CRETACEOUS OIL AND GAS HORIZONS OF THE SAN JUAN BASIN, COLORADO AND NEW MEXICO

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DAKOTA FORMATION

The Dakota formation of Upper Cretaceous age is widespread throughout the San Juan Basin of Colorado and New Mexico. Within the prospective area the Dakota measures about 125 miles by 120 miles and covers approximately 15,000 square miles from T-14N in New Mexico to T-35N in Colorado. In an east-west direction this area extends from R-1W to R-20W (see map) and contains many oil and gas possibilities.

The Dakota formation over most of the prospective area has a low rate of dip ranging from 30 to 50 feet per mile and only in the area where the great Hogback circles the northern part of the San Juan Basin is the Dakota of steep dip. The Hogback extends from south of the Hogback oil field in New Mexico northeastward into Colorado and then trends southeastward back into New Mexico in the vicinity of R-1E.

The Dakota sandstone is easily recognized from well cuttings and well logs, and it is also easily recognized on the surface outcrops, where it forms reddish-brown or tan ledges in abrupt contrast to the overlying valley-forming shales of the Mancos formation. Generally, the underlying Morrison formation of softer sand and shales forms slopes which distinguishes it from the Dakota even at a distance. Close inspection of the Dakota formation shows that there is a great deal of variation within the formation itself. It is this variation that makes the study of the Dakota a complex problem and is an important factor in the determination of the occurrence of stratigraphic traps containing oil and gas.

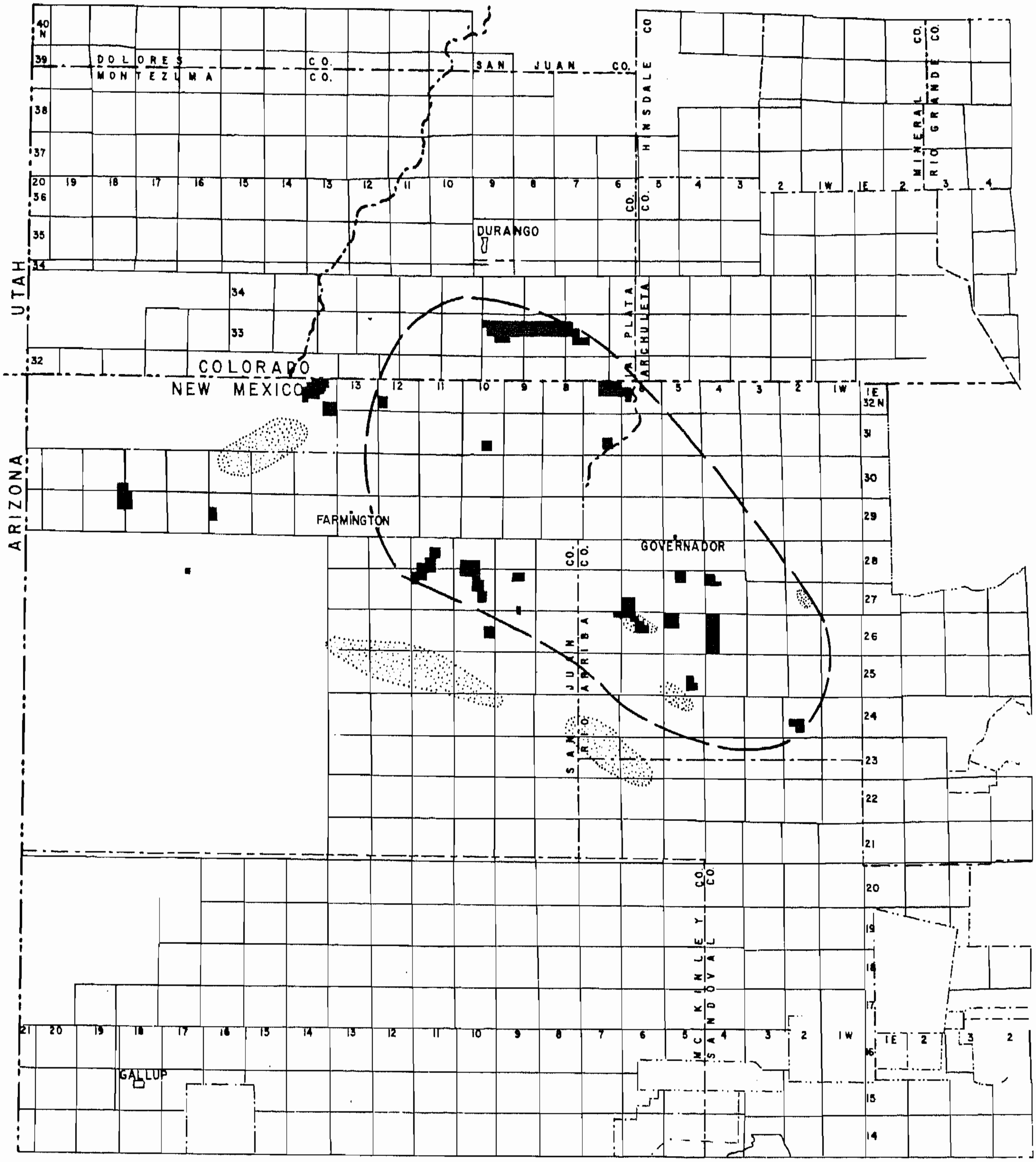
Gregory's original description of the Dakota, which is quoted from "Cretaceous Stratigraphy of the San Juan Basin," by Caswell Silver, in the New Mexico Geological Society Guidebook — Second Field Conference, 1951 — pages 105 and 108 respectively, is repeated below.

"The Dakota sandstone . . . is highly variable in structure, texture, and composition. It is characterized more by a persistent combination of features than by the persistence of any given bed. The base is commonly but by no means universally marked by conglomerate and the top is in many places a coarse brown or gray sandstone bed but may be a group of interbedded sandstones and shales or wholly sandy shale of yellow or gray tones. Coal lenses occur prevailingly in the middle of the Dakota but are found in all positions from top to bottom. The formation is everywhere lenticular; lenses and wedges of sandstone, of conglomerate, of shale, and of coal tens of feet or a few inches thick overlap, appear, and disappear along the strike and vertically in a most capricious manner."

It is this lenticularity of the sands within the Dakota formation that is thought to be responsible for the trapping of large reserves of gas and oil within the Dakota horizon.

Although Dakota production was first established in the area in 1921, stratigraphic trap accumulations have only recently been found. Prior to 1947 when oil and gas production was found in the Kutz Canyon area, all Dakota gas and oil production was found on anticlines and domes. Since 1950 stratigraphic gas and oil production has become increasingly important.

The drilling methods used on wells being drilled to the Dakota formation for gas production have been rapidly undergoing a change. The older Dakota wildcat wells within the San Juan Basin were drilled by conventional methods using mud as a drilling fluid. At present, Dakota wells are being drilled to depths of 8,000 feet by the use of gas rather than mud as a drilling medium. The method is to drill with mud through the Pictured Cliffs sandstone and to then set 7⅝" casing at depths of from 3,000 feet to 4,000 feet on the top of the Lewis shale. The well is converted to gas drilling at this point and the entire section through the Lewis shale, the Mesaverde, the Mancos shale, and the upper two-thirds of the Dakota is gas drilled. This process, in addition to speeding the drilling of the well to total depth, results in the saving of mud costs and enables gauges to be taken of the natural gas flows encountered while drilling. An example of the new drilling method can be found in the No. 4-6 well drilled by Northwest Production Corporation in section 6, T-26N, R-4W. After drilling had progressed to 4120 feet using mud as a drilling fluid, 7⅝" casing was set, and the well was converted to gas drilling and drilled to a depth of 8375 feet. A 5½" liner was then set from 4027 feet to total depth. After selectively perforating the net pay sands of the Dakota formation followed by high velocity fracture treatments, the completion gauge of the well from this formation was 4,448 Mcf of gas. A similar process of selectivity perforating and fracturing was also carried out in the overlying Mesaverde. The completion gauge in the Mesaverde was 2,256 Mcf. The actual extent of the Dakota gas reserves in the San Juan Basin is not known, but there are indications from the many stratigraphic discoveries that the reserves will cover a large area.



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SAN JUAN BASIN

NORTHWESTERN NEW MEXICO AND SOUTHWESTERN COLORADO

Mesaverde - Pictured Cliffs gas area
Gallup oil area
Dakota oil and gas area

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OIL PRODUCING SANDSTONES OF THE MANCOS SHALE

Oil producing sandstones of the Mancos formation are developed in lenses which extend over wide areas in the San Juan Basin at a distance of from 400 to 900 feet above the Dakota formation. Within this interval various sandstone bodies have been found and are termed in ascending order as the Sanostee, Tocito, Gallup and Hospah sandstones. The first important discovery in these sands was made in the Tocito lens in T-26N, R-6W on July 26, 1951 when oil was discovered at a depth of 6600 feet. No structure controlling the oil accumulation is present, but subsequent drilling showed that the Tocito sand lens pinched out to the southwest on the high side of the field. This field has now produced in excess of 3 million barrels of oil.

A second major discovery was made in the Gallup formation in the Bisti field lying on the southwest side of the San Juan Basin. This field is now approximately 30 miles long and averages from 2 to 4 miles in width. Well potentials vary from 40 to over 900 barrels of oil per day. The discovery well, the No. 1 Kelly State located in section 16, T-25N, R-12W, was drilled by El Paso Natural Gas Company to a depth of 5,150 feet and completed for 646 barrels of oil per day from the Gallup formation on August 18, 1955. Studies of the stratigraphic trap accumulation of oil in the Bisti-Gallup field have shown that the Gallup sandstones were deposited in a northwest-southeast trend with thinning of individual producing sands along trend. A second belt of Gallup sand production is now being established directly to the northeast of the present Bisti-Gallup trend. It appears that this second belt of gas and oil entrapment is in a second stratigraphic trap which is separated from the main Bisti trend by a zone of siltstones which contain low porosities and low permeabilities. The occurrence of this second belt of production from sands of the Gallup formation strongly indicates that additional parallel belts of oil and gas production will be found adjacent to the now known producing trends. This has already been evidenced by the Standard Oil Company of Texas discovery of Gallup oil production in section 27, T-25N, R-7W where a well was completed for a flowing gauge of 70 barrels of oil per day. A third indication of an additional new productive belt has been made by Skelly Oil Company in their No. B-2 well located in section 31, T-25N, R-5W. This well was completed as a pumper for 100 barrels of 33° gravity oil per day from the Hospah(?) formation at a depth of 5,980 feet to 6,060 feet.

A third major discovery has been found in the Verde-Gallup field in the western part of the San Juan Basin. The Verde-Gallup field extends in a northeast-southwest direction to trend at right angles to the other known fields. (see map). One of the reasons for this oil-productive trend is probably due to the natural fracturing of the tight sands parallel to the Hogback. A second reason for the northeast trend of the field is thought to be due to the structural control exerted by the South Barker Dome structure on which most of the discoveries to date have been made. The present undefined field limits lie in the northern part of T-30N, R-16W, the central part of T-31N, R-15W and the northwestern part of T-31N, R-14W. (see map). The oil-producing sandstones which are thought to be the Tocito and Tocito sand lenses of the Mancos shale are in general similar to the lithology of the oil-productive sands found elsewhere in the basin. They are characteristically gray to grayish-white sandstones, generally fine-grained, and of low porosity and low permeability. The discovery well in the Verde-Gallup field, the No. 1 Ute, was completed by Claude M. Carroll on October 20, 1955 for 190 barrels of oil per day from 2,335 to 2,400 feet in the Lower Gallup.

In summary, it can be said that the oil-producing sandstones of the Mancos shale have been proven to have a tremendous oil potential in the San Juan Basin as evidenced by the recent discoveries. It is now apparent that these sandstones will produce oil over very wide areas from the favorable porosity belts or stratigraphic traps which in general will trend northwest to southeast.

MESAVERDE

The Blanco Mesaverde gas field is located in the center portion of the San Juan Basin and from northwest to southeast is now approximately 65 miles in length with an average width of 25 miles. The Blanco Mesaverde trend encompasses an area of approximately 1,625 square miles, or 1,040,000 acres, of proved Mesaverde gas-bearing sandstone and has approximately 1200 wells drilled in it. The Mesaverde formation itself is divided into three members. The lower member is the Point Lookout sandstone, the middle member is the Menefee sands and shales, and the upper member is the Cliff House sandstone. It has been found that the sandstones in all three members of the Mesaverde formation are gas productive.

The Mesaverde gas productive sandstones within the stratigraphic trap area of the Blanco Mesaverde field are characteristically of low porosity and low permeability with the average porosity being about 9% and the average permeability being less than one millidarcy. The straitgraphic trap area contains net gas productive sands which average about 200 feet in thickness.

Since 1953 the Blanco Mesaverde gas field has been rapidly extended to its present huge size by the adding of large new areas of reserves as a result of drilling wildcat wells. New completion methods have also helped in the adding of new gas reserves by making all gas-bearing sandstones more available for production. These new completion methods have also resulted in sustained deliverability due to the fact that the well bores are now kept open by the casing which is run through the pay. Running the casing to total depth also makes possible the perforating and controlled fracturing of the productive sandstones.

PICTURED CLIFFS

The Pictured Cliffs formation is one of the oldest known gas-producing formations in the San Juan Basin. The Fulcher-Kutz field was discovered on November 25, 1927. Throughout the years the Pictured Cliffs gas-producing areas have been steadily enlarged and since 1950 development has been rapid. The Pictured Cliffs fields extend in northwest-southeast trending parallel belts following the original depositional trend of the Pictured Cliffs sandstones. These sands were deposited in the Cretaceous seas in a series of large sheetlike bodies of sand which overlap each other and become progressively higher in the section to the northeast in the direction of the present tilt of the basin. Where porosity is developed in the sands "blanket-like" accumulations of gas are trapped in the higher parts of the sands. The net result has been to form a series of large stratigraphic traps, examples of which are the Aztec Pictured Cliffs field, the Fulcher-Kutz Pictured Cliffs field, the South Blanco Pictured Cliffs field, and other fields. (see map).

The Pictured Cliffs sands form the basal unit of the Fruitland-Pictured Cliffs series. These sands are gray to grayish-white, salt and pepper, fine- to medium-grained, well sorted, angular to subrounded and are composed mainly of quartz with some ferro-magnesium minerals, including glauconite, cemented with calcite and bentonite. The base of the Pictured Cliffs formation, which is transitional with the underlying Lewis shale, is taken as the base of the last massive sandstone. Overlying the Pictured Cliffs formation is the Fruitland formation composed of shales, coals and sands. The top of the Pictured Cliffs sandstone is taken at the top of the first massive sandstone, which exhibits the typical Pictured Cliffs type of lithology.

Porosity in the Pictured Cliffs sandstone varies from less than 6% to as high as 20%. The permeability in the less porous sands averages about .5 millidarcy, whereas in the more porous sands there are several millidarcys of permeability. Porosity and permeability variations within the Pictured Cliffs sands are thought to be partly responsible for the stratigraphic trapping of gas. The best porosity seems to occur in belts adjacent to the up-dip wedge-out of the sand bodies. The low porosity and low permeability of the Pictured Cliffs sands are favorable factors for the entrapment of gas over large areas. Where high porosity and permeability are encountered, as on the western side of the present fields, large amounts of formation water are apt to be produced with the gas. In some cases the occurrence of fracture systems in both the porous and non-porous sands is a critical factor in the producibility of a well.

Since the completion of the first Pictured Cliffs discovery in the Fulcher-Kutz field in 1927 the shallow gas horizons of the Pictured Cliffs have become more and more commercially attractive because of increasing market demands, relatively shallow drilling in comparison to other horizons, improved well completions, and more geological information. The recent practice of dually completing with the Mesaverde or Dakota has helped in the development of additional Pictured Cliffs gas productive areas. The area within the outcrop of the Pictured Cliffs formation totals about 6,000 square miles. Of this 6,000 square miles containing the Pictured Cliffs and Fruitland formations, a minimum of 1,200 square miles, or 768,000 acres, contains proven gas reserves at an average well depth of approximately 2,800 feet. Pictured Cliffs well completion methods have changed from the shooting with nitroglycerin to selectively perforating and sand-fracturing the productive sandstones. Good potentials have resulted from the use of these improved completion methods, and it is not unusual to obtain well potentials of from 5,000 Mcfpd to over 30,000 Mcfpd.