

National and Global Petroleum Assessment

Assessment of Continuous Oil and Gas Resources in the Mississippian Delle Phosphatic Member of the Woodman Formation in the Eastern Great Basin Province of Nevada, Utah, and Idaho, 2019

Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean resources of 144 million barrels of shale oil and 559 billion cubic feet of shale gas in the Mississippian Delle Phosphatic Member of the Woodman Formation in the Eastern Great Basin Province of Nevada, Utah, and Idaho.

Introduction

The U.S. Geological Survey (USGS) quantitatively assessed the potential for undiscovered, technically recoverable continuous oil and gas resources in the Mississippian Delle Phosphatic Member of the Woodman Formation in the Eastern Great Basin Province of Nevada, Utah, and Idaho (Anna and others, 2007) (fig. 1). Eastward thrusts associated with arc-continent collision (Antler orogeny) during the Late Devonian–Mississippian resulted in the formation of the Antler foreland basin east of the thrust belt (Speed and Sleep, 1982; Giles and Dickinson, 1995). The Antler foreland basin was characterized by a foredeep basin, forebulge, and back-bulge basin (Jewell and others, 2000). The organic-rich Delle Phosphatic Member was deposited in the Antler back-bulge basin, an area that was subject to changes in sea level, anoxia, and preservation of organic matter (Sandberg and others, 1980; Nichols and Silberling, 1990; Jewell and others, 2000; Saltzman, 2003). The Delle Phosphatic Member was buried by varying thicknesses of Upper Pennsylvanian to lower Permian sediments of the Oquirrh–Wood River Basin (Jordan and Douglass, 1980; Sandberg and Gutschick, 1984; Erskine, 1997; Geslin, 1998). Differential burial largely controlled the level of thermal maturation of the Delle Phosphatic Member (Sandberg and Gutschick, 1984), which ranges from being in the oil to being in the dry-gas generation windows across northwestern Utah and eastern Nevada. Structural deformation during the Mesozoic and early Paleogene and basin and range extension in the Neogene further complicated the structural setting of the Delle Phosphatic Member.

Total Petroleum System and Assessment Units

The USGS defined the Delle Phosphatic Member Total Petroleum System (TPS) with the Delle Phosphatic Member Shale Oil Assessment Unit (AU) and the Delle Phosphatic Member Shale Gas AU within this TPS. The Delle Phosphatic Member is the basal member of several stratigraphic units—the Woodman Formation, Chainman Formation, and Deseret Limestone (Chidsey, 2013). The Delle Phosphatic Member contains as much as 8 weight percent organic carbon, presumably has Type IIS kerogen, and is as much as 60 meters thick (Sandberg and Gutschick, 1984). Correlative shales of the basal Chainman Formation can have up to 8 weight percent organic carbon, are dominated by Type II kerogen, have hydrogen indices as much as 400 milligrams of hydrocarbon per gram of organic carbon, and can be overpressured (Sandberg and others, 1980; Poole and Claypool, 1984; Anna and others, 2007).

The geologic model for the Mississippian Delle Phosphatic Member is for the organic-rich phosphatic shales to have been differentially buried by Mississippian Antler foreland basin sediments and Pennsylvanian and Permian sediments of the Oquirrh Basin, which would have placed the Delle Phosphatic Member into the oil, wet-gas, and dry-gas windows in a spatially complex pattern (Sandberg and Gutschick, 1984). In this model, part of the gas would have been retained within the shales following generation, expulsion, migration, and structural

deformation (several phases), similar to the Phosphoria Formation in the Wyoming Thrust Belt (Schenk and others, 2018). There is considerable uncertainty on the retention of oil and gas within the shales of the Delle Phosphatic Member given the tectonic history, as shown by the assigned geologic risk (table 1).

The assessment input data are also summarized in table 1. Well drainage areas, success ratios, and estimated ultimate recoveries are based on U.S. analogs.

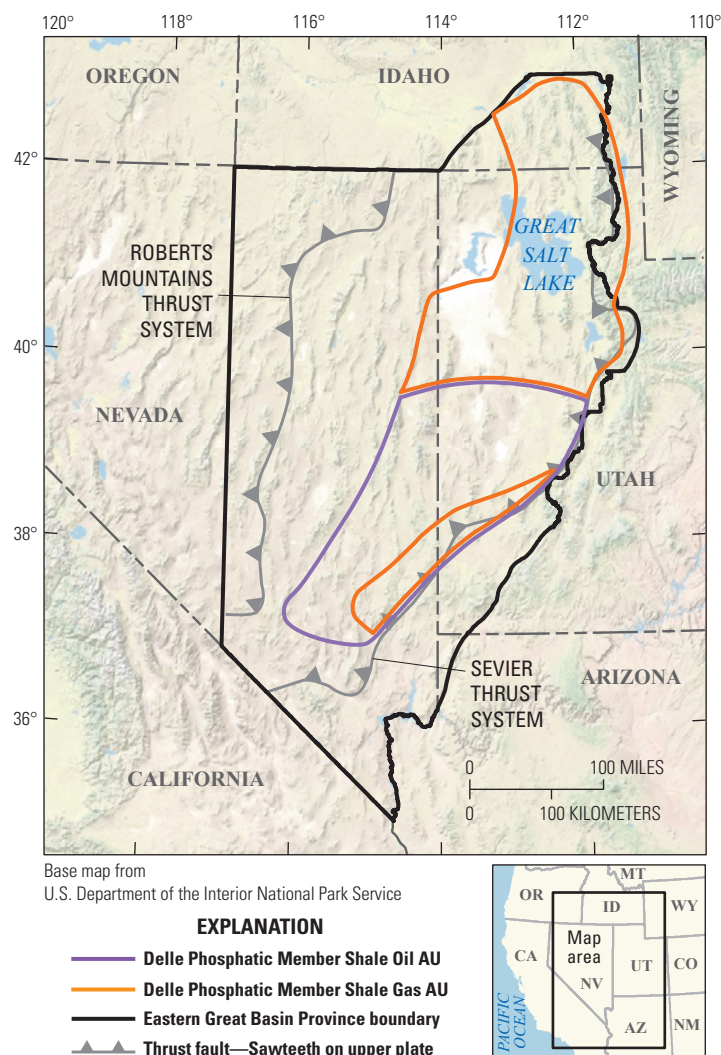


Figure 1. Map showing the location of two assessment units in the Mississippian Delle Phosphatic Member of the Woodman Formation in the Eastern Great Basin Province of Nevada, Utah, and Idaho.

Table 1. Key input data for two continuous assessment units in the Delle Phosphatic Member of the Eastern Great Basin Province of Nevada, Utah, and Idaho.

[AU, assessment unit; %, percent; EUR, estimated ultimate recovery per well; MMBO, million barrels of oil; BCFG, billion cubic feet of gas. Well drainage area, success ratio, and EUR are defined partly using U.S. shale-oil and shale-gas analogs. The average EUR input is the minimum, median, maximum, and calculated mean. Shading indicates not applicable]

Assessment input data— Continuous AUs	Delle Phosphatic Member Shale Oil AU				Delle Phosphatic Member Shale Gas AU			
	Minimum	Mode	Median	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	1,000	5,759,000	11,518,000	5,759,333	1,000	8,833,000	17,666,000	8,833,333
Average drainage area of wells (acres)	80	120	160	120	80	120	160	120
Success ratio (%)	5	15	25	15	5	15	25	15
Average EUR (MMBO, oil; BCFG, gas)	0.01	0.03	0.1	0.034	0.04	0.07	0.1	0.071
AU probability	0.6				0.6			

Undiscovered Resources Summary

The USGS quantitatively assessed the potential for continuous oil and gas resources within the Mississippian Delle Phosphatic Member of the Woodman Formation (table 2). The estimated undiscovered mean

resources are 144 million barrels of oil (MMBO) with an F95–F5 range from 0 to 472 MMBO, 559 billion cubic feet of gas (BCFG) with an F95–F5 range from 0 to 1,708 BCFG, and 2 million barrels of natural gas liquids (MMBNGL) with an F95–F5 range from 0 to 6 MMBNGL.

Table 2. Results for two continuous assessment units in the Delle Phosphatic Member of the Eastern Great Basin Province of Nevada, Utah, and Idaho.

[MMBO, million barrels of oil; BCFG, billion cubic feet of gas; NGL, natural gas liquids; MMBNGL, million barrels of natural gas liquids. Results shown are fully risked estimates. F95 represents a 95-percent chance of at least the amount tabulated; other fractiles are defined similarly. Fractiles are additive under the assumption of perfect positive correlation. Shading indicates not applicable]

Total petroleum system and assessment units (AU)	AU probability	Accumulation type	Total undiscovered resources											
			Oil (MMBO)				Gas (BCFG)				NGL (MMBNGL)			
			F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
Delle Phosphatic Member Total Petroleum System														
Delle Phosphatic Member Shale Oil AU	0.6	Oil	0	100	472	144	0	57	293	86	0	0	1	0
Delle Phosphatic Member Shale Gas AU	0.6	Gas					0	383	1,415	473	0	1	5	2
Total undiscovered continuous resources			0	100	472	144	0	440	1,708	559	0	1	6	2

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For More Information

Assessment results are also available at the USGS Energy Resources Program website at <https://energy.usgs.gov>.

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