

PRELIMINARY GEOLOGIC DESCRIPTION

ARCO
#1 B. F. PHILLIPS

September 1984

Prepared by

Shirley P. Dutton and Robert J. Finley

Bureau of Economic Geology
W. L. Fisher, Director
The University of Texas at Austin
Austin, Texas 78713-7508

Prepared for

The Gas Research Institute
Contract No. 5082-211-0708
Robert J. Finley - Principal Investigator

INTRODUCTION

Two intervals of the Travis Peak Formation were cored in the ARCO #1 B. F. Phillips well, Smith County, Texas. Core was recovered from 8,188 to 8,270 ft and from 8,367 to 8,395 ft. The top of the Travis Peak in this well is at 8,141 ft, therefore the core begins about 50 ft below the contact with the Sligo Formation.

MACROSCOPIC CORE DESCRIPTION

The Travis Peak cores were described using a hand lens and binocular microscope, and graphic logs of the cores were made at a scale of 1 in = 5 ft (fig. 1). The following features of the cores are noted on the descriptive logs: depth; rock type; accessories such as pyrite, organic matter, and burrows; sedimentary structures; texture (rounding and sorting); induration; grain size; relative amount of calcite cement; color; and special features such as fluorescence, dead oil, and calcareous clasts (fig. 1). Porosity and permeability values reported by Petrophysical Services, Incorporated, are noted on the graphic logs, as are the depths from which thin sections were made.

The cores consist of intervals of fine to very fine sandstone, siltstone, mudstone, and limestone (figs. 1, 2). Three different types of sandstone have been distinguished in the cores based on sedimentary structures, texture, character of upper and lower contacts, and amount of burrowing. The first sandstone type is best illustrated by the sandstone at 8,380 to 8,389 ft (core depths), henceforth called the 8,380-sandstone. This sandstone type has a sharp lower contact and commonly contains a zone of pebble-size carbonate nodules at the base (fig. 1). Above the carbonate nodules is an interval of clean, well sorted sandstone with high-angle cross bedding. The upper part of the sandstone contains festoon-shaped cross beds 1 to 2 cm high that were

formed by small current ripples. The ripples commonly have thin clay drapes over them (0.1 mm thick), so this interval has poorer sorting than the zone of high-angle cross beds. Burrowing is common in the upper, ripple-bedded interval, but generally does not occur in the lower interval of high-angle cross beds. The top of the sandstone is gradational and fines upward to siltstone and mudstone. The sandstone at 8,240 to 8,248 ft is also of this type (fig. 1).

The second type of sandstone is represented by the interval from 8,211 to 8,218 ft (the 8,211-sandstone). It has both a sharp base and a relatively sharp upper contact (fig. 1). High-angle cross beds are the most common sedimentary structure throughout the entire interval; planar laminations are of secondary importance. Thin clay partings may occur within the sandstone, and ripped-up mud clasts are found along some high-angle cross beds (fig. 1). The sandstone is not burrowed, even at the top, and it is well sorted except for the presence of clay partings.

The third type of sandstone is illustrated by the interval from 8,196 to 8,206 ft (fig. 1). Unlike the other sandstones, this type has a gradational, upward-coarsening sequence at the base. The center of the interval is ripple cross bedded and moderately well sorted, with some burrowing (fig. 1). At the top, the sandstone has been completely bioturbated, so that any original sedimentary structures have been destroyed. The burrows are commonly highlighted by dead oil. The uppermost part of the interval fines upward into siltstone and mudstone.

Mudstones in the cores are dark gray except at the base of the lower core, where they are red. Calcareous nodules occur scattered throughout the mudstones (fig. 1), apparently in the locations where they formed. Limestones in the core consist of lime mud and pelecypod fragments with varying amounts of

terrigenous mud. The limestones are commonly slumped and bioturbated, resulting in mixing with terrigenous mudstones.

DEPOSITIONAL HISTORY

Preliminary interpretations of the depositional environment of the part of the Travis Peak cored in the ARCO #1 B. F. Phillips are based on core description and log correlations within Chapel Hill field. Except for the base of core 4, where red mudstones occur below 8,390 ft, the cored interval is interpreted to represent marginal marine deposits. The red mudstones probably represent nonmarine deposition, possibly in a lower delta plain environment. The abundance of burrows throughout the rest of the core suggest deposition in a marine setting. Limestone intervals (as distinct from calcareous nodules) extend as deep as 8,250 ft, and these limestone zones are good evidence of marine to brackish conditions at least to that depth.

The origin of specific sandstones is open to more than one interpretation, although all interpretations made thus far suggest that the cored intervals represent a very shallow, nearshore marine setting, probably including estuarine or bay environments, tidal flats, and distributary channels. The 8,380-ft sandstone and overlying siltstones and mudstones, for example, may have been deposited as part of a channel within a prograding tidal flat sequence. Characteristics of prograding tidal flats include an upward decrease in energy as indicated by sedimentary structure (large-scale cross beds at the base, ripple cross beds at the top of the sandstone interval), upward fining grain size, and an upward increase in bioturbation (Weimer and others, 1982). Lateral juxtaposition of tidal channel sandstones may tend to form the major framework of tidal flat deposition where adequate sand is available.

Alternatively, the 8,380-ft sandstone may represent a shallow sheetflood of sediment, perhaps similar in plan to a crevasse splay and in origin to a bay-head fan delta, deposited in a shallow marine embayment. The transition

from red mudstone of possible lower delta plain origin to black mudstone immediately below the 8,380-ft sandstone may be indicative of compactional subsidence in a marine embayment which helped to localize the overlying sandstone package. Laterally, there is little doubt that channels form part of this unit, especially where it abruptly thickens and the underlying shale thins, probably due to scouring at the base of the channel. This unit can be traced over an area of approximately 2 by 3 mi in the central Chapel Hill field. An abrupt base and either abrupt or gradational, upward-fining top characterizes the sandstone on gamma ray logs; paradoxically, the thickest sandstone occurrence, interpreted to most likely be a channel, shows a somewhat gradational, upward-coarsening, rather than abrupt, lower contact.

The 8,211-ft sandstone, described above, is persistent throughout the central Chapel Hill field with a very similar gamma ray log character, consisting most frequently of a single spike. An underlying medium dark gray calcareous mudstone and carbonate-rich zone (containing pelecypod shells in the ARCO #1 Phillips) have similar lateral continuity. In one well these units are cut out by a probable channel, but lateral persistence of the 4 to 11-ft thick sandstone is otherwise very good. Such a sandstone may represent a relatively high-energy, sandy tidal flat. Cessation of deposition of this unit must have been rapid; the upper part of the sandstone is not burrowed nor are overlying siltstone and mudstone. The latter are contorted, however, indicating possible rapid deposition and subsequent physical adjustment.

Marine incursion over the entire central Chapel Hill field is indicated by the widespread occurrence of the limestone below the 8,211-ft sandstone. Such occurrence is expected in a delta fringe - tidal flat - shallow bay environment such as is postulated for the uppermost Travis. The limestone is seen in the ARCO #1 Phillips core and in core from the Delta Drilling Company #1-A Williams which is located 2.4 mi southeast of the ARCO well.

Petrographic Description

Detailed study of the core is being carried out with the scanning electron microscope (SEM) and petrographic microscope.

Grain Size

Analysis of grain size is being conducted by grain-size point counts of thin sections; fifty grains per slide are measured along their long dimension. In order to determine the original size of detrital grains, overgrowths on grains are not measured.

Grain size point counts have been completed for four samples. The results are as follows:

<u>Depth (ft)</u>	<u>Mean (mm)</u>	<u>St. Dev. (mm)</u>	<u>Sand (%)</u>	<u>Silt (%)</u>	<u>Clay (%)</u>
8,189.6	0.120	0.036	98	2	6*
8,213.5	0.148	0.047	98	2	4*
8,246.1	0.169	0.045	100	0	8*
8,386.7	0.133	0.037	100	0	0

* Denotes percentage of authigenic clay in sample. Detrital silt and sand are recalculated to total 100%.

Most sand grains are fine or very fine, between 0.062 and 0.25 mm. Most silt is coarse silt, between 0.031 and 0.062 mm. Clay particles are smaller than .004 mm. All of the clay in these four samples is interpreted to be authigenic.

Mineral Composition

Four samples have been point counted for the preliminary description of mineral composition. The sandstones are mineralogically mature and are classified as quartz arenites, with quartz comprising 95 to 99 percent of the essential framework constituents (quartz, feldspar, rock fragments). Feldspar varies from 1 to 5 percent, and rock fragments from 0 to 2 percent. No detrital clay matrix was observed, but ripped-up mud clasts form 1 to 3 percent of the sample volume.

Authigenic cements constitute between 19 and 33 percent of the sandstone volume in these four samples. Quartz overgrowths, ankerite, and illite are the most abundant diagenetic minerals. Quartz overgrowths fill 14 to 24 percent of the volume, and precipitation of authigenic quartz occluded much of the primary porosity (fig. 2). Ankerite cement is present in amounts from 0 to 2 percent of the volume. Illite cement (3 to 6 percent by volume) occurs as rims of tangentially oriented crystals around detrital grains or as pore-lining cement (fig. 3).

Solid organic matter ("dead oil", possibly pyrobitumen) was observed in many zones in the core (fig. 1), and three of the four samples that were point counted contain it in volumes that range from 1.4 to 8.9 percent. Oil entered the sandstones after the precipitation of quartz overgrowths (fig. 4), when it filled much of the remaining primary porosity. The dead oil appears as an amorphous coating on grains when viewed with the SEM (fig. 5).

Other authigenic minerals in the sandstones are chlorite, feldspar overgrowth, pyrite, barite, and anhydrite. The volume of each of these cements is less than 1 percent.

On the basis of petrographic evidence, illite was the earliest cement to form, followed by quartz overgrowths. The solid organic matter probably

migrated into the sandstones as liquid oil; it entered after quartz cementation, but its relative timing compared with ankerite precipitation has not been determined.

Porosity

The amount of porosity that can be observed in thin section is quite variable in the four samples, as follows:

<u>Depth (ft)</u>	<u>Total Porosity (%)</u>	<u>Primary Porosity (%)</u>	vs	<u>Secondary Porosity (%)</u>	<u>Porosimeter Porosity (%)</u>
8,189.6	0	0		0	5.6
8,213.5	1.4	36		64	11.0
8,246.1	8.3	67		34	12.0
8,386.7	0	0		0	7.3

Of the two samples with no measured thin-section porosity, porosity measured by porosimeter was 5.6% at 8,189.6 ft and 7.3% at 8,386.7 ft. The difference between thin-section and porosimeter porosity is probably caused by microporosity within mud clasts and authigenic clays. This microporosity cannot be seen in thin section but is measured by the porosimeter. Microporosity must be less than .001 mm in diameter, or it would be visible in thin section. This suggests that much of the porosity measured by porosimeter represents extremely small voids.

Two samples, 8,213.5 ft and 8,246.1 ft, had measurable thin-section porosity. The most common pore size is approximately .03 x .015 mm. Pores in the sample from 8,246.1 ft range from .015 x .006 mm to about .18 x .015 mm. Pores in the sample from 8,213.5 ft are somewhat smaller, ranging from .015 x .006 mm to .11 x .02 mm. Secondary porosity is common in both samples; some of the secondary pores contain remnants of a leached framework grain. The

sample from 8,386.7 ft had no measurable porosity because of the presence of 8.9 volume percent dead oil.

REFERENCES

Weimer, R. J., Howard, J. D., and Lindsay, D. R., 1982, Tidal flats and associated tidal channels, in P. A. Scholle and Darwin Spearing, eds., Sandstone depositional environments: Tulsa, American Association of Petroleum Geologists, p. 191-245.

FIGURE CAPTION

Figure 1. Descriptive log of core of the Travis Peak from the ARCO #1 B. F. Phillips well, Smith County, Texas. Core depths are 8,188 to 8,270 ft and 8,367 to 8,395 ft.

EXPLANATION OF SYMBOLS

CONTACT

Gradational G
Upward fining

Planar

Erosive E

Upward
coarsening

Slightly
irregular

ROCK TYPE (%)

Mudstone

Siltstone and sandy
siltstone (— · — · —)

Sandstone

Mud clast and mud flake
(~ ~ ~) conglomerate

Interbedded sandstone (· · · · ·),
siltstone (— · — · —), and

Mudstone

Coal

Porosity

ACCESSORIES

Vertical and horizontal burrows

Organic fragments

Rootlets

Shells

Mica flakes

Pyrite

Callianassa burrows

TEXTURE

Sorting

vp-s Very poor

p-s Poor

m-s Moderately well

w-s Well

Rounding

a Angular

s-a Subangular

s-r Subrounded

r Rounded

STRUCTURES

Trough crossbedding

Planar crossbedding

Crossbeds with oversteepened foresets

Indistinct cross-stratification

Gently inclined lamination = GI

Gently inclined lamination separated by
low-angle discordances

Horizontal lamination

Ripple trough lamination

Planar ripple lamination

Climbing-ripple lamination

Heavily bioturbated sandstone

"Massive" sandstone = M

Contorted bedding

Graded bedding

INDURATION

WI Well indurated

I Indurated

IF Indurated but friable

IS Indurated but shaly

RELATIVE CALCITE CONTENT

1 Slight effervescence

3 Moderate effervescence

5 Strong effervescence

10 Very strong effervescence

COLOR

Abbreviations from Rock-
Color Chart, Geological
Society of America

Abbreviations from Rock-Color Chart

N8	Very light gray
N7	Light gray
N6	Medium light gray
N5	Medium gray
N4	Medium dark gray
N3	Dark gray
5R 4/2	Grayish red

FIGURE 2.

SEM photograph of quartz overgrowths (Q) and authigenic clay (C), probably illite, covering detrital sand grains. Depth is 8,386.8 ft. Bar length is 10 μ m; magnification is 1500x.

FIGURE 3.

SEM photograph of abundant authigenic illite (I) lining a pore. Depth is 8,386.8 ft. Bar length is 10 μ m; magnification is 1500x.

FIGURE 4.

Photomicrograph of "dead oil" (dark areas) in primary porosity at a depth of 8,386.7 ft. Oil entered the pores after precipitation of quartz overgrowth. Long dimension of photo = 0.89 mm; plane light.

FIGURE 5.

SEM photograph of "dead oil" (O) forming an amorphous coating on a detrital grain. Depth is 8,386.8 ft. Bar length is 10 μ m; magnification is 1500x.

