

COLORADO GEOLOGICAL SURVEY

Open-file Report OF-01-19

Evaluation of Mineral and Mineral Fuel Potential of Prowers 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 63,248 acres of state mineral lands located in Prowers 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 86 individual tracts that range from approximately 40 acres to 8,080 acres. Authors on this report are Mrs. Nicole Koenig, CGS Petroleum Geologist, Mr. Alex Scarbrough, a consulting minerals geologist and Mr. Harry TerBest, a consulting petroleum geologist, both retained by the CGS. Ms. Rachel Garrison, a consulting GIS analyst retained by the CGS, provided GIS production in the form of tract and index maps, as well as editing and documentation support.

This open file report includes an introduction to the geology and mineral resources of the county. The main body of the report includes evaluations of each individual tract, involving descriptive text as well as corresponding topographic and geologic maps. A county reference map with tract locations is included, as well as maps of oil and gas test wells with oil field locations, and industrial mineral prospects. Maps for coal resources and metallic mineral prospects are not applicable in this county. A spreadsheet summary of the tract locations and commodity ratings is also included as a separate file. Abbreviations used throughout the tract documentation are listed on the next page.

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.

The abbreviations used in the tract documentation, with their definitions, are as follows:

MCF – thousand cubic feet
MMCF – million cubic feet
BCF – billion cubic feet
TCF – trillion cubic feet
BBL barrels
BO – barrels of oil
BW – barrels of water

MBO – thousand barrels of oil
MMBO – millions of barrels of oil
DST – drill stem test

Geological Overview

Prowers County is geologically situated southeast of the Las Animas Arch, which has been a positive feature since at least the Mississippian. Pertaining to the State Land Board tracts, surface mapping in Prowers County has identified nine unconsolidated surficial units of Quaternary age and eight consolidated bedrock units ranging in age from Upper Jurassic through Cretaceous.

Oil and Gas Resources

County Production Statistics

Prowers County produced 1,131,514 thousand cubic feet of gas and 1,452 barrels of oil in 1998 from 27 producing wells. This placed Prowers County 15th in annual gas and 28th in annual oil production among Colorado's 35 gas-producing and 30 oil-producing counties.

The cumulative production from 18 producing fields in Prowers County reached 34,788,057 thousand cubic feet of gas and 322,900 barrels of oil at the end of 1998. Prowers County was ranked 21st for cumulative gas production in 1998 and 26th for cumulative oil production among Colorado's producing counties.

Producing Horizons

There are six individual formations/producing horizons that have produced gas and oil in Prowers County. These pay zones, with their accompanying lithologic description and geologic age, are listed below in stratigraphic order.

| Formation | Lithology | Age |
|---------------|---|----------------------|
| "J" Sand | Sandstone | Lower Cretaceous |
| Marmaton | Limestone and Dolomite | Middle Pennsylvanian |
| Cherokee | Limestone and Dolomite | Middle Pennsylvanian |
| Morrow | Sandstone (including the McClave Sandstone) | Lower Pennsylvanian |
| Keyes | Sandstone | Lower Pennsylvanian |
| Mississippian | Interbedded Limestone and Dolomite (including the Warsaw and Osage Formations) | Mississippian |

Summary of production by fields

The following list contains the Prowers County oil and gas fields, their general locations, current status (producing, shut-in, or abandoned), producing formation(s), and cumulative oil and gas production at the end of 1998. Fields that had significant production are shown in bold print.

| Field Name | Section, Township and Range | Status | Year Disc. | Year Aband. | Producing Formation | CUM OIL (BO) | CUM GAS (MCF) |
|---------------------------|-----------------------------|------------------|-------------|-------------|--------------------------|----------------|-------------------|
| Barrel Springs | 27-25S-45W | Producing | 1958 | | Morrow | 30,161 | 3,617,396 |
| Barrel Springs | 27-25S-45W | Producing | 1958 | | U. Morrow | 0 | 115,898 |
| Barrel Springs N | 2-25S-45W | Producing | 1981 | | Morrow | 3,582 | 2,627,058 |
| Berry Patch | 32-22S-45W | Producing | ? | ? | Morrow | 9,319 | 1,451,211 |
| Beta | 32-22S-47W | Producing | 1961 | | Morrow | 4,679 | 5,072,049 |
| Buffalo Creek | 28-22S-44W | Abandoned | 1979 | 1981 | Marmaton | 2,210 | 155 |
| Channing | 32-21S-46W | Producing | 1984 | | Morrow | 7,878 | 6,286,369 |
| Channing | 32-21S-46W | Producing | 1984 | | Marmaton | 0 | 16,293 |
| Clay Creek | 28-23S-46W | Abandoned | 1981 | 1988 | Cherokee | 754 | 0 |
| Clay Creek | 28-23S-46W | Abandoned | 1981 | 1988 | Miss | 34,398 | 0 |
| Clyde | 15-22S-45W | Abandoned | 1978 | ? | Keyes | 7,855 | 14,479 |
| Clyde | 15-22S-45W | Producing | 1978 | | Morrow | 36,329 | 6,489,522 |
| Clyde | 15-22S-45W | Abandoned | 1978 | ? | Marmaton | 79,053 | 0 |
| Clyde North | 2-22S-45W | Abandoned | 1980 | 1982 | Morrow | 714 | 0 |
| Comanche | 30-21S-46W | Abandoned | 1964 | ? | Miss-Osage | 36,892 | 0 |
| Comanche | 30-21S-46W | Abandoned | 1964 | ? | Miss | 37,579 | 4,686 |
| Comanche | 30-21S-46W | Abandoned | 1964 | ? | Osage | 9,919 | 0 |
| Great Expectations | 27-23S-47W | Producing | 1988 | | Morrow | 704 | 709,060 |
| Lamar | 15-22S-46W | Abandoned | 1983 | ? | Marmaton | 14,857 | 0 |
| McClave | 1-21S-47W | Abandoned | 1952 | ? | McClave | 87 | 119,813 |
| McClave | 1-21S-47W | Abandoned | 1952 | ? | Morrow | 348 | 539,011 |
| Royal Flush | 4-21S-43W | Abandoned | 1988 | ? | Miss | 894 | 0 |
| Sand Creek | 24-21S-45W | Abandoned | 1983 | 1984 | Marmaton – Morrow | 1,962 | 0 |
| Sand Creek | 24-21S-45W | Abandoned | 1983 | 1984 | Marmaton | 1,617 | 773 |
| Signal Hill | 13-24S-45W | Abandoned | 1976 | 1984 | J Sand | 182 | 71,069 |
| Signal Hill | 13-24S-45W | Producing | 1976 | | Morrow | 963 | 1,330,645 |
| Tabletop | 7-25S-47W | Producing | 1980 | | Morrow | 51 | 1,401,491 |
| Wild Dove | | Abandoned | 1998 | ? | Miss – Morrow | 0 | 40,892 |
| COUNTY TOTALS: | | | | | | 322,900 | 34,788,057 |

*BO = barrels of oil, MCF = thousand cubic feet

Structural and stratigraphic controls on production

The Laramide Orogeny controlled the present-day structural configuration of Prowers County. Prowers County's major gas and oil fields are situated along anticlinal features of the Las Animas Arch (USGS, 1996). The Las Animas Arch, trending northeast-southwest to the northwest of Prowers County, separates the Hugoton Embayment in eastern Prowers County from the Denver Basin located in northeastern Colorado.

Sedimentary formations range in age from Upper Cambrian Reagan Sandstone through Upper Cretaceous clastics. Gas and oil production is derived from strata of Mississippian and primarily Lower Pennsylvanian shelf sandstones and carbonates. Significant production came from the Morrow Formation. The lower Morrow is comprised of offshore marine shales and shoreface sandstones that are located in the area of the Hugoton Embayment. These units onlap the upper Morrow that is comprised of marine shales that encase transgressive valley-fill sequences. Backfilling of these valleys occurred during a relative sea-level rise and are comprised of fluvial sandstone at the base. These sandstones are the primary targets for exploration (Wheeler et al., 1990).

Middle and Upper Pennsylvanian carbonate reservoirs

Production from these reservoirs is minimal and is from finely crystalline, fossiliferous dolomites and dolomitic limestones. Porosities may reach 17 percent, but the extent of these porous zones is limited. Therefore, production rarely exceeds 40 to 80 acres from reservoir thicknesses of less than ten feet. Average porosities range from 10 to 15 percent; permeability data is not available (USGS, 1996).

The source rocks for these reservoirs are unknown. Generation may have come from Mississippian and Pennsylvanian shales and carbonates that migrated to the reservoirs during the Laramide Orogeny (USGS, 1996). Production from these reservoirs in Prowers County is very limited and restricted to oil.

Lower Pennsylvanian (Morrowan) sandstone reservoirs

These reservoirs are restricted to fluvial sandstones in the Morrow Formation and are interpreted to be fill in incised paleovalleys located in southeastern Colorado and extend into western Kansas. Production depths vary between 4,500 and 6,200 feet. Reservoir thickness varies between 5 and 60 feet, but the most typical thickness is less than 20 feet. The primary traps in these reservoirs appear to be stratigraphic, although some structural elements may exist. Shale units usually seal the reservoirs. Porosity values range from 13 to 19 percent. Permeability values range from .5 millidarcies and 1-2 millidarcies (USGS, 1996).

The source rock for the Morrow Formation is most likely Morrow shales (Burruss et al., 1990). Thermal maturation and migration of hydrocarbons may have begun in the late Cretaceous to early Tertiary. Good potential for production of oil and gas exist due to high discovery rates and continued drilling activity success. McClave Field, located in northwest Prowers County, was discovered in 1952 and is the first significant gas field for this type of reservoir (USGS, 1996).

Mississippian carbonate reservoirs

This play is defined by the occurrence of oil in Mississippian shelf carbonate rocks of the Osage/Warsaw Formations in Prowers County. Oil is preferentially trapped along gently dipping anticlinal crests and zones of higher, secondary porosity in dolomitized limestones which trend parallel to the long direction of the Las Animas Arch (northeast-southwest). Dense limestones or dolomite form the seals. Porosity values range from 10 to 15 percent. Permeability values range from 0.1 and 30 millidarcies. (USGS, 1996).

Mississippian or early Pennsylvanian strata are the most likely source rocks. Hydrocarbon generation and migration probably occurred during the late Mississippian-Pennsylvanian and the late Cretaceous-early Tertiary orogenies. The latest discovery, Archer Field in Cheyenne County, was discovered in 1989 and has a potential of more than 1 MMBO. Although it is likely that other 1 MMBO fields remain to be found, smaller fields are more likely and remain oil plays (USGS, 1996).

Coal Resources

There are no known coal resources in Prowers County.

Metallic Mineral Resources

There are no known metallic mineral resources in Prowers County

Industrial Mineral Resources

Sand and gravel is the only commonly mined mineral resource in this category in Prowers County. Numerous gravel pits are present in the county, especially along the Arkansas River Valley near the town of Lamar. Quaternary alluvial gravel, transported and deposited by the river, is well suited for use as aggregate and road base. Other smaller creek drainages and older terrace gravels scattered throughout the county are also sources of useable sand and gravel. Wind-blown deposits of sand that occur in sheets and dunes up to 100 feet high represent a large potential sand resource, and are occasionally mined. The State Land Board has leased two tracts of land in the county for purposes of sand and gravel mining. These tracts are 99-19 and 99-39.

According to a report by Schwochow (1981), two limestone deposits have been mined in the past in the county. These deposits were mined from exposed areas of the Fort Hays Member of the Niobrara Formation along the Arkansas Valley in northern Prowers County. The Niobrara Formation is quarried in Larimer and Fremont Counties for cement-making purposes. This formation thus represents a potential resource for cement raw materials in Prowers County.

Schwochow (1981) also shows one silica sand deposit that was previously mined in the southern part of the county. The silica sand deposit occurs within the Dakota Sandstone of Lower Cretaceous age. The only silica sand mining operations in the state currently are located in El Paso County.

Stratigraphic Units Occurring on State Land Board Tracts

Listed below are geologic descriptions of the Prowers County map units.

Surface Geologic Units:

Qal/Qa Alluvium (Holocene) – This unit is comprised of cross-bedded, dark-yellowish-gray to yellowish-tan silt, sand and gravel; unconsolidated deposits of two ages in modern day stream channels and floodplains. Thickness generally ranges from 0 to 43 feet thick. The Piney Creek Alluvium consists of dark-yellowish-brown or grayish-orange, clayey to fine sandy, well-stratified silt exceeding 30 feet in thickness. The Post-Piney Creek Alluvium consists of five feet of loose, stratified, yellowish-gray, sand that is underlain by sandy gravel generally free of silt and clay; grain size averages 0.25 inches and reaches a maximum of four inches in diameter. Clasts are composed of quartz, feldspar, granite, gneiss, pegmatite, and chert.

Qsw Slopewash (Holocene) – Material deposited on slopes by sheetwash and ephemeral rills. Consists mainly of sandy silt but may include gravel or fragments of limestone, shale, or any other rocktype occurring upslope from depositional site.

Qe Eolian Deposits (Holocene and Pleistocene) – This unit is comprised of yellowishbrown, loose, wind-blown, very-fine to medium silty quartz sand and occurs in sheets and dunes up to 100 feet thick/high.

Qlo Loess – (Holocene and Pleistocene) – This unit consists of brown, wind-blown, silt, sandy silt and very fine sand which is largely equivalent to the Peoria Loess. Thickness may be up to 120 feet thick.

Qn Nussbaum Alluvium – (Pleistocene) – This unit is comprised of cobbly gravel and silty sand in terraces 320 to 410 feet above the Arkansas River as well as in remnants of a broad alluvial fan on uplands; basal portion is usually cemented by caliche.

Qds Dune Sand (Pleistocene) – Yellowish-gray medium sand, forming widespread dunes.

Qb Broadway Alluvium (Pleistocene) – This unit consists of gravel sand and silt in terraces 15 to 50 feet above the Arkansas River and its major tributaries.

Qs Slocum Alluvium (Pleistocene) – This unit consists of cobbly and bouldery gravel containing silty sand in terraces 65 to 100 feet above the Arkansas River and its major tributaries.

Qv Verdos Alluvium (Pleistocene) – This unit consists of cobbly gravel and silty sand in terraces 120 to 180 feet above the Arkansas river and its major tributaries.

Bedrock Geologic Units:

To Ogallala Formation (Miocene) – The formation consists chiefly of sandy gravel containing interbedded silt locally capped by a thin, hard limestone (caliche). The gravel is probably similar in character to that occurring in the formation in non-consolidated fine gravel composed of rounded granitic, sedimentary, and volcanic clasts is abundant and has resource value as road metal. Beds of silver-gray, biotite-rich, volcanic ash and semi-consolidated ashy sand and silt beds observed elsewhere also may be present. Thickness ranges from approximately 3 to 390 feet thick and thins westward.

- Knf Fort Hays Limestone Member of the Niobrara Formation (Upper Cretaceous) – The Fort Hays Member of Niobrara Formation consists of hard yellowish gray massive-bedded limestone. Thickness ranges from 75 to 100 feet.
- Kcgg Carlile Shale, Greenhorn Limestone, and Graneros Shale (Upper Cretaceous) – Map unit includes the following: Carlile Shale – Yellowish-brown fossiliferous calcarenite, black shale containing large septarian concretions, and yellowish-brown soft bentonitic platy shale. Greenhorn Limestone – Gray shaly weathering ledge-forming fossiliferous limestone, dark-gray calcareous platy shale, and yellowish-gray, fossiliferous ledge-forming beds of calcarenite and limestone. Graneros Shale – Dark-gray non-calcareous shale, containing orange hard Thatcher Limestone member below middle portion of unit.
- Kdp Dakota Sandstone and Purgatorie Formation (Lower Cretaceous) – Map unit includes the following: Dakota Sandstone – Yellowish-brown, cross-laminated cliff-forming sandstone. Purgatorie Formation – Fossiliferous marine dark-gray claystone, siltstone, and sandstone of Glencairn Shale Member (laterally equivalent top Kiowa Shale Member) and underlying yellowish-brown cross-laminated sandstone of Lytle Sandstone Member (laterally equivalent to Cheyenne Sandstone Member).
- Jmre Morrison and Ralston Creek Formations and Entrada Sandstone (Upper Jurassic) – Map unit includes the following: Morrison Formation – Varicolored claystone, brown-weathering sandstone, and gray limestone. Ralston Creek Formation – Greenish-gray claystone, gray limestone, red jasper, blue and pink agate, and lower local sandy beds containing pink alabaster and white gypsum. Entrada Sandstone – White massive cross-laminated sandstone; contains minor redbed-type copper deposits in southwest Baca County.
- Tl Laccolith and Dikes (Miocene ?) – Dark greenish-gray finely crystalline syenitic lamprophyre and minor coarsely crystalline facies constituting a central mass at Two Buttes.
- TRd Dockum Group (Upper Triassic) – Moderate-reddish-brown medium-grained sandstone, moderate-reddish-brown and grayish-yellow-green siltstone, and local gray limestone.
- Pbdw Big Basin Formation of Cragin (1896), Day Creek Dolomite, and Whitehorse Sandstone equivalent (Upper Triassic) – Map unit includes the following: Big Basin Formation – Pale reddish-brown platy siltstone and fine-grained sandstone. Day Creek Dolomite – Grayish-orange-pink finely crystalline cross-laminated dolomite locally in two or more beds separated by calcareous red siltstone. Whitehorse Sandstone equivalent – Yellowish-gray to red fine-grained sandstone and shale.

References

- Burruss, R.C., Blakeney, B.A., Castle, R.A., and Kirkby, K.C., 1990, Petroleum source rock potential and thermal maturation of the Mississippian “Harrison” and Spergen Formations and Pennsylvanian Morrow Formation and Marmaton Group, southeastern Colorado, in Sonnenberg, S.A., Sannon, L.T., Rader, K., Von Drehle, W.F., and Gregory, W.M., eds., Morrow sandstones of southeast Colorado and adjacent areas, Rocky Mountain Association of Geologists, Denver, CO, p. 59.
- Schwochow, S.D., 1981, Inventory of non-metallic mining and processing operations in Colorado: Colorado Geological Survey Map Series 17, 39 p., 17 pl.
- Scott, Glenn R., 1968, Geologic and structure contour map of the La Junta (1; X 2;) quadrangle, Colorado and Kansas: U.S. Geological Survey Miscellaneous Investigations Map I-560, Scale - 1:250,000.
- Sharps, Joseph A., 1980, Geologic map of the Lamar (1; X 2;) quadrangle, Colorado and Kansas: U.S. Geological Survey Miscellaneous Investigations Map I-944, Scale - 1:250,000.
- United States Geological Survey Digital Data Series DDS-36, 1996, compiled by Ronald R. Charpentier, Timothy R. Klett, Raymond C. Obuch, and James D. Brewton, CD-ROM.

Wheeler, D.M., Scott, A.J., Coringrato, V.J., and Devine, P.E., 1990, in Sonnenberg, S.A., Sannon, L.T., Rader, K., Von Drehle, W.F., and Gregory, W.M., eds., Morrow sandstones of southeast Colorado and adjacent areas, Rocky Mountain Association of Geologists, Denver, CO, p. 59.