

TRENTON - BLACK RIVER FORMATION DEVELOPMENTS IN MICHIGAN

By

Robert E. Ives
 Petroleum Geologist
 Michigan Geological Survey Division
 Lansing, Michigan

LITHOLOGY

In the subsurface of the lower peninsula the Trenton-Black River is principally a brown to gray crystalline limestone. In southeastern and south central Michigan both limestone and dolomite are present. In extreme western and southwestern Michigan the section is mostly dolomite. The basal member of the Trenton-Black River is a thin transitional unit which consists of gray to green calcareous shale. Locally, there are lenses of dolomite or limestone present. The shale usually is sandy and pyritic. This unit has been correlated with the Glenwood of Wisconsin. It lies unconformably on successively older Ordovician and Cambrian sediments as you progress from west to east across southern Michigan. The basal unit of the Trenton is a small carbonaceous bed which appears fairly uniform throughout southern Michigan. The upper part of the unit may contain some black chert. The entire unit is about 30 feet thick. A black carbonaceous dolomitic shale bed, about 3 feet thick, is present at the base of the unit. The top of the Black River is placed at the base of the black shale. In the general limestone area, the Black River is much finer grained, and not so fossiliferous, as the overlying Trenton. The upper most bed of the Trenton is a 5 to 10 broken crystalline dolomite. The black Utica shale of the Cincinnati group overlies the Trenton throughout the area.

INTRODUCTION

Drilling and lease activity increased significantly in Michigan during the past year. Much of this increase can be attributed to the discovery and current development of a Trenton-Black River Fracture trend in south central Michigan. Good producers, large lost circulation zones, blowouts, and high proration have attracted the attention of the petroleum industry throughout the nation. As of May 1, 1960, there were 178 oil wells located along the trend which were averaging 19,731 barrels of oil per day. The trend is still in an active development stage with some 20 to 30 wells being added each month. Operators are delegating their efforts to drilling inside locations and extending the present trend. Also, an extensive search is being conducted for a similar feature.

GENERAL DISTRIBUTION STRUCTURE, AND LITHOLOGY OF THE TRENTON-BLACK RIVER IN MICHIGAN

Trenton-Black River carbonates of Middle Ordovician age occur throughout the Michigan Basin in the subsurface, Figure 1. They outcrop in the upper peninsula, Canada and adjacent states. In the central basin area they are at an approximate depth of 11,000 feet. Maximum thickness of the unit is about 1,000 feet, and this thickness occurs in the thumb area of eastern Michigan. In the extreme western and southwestern part of the state, the formation is less than 400 feet thick.

Structural contours on the top of the Trenton define the various Cambrian and Pre-Cambrian arches that outline the basin. The Logansport and Chatham sags on the Kankakee and Findlay arches, respectively, were considered as inlets to the basin during different periods of deposition. Where adequate control is available in southeastern Michigan, several prominent structures are indicated on the Trenton. The better known features are the Howell anticline which trends northwest through Wayne, Washtenaw and Livingston counties and the Lucas-Monroe monocline which trends north from Lucas County, Ohio into Monroe County, Michigan. The lesser known Freedom structure in central Washtenaw County parallels the Howell feature. Other structures are also indicated but these are not clearly defined because of the minimum amount of well control.

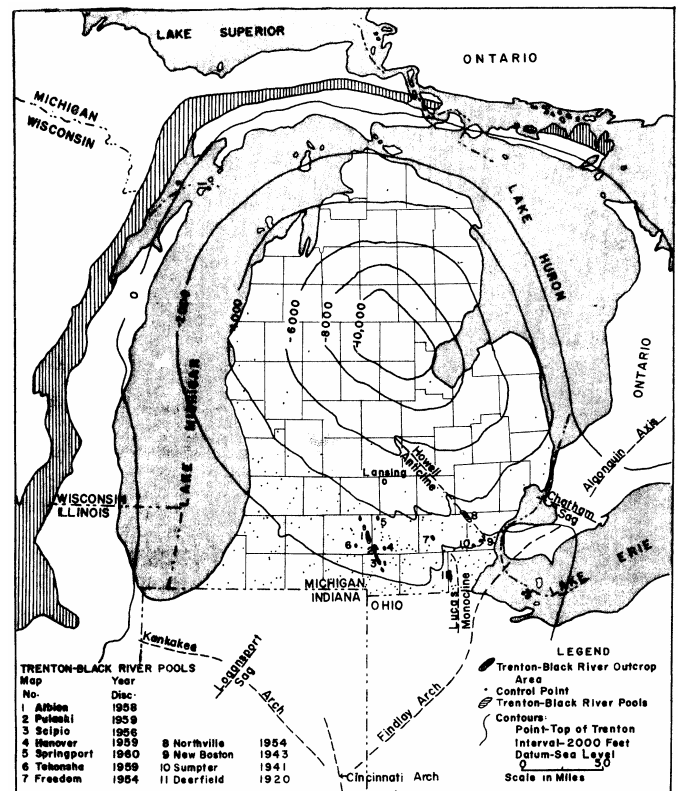


FIGURE 1 - General structure and distribution of the Trenton-Black River sediments in the Michigan Basin.

PREVIOUS TRENTON-BLACK RIVER PRODUCTION

The first Trenton production was from the Deerfield field in Dundee Township, Monroe County at a depth of 2100 feet. The field was discovered in 1920 but not actively developed until 1937. At the end of 1959 the 37 successful wells had produced an accumulative total of 615,402 barrels of oil. Fifteen of the wells are still producing. Initial production ranged from 5 to 500 barrels of oil per day with pays from 10 to 125 feet into the Trenton. Porosity zones were in a dolomitized part of the limestone and located on the western flank of the Deerfield anticline which is associated with the Lucas monocline.

In 1941 and 1942 two small pools were found in Surnpeter and Huron townships of Wayne County. Only three wells were completed in the pools and these were abandoned at an early date. Initial production was about 10 barrels of oil a day per well.

The next Trenton discovery and the most important to that date was the Northville Pool in northeastern, Washtenaw and northwestern Wayne Counties. On January 1, 1954 the Raggart No. 1 LeMaster, Section 1, Salem Township, Washtenaw County was completed flowing natural 200 barrels of oil per hour through a two inch choke from a depth of 4369 feet. The top of the Trenton was logged at 4247 feet. By the end of 1959 there were 32 producers in the pool. The accumulative oil production was 548,479 barrels and 6,620,118 MCF of gas. About 80% of the oil produced has been from the discovery well. The field is lineated northwest-southeast and extends eight miles. It appears to be directly associated with the Howell anticline. Approximately 400 feet of relief is indicated. All the production is very spotty and in a secondary dolomite on the northeast flank of the structure. Pays vary from a few feet into the Trenton to over 500 feet in.

Another small field was discovered in September of 1954. The Sun Oil Company, Haab et al No. 1, Section 8, T. 3 S., R. 4 E., Freedom Township, Washtenaw County encountered gas at a depth of 3915 feet about 140 feet below the top of the Trenton. The first shows of oil were reported at 3962 feet. Initial production after acid was swab and flow 100 barrels of oil and 75 barrels of water per day. Efforts to extend the field failed and operators finally abandoned the well after recovering approximately 7000 barrels of oil. Although the success was short lived the succeeding tests definitely established the presence of another prominent northwest-southeast trending structure.

Production from all the previous noteworthy Trenton fields in southern Michigan has been associated with fractures along the flanks of pronounced structural features which trend north and northwest. The fracturing appears to have occurred in the zones of maximum stress. In the producing areas the limestone has been differentially altered to dolomite. The producing pools are in the nature of porosity and permeability traps.

Comparable as far as the type of trap is concerned, but unlike relative to structure relationship and productivity, is the present Albion-Pulaski-Scipio Trend in south central Michigan.

ALBION-PULASKI-SCIPIO TREND

The Albion-Pulaski-Scipio fracture trend was discovered in September of 1956. Current development is along a narrow trend which begins in Adams Township, Hillsdale County and extends north-northwest through Pulaski Township, Jackson County, the City of Albion and into Lee Township of Calhoun County, Figure 2. At present the trend is about 3/4 of a mile wide and 35 miles long. Production has been found sporadically all along the trend with the main developed areas being in Scipio, Pulaski, and Albion townships of Hillsdale, Jackson, and Calhoun counties, respectively. Eighty-one wells were completed along the trend during 1959 and 2,046,248 barrels of oil were produced.

DEVELOPMENT HISTORY

Only a few widely spaced trenton tests had been drilled in Hillsdale and adjacent counties prior to the present developments. Some of these tests were drilled as a result of gravity surveys and others as hunches or on the little subsurface data available. The actual discovery well for the Scipio pool was a nontechnical location between two gravity highs. The test, Perry No. 1 Houseknecht, NW1/4 SE1/4 NE1/4, Section 10, T. 5S., R. 3W., spudded in May of 1955. The top of the Trenton was penetrated at 3563 feet. The first gas shows were recorded in September of 1956, at a depth of 3650 feet. It was not until January of the following year that oil was encountered at a depth of 3776 feet. The well finally bottomed out at 3900 feet in July and was completed for flowing 10 barrels of oil per hour. The pool did not receive national attention until September of 1957 when the fourth well to be drilled, Ohio Oil Company, Stephens No. 1 blew out of control for 25 hours. A large lost circulation zone was encountered at 3770 feet. Operators tried to shut the well in, but the surface began to crater. Approximately 4,000 barrels of oil and 15,000 MCF of gas were lost before the well was killed with salt water.

In December of 1958 the Albion Pool was discovered about 12 miles north and west of Scipio and aligned with that field. The discovery well, Rosenau No. 1, was completed for an initial production of 200 barrels of oil per day from 4324 feet.

TABLE 1. Status of the Albion-Pulaski and Scipio Pools as of May 1, 1960

Pool	Total Wells	Oil bbls./day	Gas MCF/day	Water bbls./day	Latest Ave. GOR	Well Status				Shut-in Gas Well	
						Pump	Flow	Prod. Wtr.	Making Allow-able		Test-ing
Albion	54	5,360	5,108	230	953	3	46	19	18	2	3
Pulaski	33	3,493	2,976	150	852	2	27	6	16	1	3
Scipio	91	10,868	7,021	1,203	646	11	74	51	52	1	5
Total	178	19,731	15,105	1,583	766	16	147	76	86	4	11

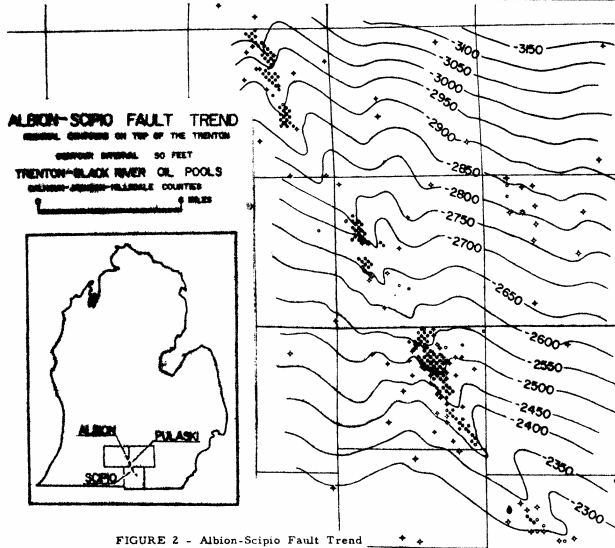


FIGURE 2 - Albion-Scipio Fault Trend

Early in January of 1959 a third discovery, the Pulaski pool was completed on the trend between Albion and Scipio. The Blair No. 1 logged to the top of the Trenton at 3675 feet. The first show of gas was at 3766 feet, and the first oil at 3815 feet. The well bottomed out at 3832 feet with an initial production of flowing 386 barrels of oil per day. Later completions have established limited areas of production along the trend and extended it for approximately 35 miles north-northwest and south-southeast.

Structure and Pay Conditions: The Albion-Pulaski-Scipio trend is located on the south flank of the Michigan basin with the various formations dipping north and northeasterly about 50 feet per mile. Detailed structure contours on the Trenton indicate a shallow depression which plunges in a northwesterly direction about 50 feet per mile. Contours on the Clinton definitely reflect the same flexure. Other younger formations show a slight indication of the structure, Figure 4. However, the low vertical relief, 30 feet, makes it difficult to ascertain their relationship. Differential fracturing and subsequent dolomitization has occurred along the depressed trend. Production has been found throughout the Trenton-Black River section. Pays are irregular depending on the degree of fracturing and solution activity. They consist of vugular zones lined with white, crystalline dolomite tightly interconnected with fractures. Average oil pay thickness is about 60 feet. The overall porosity is about 5% and the average permeability between three and four millidarcys. However, this varies greatly with the vugular

sections. Some of the fractured and brecciated zones have been completely resealed. Reservoir energy is furnished principally by a large gas cap and gas solution with indications of a limited bottom hole water drive. The utilization of this energy will have a direct effect on the ultimate recovery of oil from the pools.

Stratigraphic Chart of Formations Encountered in the Scipio, Pulaski and Albion Fields

RECENT PLEISTOCENE	PRINCIPAL LITHOLOGY	VARIABLE OR AVERAGE THICKNESS	POROSITY, PAYS, AND POTENTIAL	SIMULATED LOG			
				GAMMA RAY	NEUTRON		
MISSISSIPPIAN	MARSHALL SS.	DRIET SANDSTONE SILTSTONE	0'-160'	FRESH WTR.			
	COLDWATER	SHALE	900'-1050'				
	SUNBURY	BLK SHALE	10'-20'				
	BEREA	SILTSTONE SHALE	30'-40'				
	BEDFORD	BLK SHALE	190'-215'				
	ANTRIM	SHALE	40'				
	TRAVERSE GR.	"TRAVERSE FM" LIME	LIMESTONE SHALY LS. CHERTY LS.	175'-200'	GAS, OIL, SALT WTR.		
	DEVONIAN	DUNDEE	LIMESTONE	25'-35'	SALT WTR.		
		LUCAS FM.	DOLOMITE & THIN ANHYDRITE	265'-300'	SALT WTR.		
		AMHERSTBERG FM.					
SYLVANIA SS.		SANDY DOLOMITE	10'-30'				
BOIS BLANC FM.		DOLOMITE	UNCONFORMITY				
SILURIAN	BASS ISLAND FM.	DOLOMITE	0'-125'				
	SALINA FORMATION	SHALE DOLOMITE SOME ANHY. (SALT BEDS BASINWARD)	425'-500'	OIL, WATER			
	GUELPH-LOCKPORT	DOLOMITE	300'-425'	GAS, OIL, SALT WTR.			
	CLINTON	DOLOMITE					
	CATARACT FM.	SHALE DOLOMITE	100'-115'				
ORDOVICIAN	RICHMOND	SHALE SHALY DOLOMITE	340'-350'				
	UTICA	SHALE	320'-330'				
	TRENTON	LIMESTONE	340'-350'	GAS, OIL, SALT WTR.			
	BLACK RIVER	LIMESTONE	230'-360'				
	GLENWOOD ST PETER	SANDY SH. SANDSTONE	10', 50'	SALT WTR.			
PRAIRE DU CHIEN GROUP	DOLOMITE SANDY DOLOMITE	50 +	SALT WTR.				

(Illustration not to scale)

FIGURE 3 - Generalized stratigraphic section along the trend.

The wells are presently prorated at 125 barrels of oil per day, but not allowed to produce in excess of 165 MCF for the same period. Spacing is one well to 20 acres with the wells being located in the center of the northwest and southeast ten acres of each forty-acre tract.

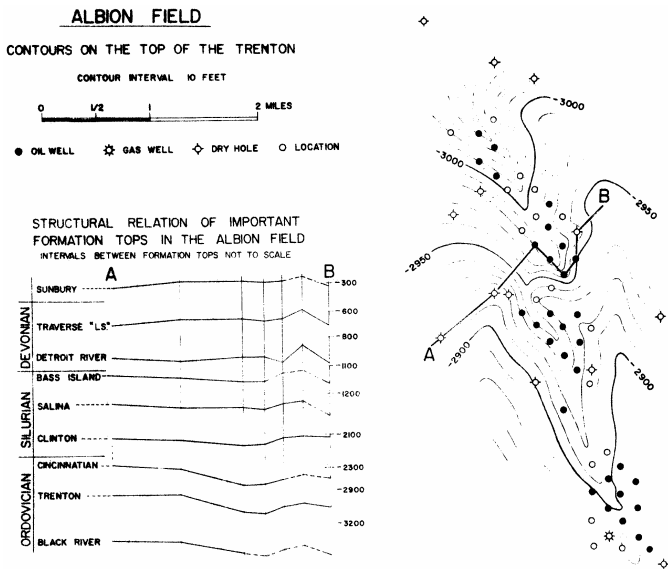


FIGURE 4 - Albion Field

Reserves: The variable nature of the reservoir rock along the trend poses a formidable barrier for the petroleum engineer in estimating recoverable reserves on the basis of volume content. The lateral extent of the fractures and the net thickness of the porosity zones vary considerably along the trend. Over all the total Trenton-Black River section has been found productive. However, in the local pool areas only a small part of the section is productive. With this obstacle present the best basis for establishing reserves is by individual well performance. This is still not satisfactory because the pools along the trend are in a very active stage of development. Tentatively on this basis the average well along the trend will probably not exceed in an excess of 5,000 barrels of oil per acre. As of May 1st, approximately 4,000 acres have been proven productive.

Future Prospects: The search for similar trends in the area has been somewhat disappointing to date. However, they have resulted in the discovery of two Trenton gas pools and one Trenton oil pool. The first gas discovery was by Bell and Gault Drilling Company on the Bissell farm, Section 8, T. 4S., R. 2W., Hanover Township, Jackson County, east of the Pulaski Pool, The well logged the Trenton at 3838 feet and encountered the first shows of gas at 3989 to 3991 feet. Increases in gas were noted at 4002-4009 feet with a large increase at 4009-4012 feet. Total depth was reached at 4454 feet with about 100 feet of lensed porous dolomite being logged. No oil was encountered and the test was completed as a shut-in gas well with an estimated initial production of 17,000 MCF per day. Several follow-up tests were drilled with no success. Another gas discovery was recorded in February of 1960 on the Prichard farm in Section 11, T. 1S., R. 3W., Springport Township, which is in northwestern Jackson County. Operators topped the Trenton at 4624 to 4710 feet. The well bottomed out at 5074 and gauged in excess of 6,000 MCF with some oil after treatment. No follow-up tests have been drilled. The small oil discovery was on the Willis and Johnson farm, Section 17, T. 4S., R. 6W., Tekonsha Township, in south central Calhoun County. The well, after sand fracturing, is producing about 10 barrels of oil per day from a depth of 3553 feet. No additional wells have been drilled. These discoveries indicate that additional fracture zones are present in the general area.

Exploration for the type of trend discussed above is both costly and hazardous. The slight differences in relief are not really depicted on regional contours, such as the Northville and Deerfield structures. If relief is indicated, it does not necessarily follow that a fracture or fault zone is present. However regardless of the difficulties encountered, the gratifying results of the present trend have encouraged operators to carry on an extensive exploration program throughout southern Michigan.

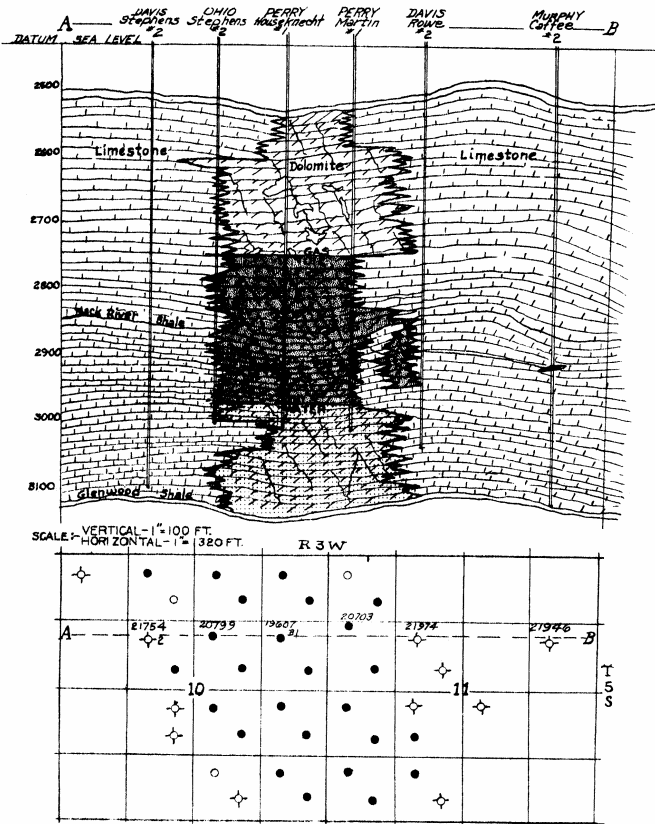


FIGURE 5 - Generalized west to east cross section of the Trenton-Black River formation through the Scipio Field indicating the differential dolomitization.