OIL AND GAS OCCURRENCE AND POTENTIAL IN ARIZONA

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Drill rig near Florence, deepest well in AZ 18,013 ft
1,127 oil/gas exploratory wells have been drilled in Arizona.
Generalized Geologic Map Of Arizona

SW-NE cross-section of Arizona
PRODUCTION HISTORY

21 million barrels oil
31 billion cubic feet natural gas
10 billion cf gas with 8% helium
378 thousand cubic feet of CO2
Production of oil, gas in the Paradox Basin (in barrels oil, mcf gas) and CO2/helium in the Holbrook Basin.
Oil/Gas Fields Location Map

Locations & Names of Oil/Gas Fields
Paradox Basin stratigraphy
and producing intervals

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>FORMATION</th>
<th>Lithology</th>
<th>MEMBER</th>
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<tr>
<td>TRIASSIC</td>
<td>Chinle Fm.</td>
<td>Shinarump Mbr.</td>
<td>DeChelly Ss.</td>
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<td></td>
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<td>middle member</td>
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<td></td>
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<td>lower member</td>
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<td>PERMIAN</td>
<td>Cutler Fm.</td>
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<td>PENNSylvanian</td>
<td>Hermosa Gp.</td>
<td>Paradox Fm.</td>
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<td></td>
<td>Molas Fm.</td>
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<td></td>
<td>Leadville Ls.</td>
<td>Ouray Ls.</td>
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<td>MISSISSIPPIAN</td>
<td>Elbert Fm.</td>
<td>McCracken Ss. Mbr.</td>
<td>Aneth Fm.</td>
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<td>DEVO-NIAN</td>
<td>Tapeats Ss.</td>
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Pennsylvanian Hermosa Group

Paradox Basin stratigraphy and producing intervals
### Mississippian Redwall (Leadville) Limestone

Paradox Basin producing intervals by field
Location of Dineh-bi-Keyah Field
NE-SW cross section of Dineh-bi-Keyah Field. Producing interval is an igneous sill in Pennsylvanian limestone.
AREAS OF POTENTIAL OIL AND GAS PRODUCTION

- Marine sedimentary rocks
- Oil & gas shows
- Structural and stratigraphic traps
- cf. adjacent areas of production
AREAS OF POTENTIAL OIL AND GAS PRODUCTION

- Paradox Basin
- Chuar Basin
- Cordilleran Shelf
- Black Mesa Basin
- Holbrook Basin
- Pedregosa Basin
- Bisbee Basin
- Salton Trough
Potential Areas

Total thickness of Paleozoic rocks

Contour Interval = 500 feet
Upper Paleozoic section at Grand Canyon

Contour interval = 500 ft

Thickness of upper Paleozoic rocks
 Thickness of lower Paleozoic rocks

Devonian Martin Formation, central Arizona
BLACK MESA BASIN

- Paleozoic marine rocks
- Lower Paleozoic pinchouts
- Mesozoic basin/shelf/shore deposits
- Laramide folds
- Coalbed methane potential
- Untested by drilling
  
  cf. Paradox, San Juan, Uinta basins
  Navajo Ss. production in S. Utah
Potential Areas:
Black Mesa Basin

Geologic Map of Arizona:
Cretaceous outcrop area
Aerial of Black Mesa - Jurassic to Cretaceous

Cross Section of Black Mesa
Cross Section: Cretaceous of Western Interior

Cretaceous paleogeography
Coal in Wepo Formation: methane potential

Cretaceous strata: Black Mesa Basin
Cretaceous total coal isopach, Black Mesa

Cretaceous stratigraphic section of Black Mesa
Jurassic Navajo Sandstone

Generalized cross section:
Grand Canyon to Black Mesa
CORDILLERAN SHELF AND CHUAR BASIN

- Pz marine rocks thicken to west
- Oil shows north of Grand Canyon
- Production in Utah and Nevada
- 12,000 ft. - well planned near Kingman
- Oil rich Chuar Group rocks in Grand Canyon
Paleozoic Cordilleran Shelf & Proterozoic Chuar Basin
Permian Kaibab Formation

Pennsylvanian-Permian Supai Group
Mississippian Isopach, CI= 250 ft.

Pennsylvanian Isopach, CI=250 ft

Mississippian Redwall Ls.; Cambrian Muav Ls. & Bright Angel Sh.
Proterozoic Chuar Group in Grand Canyon (note scale change)
HOLBROOK BASIN

- Thick Pennsylvanian-Permian marine strata
- Thick evaporite sequence (cf. Permian Basin)
- Oil shows in numerous test wells
- Helium/CO2 production
- Pinchouts of lower Pz strata at Defiance Uplift
Holbrook Basin

Permian Fort Apache Ls
CURRENT ACTIVITY IN HOLBROOK BASIN

- CO2/helium drilling by Ridgeway-Arizona Petroleum Corporation
- CO2 (80-90%) and He (0.1-0.8%)
- 28 wells in AZ, 8 in NM
- 17 temporarily abandoned, 1 produced CO2
- CO2 development plan in progress
- Salt cavern storage of LPG
PEDREGOSA BASIN

- Thick Paleozoic marine (cf. Permian Basin)
- Oil/gas recovered in drillstem tests
- Effect of Basin & Range faulting (?)

cf. Grant Canyon, Eagle Springs fields in Nevada
Potential Areas:
Pedregosa Basin (Paleozoic)
Bisbee Basin (Mesozoic)
Oil and gas shows in wells:

- Horquilla Ls. Martin Fm.
- Horquilla Ls.
- Martin Fm.
- Horquilla Ls.
- Martin Fm.
Stratigraphic column: SE AZ and Permian Basin

Paleozoic section near Naco
BISBEE BASIN

• Thick Cretaceous marine section
• Reefs and organic basin sediments
cf. Golden Trend of Mexico
• Effect of Basin & Range faulting?
Cross section of Cretaceous rocks, SE AZ
Mural Limestone reef

Reef matrix of rudistids and corals
Geologic Map of AZ

Basin & Range structure with normal & thrust faults
SALTON TROUGH

• Cenozoic marine sediments
• Gas in Gulf of Mexico
• Updip pinchout of marine sands
• San Andreas fault effect?

  cf. basins of southern California
Potential Areas: Salton Trough

Structure map: San Luis Basin
Stratigraphic Column:
Cenozoic of San Luis/Altar Basin

Map: Tectonic relationships with southern California
GAS STORAGE DEVELOPMENT

LPG/ GAS STORAGE IN SALT SOLUTION CAVERNS:
- 86 mm gallons in Holbrook Basin
- 156 mm gallons in Luke Basin

POTENTIAL FOR MORE LPG/GAS
Holbrook, Picacho, etc.

STRATEGIC PETROLEUM RESERVE

POTENTIAL FOR COMPRESSED AIR ENERGY STORAGE (CAES)
Germany, Alabama, Ohio

UA proposed development in AZ

Green pattern = known salt deposits
Red pattern = potential salt deposits
GEOTHERMAL POTENTIAL

Yellow areas = known geothermal areas of low to moderate temperatures
HOT SPOTS FOR OIL/GAS DRILLING, 1980s
OVERTHRUST BELT ACROSS ARIZONA?

- SEISMIC SECTION
- POTENTIAL AREAS MAP
9 wells drilled on overthrust play, incl. 18,013 ft test near Florence.
PRICE FOR 42 GALLON BARREL OF OIL

WESTERN'S (GIANT'S) WEEKLY POSTED PRICE FOR PARADOX BASIN SWEET IN $/BBL

January, 2002

$20/barrel

January, 2008

$100/barrel

$106 Today