIGURE 8. Lithologic description and interpretation and porosity-permeability data, San Andres Formation, Goldsmith 1359-56 cores. Open- and shallow-shelf dolowackestone/dolopackstones are similar. The capping tidal-flat section is more shaly in the Goldsmith 1359-56 well than in either of the other two cores described in this paper. Porosity and associated good permeability occur in a thick section of the shoal and shallow-water shelf interval.

moldic pores were subsequently filled with anhydrite. Permeability is variable but higher toward the top of the shallow-water shelf unit. Porosities are more consistently near 15 percent in overlying shoal dolograstones (plate 6A and 6B), and permeabilities reach 100 md or more. Tidal-flat deposits at the top of the sequence are anhydrite-cemented, brecciated dolomudstones overlain by shaly dolowackestones/dolopackstones containing rip-up clasts (plate 6C and 6D). Porosities in this upper unit are 5 percent or less.

## Depositional Model

We interpret the depositional sequence present in cores from the San Andres/Grayburg interval of the McElroy 223-R, Snodgrass 35, and Goldsmith 1359-56 wells to have formed in a similar facies tract of shallow shelf and shoal (or inner ramp) environments and related evaporitic tidal flats (sabkhas) (fig. 9). The facies developed during easterly progradation across a deeper-water (below normal wave base) open shelf (or outer ramp). Although some

variability exists between cores described in this study, as well as within the fields themselves, the major depositional environments represented in the cores and the overall sequence in which they occur are similar. Core data and depositional models previously presented for Yates field (Adams, 1930; Donoghue and Gupton, 1957; Craig and others, 1986), Foster field (Young and Vaughn, 1957), and Means field (George and Stiles, 1978, 1986), together with the more recent studies by Longacre (1980, 1983), Harris and others (1984), and Walker and Harris (1986) of McElroy field and by Bebout (1986) and Bebout and others (1987) of Dune field, suggest that major portions of the eastern margin of the Central Basin Platform were dominated by carbonate sand-shoal and updip tidal-flat facies belts.

Our findings contradict those of Galloway and others (1983). They infer that the principal reservoir facies in the fields along the eastern edge of the Central Basin Platform occur in dolostones having a structural framework dominated by sponges and algae and porosity formed by secondary solution. Longacre (1983) has shown that a thick, shelf-margin reef section is indeed present along a portion of the easternmost boundary of the North McElroy

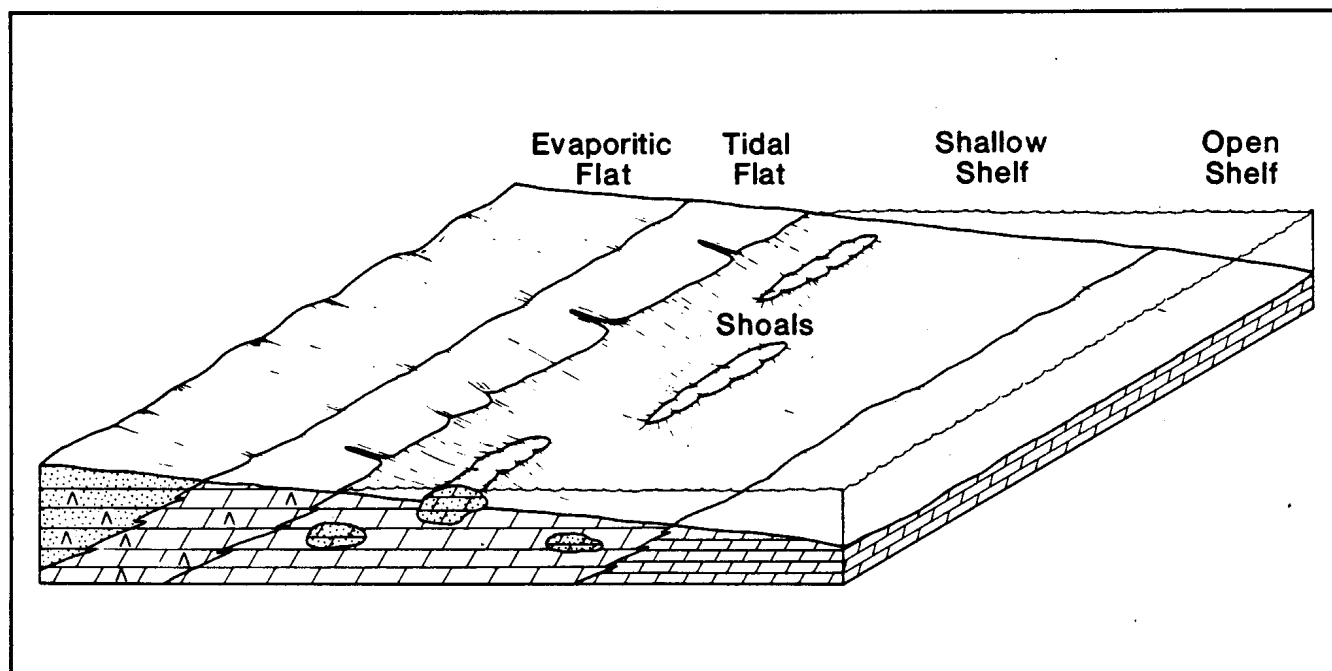


FIGURE 9. Depositional model of sedimentation along the Central Basin Platform during San Andres/Grayburg time. Relationships among depositional environments (facies) that were recognized during our studies are shown. Not to scale.

Unit. But the continuity of the reef elsewhere along the margin of the Central Basin Platform is not yet proven, nor does the reef interval contribute to the reservoir in North McElroy. Smaller patch reefs or mounds described by Longacre (1983) and Harris and others (1984) contribute only locally to the reservoir interval in McElroy field in both the open-shelf and overlying shallow-shelf portions of the Grayburg/San Andres section. An interval of low-porosity sponge and algal framestone may form part of the reservoir zone locally in some of the fields, such as Dune field as described by Bebout (1986) and Bebout and others (1987), but the examples described in this paper and comparisons with the results of most previous studies clearly suggest to us that the reservoir intervals are not reefal in nature but are part of a common association of shoal grainstones and packstones and related shallow-water shelf sediments.

## Porosity and Diagenesis

Porosity in the fields under discussion was formed by dolomitization and minor dissolution, with perhaps greater solution being more important locally

to the south, as illustrated by karst formation in Yates field (Craig and others, 1986). The best reservoir zones in the McElroy 223-R, Snodgrass 35, and Goldsmith 1359-56 wells occur within the shoal and shallow-shelf facies, where the predominant porosity types are intercrystalline and moldic. Diagenesis occurred in two major stages: (1) submarine cementation, pervasive dolomitization, leaching of grains, minor dolomite cementation, and sulfate cementation and replacement—all occurring during deposition and earliest burial (plate 8); and (2) fracturing, anhydrite cementation, minor calcite replacement of anhydrite, dissolution of sulfate, and formation of gypsum and kaolinite—all forming near maximum burial depth and during subsequent uplift (plate 7). The pervasive dolomite that led to the development of reservoir zones in the middle unit of our depositional sequence is commonly finely crystalline, anhedral to subhedral, and inclusion rich and preserves original depositional texture. Reservoir zones average 9 percent intercrystalline and moldic porosity and 10 md permeability.

Stable carbon and oxygen isotopic analyses of both whole-rock samples and microsamples and cathodoluminescence suggest a near-surface to shallow-burial diagenetic origin for the dolomite;  $\delta^{13}\text{C}$  values average +5.52‰ PDB (ranging from +3.35 to

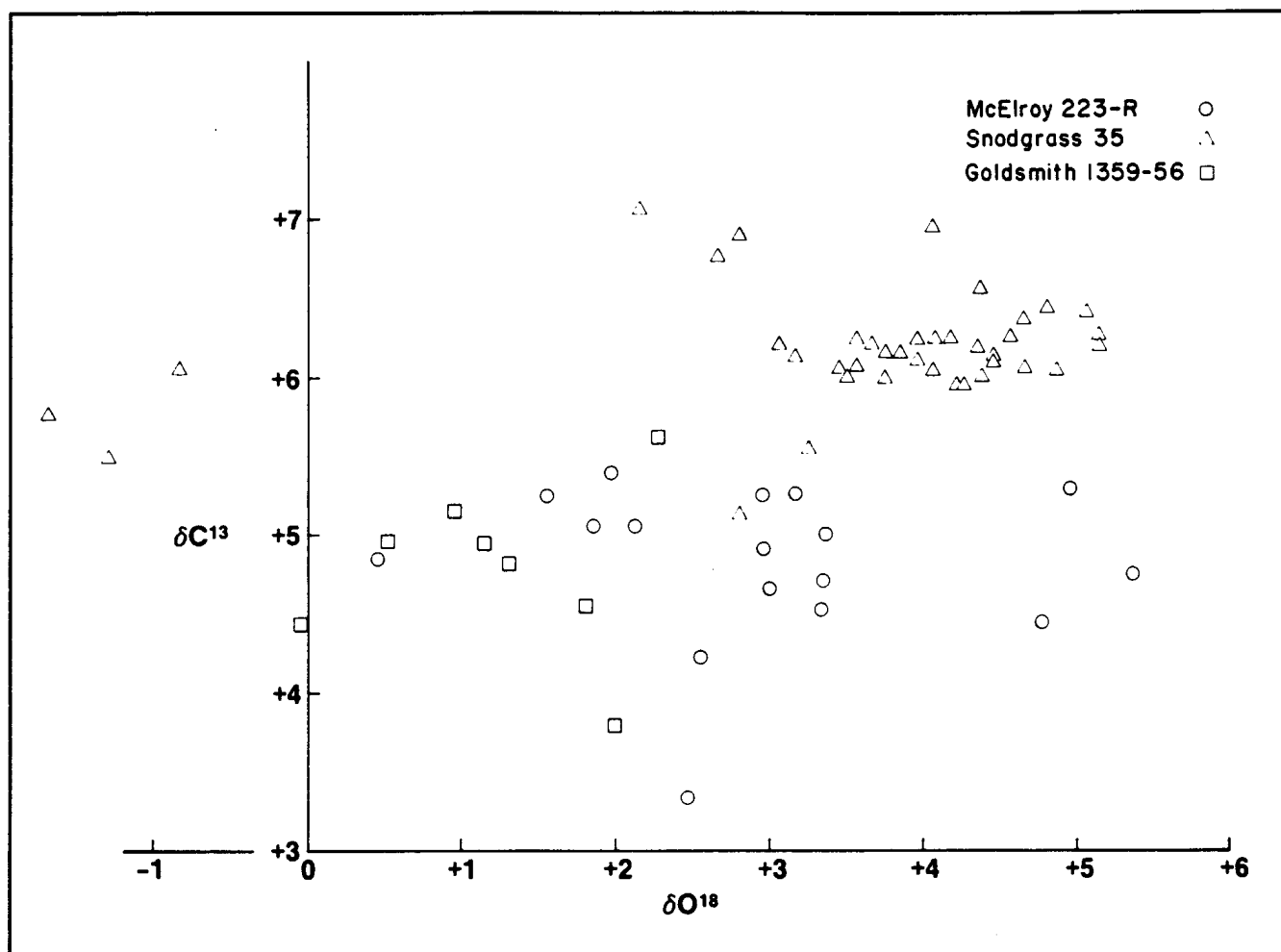


FIGURE 10. Stable carbon and oxygen isotopic variation in dolomite samples from the Gulf Oil McElroy 223-R, Snodgrass 35, and Goldsmith 1359-56 wells. All data are from microsamples of grains, matrix, or early-phase cements.

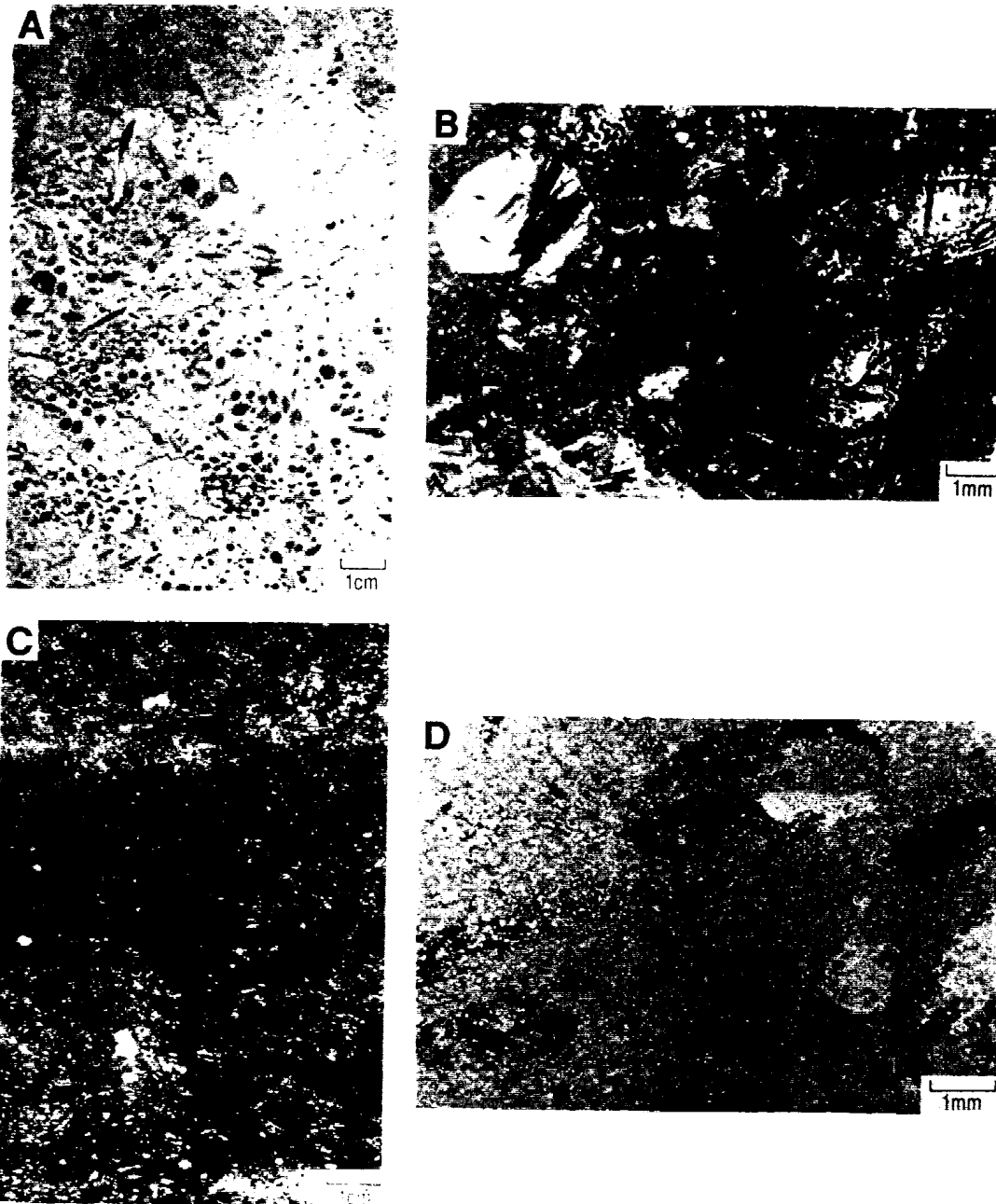
+7.08‰), and  $\delta^{18}\text{O}$  values range from -1.70 to +5.35‰ PDB (fig. 10). Under cathodoluminescence the dolomite is mainly a dull orange-brown with only minor bright orange rims lining some pores. Isotopic composition of various dolomitized constituents (grains, matrix, early cements) shows little variation among microsamples. Regional deviations in  $\delta^{18}\text{O}$  to heavier values (that is, samples from Snodgrass 35 well are uniformly heavier) are interpreted to represent dolomitization from higher salinity fluids. Variations toward lighter values are thought to

represent either mixed-water dolomitization or early dolomite that was subjected to incomplete recrystallization or minor additions of later dolomite during burial.

## Acknowledgments

Chevron Oil Field Research Company permitted publication of this paper. We thank our co-workers in the Midland, Texas, office of Chevron U.S.A., Inc., for valuable interaction over the years.

## Grayburg/San Andres Facies



**PLATE 1. Representative shelf facies of J. T. McElroy Cons. 223-R core.**

### Open Shelf

- A. Slab photograph of bioturbated fusulinid and peloidal dolopackstone, 2,958 ft.
- B. Photograph of thin section from slab shown in A. Fusulinid molds are filled with anhydrite and are widely spaced within a peloidal and micritic matrix. Cross-polarized light.

### Shallow Shelf

- C. Slab photograph of oil-stained fusulinid dolowackestone, 2,881 ft.
- D. Photograph of thin section from slab shown in C. Fusulinid molds are filled with dead hydrocarbon and, in places, anhydrite (white) in a dominantly micritic matrix. Plane-polarized light.

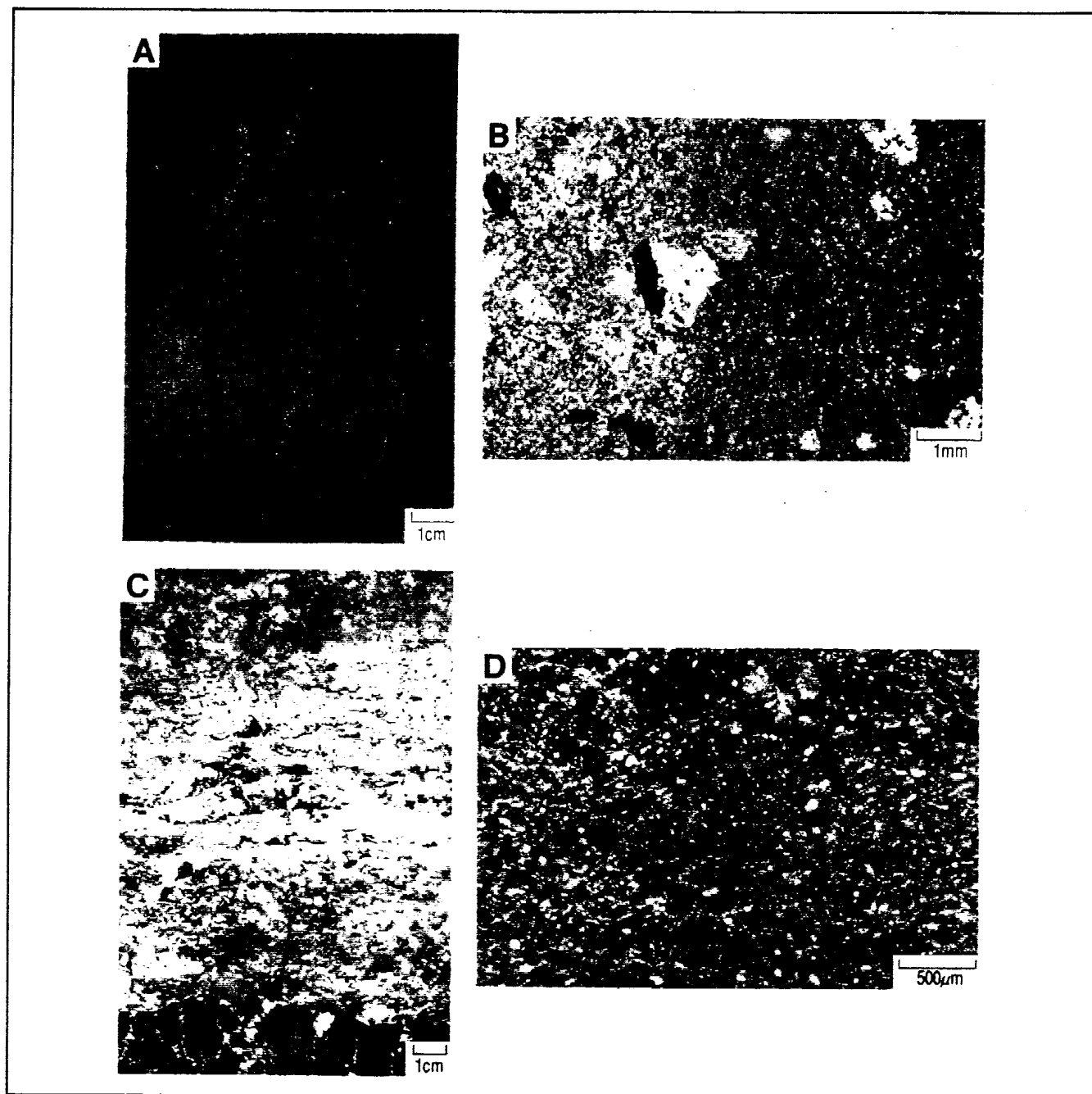


PLATE 2. Representative shallow-water nearshore facies of J. T. McElroy Cons. 223-R core.

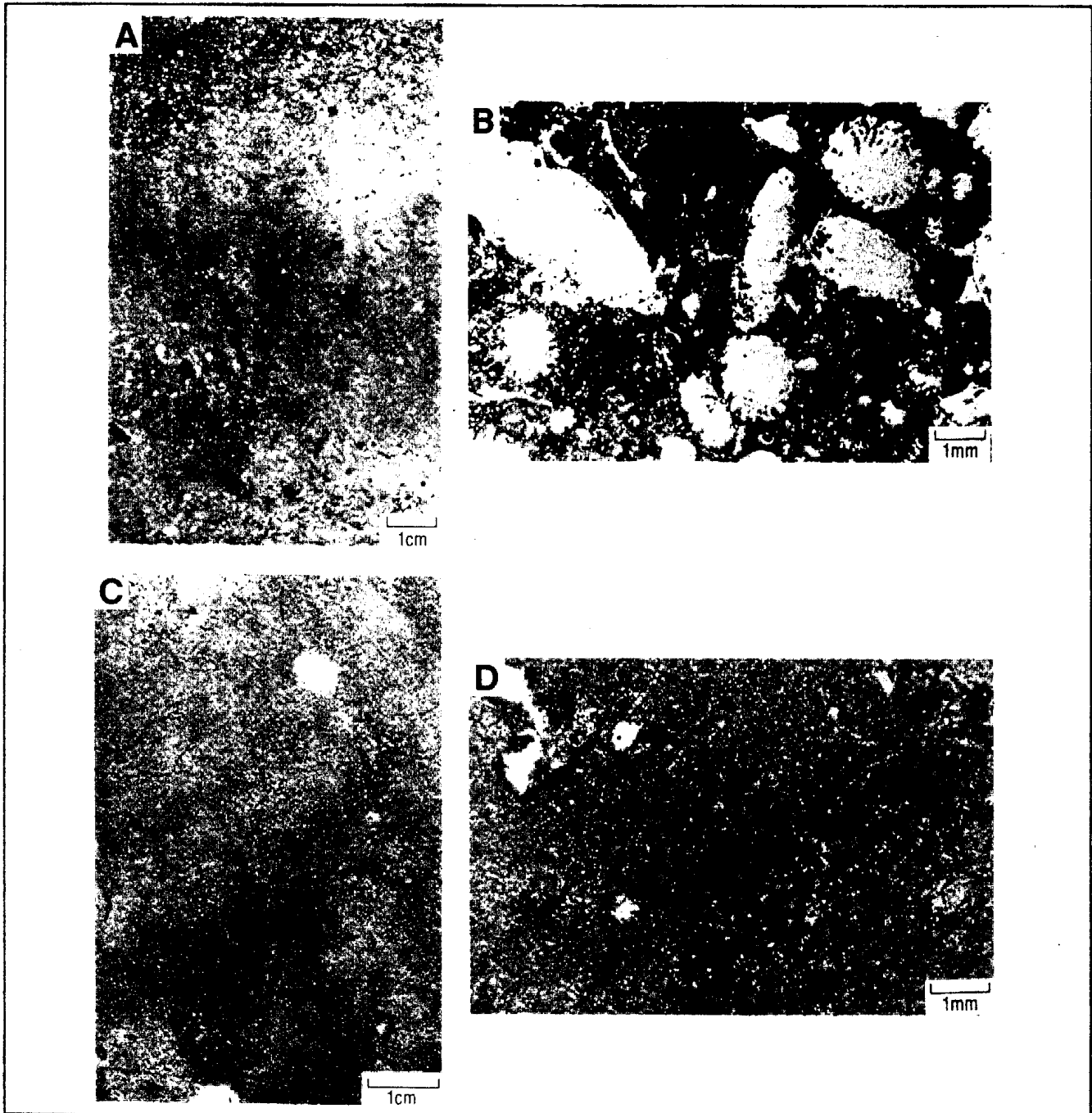
Shoal

- A. Slab photograph of peloidal dolopackstone/dolograinstone, 2,728 ft.
- B. Photograph of thin section from slab shown in A. Pervasive dolomitization has nearly destroyed the original grainstone texture. Several large anhydrite crystals are present, possibly replacing echinoderm fragments or filling molds of peloids. Cross-polarized light.

Tidal Flat

- C. Slab photograph of anhydritic and silty peloidal dolopackstone with cement-filled fenestral porosity, 2,655 ft.
- D. Photograph of thin section from slab shown in C. Scattered peloids and silt grains are cemented by cryptocrystalline dolomite and anhydrite. Plane-polarized light.

## Grayburg/San Andres Facies



**PLATE 3. Representative shelf facies, Snodgrass No. 35 core.**

### Open Shelf

- A. Slab photograph of burrowed peloidal and fusulinid dolopackstone, 3,509 ft. Darker zones filling molds are oil stains.
- B. Photograph of thin section from slab shown in A. Fusulinid molds are filled with anhydrite and are surrounded by peloids in a micritic matrix. Plane-polarized light.

### Shallow Shelf

- C. Slab photograph of bioturbated peloidal dolowackestone with stylolites, 3,397 ft.
- D. Photograph of thin section from slab shown in C. Peloidal texture is barely recognizable as a result of pervasive dolomitization. Anhydrite replaced intraclast in upper left. Plane-polarized light.

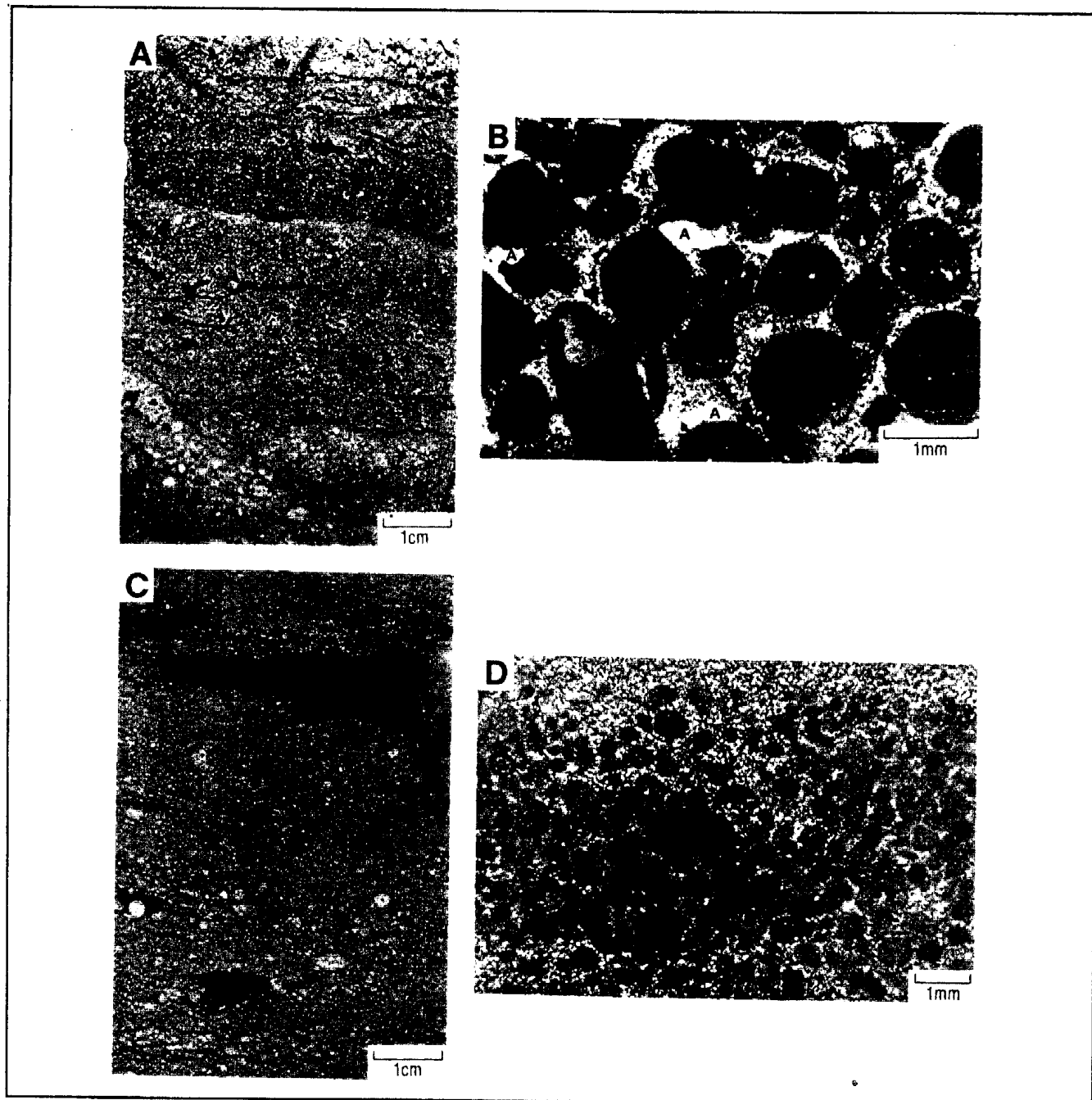


PLATE 4. Representative nearshore shallow-water lithofacies, Snodgrass No. 35 core.

Shoal

- A. Slab photograph of oolitic and pisolitic dolograinstone, 3,347 ft. Although fenestral fabric is common in this example, it is not typical of the shoal facies.
- B. Photograph of thin section from slab shown in A. Oolitic and pisolitic grains commonly contain other coated grains within their nuclei. Grains are cemented by dolomicritic cement; anhydrite fills some intergranular pores (A). Cross-polarized light.

Tidal Flat

- C. Slab photograph of nodular anhydrite and dolowackestone/dolopackstone, 3,236 ft. Anhydrite plugs all pore space.
- D. Photograph of thin section from slab shown in C. Peloids and ooids are surrounded by silt and dolomicrite.

## Grayburg/San Andres Facies

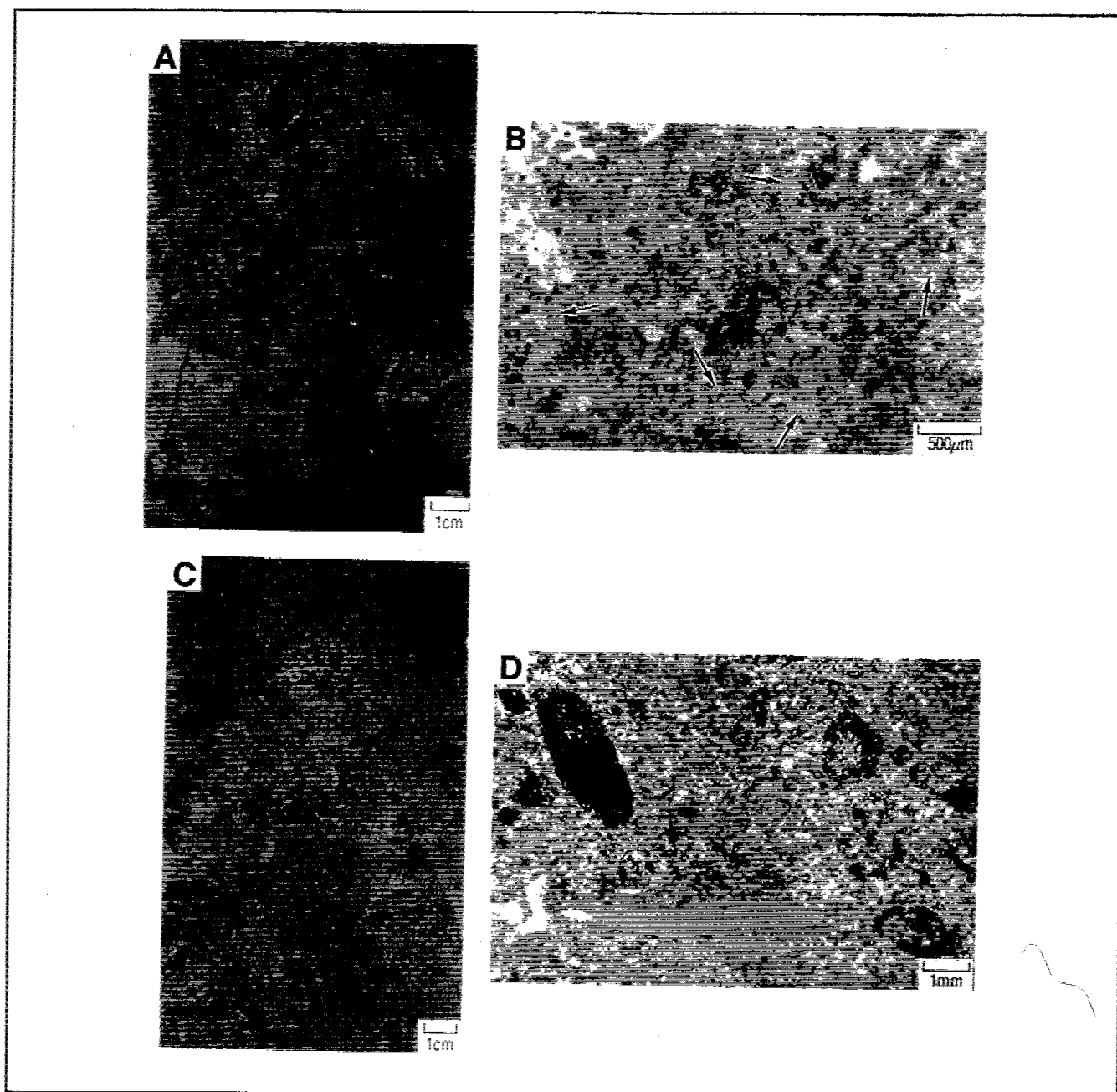


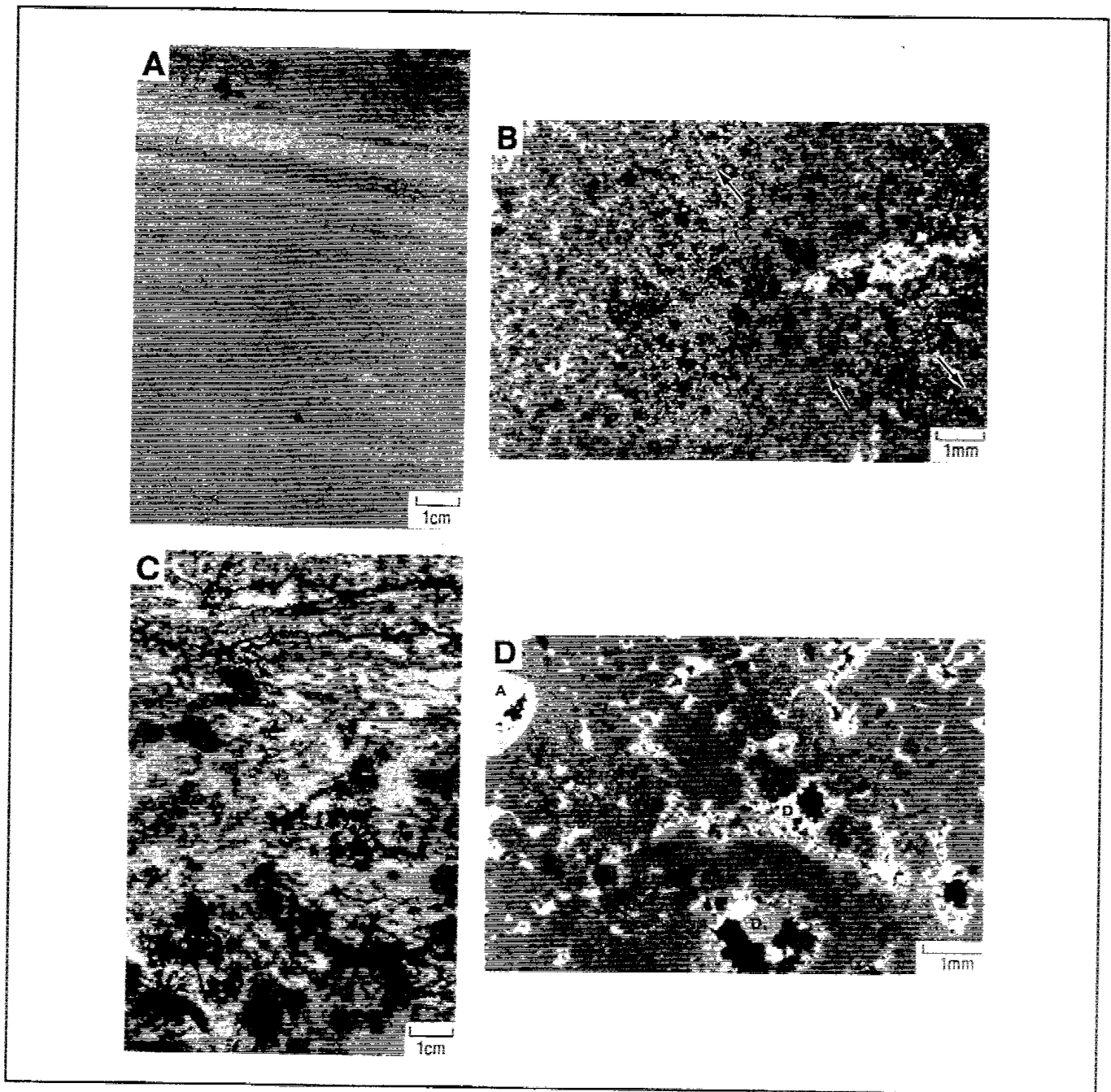
PLATE 5. Representative shelf lithofacies, Goldsmith 1359-56 core.

### Open Shelf

- A. Slab photograph of burrowed fusulinid dolowackestone with thin vertical fractures and patchy oil stain, 4,175 ft.
- B. Photograph of thin section from slab shown in A. Pervasive dolomitization has destroyed much of the original texture; only minor anhydrite cement is present (white areas). There is good intercrystalline porosity (some pores shown by arrows). Plane-polarized light.

### Shallow Shelf

- C. Slab photograph of burrowed peloidal and fusulinid dolowackestone (similar to plate 5A), 4,164 ft.
- D. Photograph of thin section from slab shown in C. Peloids, intraclasts, and fusulinid molds are surrounded by dolomicritic matrix; only minor anhydrite cement is present (white). Moldic and intercrystalline porosity are excellent. Plane-polarized light.



**PLATE 6.** Representative nearshore shallow-water lithofacies, Goldsmith 1359-56 core.

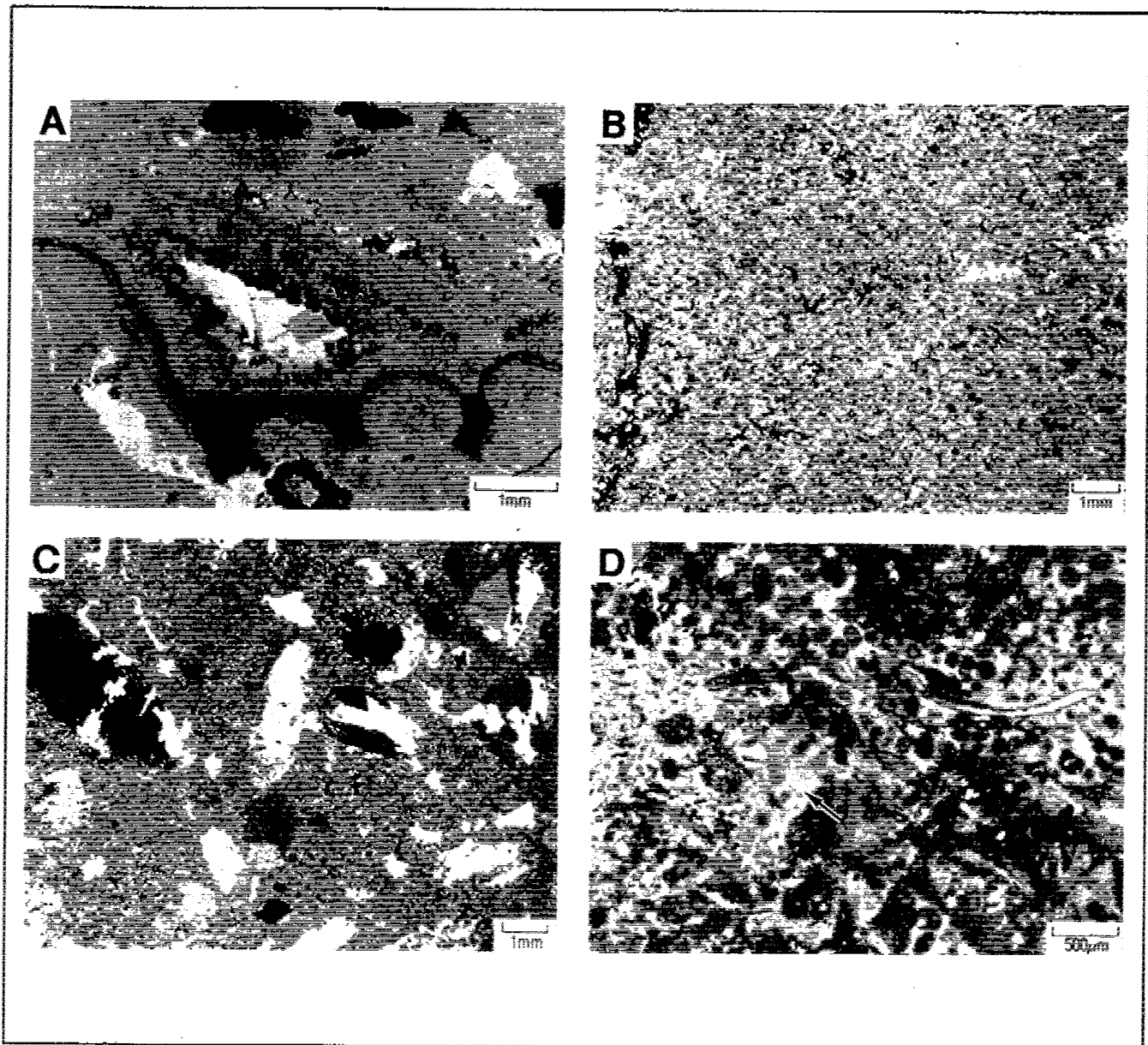
Shoal

- A. Slab photograph of cross-bedded dolograinstone, 4,011 ft.
- B. Photograph of thin section from slab shown in A. Original texture of this peloidal grainstone has been highly altered by thorough dolomitization. It is partially cemented by anhydrite, and moldic and intercrystalline porosity are common (solid light gray; some pores shown by arrows). Plane-polarized light.

Tidal Flat

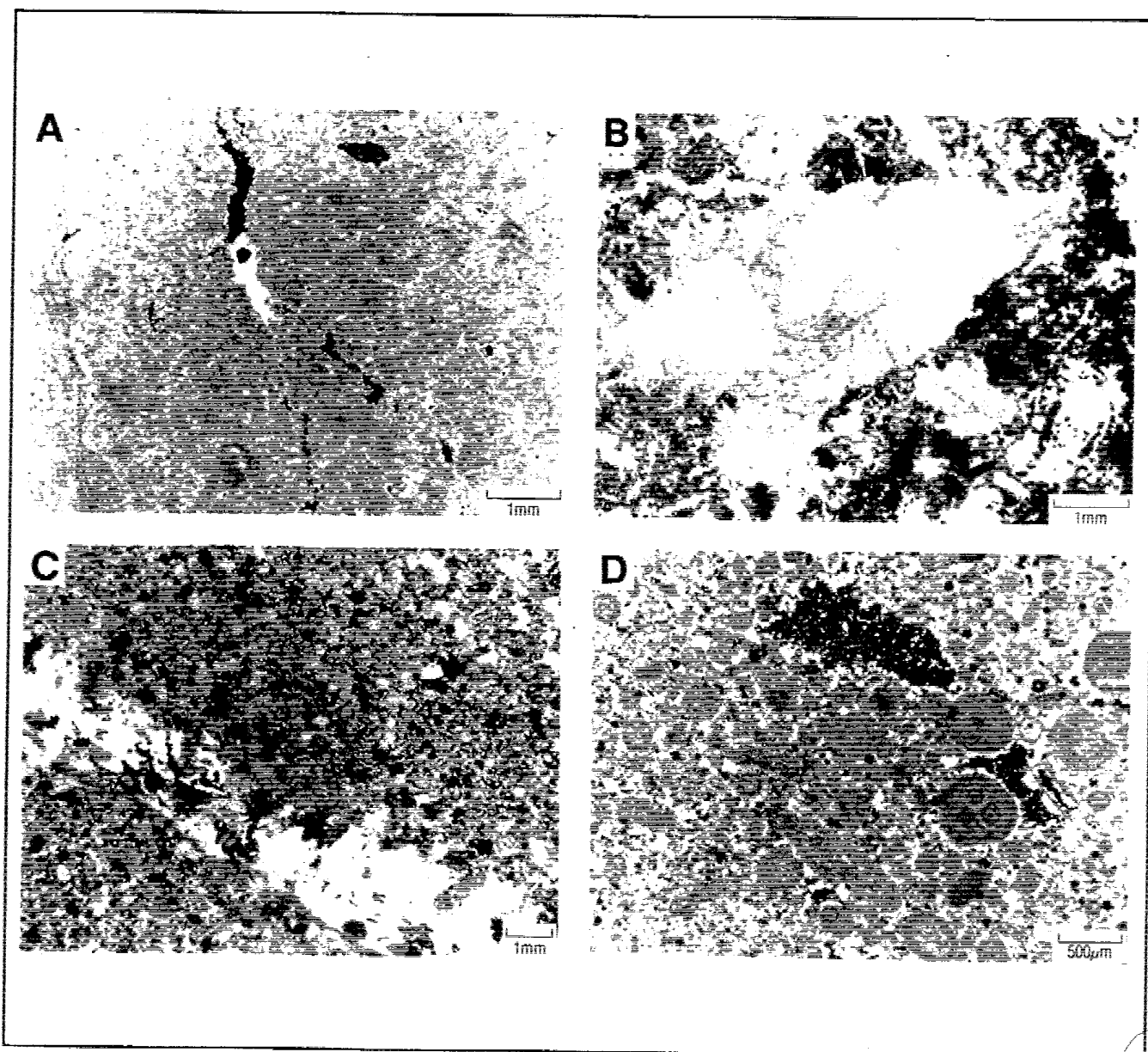
- C. Slab photograph of anhydritic peloidal dolopackstone, 3,949 ft.
- D. Photograph of thin section from slab shown in C. Peloids are highly micritized and coalescing. Fenestral, intergranular, and moldic pores are filled with medium to coarsely crystalline dolomite (D) and anhydrite (A). Cross-polarized light.

# Grayburg/San Andres Facies



**PLATE 7. Photomicrographs showing early-stage diagenesis, San Andres/Grayburg Formations, Central Basin Platform.**

- A. Pore partially filled with geopetal carbonate mud and lined with dolomitized fibrous to bladed early marine cement. Anhydrite fills the center of the pore. McElroy 223-R, 2,967 ft. Cross-polarized light.
- B. Pervasively dolomitized open-shelf facies. Note complete lack of textural preservation. McElroy 223-R, 2,972 ft. Cross-polarized light.
- C. Fusulinid dolowackestone in which fusulinids have been dissolved. Molds are filled with anhydrite. Snodgrass 35, 3,520 ft. Cross-polarized light.
- D. Anhydrite-cemented peloidal and intraclastic dolowackestone. Anhydrite also replaces some grains (arrow). McElroy 1026, 2,646 ft. Cross-polarized light.



**PLATE 8. Photomicrographs showing late-stage diagenesis, San Andres/Grayburg Formations of the Central Basin Platform.**

- A. Fractured dolostone. Anhydrite fills some fractures and partially cements the rock. McElroy 1026, 3,034 ft. Plane-polarized light.
- B. Fusulinid dolowackestone. Large pore in center filled with calcite (light gray) that almost completely replaced anhydrite (white). McElroy 1026, 2,883 ft. Plane-polarized light.
- C. Medium crystalline dolomite with gypsum-filled fracture. McElroy 223-R, 2,982 ft. Cross-polarized light.
- D. Silty dolograinstone. Large pores (arrows) filled with kaolinite. Snodgrass 35, 3,509 ft. Cross-polarized light.

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