# Carbon Dioxide in the St. Johns - Springerville Area, Apache County, Arizona

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## Introduction

The St. Johns - Springerville area consists of about 700 $mi^2$ including Townships 9 through 12 North and Ranges 28 through 31 East in Apache Co., Arizona, and Townships 1 South through 3 North and Ranges 19 through 21 West in Catron Co., New Mexico (Figure 1). The graveled Salt Lake road between St. Johns and Salt Lake, New Mexico, and paved U.S. Highway 180/191 between St. Johns and Springerville, and U.S. Highway 60 between Springerville and Socorro, New Mexico, generally define the north, west, and south boundaries of the area.

In December 1998, Ridgeway Arizona Oil Corporation (Ridgeway) reported that it had leased about 400,000 acres in the area in connection with its carbon dioxide ($CO_2$) project. Acreage is mostly state and private land in Arizona and mostly federal land in New Mexico.

The St. Johns - Springerville area lies in the high plateau country of east-central Arizona. Elevations range from 5730 ft at St. Johns to 7810 ft at Coyote Peak to about 7000 ft at Springerville. The terrain is relatively flat with numerous low, grassy hills and patches of juniper and lesser patches of pinyon pine. The area around Springerville contains some of the finest high altitude grazing land in Arizona.

The St. Johns - Springerville area lies in the rain shadow of the high, pine-covered Mogollon Rim and White Mountains. Average precipitation is about 11 inches per year, and is generally light, widespread and long-lasting snow in winter but spotty and brief thundershowers in the summer. The numerous unimproved access roads are frequently washed out and in many places turn into impassable heavy, sticky mud during the brief summer thundershowers and after snow melts.

Summer temperatures are generally pleasant, ranging from 65 to 75° F. Winter temperatures generally range from 30 to 40° F and temperatures as low as 0° F are not uncommon.

Two major coal-fired electric power plants are located in the region. The Salt River Project plant is just north of the area in Section 33, T. 14 N., R. 29 E. The Tucson Electric Power (TEP) plant is centrally located in the area in Section 28, T. 11 N., R. 30 E. The TEP plant has been included in several proposed options for the processing and development of $CO_2$ in the area.

## Stratigraphy

Permian, Triassic, Cretaceous, Tertiary, and Quaternary rocks are exposed in the area. Surface rocks are mainly Triassic redbeds near St. Johns and Tertiary to Quaternary sedimentary

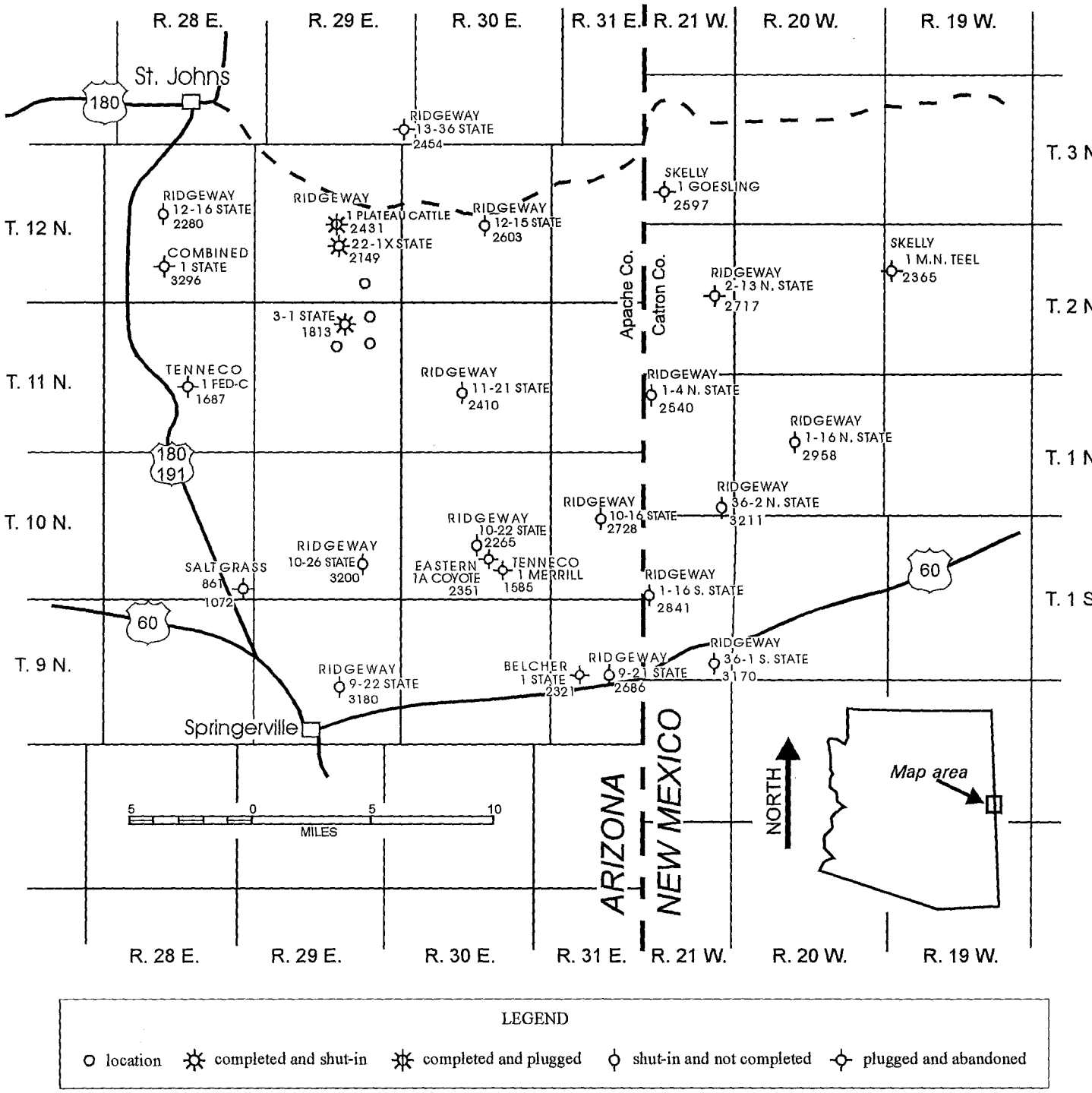


Figure 1. Location of wells in the St. Johns - Springerville area, showing operator, well number and lease, total depth in feet, and status as of March 1999.

and volcanic rocks near Springerville (Kamilli and Richard, 1998; Sirrine, 1956, Plate 6). The volcanic rocks near Springerville are part of the widespread Springerville volcanic field, which lies just north of the volcanic White Mountains. Pink-orange Precambrian granite underlies the Permian rocks at depths between 2200 to 3200 ft. General stratigraphy is shown in Figure 2.

Permian strata include San Andres Limestone, Glorieta Sandstone, and the Supai Formation. The Supai Formation of Winters (1963) is used here.

The San Andres Limestone of New Mexico and the Kaibab Formation of Arizona are both present in east-central Arizona based on contrasting paleogeographic position, lithology, and fauna (Akers, 1964, p. 23; Peirce and Wilt, 1970, p. 71-72; Peirce, 1976, p. 50; Aldrich and others, 1986, p. 106). The Salt River Lineament of Peirce (1986, Figure 1) appears to have influenced the transition between the two contrasting realms (Peirce, 1989, Figure 1 and p. 363). The Permian carbonate beneath Triassic strata in the St. Johns - Springerville area is within the domain of the San Andres Limestone of New Mexico and eastern Arizona (Rauzi, 1994, Plates 4 and 5).

The San Andres Limestone is gray-brown, finely crystalline, and locally fractured and cavernous in the St. Johns - Springerville area. Lost circulation is common. Incipient karst is indicated by numerous closed elevation contours on surface topographic maps. The San Andres Limestone is generally 250 to 350 ft thick in the area. Correlation of the top of the San Andres Limestone is difficult because solution collapse breccia is common at the top of the unit.

The Glorieta Sandstone is predominately white to gray, very fine to fine grained, well sorted, and friable to unconsolidated in the St. Johns - Springerville area. The large-scale cross bedding common to the Coconino Sandstone is not observed in the available conventional core of the Glorieta Sandstone. Lost circulation is not uncommon. The Glorieta is an important aquifer in the region that produces carbonated water in some wells. Lost circulation in the Glorieta Sandstone may be due in part to reduced water levels in the unit caused by years of groundwater withdrawal. The Glorieta Sandstone is 180 to 273 ft thick in the area. Extension of the Salt River Lineament of Peirce (1986, Figure 1) is used to mark the approximate transition between Coconino Sandstone to the west and Glorieta Sandstone to the east (Rauzi, 1994, Plates 6 and 7).

The terminology used by Winters (1963, p. 9) to define the widely exposed Permian Supai Formation in the Fort Apache region is readily applied to subsurface wireline log correlation of the Supai Formation in the St. Johns - Springerville area. From the top, it consists of the Corduroy, Fort Apache, Big A Butte, and Amos Wash Members. This rock grouping contains the Yeso and Abo Formation equivalents in adjoining New Mexico.

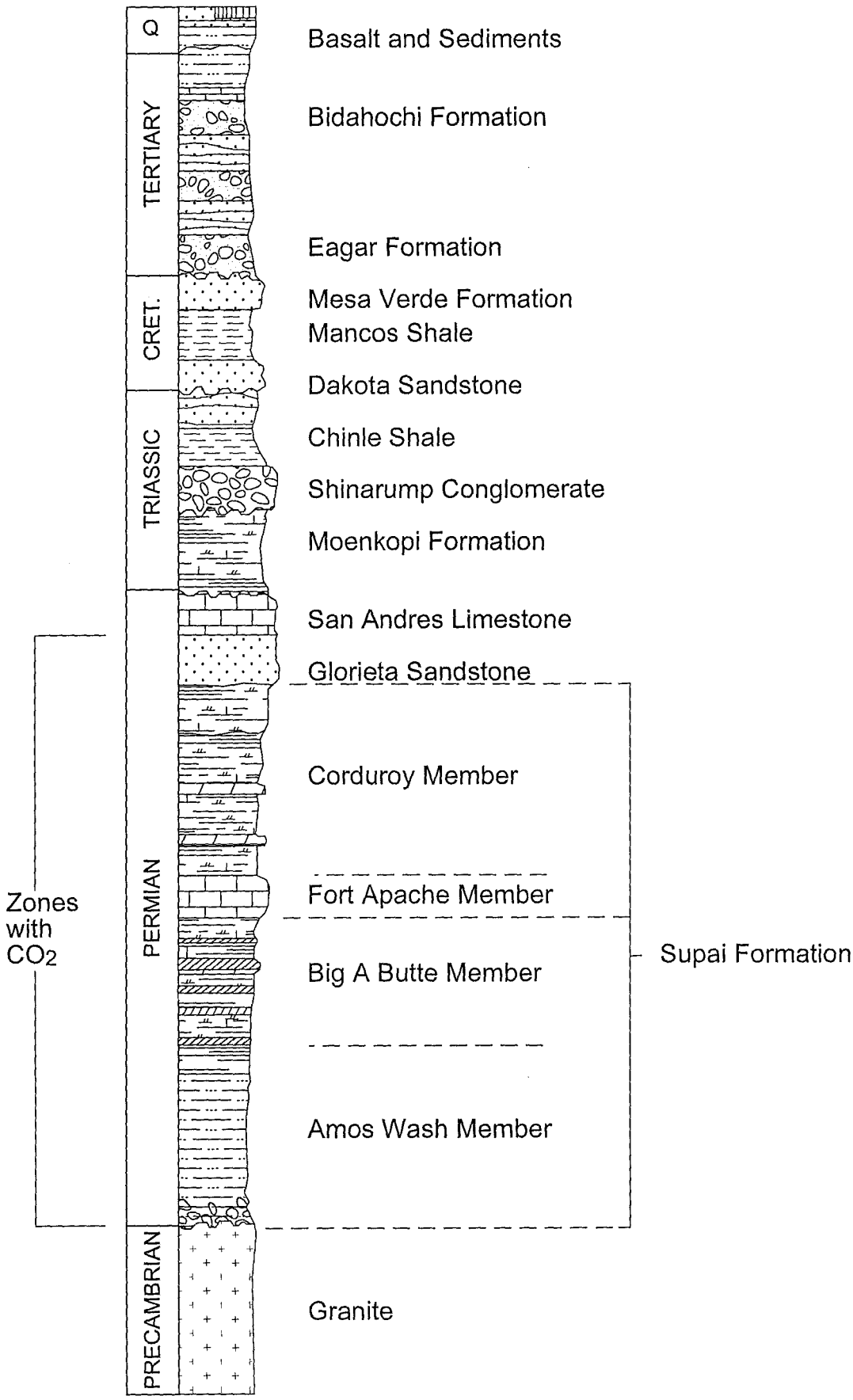


Figure 2. General Stratigraphy in Southern Apache County, Arizona. The Supai rock grouping contains the Yeso / Abo Formation equivalents in adjoining New Mexico.

The Corduroy Member of the Supai Formation consists of very fine-grained, red-bed clastics interbedded with thin anhydrite and carbonate beds. Friable to unconsolidated water sands are locally present at the base of the Corduroy Member. Logs indicate that 3 to 5 ft of salt may be present in the northern part of the mapped area. Depth to the top of the Corduroy Member varies from 640 to 1632 ft. The Corduroy Member is 596 to 756 ft thick in the mapped area.

The Fort Apache Limestone Member of the Supai Formation is a distinctive marker unit that can be regionally traced throughout central and east-central Arizona (Winters, 1963, p. 10; Gerrard, 1966, p. 2441 and 2444; Peirce, 1989, p. 366). In the subsurface, the base of the Fort Apache Member is easily picked in well logs because it is characterized by a distinctive gamma ray log curve break (Figure 3). It is an important subsurface correlation horizon in central and east-central Arizona and western Catron County, New Mexico (Figure 4).

The Fort Apache Limestone Member generally consists of an upper anhydrite with anhydrite-laminated red-brown siltstone to very fine grained sandstone and lower gray-brown slightly to moderately silty vuggy to cavernous dolomite in the St. Johns - Springerville area. Depth to the top of the Fort Apache Member ranges from 1290 to 2208 ft. The Fort Apache Member is 64 to 108 ft thick, which is consistent with the regional study of Gerrard (1966, Figure 10). Available conventional core plug porosities range from 3.1 to 26.7% in the siltstone and 3.5 to 30.1% in the dolomite. Core plug permeabilities vary from .01 to .78 md in the siltstone and .01 to 232.77 md in the dolomite.

The Big A Butte Member of the Supai Formation consists of 5 thin but persistent anhydrite beds within a section of mainly red-brown siltstones and very fine grained sandstones and minor gray-brown dolomite beds. A gray, argillaceous limestone about 2 ft thick defines the base of the Big A Butte Member in the Fort Apache region (Winters, 1963, p. 10). The lowest anhydrite or carbonate bed also marks the base of the Big A Butte Member in the St. Johns - Springerville area. Ridgeway refers to one of the anhydrite beds in the Big A Butte Member as the Raven marker. Depth to the top of the Big A Butte Member varies from 1368 to 2370 ft. The Big A Butte Member is 266 to 416 ft thick over the mapped area. Conventional core plug porosities range from 4.7 to 30.3% in the very fine grained clastics and 0.4 to 21.5% in the dolomite. Core plug permeabilities vary from <.01 to 312.44 md with one plug reading as high as 1618.65 md in the very fine grained sandstone and <.01 to 19.2 md in the dolomite.

The Amos Wash Member of the Supai Formation consists of red to maroon mudstones, siltstones and very fine grained sandstones with patches or channel fills of conglomerate and granite wash at its basal, unconformable contact with pink-orange Precambrian granite. Purple-green highly fractured, deeply weathered and altered igneous rock underlies the Amos Wash

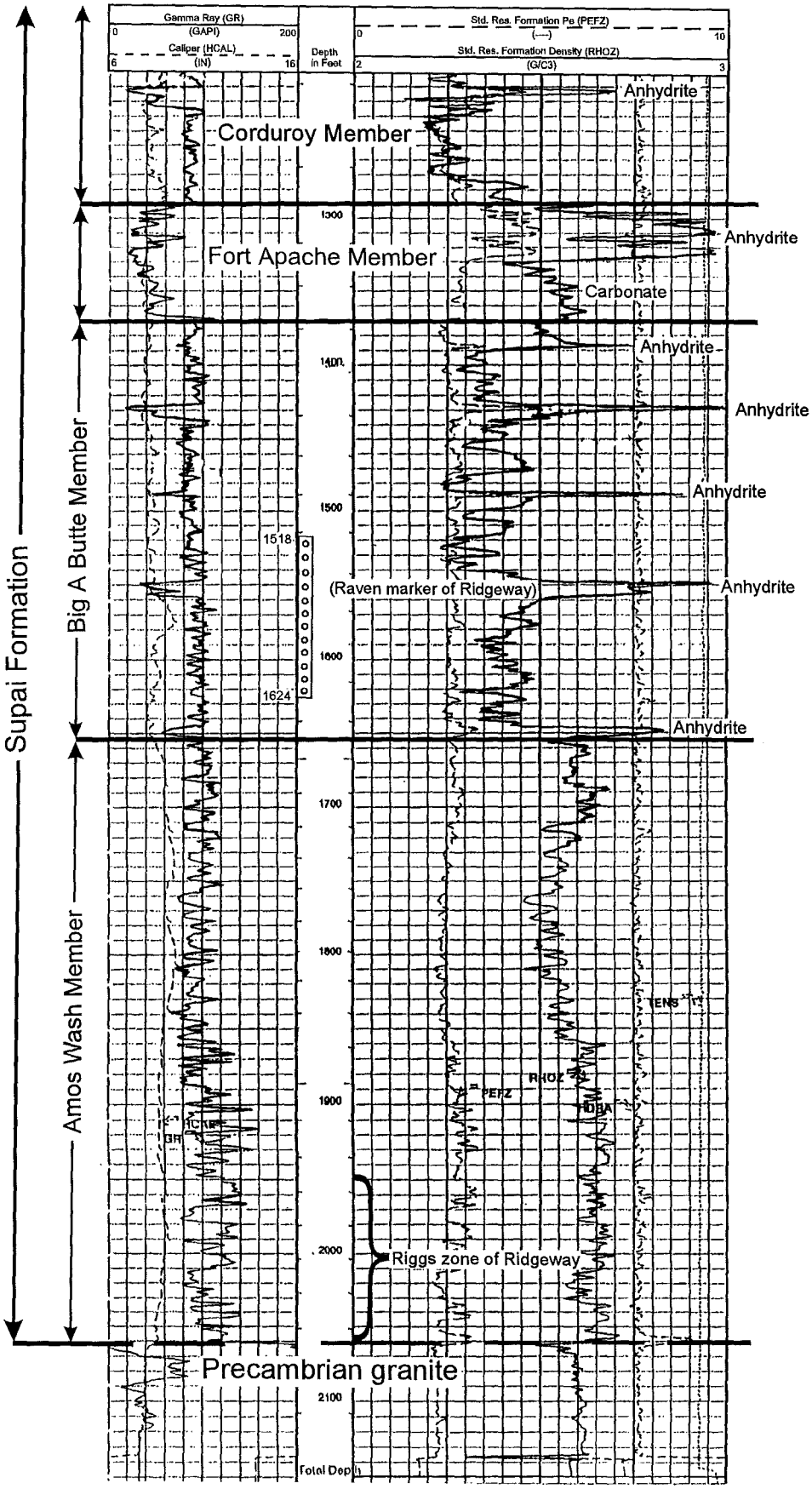


Figure 3. Gamma-ray density log , Ridgeway Arizona Oil Corporation, 22-1X State well in Sec. 22, T. 12 N., R. 29 E., Apache County, Arizona

Member in one well. Ridgeway has reported gas in the granite wash at the base of the Amos Wash Member and refers to the basal conglomerate and granite wash as the Riggs zone. Depth to the top of the Amos Wash Member of the Supai Formation ranges from 1652 to 2636 ft. The Amos Wash Member is 404 to 760 ft thick. Full diameter conventional core porosities of the basal conglomerate and granite wash of the Amos Wash Member range from 4.1 to 8.1%. Full diameter core permeabilities vary from .17 to 1.44 md with one reading as high as 18.92 md.

Impermeable anhydrite beds in the Fort Apache and Big A Butte Members and impermeable clay and mudstones in the Amos Wash Member of the Supai Formation provide effective seals to gas accumulations trapped in underlying porous and permeable red-bed clastics, carbonates, granite wash, and fractured granite.

## Structure

The main structural elements of the southeastern part of the Colorado Plateau are the Black Mesa Basin, Defiance Uplift, Zuni Uplift, and the Mogollon Slope. Permian strata on the Mogollon Slope in east-central Arizona tend to rise in elevation in a southerly direction as evidenced by the gentle northerly dip of Coconino Sandstone (Conley, 1979, Map G-10) and the Fort Apache Limestone Member of the Supai Formation (Conley, 1977, Map G-7) between Black Mesa Basin to the north and Mogollon Rim to the south.

Plate 1 is a structure map of the base of the Fort Apache Member (top Big A Butte Member) of the Permian Supai Formation. The structure contours are drawn on the base of the Fort Apache Member because it forms a distinctive gamma ray curve break that is easily correlated in the subsurface throughout east-central Arizona and western Catron County, New Mexico. A listing of wells and the author's correlations are provided in Appendix 1.

Permian strata in the St. Johns - Springerville area form a broad, asymmetrical anticline trending northwest, which is the major tectonic trend in the region. The axis plunges to the northwest and southeast. Dips are steeper on the faulted, southwest flank. Faulting extends into, and is probably controlled by, Precambrian granite.

Presence of the southwest-bounding fault is indicated by surface mapping by Sirrine (1956), elevation difference of the base of the Fort Apache Member, and thickness variation of the Permian Supai Formation. Presence of the northwest-trending fault between the Mae Belcher #1 State and Ridgeway #9-21 State wells is indicated by the presence of highly fractured, deeply weathered and altered igneous rock beneath the Amos Wash Member in the #9-21 well and the elevation difference of 126 ft of the base of the Fort Apache Member of the Supai Formation

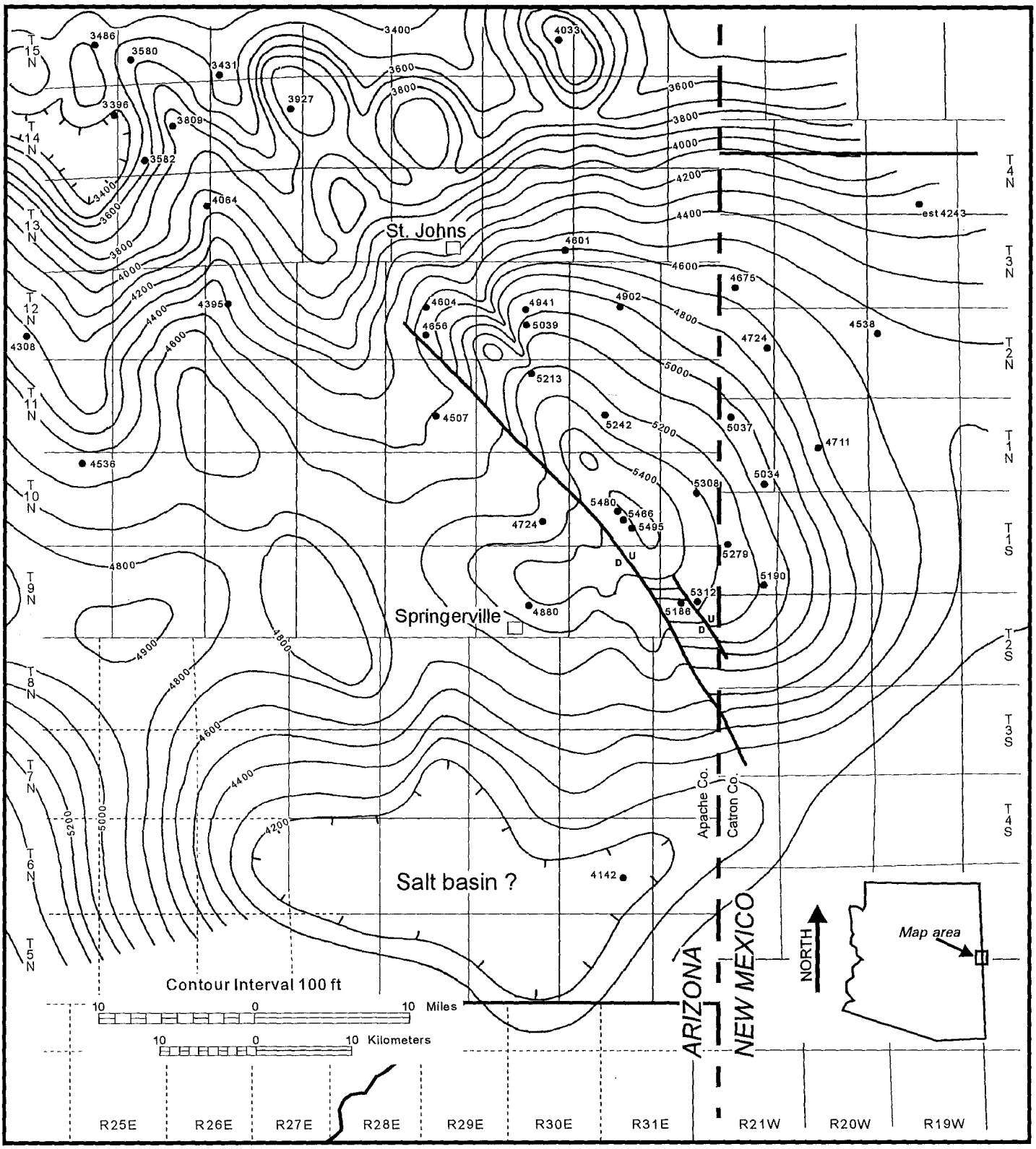


Figure 4. Regional structure base Fort Apache Limestone Member (top Big A Butte Member) of the Permian Supai Formation. Based in part on Conley and Scurlock, 1976. Shows possible concealed Permian salt basin of Rauzi, 1996.

between the 2 wells.

Several smaller folds or undulations are superimposed on the broader fold. The smaller folds include the Buttes, Cedar Mesa, North and South Malpais, Almandoz, and Antelope or Coyote Creek anticlines (Sirrine, 1956, Plate 6). The steep monoclinal dip observed at the surface on the southwest flank of the Buttes anticline splits the northwest plunge of the broader fold between the Buttes anticline to the east and Cedar Mesa anticline to the west and may represent a northern extension or segment of the northwest-trending fault.

Two wireline log structural cross sections were drawn across the area (Plates 2 and 3). Plate 2 trends SW to NE, approximately perpendicular to the axis of the broad fold. Plate 3 trends approximately S to N, parallel to the axis of the broad fold. Vertical scale on both structural cross sections is exaggerated by about 53 times.

The broad anticlinal fold in the St. Johns - Springerville area gives way to the south to a broad syncline or depression in the White Mountain area that interrupts the regional low-gradient, northerly-dipping tendency of Permian units of the Mogollon slope in east-central Arizona.

The southern flank of the gentle syncline south of the St. Johns - Springerville area probably abuts the east-northeast-trending northern boundary of the Morenci high and may be displaced by northeast-trending faulting south of the Mae Belcher hole (Rauzi, 1994, Plate 1).

The broad syncline or depression south of the St. Johns - Springerville area was revealed in 1993 when the Tonto #1 Alpine Federal well, north of the town of Alpine in Section 23, T. 6 N., R. 30 E., was continuously cored from 500 to 4505 ft. The depression may represent a concealed salt basin (Rauzi, 1996).

## Carbon Dioxide in Wells

The 1st recorded report of naturally occurring $CO_2$ in the St. Johns - Springerville area was from the Mae Belcher #1 State well drilled about 12 miles east of Springerville in 1959. A flow of $CO_2$ was reported from 698 to 743 ft and 1135 to 1675 ft. The volume from the former, a probable Cretaceous sand, was estimated at 2.5 million cubic feet per day and contained a reported 78 to 87% $CO_2$ with 0.17% helium.

In 1994, Ridgeway drilled the Ridgeway/Canstar #1 Plateau Cattle well as an oil test about 7 miles southeast of St. Johns. Ridgeway announced the #1 Plateau Cattle well as a $CO_2$ discovery. Initial production was reported at 640,000 cubic feet of gas (640 mcfd) and 436 barrels of water per day from the Fort Apache and Big A Butte Members of the Supai Formation between 1300 and 1704 ft. Ridgeway stopped the water production by squeezing cement into

the Fort Apache perforations between 1300 and 1428 ft. Initial flowing tubing pressure was reported at 130 psi on a 3/4" choke. Gas analysis by the U.S. Bureau of Mines (USBOM) in Amarillo, Texas, indicated 90% $CO_2$, 6% nitrogen, and 0.5 to 0.8% helium. Ridgeway has reported higher $CO_2$ percentages in other wells.

The #1 Plateau Cattle well was replaced by an offset well, the #22-1X State, in 1997 because the $CO_2$ and initial water production corroded the steel pipe used in its completion. As a result, Ridgeway used fiberglass casing for the long string in its 1997 drilling series in Arizona to avoid corroded steel casing as experienced in the #1 Plateau Cattle well.

In 1995, Ridgeway drilled a follow-up well, the #3-1 State, 4 miles south of the #1 Plateau Cattle well. Ridgeway completed the #3-1 State for a reported 657 mcfd from the Big A Butte Member of the Supai Formation between 1536 and 1676 ft. Flowing tubing pressure was reported at 95 psi on a 1/2" choke. USBOM analysis indicated 89% $CO_2$, 10% nitrogen, 0.7% helium, and 0.1% each of methane and argon.

Based in part on the presence of $CO_2$ in the Mae Belcher well east of Springerville and the #1 Plateau Cattle and #3-1 State wells southeast of St. Johns, Ridgeway drilled a series of 11 widely-spaced wells between St. Johns and Springerville in early 1997. Ridgeway continued the series with 6 wells in western Catron County, New Mexico, in late 1997 and early 1998. Location and status of Ridgeway's wells as of March 1999 is listed in Table 1.

Of the 11 wells Ridgeway drilled in Arizona in 1997, 2 were plugged as dry holes, 1 was completed as a replacement well for the corroded #1 Plateau Cattle well, and 8 are shut-in until testing is completed. The replacement well, the #22-1X State, was completed in June 1997 for a reported 1894 mcfd from the lower Big A Butte Member of the Supai Formation between 1518 and 1624 ft after fracture stimulation. Ridgeway has reported higher flow rates in other wells. Initial completion testing indicates potential water problems in some wells.

Of the 6 wells Ridgeway drilled in New Mexico in late 1997 and early 1998, one was plugged as a dry hole and 5 are shut-in until testing is completed. A horizontal segment was drilled in the Ridgeway 36-2 N. State in Section 36, T. 1 N., R. 21 W.

Ridgeway ran 10 drill-stem tests (DSTs) in 4 of the wells it drilled in Arizona between 1994 and 1997 and a reported 5 DSTs in 4 of the wells it drilled in New Mexico. Complete DST results are not yet available for some of the wells drilled in New Mexico. DST data available as of March 1999 is summarized in Appendix 2.

Ridgeway cut 689 ft of conventional core in 3 of the wells it drilled in Arizona in 1997 and 766 ft of conventional core in 5 of the wells it drilled in New Mexico. The core is stored and is available for study at the Arizona Geological Survey in Tucson and the New Mexico Bureau of Mines and Mineral Resources in Socorro.

**Table 1.** **Location and status of Ridgeway Arizona Oil Corporation wells in the St. Johns - Springerville area as of March 1999.**

| WELL | LOCATION SEC-TWP-RGE | TOTAL DEPTH | COMMENT |
|---|---|---|---|
| | **Apache County, Arizona** | | |
| 15-28-29 State | ne nw 28-15n-29e | 2410 ft | Drilled & abandoned 6/97 |
| 13-36-29 State | sw ne 36-13n-29e | 2454 ft | Drilled & abandoned 5/97 |
| 12-16-28 State | nw ne 16-12n-28e | 2280 ft | Shut-in 5/97 |
| 1 Plateau Cattle | ne sw 15-12n-29e | 2431 ft | Completed as gas well & shut-in 8/94 Casing corroded by $CO_2$, plugged 9/97 |
| 1A Plateau Cattle | ne sw 15-12n-29e | 220 ft | Shut-in 11/94, Plugged 11/97 |
| 22-1 State | nw nw 22-12n-29e | 218 ft | Shut-in 8/95, Plugged 8/97 |
| 22-1X State | se nw 22-12n-29e | 2149 ft | Completed as gas well & shut-in 6/97 |
| 35-1 State | ne sw 35-12n-29e | -- | Permit expired 4/97 |
| 12-15-30 State | ne sw 15-12n-30e | 2603 ft | Shut-in 5/97 |
| 2-1 State | se nw 2-11n-29e | -- | Permit expired 4/97 |
| 3-1 State | ne se 3-11n-29e | 1813 ft | Completed as gas well & shut-in 9/95 |
| 10-1 State | sw ne 10-11n-29e | -- | Permit expired 4/97 |
| 11-1 State | se nw 11-11n-29e | -- | Permit expired 4/97 |
| 11-21 State | ne sw 21-11n-30e | 2410 ft | Shut-in 3/97 |
| 10-26-29 State | nw sw 26-10n-29e | 3200 ft | Shut-in 5/97 |
| 10-22 State | sw sw 22-10n-30e | 2265 ft | Shut-in 3/97 |
| 10-16-31 State | ne sw 16-10n-31e | 2728 ft | Shut-in 5/97 |
| 9-22-29 State | sw se 22-9n-29e | 3180 ft | Shut-in 4/97 |
| 9-21 State | sw ne 21-9n-31e | 2686 ft | Shut-in 3/97 |
| | **Catron County, New Mexico** | | |
| 2-13 N. State | se sw 13-2n-21w | 2717 ft | Drilled & abandoned 3/98 |
| 1-16 N. State | se se 16-1n-20w | 2958 ft | Shut-in 3/98 |
| 1-4 N. State | se se 4-1n-21w | 2540 ft | Shut-in 2/98 |
| 36-2 N. State | se se 36-1n-21w | 3211 ft | Shut-in 4/98 |
| 1-16 S. State | sw nw 16-1s-21w | 2841 ft | Shut-in 2/98 |
| 36-1 S. State | nw nw 36-1s-21w | 3170 ft | Shut-in 12/97 |

In April 1998, after drilling 21 wells in Arizona and New Mexico, Ridgeway requested the U.S. Bureau of Land Management in New Mexico to initiate an environmental impact study of its $CO_2$ project area and indicated its intention to propose a 2-state exploration unit. Snow Oil and Gas, Inc., proposed two separate 1-state exploration units. A final decision on the proposed 2-state exploration unit is not expected until Ridgeway has completed testing all of its current wells. The various proposed units range from about 150,000 to 265,000 acres.

## Drilling Problems

Lost circulation is a common drilling problem in the St. Johns - Springerville area. Skelly Oil Company in 1952, Eastern Petroleum in 1962, Combined Drilling Ventures in 1987, and Ridgeway in 1995 and 1997 all reported lost circulation in the San Andres Limestone. All but 2 of the wells that Ridgeway drilled in the 1st half of 1997 experienced lost circulation. Three operators had to abandoned holes because of lost circulation in open fractures and caverns in the San Andres Limestone. Eastern Petroleum, Combined Drilling Ventures, and Ridgeway in 1995 all abandoned holes at depths between 200 to 300 ft because of severe lost circulation. Ridgeway converted to drilling with a powerful air package in the middle of its 1997 drilling program in Arizona to overcome the persistent and widespread lost circulation. Ridgeway reported lowering drill pipe 45 ft in an open fracture or cavern in one of its wells in Arizona.

Lost circulation in the St. Johns - Springerville area extended beyond drilling. Ridgeway was unable to circulate cement on surface casing in 9 of the 11 wells drilled in its 1997 drilling program in Arizona. Ridgeway had to pour concrete from the top to cement the surface casing back to the surface in these wells.

## Origin of $CO_2$

Postulated origins for $CO_2$ in the region include primarily high temperature thermal decomposition of calcite in the Leadville Limestone at the McElmo Field in southwestern Colorado (Cappa and Rice, 1995) to primarily migration from the upper mantle (juvenile source) at the Bravo Dome Field in northeastern New Mexico (Staudacher, 1987; Broadhead, 1993).

Proximity of the St. Johns - Springerville area to the extensive White Mountain and Springerville volcanic fields, general lack of significant volumes of carbonate below the Fort Apache Limestone Member of the Supai Formation, and association of structure to basement-controlled faulting suggest a primarily juvenile source for the $CO_2$ in the St. Johns - Springerville area.

On the other hand, vast travertine deposits and extensive lost circulation in widespread fractured and cavernous Permian carbonate strata in the area suggest that some $CO_2$ is the result of dissolution of carbonate rocks by groundwater.

A detailed analysis for noble gases similar to that of Phinney and others (1978) and Staudacher (1987) would help determine the primary origin of $CO_2$ in the St. Johns - Springerville area.

## Conclusion

The St. Johns - Springerville area could prove to be a substantial discovery of naturally occurring $CO_2$ if the 13 wells still being tested justify construction of a pipeline to deliver the $CO_2$ to enhanced recovery markets in California or southeastern New Mexico and west Texas.

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**Appendix 1.** **Summary of wells and author's correlations in the St. Johns - Springerville area, Arizona and New Mexico**

## ARIZONA WELLS

Ridgeway Arizona Oil #13-36-29 State **sw ne 36-13n-29e** (901): Elevation: 6181' KB; 6167' gl (TD reached 5/97)

| | | |
|---|---|---|
| Quaternary | 0' (+6167') | |
| Triassic Chinle | 89' (+6092') | 199' |
| Permian San Andres Ls | 288' (+5893') | 270' |
| Permian Glorieta Ss | 558' (+5623') | 214' |
| Permian Supai Fm | 772' (+5409') | 1648' |
| Supai Corduroy Mbr | 772' (+5409') | 730' |
| Supai Ft. Apache Mbr | 1502' (+4679') | 78' |
| Supai Big A Butte Mbr | 1580' (+4601') | 386' |
| Supai Raven mkr | 1825' (+4356') | ---- |
| Supai Amos Wash Mbr | 1966' (+4215') | 454' |
| Supai Riggs zone | 2228' (+3953') | ---- |
| Precambrian granite | 2420' (+3761') | 34' |
| TD | 2454' (+3727') | |

Ridgeway Arizona Oil #12-16-28 State, **nw ne 16-12n-28e** (902) Elevation: 6002' KB; 5988' gl (TD reached 5/97)

| | | |
|---|---|---|
| Triassic Chinle | 0' (+5988') | 152' |
| Permian San Andres Ls | 152' (+5850') | 308' |
| Permian Glorieta Ss | 460' (+5542') | 190' |
| Permian Supai Fm | 650' (+5352') | 1630'+ |
| Supai Corduroy Mbr | 650' (+5352') | 660' |
| Supai Ft. Apache Mbr | 1310' (+4692') | 88' |
| Supai Big A Butte Mbr | 1398' (+4604') | 377' |
| Supai Raven mkr | 1634' (+4368') | ---- |
| Supai Amos Wash Mbr | 1775' (+4227') | 505'+ |
| TD | 2280' (+3722') | |

Combined Drilling Ventures #1 State, **ne nw 28-12n-28e** (862) Elevation: 6096' KB; 6090' gl (TD reached 2/87)

| | | | |
|---|---|---|---|
| Triassic Moenkopi? | 0' (+6090') | | |
| Permian Kaibab Ls | 112' (+5984') | 386' | No electric log below 1810' |
| Permian Coconino Ss | 498' (+5598') | 197' | |
| Permian Supai Fm | 695' (+5401') | 2285' | |
| Supai Corduroy Mbr | 695' (+5401') | 657' | |
| Supai Ft. Apache Mbr | 1352' (+4744') | 88' | |
| Supai Big A Butte Mbr | 1440' (+4656') | 380' | |
| Supai Raven mkr | 1672' (+4424') | ---- | |
| Supai Amos Wash Mbr | 1820' (+4276') | 760' | |
| Precambrian granite | 2580' (+3516') | 717' | |
| TD | 3297' (+2799') | | |

Ridgeway Arizona Oil #1 Plateau Cattle, **ne sw 15-12n-29e** (880) Elevation: 6377' KB; 6372' gl (TD reached 8/94)

| | | |
|---|---|---|
| Triassic Chinle | 0' (+6372) | |
| Triassic Moenkopi | 198' (+6179') | 15' |
| Permian San Andres Ls | 213' (+6164') | 267' |
| Permian Glorieta Ss | 480' (+5897') | 180' |
| Permian Supai Fm | 688' (+5689') | 1452' |
| Supai Corduroy Mbr | 688' (+5689') | 678' |
| Supai Ft. Apache Mbr | 1366' (+5011') | 70' |
| Supai Big A Butte Mbr | 1436' (+4941') | 272' |
| Supai Raven mkr | 1606' (+4771') | ---- |
| Supai Amos Wash Mbr | 1708' (+4669') | 432' |
| Supai Riggs zone | 2000' (+4377') | ---- |
| Precambrian Granite | 2140' (+4237') | 291' |
| TD | 2431' (+3946') | |

**Appendix 1 (continued).** **Summary of wells and author's correlations in the St. Johns - Springerville area, Arizona and New Mexico**

## ARIZONA WELLS

Ridgeway Arizona Oil #22-1X State, **se nw 22-12n-29e** (888) Elevation: 6407' KB; 6393' gl (TD reached 2/97)

| | | | |
|---|---|---|---|
| Triassic Chinle | 0' (+6393) | | |
| Permian San Andres Ls | 148' (+6259') | 287' | |
| Permian Glorieta Ss | 435' (+5972') | 205' | |
| Permian Supai Fm | 640' (+5767') | 1420' | |
| Supai Corduroy Mbr | 640' (+5767') | 650' | |
| Supai Ft. Apache Mbr | 1290' (+5117') | 78' | |
| Supai Big A Butte Mbr | 1368' (+5039') | 284' | |
| Supai Raven mkr | 1548' (+4859') | ---- | |
| Supai Amos Wash Mbr | 1652' (+4755') | 408' | |
| Supai Riggs zone | 1948' (+4459') | ---- | |
| Precambrian Granite | 2060' (+4347') | 89' | Pink-orange granite from rotary side wall core |
| TD | 2149' (+4258') | | |

Ridgeway Arizona Oil #12-15-30 State, **ne sw 15-12n-30e** (900) Elevation: 6726' KB; 6712' gl (TD reached 5/97)

| | | |
|---|---|---|
| Quaternary Richville | 0' (+6712') | 344' |
| Triassic Chinle | 344' (+6382') | 238' |
| Permian San Andres Ls | 582' (+6144') | 268' |
| Permian Glorieta Ss | 850' (+5876') | 232' |
| Permian Supai Fm | 1082' (+5644') | 1413' |
| Supai Corduroy Mbr | 1082' (+5644') | 678' |
| Supai Ft. Apache Mbr | 1760' (+4966') | 64' |
| Supai Big A Butte Mbr | 1824' (+4902') | 288' |
| Supai Raven mkr | 2012' (+4714') | ---- |
| Supai Amos Wash Mbr | 2112' (+4614') | 383' |
| Supai Riggs zone | 2408' (+4318') | ---- |
| Precambrian Granite | 2495' (+4231') | 108' |
| TD | 2603' (+4123') | |

Tenneco Oil #1 Federal-C, **se nw 22-11n-28e** (375): Elevation: 6064' KB; 6053' gl (TD reached 2/67)

| | | |
|---|---|---|
| Triassic Moenkopi | 0' (+6053') | 150' |
| Permian San Andres Ls | 150' (+5914') | 360' |
| Permian Glorieta Ss | 510' (+5554') | 212' |
| Permian Supai Fm | 722' (+5342') | 965'+ |
| Supai Corduroy Mbr | 722' (+5342') | 740' |
| Supai Ft. Apache Mbr | 1462' (+4602') | 95' |
| Supai Big A Butte Mbr | 1557' (+4507') | 130'+ |
| TD | 1687' (+4377') | |

Ridgeway Arizona Oil #3-1 State, **ne se 3-11n-29e** (884): Elevation: 6729' DF; 6726' gl (TD reached 9/95)

| | | |
|---|---|---|
| Triassic Chinle | 0' (+6726') | 236' |
| Permian San Andres Ls | 236' (+6493') | 307' |
| Permian Glorieta Ss | 543' (+6186') | 202' |
| Permian Supai Fm | 745' (+5984') | 1068'+ |
| Supai Corduroy Mbr | 745' (+5984') | 677' |
| Supai Ft. Apache Mbr | 1422' (+5307') | 94' |
| Supai Big A Butte Mbr | 1516' (+5213') | 272' |
| Supai Raven mkr | 1683' (+5046') | ---- |
| Supai Amos Wash Mbr | 1788' (+4941') | 25'+ |
| TD | 1813' (+4916') | |

**Appendix 1 (continued).** **Summary of wells and author's correlations in the St. Johns - Springerville area, Arizona and New Mexico**

## ARIZONA WELLS

Ridgeway Arizona Oil #11-21 State, **ne sw 21-11n-30e** (895) Elevation: 6932' KB; 6918' gl (TD reached 3/97)

| | | |
|---|---|---|
| Quaternary | 0' (+6918') | |
| Quaternary Richville | 92' (+6840') | 143' |
| Triassic Chinle | 235' (+6697') | 212' |
| Permian San Andres Ls | 447' (+6485') | 221' |
| Permian Glorieta Ss | 668' (+6264') | 222' |
| Permian Supai Fm | 890' (+6042') | 1510' |
| Supai Corduroy Mbr | 890' (+6042') | 713' |
| Supai Ft. Apache Mbr | 1603' (+5329') | 87' |
| Supai Big A Butte Mbr | 1690' (+5242') | 286' |
| Supai Raven mkr | 1872' (+5060') | ---- |
| Supai Amos Wash Mbr | 1976' (+4956') | 424' |
| Supai Riggs zone | 2300' (+4632') | ---- |
| Precambrian Granite | 2400' (+4532') | 10' |
| TD | 2410' (+4522') | |

Salt Grass #A-1 State, **se se 36-10n-28e** (861): Elevation: 6716' KB; 6706' gl (TD reached 10/86)

| | | |
|---|---|---|
| Quaternary basalt | 0' (+6706') | 25' |
| Tertiary & Cret? | 25' (+6691') | 570' |
| Permian San Andres Ls | 595' (+6121') | 365' |
| Permian Glorieta Ss | 960' (+5756') | 112' + |
| TD | 1072' (+5644') | |

Ridgeway Arizona Oil #10-26-29 State, **nw sw 26-10n-29e** (903) Elevation: 6946' KB; 6932' gl (TD reached 5/97)

| | | |
|---|---|---|
| Quaternary | 0' (+6932') | 433' |
| Triassic Chinle | 433' (+6513') | 447' |
| Permian San Andres Ls | 880' (+6066') | 296' |
| Permian Glorieta Ss | 1176' (+5770') | 224' |
| Permian Supai Fm | 1400' (+5546') | 1756' |
| Supai Corduroy Mbr | 1400' (+5546') | 730' |
| Supai Ft. Apache Mbr | 2130' (+4816') | 92' |
| Supai Big A Butte Mbr | 2222' (+4724') | 288' |
| Supai Raven mkr | 2394' (+4552') | ---- |
| Supai Amos Wash Mbr | 2510' (+4436') | 646' |
| Supai Riggs zone | 2844' (+4102') | ---- |
| Precambrian Granite | 3156' (+3790') | 44' |
| TD | 3200' (+3746') | |

Ridgeway Arizona Oil #10-22 State, **sw sw 22-10n-30e** (896) Elevation: 6992' KB; 6978' gl (TD reached 3/97)

| | | |
|---|---|---|
| Triassic Chinle | 0' (+6978') | 172' |
| Permian San Andres Ls | 172' (+6820') | 308' |
| Permian Glorieta Ss | 480' (+6512') | 232' |
| Permian Supai Fm | 712' (+6280') | 1508' |
| Supai Corduroy Mbr | 712' (+6280') | 703' |
| Supai Ft. Apache Mbr | 1415' (+5577') | 97' |
| Supai Big A Butte Mbr | 1512' (+5480') | 266' |
| Supai Raven mkr | 1670' (+5322') | ---- |
| Supai Amos Wash Mbr | 1778' (+5214') | 442' |
| Supai Riggs zone | 2084' (+4908') | ---- |
| Precambrian Granite | 2220' (+4772') | 45' |
| TD | 2265' (+4727') | |

**Appendix 1 (continued).** **Summary of wells and author's correlations in the St. Johns - Springerville area, Arizona and New Mexico**

## ARIZONA WELLS

Tenneco #1 Merrill, **sw sw 26-10n-30e** (371) Elevation: 7033' KB; 7022' gl (TD reached 2/67)

| | | |
|---|---|---|
| Triassic Moenkopi | 0' (+7022') | 183' |
| Permian Kaibab Ls | 183' (+6850') | 335' |
| Permian Coconino Ss | 518' (+6515') | 236' |
| Permian Supai Fm | 754' (+6279') | 823'+ |
| Supai Corduroy Mbr | 754' (+6279') | 690' |
| Supai Ft. Apache Mbr | 1444' (+5589') | 94' |
| Supai Big A Butte Mbr | 1538' (+5495') | 39'+ |
| TD | 1577' (+5456') | |

Eastern Petroleum #1A Coyote Creek, **sw ne 27-10n-30e** (207) Elevation: 6979' DF; 6975' gl (TD reached 9/62)

| | | |
|---|---|---|
| Triassic Moenkopi | 0' (+6975') | 176' |
| Permian Kaibab Ls | 176' (+6803') | 322' |
| Permian Coconino Ss | 498' (+6481') | 235' |
| Permian Supai Fm | 733' (+6246') | 1577' |
| Supai Corduroy Mbr | 733' (+6246') | 687' |
| Supai Ft. Apache Mbr | 1420' (+5559') | 93' |
| Supai Big A Butte Mbr | 1513' (+5466') | 269' |
| Supai Raven mkr | 1674' (+5305') | ---- |
| Supai Amos Wash Mbr | 1782' (+5197') | 528' |
| Supai Riggs zone | 2092' (+4887') | ---- |
| Precambrian Granite | 2310' (+4669') | 41' |
| TD | 2351' (+4628') | |

Ridgeway Arizona Oil #10-16-31 State, **ne sw 16-10n-31e** (899) Elevation: 7260' KB; 7246' gl (TD reached 5/97)

| | | |
|---|---|---|
| Quaternary | 0' (+7246') | 365' |
| Triassic Chinle | 365' (+6895') | 461' |
| Permian San Andres Ls | 826' (+6434') | 232' |
| Permian Glorieta Ss | 1058' (+6202') | 208' |
| Permian Supai Fm | 1266' (+5994') | 1366' |
| Supai Corduroy Mbr | 1266' (+5994') | 596' |
| Supai Ft. Apache Mbr | 1862' (+5398') | 90' |
| Supai Big A Butte Mbr | 1952' (+5308') | 276' |
| Supai Raven mkr | 2122' (+5138') | ---- |
| Supai Amos Wash Mbr | 2228' (+5032') | 404' |
| Supai Riggs zone | 2545' (+4715') | ---- |
| Precambrian Granite | 2632' (+4628') | 96' |
| TD | 2728' (+4532') | |

Ridgeway Arizona Oil #9-22-29 State, **sw se 22-9n-29e** (898) Elevation: 7192' KB; 7178' gl (TD reached 4/97)

| | | |
|---|---|---|
| Quaternary basalt | 0' (+7178') | 142' |
| Cretaceous-Tertiary Eager | 142' (+7050') | 350' |
| Triassic Chinle | 492' (+6700') | 488' |
| Permian San Andres Ls | 980' (+6212') | 294' |
| Permian Glorieta Ss | 1274' (+5918') | 226' |
| Permian Supai Fm | 1500' (+5692') | 1680' |
| Supai Corduroy Mbr | 1500' (+5692') | 704' |
| Supai Ft. Apache Mbr | 2204' (+4988') | 108' |
| Supai Big A Butte Mbr | 2312' (+4880') | 266' |
| Supai Raven mkr | 2478' (+4714') | ---- |
| Supai Amos Wash Mbr | 2578' (+4614') | 602' |
| Supai Riggs zone | 2934' (+4258') | ---- |
| Precambrian Granite | 3180' (+4012') | |
| TD | 3180' (+4012') | |

**Appendix 1 (continued). Summary of wells and author's correlations in the St. Johns - Springerville area, Arizona and New Mexico**

## ARIZONA WELLS

Mae Belcher #1 State, **sw ne 20-9n-31e** (66) Elevation: 7274' DF; 7274' gl (TD reached 6/59)

| | | | |
|---|---|---|---|
| Basalt & cinders | 0' (+7274') | 235' | |
| Cretaceous Mancos | 235' (+7039') | 137' | No electric log run |
| Cret. Tres Hermanos | 372' (+6902') | 312' | Formation tops in part from American Stratigraphic Co. log |
| Cretaceous Dakota | 684' (+6590') | 91' | |
| Permian San Andreas | 775' (+6499') | 295' | |
| Permian Glorieta Ss | 1070' (+6204') | 273' | |
| Permian Supai Fm | 1343' (+5931') | 1578' | |
| Supai Corduroy Mbr | 1343' (+5931') | 659' | |
| Supai Ft. Apache Mbr | 2002' (+5272') | 86' | |
| Supai Big A Butte Mbr | 2088' (+5186') | 297' | |
| Supai Amos Wash Mbr | 2385' (+4889') | 467'? | |
| Conglomerate | 2852' (+4422') | 69'? | |
| TD | 2921' (+4353) | | |

Ridgeway Arizona Oil #9-21 State, **sw ne 21-9n-31e** (897) Elevation: 7212' KB; 7198' gl (TD reached 3/97)

| | | | |
|---|---|---|---|
| Cretaceous-Tertiary Eager | 0' (+7198') | 434' | |
| Triassic Chinle | 434' (+6778') | 278' | |
| Permian San Andres Ls | 712' (+6500') | 216' | |
| Permian Glorieta Ss | 928' (+6284') | 210' | |
| Permian Supai Fm | 1138' (+6074') | 1512' | |
| Supai Corduroy Mbr | 1138' (+6074') | 674' | |
| Supai Ft. Apache Mbr | 1812' (+5400') | 88' | |
| Supai Big A Butte Mbr | 1900' (+5312') | 262' | |
| Supai Raven mkr | 2062' (+5150') | ---- | |
| Supai Amos Wash Mbr | 2162' (+5050') | 488' | |
| Supai Riggs zone | 2478' (+4734') | ---- | |
| Precambrian Granite | 2650' (+4562') | 44' | Purple-green, highly fractured, deeply weathered, altered |
| TD | 2694' (+4518') | | igneous rock from conventional core |

Tonto #1 Alpine Federal, **nw sw 23-6n-30e** (878) Elevation: 8556' gl (TD reached 8/93)

| | | | |
|---|---|---|---|
| Tertiary Datil | 0' (+8556') | 1093' | |
| Tertiary Baca Fm | 1093' (+7463') | 2046' | |
| Tertiary redbeds | 3139' (+5417') | 121' | |
| Cretaceous | 3260' (+5296') | 109' | |
| Permian San Andres Ls | 3369' (+5187') | 67' | |
| Permian Glorieta Ss | 3436' (+5120') | 203' | |
| Tertiary igneous | 3639' (+4917') | 112' | |
| Permian Supai Fm | 3751' (+4805') | 604'+ | |
| Supai Corduroy Mbr | 3751' (+4805') | 473'+ | |
| Supai Ft. Apache Mbr | 4224' (+4332') | 36' | |
| Tertiary igneous | 4260' (+4296') | 100' | |
| Supai Ft. Apache Mbr | 4360' (+4196') | 54' | (total Ft. Apache Mbr = 90') |
| Supai Big A Butte Mbr | 4414' (+4142') | 41'+ | |
| Tertiary igneous | 4455' (+4101') | 50' | |
| TD | 4505' (+4051') | | |

**Appendix 1 (continued).** **Summary of wells and author's correlations in the St. Johns - Springerville area, Arizona and New Mexico**

## NEW MEXICO WELLS

Skelly #1 Goesling, **c sw 27-3n-21w** Elevation: 6377' DF; 6372' gl (TD reached 11/52)

| | | | |
|---|---|---|---|
| Triassic Shinarump | 0' (+6372') | 190' | |
| Triassic Moenkopi | 190' (+6182') | 230 | |
| Permian San Andres Ls | 420' (+5952') | 252' | |
| Permian Glorieta Ss | 672' (+5700') | 243' | |
| Permian Upper Supai Fm | 915' (+5457') | 627' | total supai 1645' |
| Permian Ft. Apache Mbr | 1542' (+4830') | 68' | |
| Permian Upper Supai Fm | 1610' (+4762') | 500' | |
| Permian Middle Supai(Abo) | 2110' (+4262') | 450' | |
| Precambrian | 2560' (+3812') | 37' | |
| TD | 2597' (+3775') | | |

Author's e-log picks

| | | |
|---|---|---|
| San Andres Ls | 420' (+5957') | 252' |
| Glorieta Ss | 672' (+5705') | 270' |
| Supai Fm | 942' (+5435') | 1629' |
| Corduroy Mbr | 942' (+5435') | 700' |
| Ft. Apache Mbr | 1642' (+4735') | 60' |
| Big A Butte Mbr | 1702' (+4675') | 416' |
| Amos Wash Mbr | 2118' (+4259') | 453' |
| Riggs zone | 2535' (+3842') | ---- |
| Precambrian | 2571' (+3806') | 26' |
| TD | 2597' (+3780') | |

Skelly #1 M.N. Teel, **se se sw 7-2n-19w** Elevation: 6696' DF; 6691' gl (TD reached 3/52)

| | | | |
|---|---|---|---|
| Cretaceous Tres Hermanos | 0' (+6691') | 30' | |
| Cretaceous Mancos | 30' (+6661') | 132' | |
| Cretaceous Dakota | 162' (+6529') | 113' | |
| Triassic Chinle | 275' (+6416') | 170' | |
| Triassic Shinarump | 445' (+6246') | 20' | |
| Triassic Moenkopi | 465' (+6226') | 365' | |
| Permian San Andres Ls | 830' (+5861') | 340' | |
| Permian Glorieta Ss | 1170' (+5521') | 230' | |
| Permian Upper Yeso | 1400' (+5291') | 305' | total Yeso 965'+ |
| Permian Middle Yeso | 1705' (+4986') | 315' | |
| Permian Ft. Apache Mbr | 2020' (+4671') | 65' | |
| Permian Lower Yeso | 2085' (+4606') | 280' | |
| TD | 2365' (+4326') | | |

Author's e-log picks

| | | |
|---|---|---|
| San Andres Ls | 894' (+5802') | 261' |
| Glorieta Ss | 1155' (+5541') | 297' |
| Supai Fm | 1452' (+5244') | 913'+ |
| Corduroy Mbr | 1452' (+5244') | 640' |
| Ft. Apache Mbr | 2092' (+4604') | 66' |
| Big A Butte Mbr | 2158' (+4538') | 207'+ |
| TD | 2365' (+4331') | |

Ridgeway #2-13 No. State, **se sw 13-2n-21w** (30-003-20024) Elevation: 6524' KB; gl 6510' (TD reached 3/98)

| | | |
|---|---|---|
| Permian San Andres Ls | 518' (+6006') | 262' |
| Permian Glorieta Ss | 780' (+5744') | 225' |
| Permian Supai Fm | 1005' (+5519') | 1553' |
| Supai Corduroy Mbr | 1005' (+5519') | 733' |
| Supai Ft. Apache Mbr | 1738' (+4786') | 62' |
| Supai Big A Butte Mbr | 1800' (+4724') | 300' |
| Supai Raven mkr | 1988' (+4536') | ---- |
| Supai Amos Wash Mbr | 2100' (+4424') | 458' |
| Supai Riggs zone | 2428' (+4096') | ---- |
| Precambrian Granite | 2558' (+3966') | 159' |
| TD | 2717' (+3807') | |

Ridgeway #1-16 No. State, **se se 16-1n-20w** (30-003-20025) Elevation: 6907' KB; gl 6892' (TD reached 3/98)

| | | |
|---|---|---|
| Permian San Andres Ls | | |
| Permian Glorieta Ss | 1218' (+5689') | 202' |
| Permian Supai Fm | 1420' (+5487') | 1486' |
| Supai Corduroy Mbr | 1420' (+5487') | 708' |
| Supai Ft. Apache Mbr | 2128' (+4779') | 68' |
| Supai Big A Butte Mbr | 2196' (+4711') | 304' |
| Supai Raven mkr | 2388' (+4519') | ---- |
| Supai Amos Wash Mbr | 2500' (+4407') | 406' |
| Supai Riggs zone | 2780' (+4127') | ---- |
| Precambrian Granite | 2906' (+4001') | 52' |
| TD | 2958' (+3949') | |

**Appendix 1 (continued).** **Summary of wells and author's correlations in the St. Johns - Springerville area, Arizona and New Mexico**

## NEW MEXICO

Ridgeway #1-4 No. State, **se se 4-1n-21w** (30-003-20019) Elevation: 6860' KB; gl 6845' (TD reached 2/98)

| | | |
|---|---|---|
| Permian San Andres Ls | 488' (+6372') | 298' |
| Permian Glorieta Ss | 786' (+6074') | 210' |
| Permian Supai Fm | 996' (+5864') | 1504' |
| Supai Corduroy Mbr | 996' (+5864') | 756' |
| Supai Ft. Apache Mbr | 1752' (+5108') | 71' |
| Supai Big A Butte Mbr | 1823' (+5037') | 313' |
| Supai Raven mkr | 2012' (+4848') | ---- |
| Supai Amos Wash Mbr | 2136' (+4724') | 404' |
| Supai Riggs zone | 2446' (+4414') | ---- |
| Precambrian Granite | 2540' (+4320') | |
| TD | 2540' (+4320') | |

Ridgeway #36-2 No. State, **c se se 36-1n-21w** (30-003-20026) Elevation: 7322' KB; gl 7307' (TD reached 4/98)

| | | | |
|---|---|---|---|
| Permian San Andres Ls | | | |
| Permian Glorieta Ss | 1323' (+5999') | 207' | |
| Permian Supai Fm | 1530' (+5792') | 1518' | |
| Supai Corduroy Mbr | 1530' (+5792') | 678' | |
| Supai Ft. Apache Mbr | 2208' (+5114') | 80' | |
| Supai Big A Butte Mbr | 2288' (+5034') | 310' | |
| Supai Raven mkr | 2473' (+4849') | ---- | |
| Supai Amos Wash Mbr | 2598' (+4724') | 485' | |
| Supai Riggs zone | 2920' (+4402') | ---- | Drilled horizontal segment below 2840' |
| Precambrian Granite | 3048' (+4274') | 163' | |
| TD | 3211' (+4111') | | |

Ridgeway #1-16 So. State, **sw nw 16-1s-21w** (30-003-20023) Elevation: 7423' KB; gl 7410' (TD reached 2/98)

| | | |
|---|---|---|
| Permian San Andres Ls | 952' (+6471') | 233' |
| Permian Glorieta Ss | 1185' (+6238') | 211' |
| Permian Supai Fm | 1396' (+6027') | 1420' |
| Supai Corduroy Mbr | 1396' (+6027') | 660' |
| Supai Ft. Apache Mbr | 2056' (+5367') | 88' |
| Supai Big A Butte Mbr | 2144' (+5279') | 264' |
| Supai Raven mkr | 2295' (+5128') | ---- |
| Supai Amos Wash Mbr | 2408' (+5015') | 408' |
| Supai Riggs zone | 2722' (+4701') | ---- |
| Precambrian Granite | 2816' (+4607') | 25' |
| TD | 2841' (+4582') | |

Ridgeway #36-1 So. State, **nw nw 36-1s-21w** (30-003-20022) Elevation: 7560' KB; gl 7548' (TD reached 12/97)

| | | |
|---|---|---|
| Permian San Andres Ls | 1188' (+6372') | 247' |
| Permian Glorieta Ss | 1435' (+6125') | 197' |
| Permian Supai Fm | 1632' (+5928') | 1453' |
| Supai Corduroy Mbr | 1632' (+5928') | 648' |
| Supai Ft. Apache Mbr | 2280' (+5280') | 90' |
| Supai Big A Butte Mbr | 2370' (+5190') | 266' |
| Supai Raven mkr | 2530' (+5030') | ---- |
| Supai Amos Wash Mbr | 2636' (+4924') | 449' |
| Supai Riggs zone | 2960' (+4600') | ---- |
| Precambrian Granite | 3085' (+4475') | 85' |
| TD | 3170' (+4390') | |

**Appendix 2.** **Summary of drill-stem test (DST) data in Ridgeway Arizona Oil Corporation wells in the St. Johns - Springerville area. Data available as of March 1999.**

| WELL DST # & DEPTH | ROCK UNIT | TIME (MIN) IF:SI:FF:SI | PRESSURE IN PSI IF1-FF1-SIP1; IF2-FF2-SIP2 | SUMMARY OF RESULTS |
|---|---|---|---|---|
| | | | **Arizona** | |
| #1 Plateau Cattle | | | | |
| 1. 1680-1720' | Big A/Amos | 15:30:60:120 | (112-191--500; 112-193--501) | 162 mcfd, 1/4" ck, 95 psi, 175' gcm |
| 2. 1410-1480' | Ft. Apache | 20:30:65:130 | (196-387--423; 315-391--423) | 228 mcfd, 1/4" ck, 140 psi, 475' gcmw |
| #11-21 State | | | | |
| 1. 1610-1664' | Ft. Apache | 30:60:30:60 | (157-342--343; 160-321--345) | ngts 1/2" blow, 600' sgcmw |
| 2. 1665-2410' | Amos Wash | 30:60:30:60 | (185-340--367; 315-345--367) | ngts 4" blow, 660' hgcmw |
| #10-22 State | | | | |
| 1. 1428-1490' | Ft. Apache | 30:60:30:60 | (050-066--128; 081-073--112) | ngts 4" blow, 30' wcm |
| 2. 1575-1790' | Big A Butte | 30:60:30:60 | (272-398--416; 317-372--421) | 45 mcfd, 1/8" ck, 90 psi, 610' hgcm |
| 3. 2054-2265' | Granite Wsh | 30:60:30:60 | (058-076--258; 075-090--186) | ngts 4 oz blow, 60' hgcm |
| #9-21 State | | | | |
| 1. 1860-1964' | Ft. Apache | 30:60:30:60 | (081-385--478; 391-465--478) | ngts 6" blow, 925' mw |
| 2. 1963-2160' | Big A Butte | 30:60:60:60 | (096-421--522; 426-507--522) | ngts 5" blow, 600' wcm + 450' mcw |
| 3. 2590-2694' | Granite Wsh | 40:60:60:60 | (078-143--690; 112-178--690) | 19 mcfd, 1/8" ck, 30 psi, 370' hgcm |
| | | | **New Mexico** | |
| #2-13 N. State* | | | | |
| 1. 2460-2597' | Pennsylv. | 30:60:30:60 | (033-037--285; 036-038--175) | ngts? 2300 cc mud, 3200 ppm |
| #1-16 N. State* | | | | |
| 1. 2694-2841' | Pennsylv. | 30:60:30:60 | (167-046--___; 050-031--___) | ngts? .02 cfg, 1800 cc wtr, 50' wtr |
| #1-16 S. State | | | | |
| 1. 2694-2841' | Supai* | NO DATA AVAILABLE | | |
| #36-1 S. State | | | | |
| 1. 2333-2358' | Ft. Apache | 60:60:60:60 | (113-458--509; 464-506--512) | ngts no blow, 1130' wtr, 250 ppm |
| 2. 2375-2430' | Big A Butte | 30:60:30:60 | (051-044--475; 074-061--465) | ngts 1" blow, 90' wtr, 850 ppm |

**Note:**

cc = cubic centimeters
cfg = cubic feet of gas
ck = choke (orifice diameter)
FF = final flow
gcm = gas cut mud
gcmw = gas cut muddy water
hgcm = highly gas cut mud
hgcmw = highly gas cut muddy water
IF = initial flow
mcfd = thousand cubic feet per day
mcw = mud cut water
mw = muddy water
ngts = no gas to surface
ppm = saltiness in parts per million
psi = pounds per square inch
SI = shut in
SIP = shut in pressure
sgcmw = slightly gas cut muddy water
wcm = water cut mud
wtr = water

* from PI Reports