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DEVONIAN SYSTEM OF THE BLACK MESA BASIN

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The Devonian system, present throughout the entire Black Mesa basin region, is one of the major potential oil and gas reservoir horizons in the area.

Shows of oil and gas are noted on the north, west, and south sides of the basin. Oil stains in samples have been noted in the No. 1 Navajo-Humble Oil and Refining Company test in Sec. 4, T. 41 N., R. 28 E., Apache County, Arizona. Residual oil in fractures has been recorded in the No. 1 L. M. Lockhart - Babbitt Company, Sec. 21, T. 27 N., R. 9 E., Coconino County, Arizona. Petroliferous odor is notable on the outcrop of the Devonian in the Pine — Peyson area along the Mogollon Rim in Gila County, Arizona. Gas was recovered from drill stem test at the No. 1 C. Reed, Western Natural Gas Company et al., in Sec. 23, T. 34 S., R. 25 E., San Juan County, Utah. Gas and oil was recovered on drill stem test of the No. 1 Bluff unit, Shell Oil Company, Sec. 32, T. 39 S., R. 23 E., San Juan County, Utah. Shows of oil and small initial production in addition to carbon dioxide has been reported from the drilling of the No. 1 R. L. Raplee, Sec. 5, T. 42 S., R. 19 E., San Juan County, Utah.

It becomes quite clear, from these evidences of oil and gas, that the Devonian must be considered a potential reservoir unit anywhere within the basin. Evidence of oil accumulation appears on the north, the west, and the south side of the Black Mesa basin extending from southern Utah, through the western rim of the basin near the Grand Canyon and south to the Mogollon Rim on the south side of the basin. A more detailed examination of the potential of the Devonian system and its stratigraphy should be of critical interest to any operator in this area.

STRATIGRAPHY

Published terminology applicable to the Devonian system in the Black Mesa basin is fraught with similar complications to that of all other systems present in the basin. The development work within the central portion of the basin has required the projection of names from at least five widely separated type sections. Various students of the Devonian project the terminology of their "frame of reference" and region of familiarity into the basin and rename or adjust facies variations to conform with at least five major type localities. Terminology may therefore be projected into the basin in the pattern of spokes of a wheel. Names are drawn southwestward from type sections at Ouray, and the Animas River section, Colorado; from deeper parts of the Paradox basin, Utah; from the Kaibab uplift of Utah and Arizona; from the Grand Canyon section, and from the Mogollon Rim or the Escabrosa Range, Arizona. It is quite apparent that significant facies changes can and do exsist between type localities as much as 400 miles apart. The most reliable integration of Devonian stratigraphy, across the Black Mesa basin, must therefore be developed through detailed studies of samples and cores related to each of the known and well described type sections. Concepts of Devonian paleogeology will undoubtedly be altered materially with each Devonian test within the basin.

TYPE LOCALITY DESCRIPTIONS

Ouray Limestone

The upper Devonian Ouray limestone was first named by W. Cross and A. C. Spencer in 1899 in the U.S.G.S. LaPlata folio, No. 60. Later reports by A. C. Spencer and W. Cross have further restricted the Devonian from the type locality in the vicinity of Ouray at the junction of Canyon Creek with the Uncompahgre River. The type locality was originally described as 100 to 300 feet of massive limestones varying from a single massive layer to 2 or 3 heavy limestone bands separated by greenish crumbling marls. The limestones are usually white but sometimes are stained red or pink, certain strata being somewhat coarsely crystalline. As a general rule the limestone is fine-grained. Devonian fossils have been recovered from the upper section, however, neither the extreme upper or lower layers have yielded fossils. The original author recognized from 0 to 100 feet of Devonian shale below the upper unit and in places described the upper unit as lying on Precambrian. Later reports by Cross (1904) identified the Ouray limestone in the San Juan region as the lithologic unit containing Mississippian fossils in the upper part and Devonian fossils in the lower. Still later, W. S. Burbank (1930) identified the Ouray as chiefly Mississippian in age; the Devonian part being 65 to 70 feet thick and the Mississippian part, 180 to 235 feet thick. The Devonian, as Burbank describes the section, is chiefly gray, buff, or white limestone of medium grain; the Mississippian portion is largely gray or brownish-gray crystalline limestone alternating with beds of limestone breccia containing red shaly seams. The top of the Devonian is drawn by Burbank in the Ouray district at the base of a blue-gray thin-bedded limestone that commonly contains nodules of black chert. An inconspicuous limestone breccia occurs at places in overlying beds. In 1931 E. Kirk restricted the Ouray limestone term to the Devonian part of the Ouray limestone as previously used, the Mississippian part hereafter to be called the Leadville limestone. Kirk made it very clear that the Ouray limestone terminology should not be applied outside of southwestern Colorado.

Elbert Formation

Strata underlying the Ouray limestone and carrying fish remains at the base and near the top were named by W. Cross (1904) as a lithologic, stratigraphic, and faunal unit. In the type locality at Elbert Creek, a western tributary of the Animas River above Rockwood, the Elbert may be described as a crumbling calcareous shale with casts of salt crystals. The most important variation in its lithology is the appearance of dense earthy limestones of conchoidal fracture in the upper part.

At Devon Point the Elbert consists of, in descending order:

Elbert formation:	feet	inches
Red Shale or clay	5	
Sandstone or quartzite containing fish scales	1?	
Calcareous shales and thin limestones, buff or gray, fissile, salt casts	25	
Thin alternate quartzites and dull gray arenaceous limestone and red calcareous shales	8	
Hard, fine-grained gray quartzite	2?	
Red calcareous shale	1-	
Yellow earthy limestone		9
Calcareous and sandy shale, variegated	1-	
Fine-grained yellow-brown quartzite	5	
Sandy shale, red, greenish, mottled	5	
Sandy shale, shaly in part, rich in fish scales and plates	1?	
Red shale, calcareous and sandy, with bone or shell fragments	2	
Total thickness — Devon Point	52	9

Upper Elbert

Later work on the Devonian and the development of a significantly different stratigraphic section in the Paradox basin has led to a renaming and subdivision of the Elbert formation. The confusion of terminology which has ensued is ably discussed by Cooper (1955). Subsurface exploration has required the subdivision of the Elbert into the upper Elbert and the McCracken sandstone member. Knight and Cooper (1955) identified the upper Elbert member as thin-bedded sandy dolomite with partings of gray to green and red shales. The upper unit, unconformably underlying the Ouray limestone, is apparently gradational through a transition zone of arenaceous dolomites to the underlying McCracken sandstone member. The "type locality", for the naming of these local units, is in the Shell Oil Company No. 1 Bluff, Sec. 32, T. 29 S., R. 22 E., San Juan County, Utah.

McCracken Sandstone Member

The predominantly sandstone unit underlying the upper Elbert ranges from fine to medium-grained, is light gray to red in color, and is generally poorly sorted and glauconitic. Thin stringers of sandy dolomites are common within the McCracken. The subdivided Elbert formation is believed by the original authors to coalesce westward into the undifferentiated Elbert formation and is presumed to lie unconformably upon the Aneth formation. The McCracken sandstone member is 112 feet thick at the Shell location and the upper Elbert member is 304 feet thick at this point.

Possible extension of the subdivided Elbert formation into the Black Mesa basin has yet to be determined by additional drilling within Arizona. It appears probable that an embayment of Devonian lithology may extend southwestward from the Paradox basin well into the northeastern quarter of the Black Mesa basin. The presence of organic and fossiliferous shales and limestones combined with a significant sandstone member in the Devonian presents an extremely interesting oil potentiality in the Black Mesa basin.

Aneth Formation

Knight and Cooper (1955) named the Aneth formation for 170 feet of "resinous limestone, dolomite, and shale as logged in the Shell test." The Aneth formation, which is limited to the subsurface, is described by these authors as glauconitic and yielding fish plates and scales which serve to identify the formation as upper Devonian in age. It is extremely variable, as indicated by well sections, and includes dark-brown to black shales, vitreous shales, dolomites, coals, evaporites, limestones, and carbonaceous shales.

Although the Aneth is presumed to be a local subsurface unit limited to the closed basin of the Paradox area, it is possible that further drilling along the southern rim of the Paradox basin and the Paradox embayment into the Black Mesa basin will develop an Aneth formation equivalent within Arizona.

Martin Limestone

Variations in lithology between the Devonian of the northeastern corner of Arizona and the southern rim of the Black Mesa basin suggest that broad facies changes take place across the basin, north and south, and that more appropriate nomenclature for the southern part of the basin will be developed as exploration identifies the Devonian west and south of the Defiance uplift.

The Martin limestone was described by Ransome (1904) at the Mt. Martin type section of the Escabrosa Range, Arizona, where it is a dark gray, hard, compact light to pink limestone 340 feet in thickness. The term, Martin formation, is projected into the Black Mesa basin from the southeast and central Arizona where it is identified in the Mogollon Rim. Several authors apply this terminology to the entire Devonian section of the southern part of the basin.

Temple Butte Limestone

Terminology of the Grand Canyon area brings the term, Temple Butte limestone, into the western Black Mesa basin where it was originally named by Walcott (1889). Briefly described, the Temple Butte limestone in the Grand Canyon is composed of 100 feet of purple to cream limestone and sandstone. The possibility of future correlation of the limestone-sandstone sequence with the subdivided Elbert formation of the Paradox is a problem worthy of considerable study. Temple Butte nomenclature may very well be applied to the western Black Mesa basin since the Grand Canyon may be considered to represent the western rim of that basin.

Interfingering or pinchout relationships of the Elbert-Aneth sequence of the Paradox area, projected southwestward into Arizona, suggests interesting potential oil and gas stratigraphic traps.

Devonian Paleogeography

Recent detailed work on all systems of rocks in the Black Mesa basin (Turner, 1958) suggests a widely different interpretation of Devonian paleogeology as interpreted from isopach mapping. Previous authors have postulated a west-trending prong from the Defiance positive over which no Devonian section is present. Sample studies in the area west of the Defiance positive do not substantiate the need for an extensive positive area. The absence of clastics or other transported debris eroded from such a westward-trending promontory would seem to mitigate against a "high" within the center of the basin. McKee (1951, p. 485) substantiated this premise on the basis of samples and sections available seven years ago. Additional

wells in the area have contributed materially to support this idea.

The present writer's interpretation of the entire Paleozoic sequence develops a highly plausible trough which has been named the Oraibi trough, on the west side of the Defiance uplift. A narrow connection between the Oraibi trough and the Paradox basin in extreme northeastern Arizona has been named Chinle straits. It has been noted that a thick marine Devonian section might be found throughout the Black Mesa basin and have a narrow connection to the Paradox basin. Devonian lithologies of the Paradox basin may be expected to have continuity or at least equivalents within the Oraibi trough. It is postulated, therefore, that with the presence of both source beds and reservoir rocks of Devonian age in the Black Mesa basin, we may expect to find oil and gas potential as indicated in the Paradox basin. A considerable Devonian section of marine and shallow marine sediments is expected to exist in the Oraibi trough trend.

Conclusions

The Devonian is considered to be one of the major and most promising exploratory objectives of the Black Mesa basin. The Devonian is but one of seven potential systems for oil and gas discovery and when combined with the Four Corners Pipeline Company crude oil line and the El Paso Natural Gas Company gas lines that are already present within the basin, the entire area must be considered the newest "powder keg" in exploration.

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