Title: Analysis of Oil-Bearing Cretaceous Sandstone Hydrocarbon Reservoirs, Exclusive of the Dakota Sandstone, on the Jicarilla Apache Indian Reservation, New Mexico

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Abstract
An additional 450 wells were added to the structural database; there are now 2550 wells in the database with corrected tops on the Juana Lopez, base of the Bridge Creek Limestone, and datum. This completes the structural data base compilation. Fifteen oil and five gas fields from the Mancos-ElVado interval were evaluated with respect to the newly defined sequence stratigraphic model for this interval. The five gas fields are located away from the structural margins of the deep part of the San Juan Basin. All the fields have characteristics of basin-centered gas and can be considered as continuous gas accumulations as recently defined by the U.S. Geological Survey. Oil production occurs in thinly interbedded sandstone and shale or in discrete sandstone bodies. Production is both from transgressive and regressive strata as redefined in this study. Oil production is both stratigraphically and structurally controlled with production occurring along the Chaco slope or in steeply west-dipping rocks along the east margin of the basin. The ElVado Sandstone of subsurface usage is redefined to encompass a narrower interval; it appears to be more time correlative with the Dalton Sandstone. Thus, it was deposited as part of a regressive sequence, in contrast to the underlying rock units which were deposited during transgression.

Executive Summary
This project was designed to provide a solid understanding of the geologic framework, both sedimentologic and structural, of the oil-bearing Cretaceous formations (exclusive of the Dakota Sandstone) on the Jicarilla Apache Indian Reservation. The Tribe is faced with declining oil revenues as fields age and become less productive. In order to maximize secondary and tertiary recovery from these fields and to assist exploration in finding new oil resources on the Reservation, a sound knowledge of the geology of the area is a must. Often geologic information is available for individual leases but this information is not integrated over a larger area (regional basis). This integration is a must in order to understand the nature and geometry of the reservoirs and to predict the movement of fluids (oil, water, and secondary and tertiary recovery fluids) in the reservoirs. This project will characterize the reservoirs, determine their geometry, and assess potential flow boundaries, sedimentologic or structural, and use this information to determine the potential for future oil resources. The project will focus on the Mesaverde Formation, ElVado Sandstone Member of the Mancos Shale, and on the fractured Mancos Shale which are among the principal oil-producing rock units on the Reservation. The goals of the project will be accomplished by a comprehensive surface analysis of the potential reservoirs which will then be integrated with a comprehensive subsurface analysis using geophysical logs and seismic data (where available). These data will allow us to assess oil-migration pathways and assess intervals for by-passed resources. Use of engineering data coupled with reservoir sedimentology, geometry, and structural setting will allow us to make recommendations for more efficient future recovery and exploration efforts. We will work cooperatively with the Tribal Energy Department and their energy exploration group JAECO (Jicarilla Apache Energy Company) and will provide all data obtained in digital form in a format useful to the Tribe.

Discussion

Efforts continued on the structure database. An additional 450 wells were added to the database; there are now 2550 wells in the database with corrected tops on the Juana Lopez, base of the Bridge Creek Limestone, and datum. This completes the structural database.

Oil (and to a lesser extent gas) fields in the Mancos-ElVado interval (driller's Gallup interval in the fields listed in table 1) were evaluated with respect to the sequence stratigraphic model that has been constructed for the Mancos-ElVado interval. Fifteen oil and six gas fields in this interval on and adjacent to the Reservation were examined. The spatial distribution of these fields are shown on figures 1- 2. The field name, location, type of hydrocarbon production, type of drive, and field api gravity is listed in table1. Data for the individual fields were taken from Fassett (1978; 1983).

Gas production from the Mancos-ElVado interval from the five fields (table 1) evaluated is from lenticular sandstone (BS Mesa Gallup field and Wildhorse) or from thinly interbedded sandstone and shale (Campo Gallup, Chozo Mesa Gallup, and Lindrith Gallup). The lenticular sandstones occur in the lower part of the Mancos (below the ElVado Sandstone, as redefined in this study) and about 50 feet above the top of the Juana Lopez. These sandstones were deposited during the early stages of transgression above the unconformity that separates rocks of Carlile age from those of Niobrara age. These sandstone bodies have limited regional distribution, but are areally more extensive in a northwest-southeast direction than in a northeast-southwest direction. These sandstone bodies are in a similar position relative to the unconformity as the oil-producing Tocito sandstone lentils farther to the west. Production is neither stratigraphically nor structurally controlled, per se, although natural fracturing enhances recoverability. The gas fields lack a water drive; no water production has been reported (see discussions in Fassett, 1978). The sandstones in many Cretaceous rock units in this part of the San Juan Basin (away from the structural east margin) are gas saturated. This is a characteristic of basin-centered gas accumulations. This type of accumulation fits the "continuous-type" gas accumulation category that was first defined and used in the 1995 USGS national assessment (Schmoker, 1995). Continuous-type accumulations are considered to be large, low grade, not conventionally reservoired (i.e. are not bounded by a downdip water contact) accumulations that crosscut lithologic boundaries. They might require different development strategies from those used in conventionally reservoired gas accumulations (Schmoker, 1995). Where they occur, continuous-type gas accumulations are thought to be everywhere gas-charged in the gas-bearing interval, although the gas may not always be economic. Other characteristics of continuous-type gas accumulations include an updip water contact (i.e. the gas accumulation is located downdip from water-saturated rocks), a lack of importance of conventional traps and seals, a close association of reservoir with source rock, and low reservoir permeability in facies that have large areal extent. Reservoirs include sandstone, siltstone, shale, chalk, and coal. Although characterized by large in-place hydrocarbon volumes, production has low recovery factors, and heterogeneous production rates and ultimate recoveries from the wells (Schmoker, 1995).

Field Name	Location	Type of Hydrocarbon Production	Type of Drive	Field API Gravity
BS Mesa Gallup	T. 26-27 N., R. 4 W.	Gas/minor oil	Gas expansion	65^o
Campo Gallup	T. 29-30 N., R. 3-4 W.	Gas/condensate	Gas expansion	40^o
Chozo Mesa Gallup	T. 28, R. 3-4 W.	Gas	Gas expansion	?
Lindrith Gallup	T. 24 N., R. 2 W.	Gas/minor oil	Solution gas	38^o-40^o
Wildhorse Gallup	T. 26 N., R. 3-4 W.	Gas/condensate	Gas expansion	65^o
Blanco Tocito, South	T. 26 N., R. 5-6 W.	Oil	Solution gas	43^o-44^o
Boulder Mancos	T. 28 N., R. 1 W.	Oil	Gravity drainage/solution gas	37^o
Counselors Gallup	T. 23 N., R. 6 W.	Oil	Solution gas	40^o-45^o
Devil's Fork Gallup	T. 24 N., R. 6-7 W.	Oil	Dissolved gas/gas expansion	
Duffers Point Gallup	T. 24-25 N., R. 8 W.	Oil	Solution gas	40^o
Escrito Gallup	T. 24 N., R. 6-8 W.	Oil	Solution gas	40^o
Gavilan Gallup	T. 25 N., R. 2 W.	Oil	Solution gas/fluid expansion	41.2^o
Lindrith Gallup West	T. 24-25 N., R. 4 W.	Oil	Solution gas/fluid expansion	43.7^o
Lybrook Gallup	T. 23-24 N., R. 6-7 W.	Oil	Solution gas	40^o
Otero Gallup	T. 24-25 N., R. 4-6 W.	Oil	Gas	40.7^o
Puerto Chiquito East	T. 25-27 N., R. 1 E.	Oil	Gravity drainage/solution gas	34^o
Puerto Chiquito West	T. 25-27, R. 1 E, 1 W.	Oil	Gravity drainage	39^o-40^o
Regina Gallup	T. 24 N., R. 1 W.	Oil	Gas expansion	46^o
San Ysidro Mancos	T. 21 N., R. 3 W.	Oil	Solution gas/gravity drainage	38^o
Tapicitos Gallup	T. 26 N., R. 4-6 W.	Oil	Gas expansion	43^o-44^o

Oil production from the Mancos-ElVado interval from the fifteen fields is from thinly interbedded sandstone and shale and more laterally continuous sandstone. These rocks, termed Gallup by drillers, have no relation to the type Gallup Sandstone, which lies stratigraphically below the producing interval. Oil production is both stratigraphically and structurally controlled; all the fields are located along the structural break (Chaco slope) between the deep part of the San Juan Basin to the north and the shallow part of the basin to the south or in steeply west-dipping rocks along the east margin of the basin. Most of the oil fields produce associated gas which forms caps in the structurally updip parts of the fields. This accounts for the fact that some parts of a field are totally gas productive while other parts produce oil or oil with some quantity of gas. Gas compositions (as reported in Fassett, 1978; 1983) indicate a thermogenic origin, i.e. have several percent of ethane, propane, and higher hydrocarbons. Oil production changes stratigraphic position within the Mancos-ElVado interval, depending on location of the field with respect to sedimentary facies and structural setting. Production is from both transgressive and regressive strata, as newly defined in this study. The ElVado Sandstone, as defined by Fassett and Jentgen, 1978, p. 236, has been redefined in this study to be a much more restricted unit. This restriction is based on the original definition of the El Vado (Landis and Dane, 1967) coupled with paleontological data, which suggest that the ElVado is time equivalent to at least the lower part of the Dalton Sandstone. A more complete discussion of the various oil fields within a sequence stratigraphic context will be found in the final Mancos-ElVado report.

References

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Figure 1. Boundaries for the BS Mesa Gallup, Wildhorse Gallup gas fields, and Devils Fork Gallup oil field, New Mexico.

Figure 2. Boundaries for the Campo Gallup, Choza Mesa Gallup, and Lindrith gas fields and the Counselors Gallup, Gavilan Gallup, Regina Gallup, and San Ysidro Gallup oil fields, New Mexico.

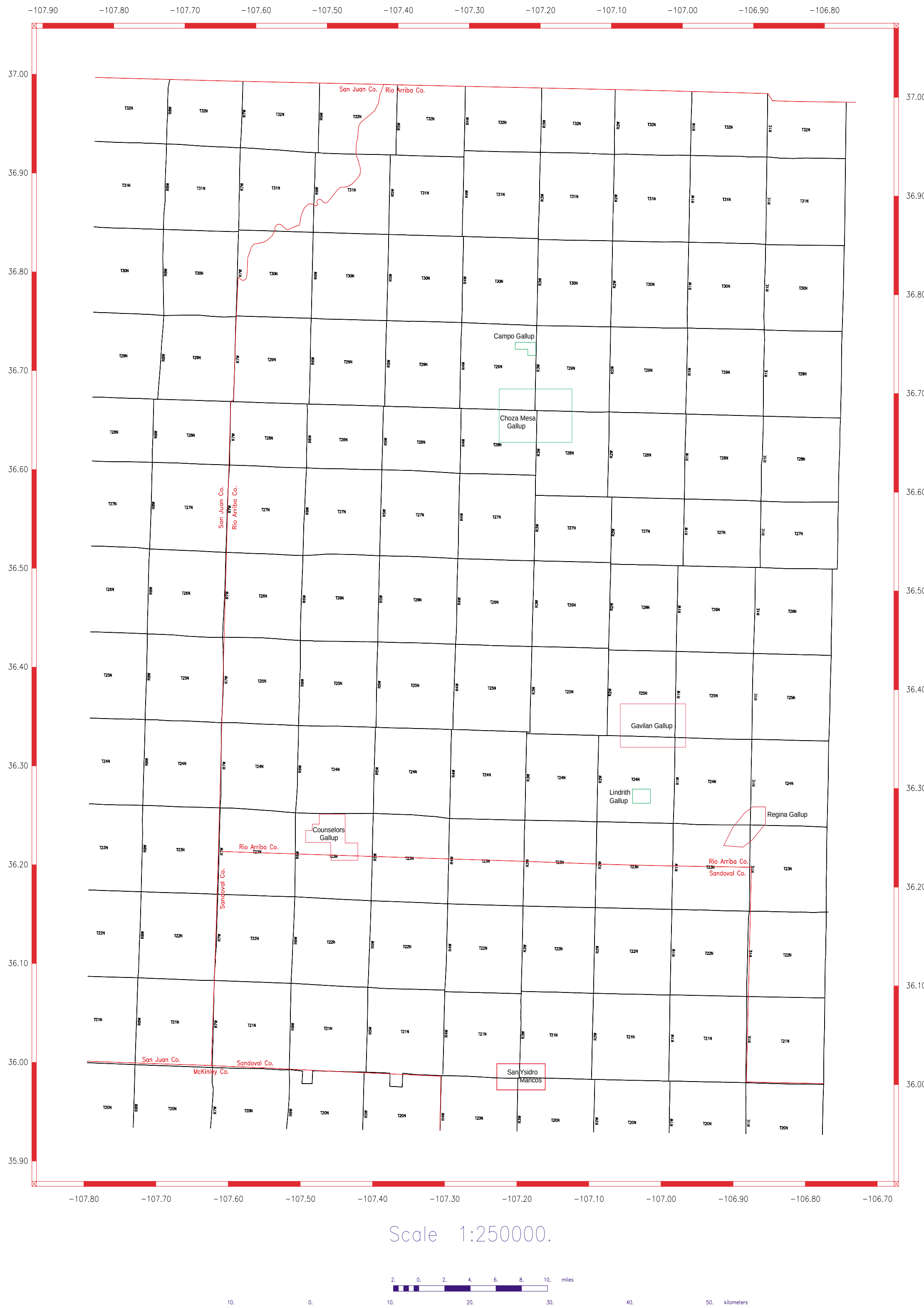

Figure 3. Boundaries for the Blanco Tocito, South, Boulder Mancos, Duffers Point Gallup Dakota, EscritoGallup, Lindrith Gallup Dakota West, Lybrook Gallup, Otero Gallup, PuertoChiquito Mancos East, PuertoChiquito Mancos West, and Tapicitos Gallup oil Fields.