HYDROCARBON ACCUMULATIONS IN THE "D" SAND ADAMS AND ARAPAHOE COUNTIES, COLORADO

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ABSTRACT

The Lower Cretaceous "D" sand in western Adams and Arapahoe Counties, Colorado, contains significant hydrocarbon reserves in stratigraphically trapped reservoirs. Reservoirs are developed in marine bar-type sandstones and in deltaic distributary channel sandstones. Trapping conditions include classical stratigraphic traps consisting of up-dip pinchout of sandstone, and more complex traps such as interchannel point bar porosity-permeability pinchout traps. Recognition of the environment of deposition of individual sand bodies combined with a practical mapping technique utilizing log shape/structure maps should lead to more discoveries in this area.

INTRODUCTION

This paper reviews oil and gas accumulations in the "D" sand (Lower Cretaceous) in the Adams and Arapahoe County area in the Colorado portion of the Denver basin (Fig. 1). Emphasis is on accumulations discovered since 1969. Since 1969, rejuvenation of drilling activity in this portion of the Denver basin has resulted in several new field discoveries and extensions of several old fields.

Traps in the "D" sand in this area are stratigraphic and consist of marine bar sands that pinch out up-dip into impermeable sands or marine shales, channels crossing very low relief structural noses, and channels with complex point bar sequences which allow interchannel trapping without benefit of structure (Martin, 1965, p. 1922-1923). Hydrocarbons may have been generated in adjacent source rock shales and did not require long migration routes to fill available "D" sand traps.

"D" SAND STRATIGRAPHY

The "D" sand in western Adams and Arapahoe Counties, Colorado, can generally be divided into two zones, an upper "D_1" unit and a lower "D_2" unit (Fig. 2).

The "D_1" sand is considered to be a marine sand, probably a transgressive sandstone representing the earliest phase of the Graneros transgression. The contact between the "D_1" sand and the overlying Graneros Shale is conformable throughout the basin. The "D_1" sand is characterized by bar-type sand developments as recognized by mechanical log shape and physical characteristics such as an upward increase in grain size, greater porosity near the top (Fig. 3), and, where the "D_2" is not developed, a gradational lower contact from shale to silt to sand. "D_1" sand bars, where well developed, have moderate to good porosity (10 to 18%) and moderate to good permeability (50 to 500 md). Sands are generally well sorted and are subangular to well rounded. Regional mapping of the "D_1" sand in Washington, Weld, Adams, Arapahoe and Elbert Counties, Colorado, indicates the bars are oriented northwest-southeast to north-south. A length-to-width ratio of 2.5 to 1 has been observed.

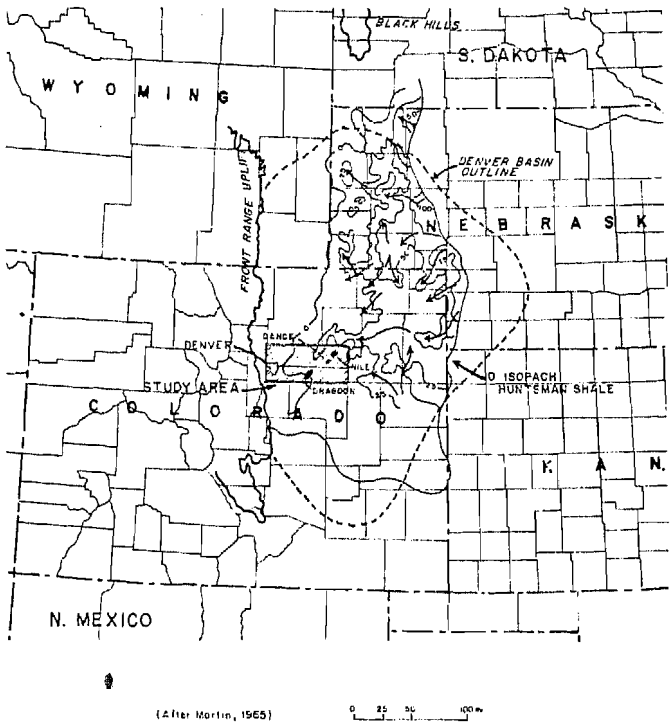

Fig. 1—Index map of the Denver basin with "D" Sandstone isolith.

The "D_2" sand is a more complex unit than the overlying "D_1" sand. Representing a more regressive phase of deposition, it is characterized by a suite of depositional environments ranging from distributary channels to spillover bars to marine bars. All combinations may occur. The same log and physical parameters used to identify "D_1" bars can be used to identify the "D_2" bars. "D_2" channels have classical log shapes and physical criteria, i.e., downward increase in grain size, greater porosity near the base, and unconformable cut-and-fill basal contacts (Fig. 4). The channel sands exhibit poorer sorting and rounding

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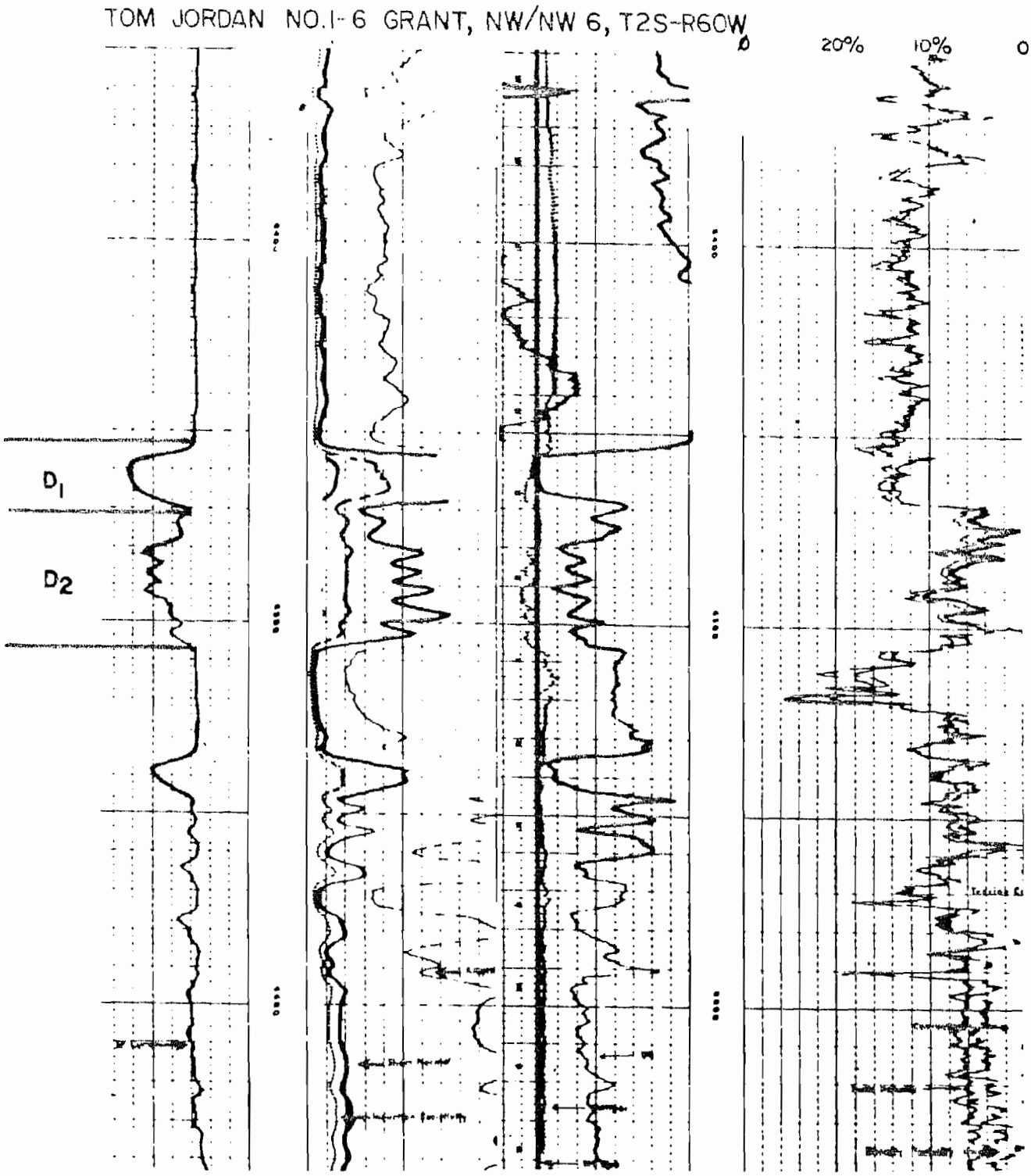

Fig. 2—Log suite from Dance, South field (T2S-R60W, Adams Co.) showing "D_1" and "D_2" zones.

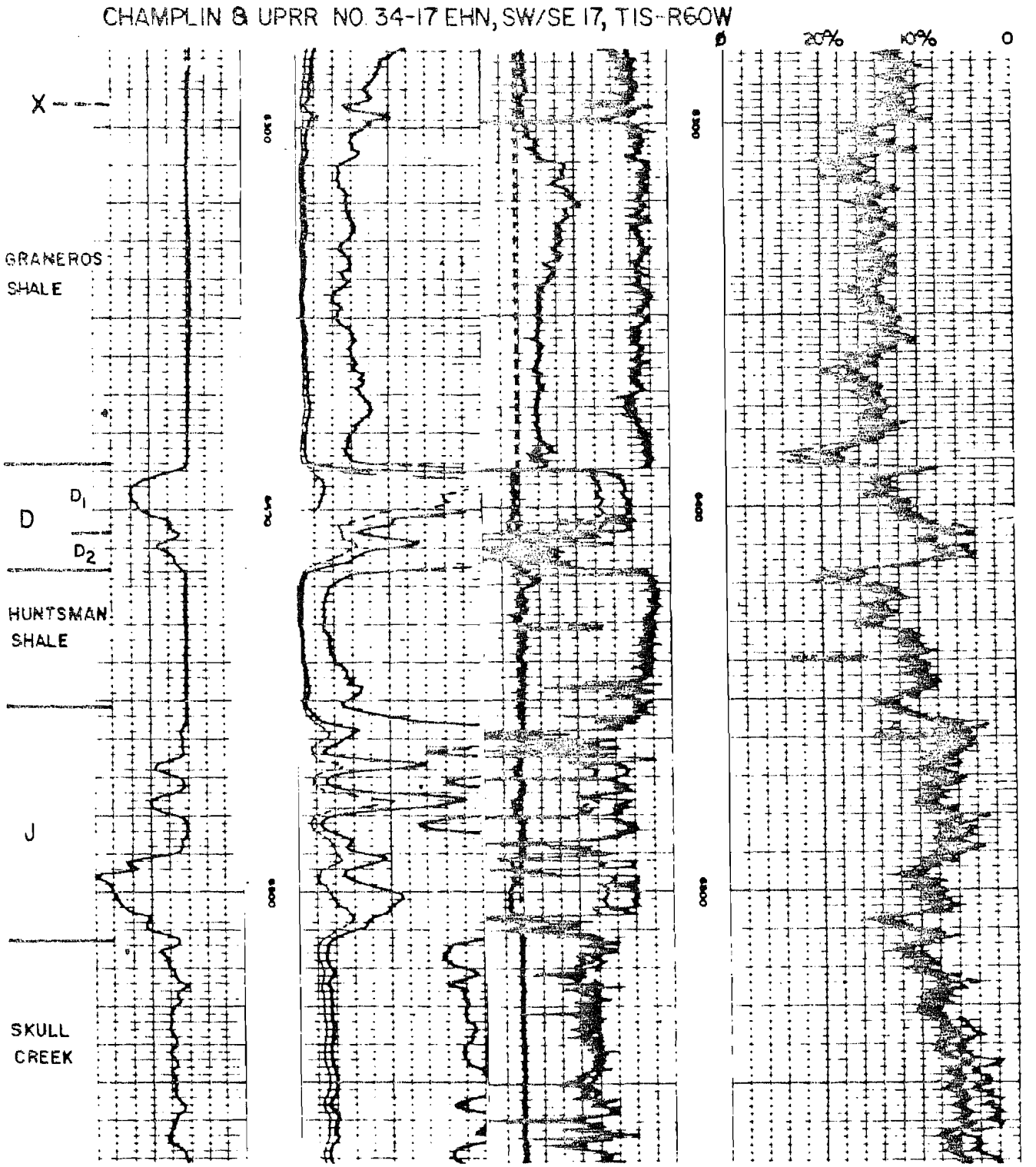

Fig. 3—Log suite from Nile field (T1S, R60W, Adams Co.) showing typical "D_1" bar sand development. Note SP and Density/Porosity profile.

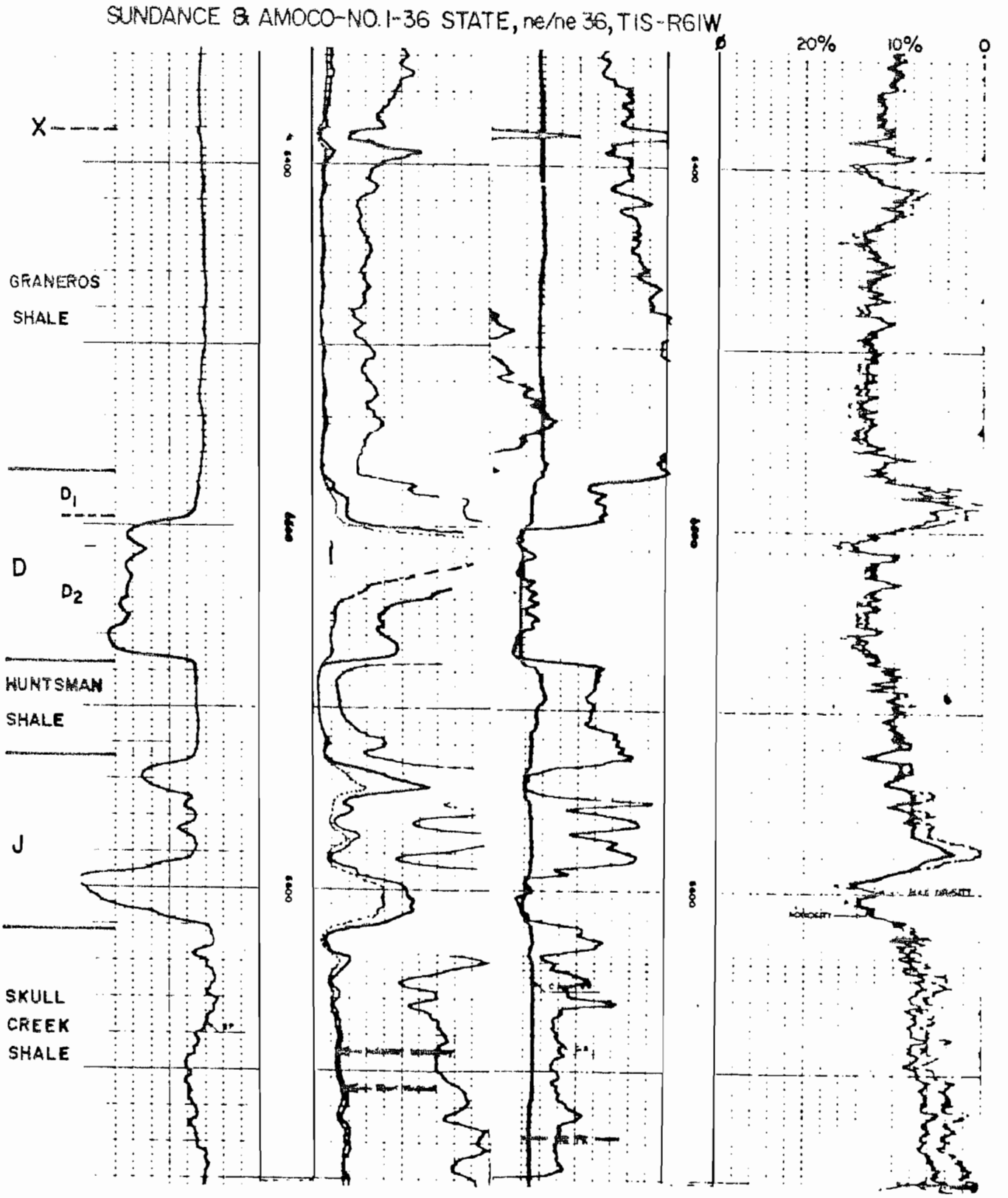

Fig. 4—Log suite from Dance field (T1S, R61W, Adams Co.) showing well developed "D_2" channel. Note SP log shape and cut-out of Huntsman Shale.

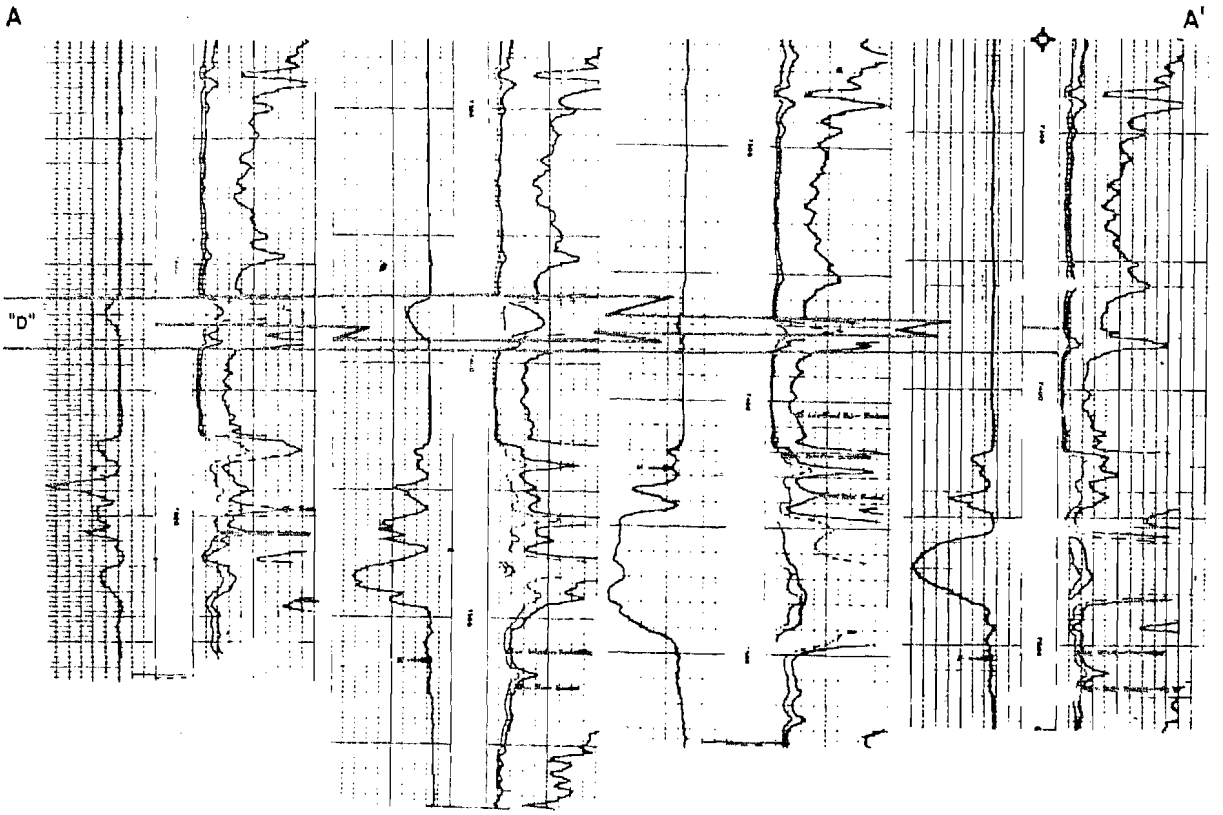

Fig. 5—Electric Log cross section A-A' in Dragoon field (Arapahoe Co.) showing pinchout of "D_1" bar sand, forming trap.

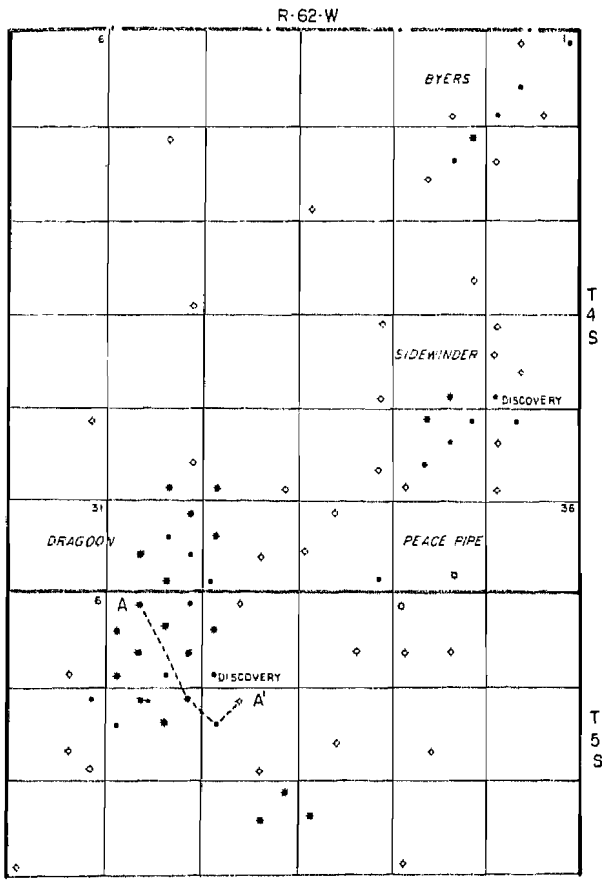

Fig. 6—Dragoon field.

than the bar sands and tend to be dirtier with both primary and secondary clay making up a significant portion of the rock. Field studies (Busy Bee, Big Bend, Dance, Dance South, and Bennet fields) and sub-regional mapping in Adams and Arapahoe Counties indicate an east-west to northwest-southeast orientation of the "D_2" distributary channels.

TRAPPING MECHANISMS

The oil and gas accumulations, within the study area, in both "D_1" and "D_2" sand units are trapped stratigraphically. Classical up-dip pinchout of the sand body to a zero sand edge or reduction of porosity and permeability in the thin beds up-dip provide the most common traps for the bar accumulations (Figs. 5 & 6). Examples of this type of trap are Dragoon field (T4&5S, R62W, Arapahoe County) and Nile field (T1S, R60W, Adams County).

Although structural noses may play an important role in trapping hydrocarbons in the channel sand reservoirs, interchannel point bar accumulations may be more common. Interchannel point bar accumulations are recognized primarily by obviously non-correlative fluid-physics relationships within apparently correlative sandstone units trending continuously up structural dip. Good examples of interchannel trapping in point bar sequences are recognized in the Busy Bee and Big Bend fields (T3S, R60W, Adams County), and in Dance South field (T1&2S, R60&61W, Adams County).

SOURCE ROCKS

"D" sand reservoirs in this area are underlain by the Huntsman Shale and overlain by the Graneros Shale. Both units have been recognized as organically rich shales capable of generating hydrocarbons when subjected to a sufficient temperature history. Recent work by Clayton and Swetland (1977) suggests that much of the western portions of Adams and Arapahoe Counties may have a sufficient temperature history to have generated hydrocarbons. Therefore, the oil and gas in this area may have been generated essentially in situ. Certainly the source rock shales in the deeper portions of the Denver basin to the west and southwest have generated hydrocarbons, and only a short lateral migration would have been required to fill available traps within the study area.

RESERVES

Hydrocarbon reserves in "D" sand reservoirs in the study area range from moderate to excellent. An average well in Dragoon field, a bar sand accumulation, is expected to produce approximately 80,000 bbl of oil and 150 MMCF of gas on 80-acre spacing (J.D. Armstrong, 1978, personal communication). Nile field, also a bar sand has produced in excess of 2,100,000 bbl from 10 wells on 80-acre spacing (Petroleum Information, 1978). Oil wells in the "bar" sand traps are generally very gassy and commercial volumes of associated gas are usually recovered from these wells.

EXPLORATION TECHNIQUES

The most important technique utilized in exploring for "D" sand accumulations in western Adams and Arapahoe Counties is the recognition of the environment of deposition of the "D" sand in a particular well bore. Recognition of a "D_1" bar sand, for instance, should cause the explorationist to look for sand bodies with a northwest-southeast or north-south orientation pinching out up-dip to the east or northeast. Application of the width-to-length principle should influence his lease buying outline and well location.

Recognition of a "D_2" channel sand should lead the explorationist toward a wider area of interest in an attempt to map the orientation of the channel. Within the study area, "D_2" channels trend east-west or northwest-southeast. Should an east-west (directly up-dip) trending channel be recognized, the assumption must be made or evidence must exist that point bar sequences (separate reservoirs) which can cause interchannel trapping are present. If a northwest-southeast trending (sub-parallel to strike) channel is mapped, a structure map becomes important. A channel crossing a structural nose alleviates the need for interchannel trapping conditions.

The most useful map to assist stratigraphic, environment of deposition, and structural interpretation is an annotated log-shape (SP-Resistivity) map with structural datums. This type of map, on a sufficiently large scale, accomodates both structural contouring and sand body interpretation without the necessity of repeated referral to logs.

SUMMARY

The "D" sand in western Adams and Arapahoe Counties, Colorado contains significant hydrocarbon reserves in stratigraphically trapped reservoirs. Reservoirs are developed in marine bar-type sandstones and in deltaic distributary channel sandstones. Trapping conditions include classical stratigraphic traps of simple up-dip sand pinchout and more complex traps such as interchannel point bar porosity-permeability pinchout traps.

Recognition of the environment of deposition of individual sand bodies combined with a practical mapping technique utilizing log shape/structure maps should lead to more discoveries within this area. A visual comparison of the drilling density of this area with the depositionally analogous area of "D" sand production in western Nebraska, which is much more densely drilled, should encourage the explorationist to look for additional "D" sand fields.

REFERENCES

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