

# COLORADO GEOLOGICAL SURVEY

## Open-file Report OF-99-01

### Evaluation of Mineral and Mineral Fuel Potential of Phillips County State Mineral Lands Administered by the Colorado State Land Board

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The Colorado Geological Survey (CGS) is releasing an evaluation of the mineral and mineral fuel resource potential of the nearly 23,860 acres of state mineral lands located in Fremont County as part of its long-term evaluation of approximately 4,000,000 acres of state lands administered by the State Land Board. The CGS divided the lands, for evaluation purposes, into 36 individual tracts that range from approximately 320 acres to 1,120 acres. Mr. Harry TerBest, a consulting petroleum and coal geologist retained by the CGS, is the senior author of this report while Mr. H. Thomas Hemborg, petroleum geologist and CGS staff member, assisted him. Together these individuals have over 50 years of private sector experience in oil and gas exploration, much of this in Colorado.

This open file report includes a general overview summary of the geology and mineral potential of Phillips County along with maps of tract locations, oil and gas tests, and industrial mineral prospects. The main body of the report is an evaluation of each individual tract.

Four general categories of resources are included in this inventory:

- oil and gas
- coal
- metallic minerals
- industrial minerals and construction materials.

Each individual tract evaluation includes:

- A bar graph which ranks each tract's resource potential for each of the four mineral categories. An explanation of the categories may be found with the tract summaries.
- Tract identifier number, county name, and county location map.
- Tract location on a 7-1/2-minute United States Geologic Survey topographic map.
- Tract location on a United States Geologic Survey surface outcrop map.
- Location as to section, township, and range and approximate acreage.
- Overview of tract geology.
- Specific assessment of the resource potential for the four resource categories.
- References used in assessing tract potential.

All maps showing Phillips County tract boundaries were prepared by Mrs. Tiffany LeHart, a University of Colorado geology student serving an internship at the CGS. These maps were assembled by overlying the boundaries provided on a State Land Board computerized base map onto the United States Geologic Survey map bases in a Graphic Information System environment. Tract boundaries were not checked against the State Land Board's detailed land records because of time constraint considerations.

## Introduction

Phillips County is situated high on the gently dipping east flank of the sedimentary Denver Basin of northeast Colorado, southeast Wyoming, and the southern panhandle of Nebraska. The surface topography of this northeastern Colorado county is relatively flat. Surface outcrops are restricted to four units.

Alluvium (Holocene) - Yellowish-gray loose gravel, sand, silt, and clay in active transport in local drainages and related terraced alluvial fill.

Eolian Sand (Holocene and Pleistocene) - These sediments consist of pale-brown, locally silty, well-sorted, loose wind blown sand. They contain brown soil at and near the surface and form sheets of sand and widespread dunes, many of which are more than 100 feet high and vegetated with grass and various types of sage brush.

Peoria Loess (Pleistocene) - Moderate yellowish-brown, slightly clayey or fine sandy, blocky, non stratified wind-blown calcareous silt. Thickness probably reaches 130 ft.

Ogallala Formation (Miocene) - Fluvial grayish-orange-pink pebbly sand and silt cemented by calcium carbonate or locally opal and forming many resistant ledges. Nonconsolidated gravel is abundant, clasts consist of granitic, sedimentary, and volcanic rocks. Contains beds of volcanic ash.

Peoria Loess and Ogallala Formation exposures are often masked because of the dry and irrigated farm land activity that commonly occurs in the county on these units. There are no extrusive or intrusive igneous bodies exposed in the county, which in many areas in the state either host and/or source metallic mineral deposits. Depth to basement in Phillips County varies from approximately 5,500 ft on the west to 6,000 ft on the east.

## **Oil and Gas Resources**

Gas production in Phillips County has been established from two horizons, Upper Cretaceous Niobrara Formation chinks and Lower Cretaceous Dakota Formation sandstones. Of the eighty-six exploratory wells that have been drilled in various sections scattered throughout the county, eleven wells flowed gas from perforations in the Smoky Hill Member of the Niobrara Formation and one well flowed gas from perforations in the Muddy (J) Sandstone of the Dakota Formation. Only two of the Niobrara wells have been placed on production, Mountain Petroleum's 1-23 Lett and 1-26 Ferguson. Both of these producers are located in T. 6 N., R. 46 W. The Colorado Oil and Gas Conservation Commission (COGCC) assigns these wells to the Puma field, which included at the end of 1996, another 9 Niobrara wells in Yuma County which is located to the south of Phillips County. The single Muddy (J) completion was designed by the COGCC as Haxtun field. Haxtun, now abandoned, was located in T. 9 N., R. 47 W. Cumulative production volume from the 3 wells at the end of 1996 stood at a very modest 136 million cubic feet of gas.

The gas flows established from the Niobrara Chinks is located along a northeast trend extending from T. 6 N., R. 46 W. to T. 9 N., R. 43 W. It is suspected this trend follows a regional lineament or fracture trend. Gas production established in the Muddy (J) Sandstone is from the proximal regions of deltas extending into the greater Denver Basin from the east. Based on current subsurface well data the best potential for expanding the production base in this northeastern Colorado County is judged to be from the Niobrara Formation. Biogenic methane is produced from porous chinks in this formation in 3 northeastern Colorado counties, Phillips, Yuma, and Washington. At the end of 1996 37 individual Niobrara fields had been discovered. Twenty-eight of these fields were located in Yuma County. Cumulative production from this zone in northeastern Colorado at the end of 1996 totaled approximately 200 billion cubic feet from just over 1,100 wells. Average subsurface depth to this zone in Phillips County is 2,700 feet.

Commercial exploitation of this reservoir requires induced fracturing because of low permeabilities. Most wells are stimulated with 50,000—100,000 pounds of sand with carbon dioxide and gelled water or high quality foam used as a fracture fluid. This type of stimulation normally improves wells with initial production rates of 30 – 60 Mcf/d to 100 – 300 Mcf/d and results in ultimate recoveries of 100 – 500 MMcfg and in some special cases up to 1.5 Bcfg.

In 1949, the Ohio Oil Company discovered oil and gas in the Upper Cretaceous D Sandstone on the northeastern flank of the Denver Basin near Gurley, Nebraska. This discovery led to the Denver Basin becoming one of the

most densely drilled of the Rocky Mountain basins. Over 900 individual fields were discovered in the Colorado portion of the basin, all but three exclusively established production from Cretaceous reservoirs. The majority of the fields and resulting production were derived from the Lower Cretaceous Muddy (J) Sandstone and the Upper Cretaceous D sandstone. The nearest segment of this prolific D and Muddy (J) productive fairway to Phillips county lies to the west in bordering Washington County.

Activity levels in the Denver Basin have varied during the years, as has the focus from one to another of the six Cretaceous horizons that include in excess of 98 percent of the basin's production. The Permian Lyons Sandstone is the source of the remainder of the basin's production. Activity for the first 20 years focused almost exclusively on the Muddy (J) and D Sandstone reservoirs on the east flank of the Denver Basin. Most of the wildcats drilled in Phillips County were 1950s projects targeted for these two objectives. All but one failed in finding production. The one well Muddy (J) Haxton Field discovered in 1955 and abandoned in 1961 is the exception.

The environment of deposition for the Muddy (J) and D Sandstone in the Phillips County area includes marine, deltaic, estuarine and strike valley fill fluvial sequences. Trapping for these two reservoirs on the eastern flank of the basin is predominately stratigraphic.

It will be rather unlikely that industry will find significant additional hydrocarbons in Muddy (J) and D Sandstone within the boundaries of Phillips County. This mainly results from of the current level of subsurface control coupled with an understanding of the petroleum system of these two reservoirs on the eastern flank of the Denver Basin.

Paleozoic structures, related to basement fault movement, profoundly influenced Paleozoic depositional patterns in northeastern Colorado. The most significant of these was the Transcontinental Arch which ran northeast-southwest from Minnesota to New Mexico. The axis of this feature passed within fifty miles to the northwest of the northwest corner of Phillips County. The area occupied by Phillips County was a gently southeastward dipping ramp off the Transcontinental Arch during Pennsylvanian early Permian time.

On the Transcontinental Arch, carbonate shoals developed during late Paleozoic time. Varied conditions of deposition and diagenesis in this setting have yielded a wide variety of porosity types. Limestone, dolomite, and sandstone facies are productive from small basement structures along the arch axis in Nebraska. On the ramp where Phillips County was located during this time period, alternating limestone/siliciclastic sequences were deposited. These limestones are characterized by both primary inter-particle and moldic porosity, a paucity of dolomite and evaporites, and terrigenous siltstones capping the depositional cycles.

The nearest Permo-Pennsylvanian production to Phillips County in an analogous geologic setting is found in Dundy County, Kansas some 30 miles east southeast of the geographic center of Phillips County. Only four wells in the county have penetrated this section. One, on a drillstem test, recovered 10 ft of oil cut mud. With known porosity and petroleum in the system, this under-explored sequence is judged to have a fair to moderate potential to be productive in Phillips County. The ingredient that is the main unknown is trapping. The average thickness of the objective section is approximately 350 ft. Depth to top of this potential reservoir sequence in Phillips County would average about 5,100 ft.

## **Coal Resources**

There are no known coal resources in Phillips County.

## **Metallic Mineral Resources**

There are no known resources of metallic minerals in Phillips County.

## **Industrial Mineral Resources**

Sand and gravel deposits are ubiquitous to every county in the state. Composition, clast hardness and color

variation is dependent on host rock. Sorting, roundness, and clast size is inter-dependent on host, transport distance and transport medium. Usage of this resource in Colorado is primarily as a road base material and as an aggregate in asphalt and cement. Mining of any particular deposit is greatly dependent on nearness to market and transportation routes though amount of interstitial clay in these clast supported deposits is also an important factor. Highly clayey deposits that would require a great deal of washing before usage are normally not brought into production.

The primary source of mined Colorado sand and gravel are Pleistocene and Holocene in age river and stream alluviums and associated terrace deposits. In Phillips County the Ogallala Formation is the main host for the sands and gravels found in active transport in the county's perennial and intermittent streams. The drainage direction for main trunk streams in Phillips County is to the east-southeast into Kansas. The North and South forks of Frenchman Creek, Wildhorse, Sandy, and Patent creeks all can be considered excellent resources of sand and gravel. These major streams have the resources available to supply the counties sand and gravel needs for many years to come. Generally the sand and gravel in transport in the tributary drainages to these main trunk streams include too much intercalated silt and clay to be considered a viable resource.

There are thirty-eight unnamed sand and gravel sites reported in The Inventory of Nonmetallic Mining and Processing Operations published by the CGS (Information Series IS-32) in 1990 for Phillips County. Four of these sites are registered and active operating sand and gravel operations. In addition to the sand and gravel operations, there is one active surface clay pit located in the southeast part of the county in the NWNW Sec 19, T6N, R43W and two ready-mix concrete plants, one located west of the town of Haxtun and the other west of Holyoke. Many of these sand and gravel pits are discussed in the various State Land Tracts in this open-file report.

## References

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