

Williston Basin Geologic History and Resource Overview

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Abstract

The Williston Basin is a large, 70 million acre, intracratonic sag basin located in the center of the North American Continent which contains a rich diversity of natural resources. The central portion of the basin is underlain by a variety of igneous and metamorphic rocks that were accreted during the Paleoproterozoic Trans-Hudson orogeny, the tectonic collision of the Hearne and Wyoming cratons with the Superior Craton during 1.7-1.8 billion years ago. Subsidence and sedimentary accumulation began during the Cambrian-Ordovician and continued intermittently during the ensuing past ~500 million years. Reaching maximum depths of >16,000 feet (5,000 m), the basin is infilled with a diverse variety of Cambrian to Quaternary, carbonate to siliciclastic, marine to terrestrial sedimentary deposits that have provided a growing number of resources. The resource discoveries and development in the Williston Basin stretch back more than 100 years. Coal mining from the Tertiary Fort Union Group began within both the Canadian and US portions of the basin during the mid-1800's and continues to present day supplying with multiple local coal-fired power plants. Potash mining began in the basin following an initial discovery in 1941 within the Devonian Prairie Formation, which currently comprises approximately 45% of the world's potash reserves that are extracted through both surface and subsurface solution mining. A series of spatially dispersed oil discoveries, spanning both the US and Canadian portions of the basin, during the 1950's led to the development of a prominent oil and gas industry. Approximately two dozen distinct formations have commercially produced hydrocarbons within the basin ranging from deep thermogenic gas within Cambrian-Ordovician sandstones, to biogenic gas within Cretaceous reservoirs, and primarily oil within the remaining intermediate, carbonate-dominated sedimentary section. More than 10 billion barrels of oil have been commercially produced from the basin to date in addition to hydrocarbon gas. Helium production began within the northwestern portion of the basin during the 1960's and is currently growing with the provincial government of Saskatchewan aiming to attain 10% of the global market share. More recently, multiple other geological resources and related industries continue to be explored and developed within the Williston Basin. Preliminary solution mining of Lithium from subsurface brine waters of the Devonian Duperow Formation is currently ongoing as part of a preliminary commercial project in southeastern Saskatchewan. The DEEP geothermal power project, which began in 2010, is currently commencing construction and progressing towards energy generation from the Cambrian-Ordovician Deadwood Formation, also in southeastern Saskatchewan. High concentrations of rare earth elements (REE's) are also currently being characterized and evaluated within the shallow, near-surficial coal deposits of western North Dakota. Additionally, carbon-capture and sequestration (storage) in Saskatchewan initially began in 2014 and North Dakota in 2022, injecting CO₂ into porous subsurface sedimentary reservoirs in effort to limit CO₂ emissions into Earth's atmosphere. With strong and ongoing fossil fuel and mineral industries, the basin is also continuing to develop a diversity of non-hydrocarbon resource industries, a diversity which will continue to make the Williston Basin relevant for many future generations.