

LAS ANIMAS ARCH PROVINCE (040)

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INTRODUCTION

The Las Animas Arch of southeastern Colorado is a north-northeast striking structural high, bounded on the south by the Apishipa Uplift. It separates the Denver Basin of northwestern Colorado from the Hugoton Embayment of southeastern Colorado and southwestern Kansas. The arch extends northeastward out of Province 040, where it meets the Cambridge Arch of Nebraska and the Central Kansas Uplift; it occupies an area of approximately 6,300 sq mi in Cheyenne, Kiowa, Otero, and Bent Counties. The Las Animas Arch has a complex history but has been a positive feature since at least the Mississippian. Within the Las Animas Arch, sedimentary rocks range in thickness from approximately 2,000 ft at the southern end of the arch, to approximately 8,000 ft along its western margin.

Sedimentary strata in the subsurface range in age from Upper Cambrian (Reagan Sandstone) through Upper Cretaceous. Upper Cretaceous strata are unconformably overlain by Pleistocene and Holocene alluvium and eolian deposits. Hydrocarbon-bearing strata are limited to strata of mid-Mississippian (Osagean) to Upper Pennsylvanian (Virgilian). Three conventional plays were assessed within this province. The plays are, from youngest to oldest, Middle and Upper Pennsylvanian Carbonates Oil Play (4001) Lower Pennsylvanian (Morrowan) Sandstone Oil, Gas, and Natural Gas Liquids Play (4004), and Mississippian Carbonate Play (4005).

Play (4001), producing oil from Middle and Upper Pennsylvanian (Desmoinesian, Missourian, and Virgilian) carbonates, is the least productive play; Brandon and Bledsoe Ranch fields have cumulative oil production (to 1991) of 1.1 MMBO and cumulative gas production of 3.7 BCFG. Play (4004) produces from Lower Pennsylvanian Morrow sandstones in Cheyenne and Kiowa Counties. The nine most productive fields in Cheyenne County have cumulative production (through 1991) of 33.4 MMBO and 36.6 BCFG; three fields in Kiowa County have cumulative production of 0.3 MMBO and 6.8 BCFG. Discoveries were made as early as 1952, but most significant discoveries were later (late 1970's and 1980's); drilling activity is still high. A series of recent reports on the Morrow Formation is available in Sonnenberg and others (1990). The Mississippian Carbonate Play (4005) yields oil from five fields in Cheyenne and Kiowa Counties and approximately 60 percent of the cumulative production of 21.7 MMBO is from the Brandon and Cavalry fields in Kiowa County.

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CONVENTIONAL PLAYS

4001. MIDDLE AND UPPER PENNSYLVANIAN CARBONATES OIL PLAY

The limited production in this play is restricted to generally thin finely crystalline fossiliferous dolomite or dolomitic limestone restricted in areal extent, often with localized, lenticular zones of higher (10-17 percent) porosity. The Brandon field in Kiowa County is located on a large, closed, asymmetric anticline plunging northwest, with approximately 50 ft of closure on the Pennsylvanian Lansing-Kansas City.

Reservoirs: Production in this play is from Pennsylvanian carbonates of limited extent (40-80 acres) and thickness (usually less than 10 ft). Porosity data are limited, but porosity is typically between 10-15 percent; permeability data are unavailable.

Source rocks, timing, and migration: Source rocks are not known, but may be associated with the Pennsylvanian and Mississippian carbonates and shales. Migration may have occurred during the Laramide orogeny.

Traps: Production appears to be from thin (generally less than 10 ft) limestones; it is localized along crests of anticlinal structures and is probably fracture related, and generally in areas of 40-80 acres. Porosity variations in the limestones also act as traps; seals are formed by dense carbonate units and shales. Depth to production is rather shallow, ranging between approximately 3,600 and 4,500 ft.

Exploration status and resource potential: Resources of this play are limited; cumulative oil production from Middle and Upper Pennsylvanian carbonates is only 1.1 MMBO and cumulative gas production is 3.7 BCFG. Only two fields (Bledsoe Ranch and Mayfield, in Cheyenne County) were producing commercial quantities of oil in 1991. Exploration along the crest of the arch and over anticlinal structures is moderate to mature, but discovery rates are low. Two fields (Archer, discovered 1981, and Mayfield, discovered 1984) in Cheyenne County, have potential combined ultimate production of approximately 2.1 MMBO. Bledsoe Ranch field in Cheyenne County and Brandon field in Kiowa County have projected ultimate oil production of 0.7 and 0.9 MMBO, respectively. No significant gas production is expected. The probability of future significant discoveries is not good, although small (less than 1 MMBO) fields are likely; most fields will probably be primarily oil.

4004. LOWER PENNSYLVANIAN (MORROWAN) SANDSTONE OIL, GAS, AND NATURAL GAS LIQUIDS PLAY

This active and productive play is restricted to fluvial sandstones in the Morrow Formation; the sandstones are interpreted as fill in incised paleovalleys. Production is concentrated in Cheyenne and Kiowa Counties, but Bent, Kit Carson, Lincoln, and Prowers Counties, Colorado, also produce. Detailed drilling-intensity maps clearly delineate outlines of paleovalleys. Traps are typically stratigraphic, but may have a structural component. Three fields have produced more than 6 BCF of natural gas; eight fields have produced more than 1 MMBO. Cumulative production from the Morrow Formation through 1991 in Cheyenne County is 33.4 MMBO and 36.6 BCFG; in Kiowa County, cumulative production was 0.3 MMBO and 6.9 BCFG.

Reservoirs: Reservoirs are in fluvial channel sandstones filling paleovalleys in southeastern Colorado, and extending into western Kansas. Depth to production varies between 4,500 and 6,200 ft; reservoir thickness varies between 5 and 60 ft, but is most typically less than 20 ft. Porosity ranges between 13 and 19 percent; permeability varies between 0.5 mD and 1-2 D.

Source rocks, timing, and migration: There is no agreement on source rocks. The Morrow is probably marginally mature; thermal generation and migration of hydrocarbons may have begun in late Cretaceous to early Tertiary.

Traps: Traps appear to be primarily stratigraphic (Morrow Sandstone), although they may include a structural element. Reservoirs are typically sealed by shale units.

Exploration status: This demonstrated play is moderately explored, and current drilling activity is high. Three gas fields with potential ultimate recovery of greater than 6 BCFG have been discovered. These include McClave (1952; 105.6 BCFG), Beta (1961; 10.7 BCFG), and Wagon Trail (1973; 27 BCFG). Eight fields have the potential for producing more than 1 MMBO. These fields include Arapahoe (1977; 53.3 MMBO) Sorrento (1979; 30.7 MMBO), Haswell (1979; 1.1 MMBO), Bledsoe Ranch (1983; 5.9 MMBO), Mt. Pearl (1984; 46.8 MMBO), Frontera (1987; 19.7 MMBO), Second Wind (1988; 18.5 MMBO), and Harker Ranch (1989; 8.1 MMBO).

Resource potential: Discovery rates and continued high drilling activity suggest a very good potential for additional significant production of oil and gas in this play. The first significant gas field (McClave, Kiowa County) was discovered in 1952; Harker Ranch field, in Cheyenne County, yields predominantly oil, and was discovered in 1989. Improved interpretation and seismic techniques should enhance the potential of the play.

4005. MISSISSIPPIAN CARBONATE PLAY

This demonstrated play is defined by the occurrence of oil in Mississippian shelf carbonate rocks in a zone over, and parallel to, the long direction of the Las Animas Arch, and concentrated in Cheyenne and Kiowa Counties. Reservoirs may be structural (along asymmetric anticlines), but many have a stratigraphic component (porosity variations within a carbonate horizon). Seven fields have produced more than 1 MMBO; the largest producer is the Brandon field in Kiowa County. Cumulative production from these fields (through 1991) is 21.7 MMBO.

Reservoirs: The reservoirs are in Mississippian shelf carbonates, including the St. Louis, Spergen, and Osage/Warsaw Formations. Depth to production varies between 4,500 and 5,400 ft; thickness of the producing horizon is typically 3-20 ft, but may reach as much as 50 ft. Porosity of the reservoir rock is between 10 and 15 percent. Permeability is highly variable, ranging between 0.1 and 30 mD; fracturing, in addition to variations in porosity, probably contributes to the wide variation in permeability.

Source rocks, timing, and migration: The source rock(s), although not clearly identified, may be Mississippian or Early Pennsylvanian strata. Generation and migration of hydrocarbons probably occurred in early Paleocene, after the Late Mississippian-Pennsylvanian orogeny, and during the Late Cretaceous-early Tertiary orogeny.

Traps: Oil is preferentially trapped along gently dipping anticlinal crests, as well as in zones of higher, secondary porosity in dolomitized limestones. Seals are formed by dense limestone or dolomite.

Exploration status: Level of exploration in this play is moderate; seven fields have been found with a production potential of greater than 1 MMBO; no significant gas fields have been found. Dates of discovery and potential ultimate production of these fields include: Brandon (1965, 18.3 MMBO), Cavalry (1968, 3.0 MMBO), Cheyenne Wells/Smoky Creek (1968, 8.1 MMBO) Golden Spike (1959, 3.4 MMBO), Ladder Creek (1969, 3.4 MMBO), Grouse (1979, 3.4 MMBO), and Archer (1982, 1.3 MMBO).

Resource potential: The largest field (Brandon) was discovered in 1965; the last discovery of a field with a potential of more than 1 MMBO production (Archer) was discovered in 1982. It is likely that a limited number of 1 MMBO fields remain to be found, but smaller fields are more likely. The play will probably remain an oil play.

UNCONVENTIONAL PLAYS

There are no unconventional plays described in this province report. However, unconventional plays listed in the surrounding provinces may include parts of this province. Individual unconventional plays are usually discussed under the province in which the play is principally located.

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., and others, eds., Morrow sandstones of southeast Colorado and adjacent areas: Rocky Mountain Association of Geologists, p. 59-66.
- Clayton, J.L., King, J.D., Threlkeld, C.N., and Vuletich, A., 1987, Geochemical correlations of Paleozoic oils, northern Denver basin - Implications for exploration: American Association of Petroleum Geologists Bulletin, v. 71, no. 1, p. 103-109.
- Higley, D.K., 1987, Central Kansas uplift-Cambridge Arch province oil and gas play summary: U.S. Geological Survey Open-File Report 87-450E, 16 p.
- Merewether, E.A., 1987, Oil and gas plays of the Las Animas Arch, southeastern Colorado: U.S. Geological Survey Open-File Report 87-450D, 22 p.
- Sonnenberg, S.A., Shannon, L.T., Rader, K., von Drehle, W.F., and Martin, G.W., eds., 1990, Morrow sandstones of southeast Colorado and adjacent areas: Rocky Mountain Association of Geologists, 236 p.
- Thomas, D., 1993, Basement paleogeography key in Colorado Morrow channel oil play: Oil and Gas Journal, v. 21, no. 29, p. 56-60.

ERA	SYSTEM	SERIES	STRATIGRAPHIC UNITS
PALEOZOIC	PERMIAN	Guadalupian	Taloga Formation Day Creek Dolomite Whitehorse Sandstone
		Leonardian	Nippewalla Group Sumner Group
		Wolfcampian	Chase Group Council Grove Group Admire Group
	PENNSYLVANIAN	Virgilian	Wabaunsee Group Shawnee Group * Douglas Group
		Missourian	Lansing Group * Kansas City Group *
		Desmoinesian	Marmaton Group * Cherokee Group *
		Atokan	Morrow Group *
		Morrowan	
	MISSISSIPPIAN	Meramecian	St. Genevieve Limestone St. Louis Formation * Salem Formation * Warsaw Formation *
		Osagean	Harrison Shale St. Joseph Formation *
		Kinderhookian	Gilmore City Limestone equivalent Misener sand
	ORDOVICIAN	Lower	Arbuckle Group
	CAMBRIAN	Upper	Reagan Sandstone
	PRECAMBRIAN		

4001

4004

4005

* Oil and gas