

U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Plays for assessment in
Region III, Colorado Plateau and Basin and Range
as of October 4, 1993
1995 National Assessment of Oil and Gas

compiled by

D.L. Gautier¹ and K.L. Varnes ¹

Open-File Report 93-596-C

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

¹ U.S. Geological Survey
Denver, Colorado

1993

Plays for assessment in
Region III, Colorado Plateau and Basin and Range
as of October 4, 1993
1995 National Assessment of Oil and Gas

compiled by

D.L. Gautier and K.L. Varnes

The U.S. Geological Survey periodically makes appraisals of the undiscovered oil and gas resources of the Nation. For the 1995 National Assessment the onshore areas and adjoining State waters of the Nation have been divided into eight Regions which are subdivided into 72 provinces. Regions II through VIII comprise the Lower 48 States; Alaska comprises Region I. A map at scale 1:5,000,000 showing the boundaries of Regions II through VIII for this assessment has been released in open file (Dolton, G.L., Varnes, K.L., Gautier, D.L., and Baird, J.K. compilers, 1992, Oil and gas assessment areas, 1992, Lower 48 States: U.S. Geological Survey Open-File Report 92-696, scale 1:5,000,000).

The provinces and assigned Province Geologists for Region III are listed in Table 1. The basic assessment unit is the play. Table 2 lists the plays considered at this time (October 1993) in Region III, the Colorado Plateau and Basin and Range. Descriptions of the plays follow; in virtually all cases these descriptions are written by the indicated Province Geologist (Table 1).

Because this National assessment is currently in progress, these listings and descriptions are preliminary. The plays and/or their names may change as work progresses, some plays may be added, and other plays may be dropped. The descriptions may also change. The plays, play names, and descriptions may or may not duplicate plays appraised in previous National assessments.

	Page
Table 1. List of Provinces and Province Geologists in Region III.....	2
Table 2. List of Plays, Region III.....	3
Descriptions of Plays.....	5

Table 1. List of Provinces and Province Geologists in Region III, Colorado Plateau and Basin and Range

Prov.	Province Name	Province Geologist(s)	Telephone Number	Telephone Number
17	Idaho - Snake River Downwarp	J.A. Peterson	(406) 542-2087	
18	Western Great Basin	Barker, C.E.	(303) 236-5797	
19	Eastern Great Basin	Peterson, J.A., and Grow, J.A.	(406) 542-2087	(303) 236-5754
20	Uinta - Piceance Basin	Spencer, C.W.	(303) 236-5761	
21	Paradox Basin	Huffman, A.C.	(303) 236-1543	
22	San Juan Basin	Huffman, A.C.	(303) 236-1543	
23	Albuquerque - Santa Fe Rift	Molenaar, C.M.	(303) 236-5732	
24	Northern Arizona	Butler, W.C., and Palacas, J.G.	(303) 236-5759	(303) 236-9383
25	Southern Arizona - Southwestern New Mexico	Butler, W.C.	(303) 236-5759	
26	South-Central New Mexico	Butler, W.C.	(303) 236-5759	

Table 2. List of plays for consideration, Region III, Colorado Plateau and Basin and Range

Prov.	Play No.	Play Name
17	1700	unassigned
17	1701	Miocene Lacustrine (Bruneau Lake)
17	1702	Pliocene Lacustrine (Idaho Lake)
17	1703	Pre-Miocene
17	1704	Older Tertiary
18	1800	unassigned
18	1801	Hornbrook Basin-Modoc Plateau
18	1802	Eastern Oregon Neogene Basins
18	1803	NW Nevada and SE Oregon, Permian-Triassic Source Rocks
18	1804	NW Nevada Basin and Range Type Basins Deep Neogene-Recent Burial of a Cretaceous Source Rock
18	1805	NW Nevada Basin and Range Type Basins Deep Neogene-Recent Burial of a Miocene to Recent Source Rock
19	1900	unassigned
19	1901	Unconformity "A"
19	1902	Late Paleozoic
19	1903	Early Tertiary - Late Cretaceous Sheep Pass and Equivalents
19	1904	Pre-volcanics Unconformity
19	1905	Younger Tertiary Basins
19	1906	Late Paleozoic-Mesozoic Thrust
20	2000	unassigned
20	2001	Tertiary Conventional Gas
20	2002	Tertiary Wasatch-Green River Shallow Oil
20	2003	Upper Cretaceous Conventional Gas
20	2004	Upper and Lower Cretaceous Dakota and Associated Rocks
20	2005	Regional Permo-Penn Sandstone Pinchouts
20	2006	Tertiary Duchesne Formation Asphaltic Oil and Gas
20	2007	Tight gas
20	2008	Deep Tertiary oil and gas
20	2009	Cretaceous Fractured Marine Shale
20	2010	Jurassic Sandstones
20	2011	Triassic Sandstones and Conglomerates
20	2012	Pennsylvanian Carbonates and Sandstones
20	2013	Mississippian Carbonates
20	2014	Basin Margin Subthrusts
21	2100	unassigned
21	2101	Buried Fault Blocks, Older Paleozoic
21	2102	Porous Carbonate Buildup
21	2103	Fractured Interbed
21	2104	Silverton Fan-Delta
21	2105	Salt Anticline Flank
21	2106	Permo-Triassic Unconformity
21	2107	Ferron Sandstone
22	2200	unassigned
22	2201	Porous Carbonate Buildup
22	2202	Fractured Interbed
22	2203	Silverton Fan-Delta Play
22	2204	Entrada
22	2205	Central Basin Dakota Gas
22	2206	Basin Margin Dakota Oil
22	2207	Gallup Sandstone Oil
22	2208	Mancos Fractured Shale
22	2209	Central Basin Mesaverde Gas
22	2210	Basin Margin Mesaverde Oil
22	2211	Pictured Cliffs Gas
22	2212	Fruitland-Kirtland Fluvial Sandstone Gas
23	2300	unassigned
23	2301	Albuquerque Basin
23	2302	Hagan - Santa Fe Embayment
23	2303	Espanola Basin
23	2304	San Luis Valley Tertiary Biogenic Gas
23	2305	San Juan Sag

Table 2. List of plays for consideration, Region III, Colorado Plateau and Basin and Range

24	2400	unassigned
24	2401	Hurricane Fault/Uinkaret Plateau
24	2402	Oraibi Trough
24	2403	Precambrian Chuar Group
24	2404	Holbrook Basin Anticline
24	2405	Holbrook Basin Petrified Forest Stratigraphic
25	2500	unassigned
25	2501	Alamo Hueco Basin
25	2502	Pedregosa Basin
25	2503	Continental Tertiary Basins
25	2504	Altar/San Luis Marine Basin
26	2600	unassigned
26	2601	Zuni Basin Coal-bed Methane
26	2602	Orogrande Basin
26	2603	Mesilla -Mimbres Basins

Descriptions of Plays to be Considered
Region III, Colorado Plateau and Basin & Range

Province 17. Idaho - Snake River Downwarp

Play 1701 Miocene Lacustrine (Bruneau Lake)

Play based on the presence of as much as 5-7,000 feet or more of primarily lacustrine lignitic shale, clay, sandstone, diatomite, oolitic limestone, ash, tuff, and lava flows of Miocene age primarily in the southwest part of the Snake River downwarp. Reservoirs are alluvial and lacustrine sandstones, and fractured oolitic and algal carbonates. Traps are fault blocks, folds, and stratigraphic traps. Source rocks are organic-rich lacustrine shale, possibly oil shale, lignitic and carbonaceous shales or coal.

Play 1702 Pliocene Lacustrine (Idaho Lake)

Play based on the presence of as much as 7-9000 feet of lacustrine clay, sandstone, conglomerate, algal and oolitic limestone, ash, tuff, and basalt of Pliocene age in the southwestern part of the Snake River downwarp. Reservoirs are alluvial and lacustrine sandstone, conglomerate, and oolitic or algal carbonates. Traps, source rocks, etc., are similar to that of the Miocene Lacustrine play (1701), except of Pliocene age.

Play 1703 Pre-Miocene

Play based on possible traps and reservoirs of Paleozoic and Mesozoic Cordilleran facies in extensions of the Laramide thrusts beneath the downwarp fill in the northeast part of the Snake River downwarp.

Play 1704 Older Tertiary

A hypothetical play based on the possible presence of a thick section of older Tertiary rocks in the southwest part of the Snake River downwarp. Regional projections suggest that this section may be present, but it has not been drilled.

Province 18. Western Great Basin

Play 1801 Hornbrook Basin-Modoc Plateau

A conceptual play based on Cretaceous or Tertiary terrestrial or marine source rocks that are buried beneath Paleogene sedimentary rocks and (or) Cascade volcanics in the Hornbrook Basin-Modoc Plateau area. Reservoir formations include Cretaceous and Tertiary sandstones and fractured Cascade volcanics or pyroclastics. Seals consist of overlying or

draping mudstones; well-cemented sandstones or diagenetically altered or Neogene tuffs. Traps are large antiforms expressed at the surface in the volcanic flows, Basin and Range type block faults or normal faults cutting interbedded reservoir and seal rocks, and mud-rock draped offshore bars and shoreline facies. Source rocks are Type III or II in the Cretaceous rock or Type III in the Tertiary rocks. Thermal maturity is marginal, mostly less than 0.7% mean random vitrinite reflectance. Some biogenic gas shows but no production.

Play 1802 Eastern Oregon Neogene Basins

A conceptual play in the Harney, Malheur Basins, and other eastern Oregon Neogene basins based on present day deep and moderate burial of known Neogene type III and possibly Type I (lacustrine) source rocks. Reservoir formations include fractured Neogene welded tuff and basalt, and Miocene fluvial sandstone intercalated with basalt, and upper Miocene and younger fluvial sandstones. Stratigraphic traps where porous reservoirs are encased in carbonate and zeolite-cemented sandstones, and where local lenticular sandstones grade into mudrock. Diatomite-rich sequences may be poor seals and enable gas to escape to the atmosphere as its forms. Traps are formed by fault truncation of reservoir rocks, local anticlines with closure, open fracture nets in basalt and ignimbrite, fluvial sandstone lenses between basalt flows, and local porous diatomite-rich lenses. Seals are formed by reservoir pods formed by fractured volcanic lithologies and porous fluvial sandstone in densely cemented sedimentary and volcanic strata. Source rocks are Neogene (6-14 Ma) coals and carbonaceous lake rocks. No known vitrinite measurements but surface coals are lignite rank. Organic-rich rocks may be thermally mature in the subsurface. Shows of gas, but no production.

Play 1803 Permian-Triassic source rocks, NW Nevada and SE Oregon

A conceptual play based on present-day deep burial of Permian-Triassic source rocks in Basin and Range type basins in NW Nevada and SE Oregon. Play based on speculation that on some fault blocks the Permian-Triassic rocks may have petroleum generation potential that was preserved until now when they are deeply buried and heated. Any earlier hydrocarbon generation from these rocks presumed lost due to tectonic disruption of traps. Reservoir formations include Permian to Triassic sandstones and limestones and overlying basin-margin alluvial fans and fractured volcanic rocks. Traps are formed by drag folds and(or) truncation related to imbricate thrust sheets and fault truncation at Neogene basin margins. Seals are draping or overlying mudrocks and faults. Source rocks are marine Permian to Triassic shales. Conodont alteration index mapping by Harris et al (1980) shows

locally preserved hydrocarbon generation potential in the Augusta and Clan Alpine Mountains but other areas of NW Nevada overmature. Shows of gas, oil in fossils, but no production.

Play 1804 Cretaceous source rocks, NW Nevada

A conceptual play based on deep Neogene to Recent burial of Cretaceous source rocks in NW Nevada Neogene basins. This play considers any Neogene to Recent basins with deep valley fill to be conceptually prospective (based on conclusions of Barker and Peterson, 1990). Reservoir formations include lacustrine beds laterally interbedded with marginal alluvial fans or sandstones interbedded with the Cretaceous lacustrine beds and fractured Tertiary volcanic rocks maybe present. Trapping mechanisms are fault truncation of reservoir rocks; mud-stone draped lenticular sandstones and Neogene lacustrine beds laterally interbedded with marginal alluvial fans-- (overlying seal= continental evaporites, lateral seal= fault truncation). Cretaceous source rocks are apparently locally mature and have produced oil and gas shows but no discoveries. Thermal maturation may also occur by heating of source rocks by geothermal convection, shallow intrusions, fluid flow up basin faults especially near the graben boundaries. All source rocks may be mature to overmature in high heat flow and geothermal areas.

Play 1805, Neogene source rocks, NW Nevada and Eastern California

A conceptual play based on deep Neogene to Recent burial of Miocene to Recent source rocks in NW Nevada and Eastern California Neogene basins. This play considers any Neogene to Recent basins with deep valley fill to be conceptually prospective (based on conclusions of Barker and Peterson, 1990). Reservoir formations include lacustrine beds laterally interbedded with marginal alluvial fans and fractured Tertiary volcanic rocks maybe present. Trapping mechanisms are fault truncation of reservoir rocks; mud-stone draped lenticular sandstones and Neogene lacustrine beds laterally interbedded with marginal alluvial fans-- (overlying seal= continental evaporites, lateral seal= fault truncation). Tertiary source rocks are apparently locally mature and have produced oil and gas shows but no discoveries. Tertiary to Recent lacustrine rocks are immature when encountered in non-geothermal wells at shallow depth. Thermal maturation may also occur by heating of source rocks by geothermal convection, shallow intrusions, fluid flow up basin faults especially near the graben boundaries. All source rocks may be mature to overmature in high heat flow and geothermal areas.

Province 19. Eastern Great Basin

Play 1901 Unconformity "A"

Play based on the unconformity seal (Unconformity "A") at the base of the basin valley fill, overlying early Paleozoic to middle Tertiary reservoir rocks of varied lithology - marine carbonates, sandstones and siltstones, and other fractured beds, and fractured volcanics. Traps are folds, faulted folds, block-faulted structures, slide blocks, stratigraphic pinchouts and buried hills beneath the valley fill.

Play 1902 Late Paleozoic

Play based on the possible preservation of Paleozoic sandstone and carbonate reservoirs in traps formed prior to late Cenozoic extensional faulting. Seals are interbedded Paleozoic shale and shaly carbonates independent of the unconformity "A" seal. Source rocks are organic-rich Mississippian, Permian, and Pennsylvanian shales.

Play 1903 Early Tertiary - Late Cretaceous Sheep Pass and Equivalents

Play based on the probable preservation of alluvial-deltaic, carbonate bank, or fractured reservoirs and traps in the lacustrine section, formed prior to Miocene and later extensional faulting and independent of the valley fill seal. Source rocks are organic-rich lacustrine oil shale or shaly limestones and siltstones of late Cretaceous-early Tertiary age.

Play 1904 Pre-volcanics Unconformity

A hypothetical play, based on the possibility that the basal beds of volcanic section may provide an effective regional seal. Potential reservoirs and source rocks are the same as those for the Unconformity "A" play (1901).

Play 1905 Younger Tertiary Basins

Play based on the expected occurrence of biogenic gas, thermal gas, and some oil in parts of the late Tertiary basin lacustrine-alluvial-volcanic beds, particularly in areas of higher heat flow.

Play 1906 Late Paleozoic-Mesozoic Thrust

Play based on the hypothesis that large thrust-generated structures may be present where Devonian or other porous carbonate or sandstone reservoirs are thrust over organic-rich Mississippian or Late Devonian source rock facies. In most cases, effective seals may be dependent on positioning beneath the unconformity "A" seal.

Province 20. Uinta - Piceance Basin

Play 2001 Tertiary Conventional Gas

A play based on stratigraphic and structural/stratigraphic traps in fluvial and lacustrine sandstone reservoirs of Tertiary age. Source rocks are underlying Tertiary Upper Mesaverde coals and organic shales.

Play 2002 Tertiary Wasatch-Green River Shallow Oil

A play based on low maturity to immature oil with moderate to high pour point (60-90°F+) with both sources and reservoirs within the Tertiary deposits and mid-to-late Tertiary generation.

Play 2003 Upper Cretaceous Conventional Gas

A play based on structural-stratigraphic, stratigraphic, and structural traps in marine and fluvial-deltaic sandstone reservoirs of the Mesaverde, Castlegate, Corcoran, Cozzette etc. Formations. The sources are from Cretaceous organic-rich shales, mudstones, and coals which are thermally mature. Generation is from Early Tertiary to present.

Play 2004 Upper And Lower Cretaceous Dakota And Associated Rocks

A play based on structural, structural-stratigraphic and stratigraphic traps in marine and fluvial sandstones and conglomerates of the Dakota and Cedar Mountain formations (including Jurassic Morrison Formation). The sources are Cretaceous organic shales, and some coaly beds with high thermal maturity. The hydrocarbon type is dominantly gas (some CO₂ expected). Generation initiated in the Late Cretaceous and continues to the present.

Play 2005 Regional Permo-Penn Sandstones Pinchouts

A play based on regional up-dip pinchouts of blanket marine and eolian sandstones of the Weber, White Rim, and Schoolhouse Formations. The thermal maturity is high; hydrocarbon type is oil and associated gas. The source rocks are not well established.

Play 2006 Tertiary Duchesne Formation Asphaltic Oil and Gas

Source rocks "very low maturity lacustrine shales". Play not well developed because of high viscosity of the oil. Gas may be biogenic or vertically migrated.

Play 2007 Tight Gas

A play based on stratigraphic, diagenetic, and water-block traps in Tertiary and Cretaceous sandstones of the Wasatch, Mesaverde, Castlegate, Neslen, Blackhawk, Ferron, Frontier, Dakota, and Cedar

Mountain Formations. The source rocks are carbonaceous shales, mudstones, and coals. The generation timing is mid-to-late Tertiary.

Play 2008 Deep Tertiary Oil and Gas (Green River And Wasatch Formations)

Play primarily stratigraphic, based on fractured fluvial and lacustrine sandstones and some carbonates. Sourced by Green River oil "shales". Reservoirs are unconventional (tight) in most of area. Maturation late Tertiary to present.

Play 2009 Cretaceous Self-Sourced Fractured Marine Shales

Fractured marine shale, siltstone, and calcareous shale. Source rock is reservoir rock. Maturation Tertiary time to present, usually associated with structure.

Play 2010 Jurassic Sandstones

Play primarily for low-relief structural traps in fluvial and eolian sandstones. Some small oil accumulations found (except significant oil at Wilson Creek field). Source beds Curtis and Carmel marine shales and Cretaceous in fault contact with sandstones. Generation Late Cretaceous to Tertiary.

Play 2011 Triassic Sandstones and Conglomerates

Minor potential, usually associated with hydrocarbon movement along faults and fractures from deeper beds.

Play 2012 Pennsylvanian Carbonates and Sandstones

Mostly minor potential to date. Associated with structure. Source beds Pennsylvanian Belden Shale and associated rocks. Known Permian-Pennsylvanian and younger paleostructure.

Play 2013 Mississippian Carbonates

Hypothetical play with probably low potential. Porous dolomites but few shows, lacks source beds over most of province. May yield CO₂.

Play 2014 Basin Margin Subthrusts

Play for Phanerozoic reservoirs on structures beneath basin margin thrusts such as south flank of Uinta uplift, west side of White River Uplift, Blue Mountain Thrust, etc.

Province 21. Paradox Basin

Play 2101 Buried Fault Blocks, older Paleozoic

This play depends on porous dolomitic intervals in the Mississippian Leadville Limestone or porous sandstones of the Devonian McCracken Sandstone being in contact with organic rich marine shales in the Leadville or Paradox Formation and sealed by evaporites. Such occurrences are most common in the vicinity of salt anticlines.

Play 2102 Porous Carbonate Buildup

This play depends primarily on the presence of algal mounds on the carbonate shelf of the Paradox evaporite basin. Porous oolitic limestones may also be associated with the mounds or may occur separately.

Play 2103 Fractured Interbed

This play is based on the presence of extensive fracturing in organic rich marine shales and associated rocks enclosed between beds of evaporites in the Paradox Formation.

Play 2104 Silverton Fan-Delta

This is a hypothetical gas play in sandstone lenses within the dominantly arkosic fan-delta emanating from the Uncompahgre highlands in the late Pennsylvanian. The play depends on the presence of organic rich marine shale.

Play 2105 Salt Anticline Flank

This play is based on the tectonic and stratigraphic pinchout of porous carbonate and sandstone reservoirs in the Hermosa and Cutler Groups against the flanks of salt diapirs. Hydrocarbons migrating up dip from the adjacent synclines are trapped against the salt or at porosity pinchouts.

Play 2106 Permo-Triassic Unconformity

This play is a down dip, non-biodegraded extension of the Tar Sand Triangle deposits. It is based on hydrocarbon migration from the west or vertically to the reservoirs of the White Rim Sandstone, Coconino Sandstone, Kaibab Limestone, or Moenkopi Formation. Both stratigraphic and structural traps have been identified.

Play 2107 Ferron Sandstone

This play is based on both stratigraphic and structural trapping in the Ferron Sandstone Member of the Mancos Shale. Most production has

been gas but play has potential for oil because of intertonguing with Mancos Shale.

Province 22. San Juan Basin

Play 2201 Porous Carbonate Buildup

This play depends primarily on the presence of algal mounds on the carbonate shelf of the Paradox evaporite basin located northwest of the San Juan Basin. Porous oolitic limestones may also be associated with the mounds or may occur separately.

Play 2202 Fractured Interbed

This play is based on the presence of extensive fracturing in organic rich marine shales and associated rocks enclosed between beds of evaporites in the Paradox Formation.

Play 2203 Silverton Fan-Delta

This is a hypothetical gas play in sandstone lenses within the dominantly arkosic fan-delta emanating from the Uncompahgre highlands in the late Pennsylvanian. The play depends on the presence of organic rich marine shale.

Play 2204 Entrada

This is a stratigraphic play based on the presence of relict dune topography on top of the eolian Entrada Sandstone. It also requires the presence of organic rich Todilto Limestone and the overlying anhydrite.

Play 2205 Central Basin Dakota Gas

This play, like all of the central basin gas plays, depends on a hydrodynamic trapping mechanism and is predominantly tight. Production is generally dependent on fracturing, both natural and induced.

Play 2206 Basin Margin Dakota Oil

This is primarily a structural or combination play with largest production from faulted anticlines. Some of this play is covered by volcanics on the northern edge of the basin.

Play 2207 Gallup Sandstone Oil

This play is based on the presence of porous lenticular marine sandstone bodies encased in organic rich marine shale. The sandstone bodies are typically long and narrow and lie above a regional

unconformity. Production has also been obtained from fluvial sandstones in contact with marine and nonmarine shales.

Play 2208 Mancos Fractured Shale

This play depends on extensive fracturing of the organic rich marine Mancos Shale on anticlinal and monoclinal structures around the eastern, northern, and western margins of the basin.

Play 2209 Central Basin Mesaverde Gas

Similar occurrences and trapping mechanisms to Central Basin Dakota Gas Play (2205). Production from Point Lookout Sandstone Menefee Formation, and Cliff House Sandstone. Designated tight in much of the basin.

Play 2210 Basin Margin Mesaverde Oil

This play is based on the intertonguing of basal Point Lookout porous marine sandstone with organic rich marine Mancos Shale. A similar situation could also occur at the contact of the Cliff House Sandstone with the overlying Lewis Shale.

Play 2211 Pictured Cliffs Gas

This play is based on the landward pinchout of nearshore marine Pictured Cliffs Sandstone into back beach and paludal facies of the Fruitland Formation. Considered tight throughout most of the basin.

Play 2212 Fruitland-Kirtland Fluvial Sandstone Gas

This is a conventional play in fluvial sandstone bodies encased in paludal coal and carbonaceous shale. Most of the gas is probably from the shale rather than the coal.

Province 23. Albuquerque - San Luis Rift

Play 2301 Albuquerque Basin

This is a structural play related to down-dropped blocks of Mesozoic and Paleozoic rocks that have been buried sufficiently for the generation of hydrocarbons. The primary objectives are Cretaceous rocks, similar to those of the San Juan basin, and secondary objectives are the Entrada Sandstone (Jurassic) and Pennsylvanian carbonates. Drilling depths in the play area are estimated to range from about 9,000 to 20,000 ft.

Play 2302 Hagan-Santa Fe Embayment

This is a structural-stratigraphic play for oil in relatively shallow Cretaceous objectives in an area only partially covered by late Tertiary synrift fill. Cretaceous rocks are mostly in the oil-generating range.

Play 2303 Espanola Basin

This is a speculative play for structural traps in Pennsylvanian carbonate reservoirs. Only about four wells have been drilled in the area and little is known about the subsurface structure and stratigraphy. Cretaceous rocks were probably removed by early Eocene erosion throughout the play area.

Play 2304 San Luis Valley Tertiary Biogenic Gas

This play is based on the many gas shows in shallow water wells in the area north and east of Alamosa. Three wells in the northern third of the San Luis Valley that penetrated the entire section found Tertiary on Precambrian.

Play 2305 San Juan Sag

This play is based on oil and gas shows in Cretaceous and igneous rocks underlying Tertiary volcanic rocks along the west side of the San Luis Valley. Problems in mapping the structure under the thick cover of volcanic rocks is one of the biggest drawbacks to this play. Drilling depths range from about 6,000 to over 13,000 ft.

Province 24. Northern Arizona

Play 2401 Hurricane Fault/Uinkaret Plateau Play

This 750-mi² oil and gas play of northwestern Arizona is hypothetical. Clastic and carbonate reservoir rocks of Devonian, Mississippian, Pennsylvanian, and Permian age may have been sourced by carbonates and mudstones of the same age. Permian gypsum and shale beds seal the reservoirs. Cenozoic drag and reverse drag folds of the Hurricane Fault, plus a southwestward up-dip migration into stratigraphic pinchouts on the Uinkaret Plateau, provide variable trapping mechanisms. Targets may range from 3,000 to 7,000 feet deep, but are most likely 4,000-4,500 feet deep.

Play 2402 Oraibi Trough Play

This 8,750-mi² Devonian oil and gas play of northeastern Arizona is based on very common hydrocarbon shows and minor production in the northeasternmost part. It lies nearly entirely on Indian land and is under-explored. Devonian deltaic sandstones off the Defiance uplift are sourced by Devonian carbonates, shales, and fine clastics and sealed

by Devonian shales, dolomites, and anhydrites. Gas-prone Mississippian and Pennsylvanian carbonates provide secondary reservoirs and source rocks. Traps include: 1) stratigraphic pinch-outs/wedge-outs to the east against the Defiance, 2) 350 miles of collective axial lengths of monoclines and anticlines, and 3) up-dip facies changes plus disconformities. Drilling depths are 3,300 to 7,200 feet.

Play 2403 Precambrian Chuar Play

This estimated 5,500-mi² oil play of north-central Arizona is hypothetical. It extends northward into Utah where extensive tar sands may be related to this deep source. In Arizona, two-thirds of the play lies on Indian lands. The 1,000+-foot-thick Walcott Member of the Chuar contains as much as 10% TOC in dark mudstones within the oil generation window and hence may have sourced superjacent Late Proterozoic clastic strata. Although the Cambrian Tapeats Ss is the best reservoir/target, many other younger Paleozoic units may have been sourced. Potential traps include Precambrian grabens plus Precambrian and Paleozoic disconformities, angular unconformities rollover anticlines, and sandstone pinchouts.

Play 2404 Holbrook Basin Anticline Play

This 550-mi² Late Paleozoic structural oil play in east-central Arizona is hypothetical. Pennsylvanian and Permian clastics and carbonates of the Horquilla Fm, Naco Group, and Supai Group are targets sourced by cyclic Pennsylvanian and Permian Naco and Supai Groups, including the dark Fort Apache Ls. Permian evaporites and Pennsylvanian-Permian porosity pinchouts provide seals along the northwest-trending 60-mile long Holbrook anticline. Maximum closure is about 250 feet. Secondary cross-trending folds and solution collapse structures also render trapping mechanisms. Numerous shows in drill core and fetid odors in outcrops indicated hydrocarbons in the system. Targets are 500 to 3,500 feet deep.

Play 2405 Holbrook Basin Petrified Forest Stratigraphic Play

This 35-mi² Late Paleozoic stratigraphic oil play of east-central Arizona (national park/monument area) is hypothetical. Intercalated clastics and carbonates of Pennsylvanian and Early Permian age, including the Horquilla, Naco, Supai, DeChelly, and Coconino groups/formations provide reservoirs sourced by cyclic Pennsylvanian and Permian units. Supai evaporites and porosity pinchouts seal reservoirs. Rapid facies changes and updip pinchouts northeastward against the Defiance uplift

plus unconformities make potential stratigraphic traps; secondarily, Laramide anticlines may likewise define accumulations. Targets are 500 to 4,000 feet deep.

Province 25. Southern Arizona - Southwestern New Mexico

Play 2501 Alamo Hueco Basin Play

This 575-mi² Late Paleozoic oil and gas play in southwestern New Mexico is hypothetical. Possible reservoirs of shelf slope/margin porous dolostones and algal mounds (Horquilla Ls), plus sandy clastics (Earp Fm), all of Pennsylvanian and Early Permian age, were probably sourced by thick, deep-basin mudstones/shales and dark limestones and shelf reef carbonates. Seals include tight facies including evaporites. Hydrocarbons may have migrated northward updip into phylloid algal mounds and folds associated with basement-cored uplifts. Late Paleozoic folds and Laramide imbricate thrusts and other structures provide abundant traps which may be as deep as 30,000 feet.

Play 2502 Pedregosa Basin Play

This 1,500-mi² Late Paleozoic oil and gas play of southeastern Arizona is hypothetical. Reservoirs are marine shelf carbonate bands plus tidal flat and deltaic siltstones and sandstones of Late Paleozoic age. Permian evaporites and fine-grained clastics and tight carbonates of Pennsylvanian-Permian age trap hydrocarbons in a very diverse structural setting which includes unconformities, folds, and thrust faults. Multiple episodes of deformation from Precambrian into Mesozoic time along the northwest-trending Texas lineament mega-shear, plus Tertiary Basin and Range block-faulting, have created and destroyed traps. Targets can be found at 6,000- to 17,000-foot drilling depths.

Play 2503 Continental Tertiary Basins Play

This 3,650-mi² Basin-and-Range oil and gas play of southeastern Arizona is hypothetical. Seven continental/lacustrine basins, some having basement floors at -10,000 feet below sea level, contain alluvial/fluviol/playa/dune reservoirs of thick siltstones and sandstones. Source rocks are lacustrine units, including marly stromatolitic limestones, evaporites and mudstones of Oligocene-Miocene age. Some deep Paleozoic carbonates and shales may also source superjacent units in these grabens. Seals of fine clastics and evaporites potentially trap hydrocarbons in stratigraphic pinchouts and along unconformities. Accumulations can be from a few hundred feet to over 12,500 feet deep.

Play 2504 Altar/San Luis Basin Play

This 400-mi² marine Tertiary basin play of south westernmost Arizona is hypothetical. Miocene and Pliocene strata of the deep, euxinic proto-Gulf of California provide reservoirs of bedded volcanics, coarse-to-fine clastics, and carbonates. The shales and carbonates have high TOC content and are potential oil and gas source rocks. Tertiary evaporites and permeability pinchouts probably trap hydrocarbons in folds and along listric normal faults. Although poorly documented, very significant shows occur in Eocene to Pleistocene strata, e.g., south in Mexico. Drilling depths are probably from 500 to 15,000 feet.

Province 26. South-Central New Mexico

Play 2601 Zuni Basin Coalbed Methane Play

This 550-mi² play in east-central New Mexico is hypothetical. Anomously-high late Cenozoic heat flow has generated gas from the Upper Cretaceous thin coal beds (mostly sub-bituminous and some high-volatile) and highly carbonaceous clastics of the Dakota Ss, Mancos Sh, Gallup Ss, and Mesaverde Group. In situ gas is derived from these reservoirs, plus possibly from coal beds of the Crevasse Canyon, Dilco, and Moreno Hill formations. These units are down-dropped in a basalt-capped rift basin where marginal folds and fractured but primarily impermeable carbonaceous beds may enhance accumulation. Northward updip migration may have occurred toward the Zuni Mountains. Targets are 250-2,000 feet deep.

Play 2602 Orogrande Basin Play

This 10,000-mi² Late Paleozoic oil and gas play of south-central New Mexico is hypothetical. Nearly half the play is on military land and is under-explored. Reservoirs include quartz sandstones but mostly various dark, fetid porous carbonates, including algal mounds, biostromes, and reefs, of Mississippian through Permian age. Thick brown to black shales, algal reefs/bioherms, and other dark carbonates of the same age may have sourced reservoirs sealed by gypsum and tight carbonate beds. Devonian and Mississippian dark shales may also be potential source rocks. Northward formational wedge-outs, unconformities, porosity pinchouts, organic buildups, and a multitude of folds and faults could act as traps at depths of 2,000 to 20,000 feet.

Play 2603 Mesilla-Mimbres Basins Play

This 2,600-mi² gas play in the frontier area of southwestern New Mexico is hypothetical. One to two-thousand feet of Ordovician, and possibly Silurian, carbonates plus Upper Cambrian sandstones have

demonstrated excellent gas shows at nearly 21,000-foot drilling depths. The Ordovician carbonates (El Paso and Montoya Dolomite Groups) are likely source rocks. Seals are impermeable carbonates. Traps are fractured and vuggy dolomites, stratigraphic porosity pinchouts, disconformities, plus commonplace Late Paleozoic and Laramide folds and faults, including thrusts. Drilling depths are 5,000 to 24,000 feet.