

Helium Potential in the Holbrook Basin, Arizona*

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Abstract

The Holbrook Basin is located on the Colorado Plateau, it is deeply eroded, and the remaining sedimentary rocks are mostly Paleozoic and lower Triassic in age. Structures are compressional, low-relief monoclines. The Permian Coconino aeolian sandstone is the primary reservoir for Helium. It has produced 9 bcfg (gross) mostly from 1961 to 1977, but some more recently. The percentage of Helium is high at 8 to 9% (90% Nitrogen). The Coconino is at shallow depths in the basin. It is an active regional aquifer that results in tilted gas/water contacts and the risk of water flushing in closures with small vertical relief. In many areas it is too shallow for an effective vertical seal. New regional maps show where the Coconino is deep enough and the major structures in the basin. Secondary reservoirs both above and below the Coconino are the main objectives for recent drilling. They were deposited in less continuous depositional environments. The Supai formation below the Coconino has sands and carbonates in cycles of evaporite deposition; good seals, less continuity avoids water flushing. Supai helium shows are widespread in the basin and have been posted on the regional maps, up to a few percent Helium with Nitrogen. In the southeastern part of the basin, CO₂ substitutes for Nitrogen. One field was delineated in anticipation of a CO₂ pipeline, Helium is less than 1% but that is still economically significant.

References Cited

Arizona Oil and Gas Conservation Commission, 2019, Oil and Gas Viewer, ogviewer.azdeq.gov

Ballard, J.H., 2018, Faulting in helium producing structures, Holbrook basin, Arizona: Project - Holbrook Basin, Arizona Helium Production Potential, on [researchgate.net](https://www.researchgate.net).

Broadhead, R.F., and L. Gillard, 2004, Helium in New Mexico: geologic distribution and exploration possibilities: New Mexico Bureau of Geology and Mineral Resources, Open-file report 483, 62 p. (available at geoinfo.nmt.edu).

Butler, W.C., 1987, The rationale for assessment of undiscovered, economically recoverable oil and gas in central and northern Arizona: play analysis of seven favorable areas, U.S. Geological Survey Open-file report 87-450-V, 150p.

Rauzi, S.L., 2003, Review of helium production and potential in Arizona: Arizona Geological Survey, Open-file report OFR 03-05 30 p. (available at azgs.arizona.edu)

Helium Potential in the Holbrook Basin, Arizona



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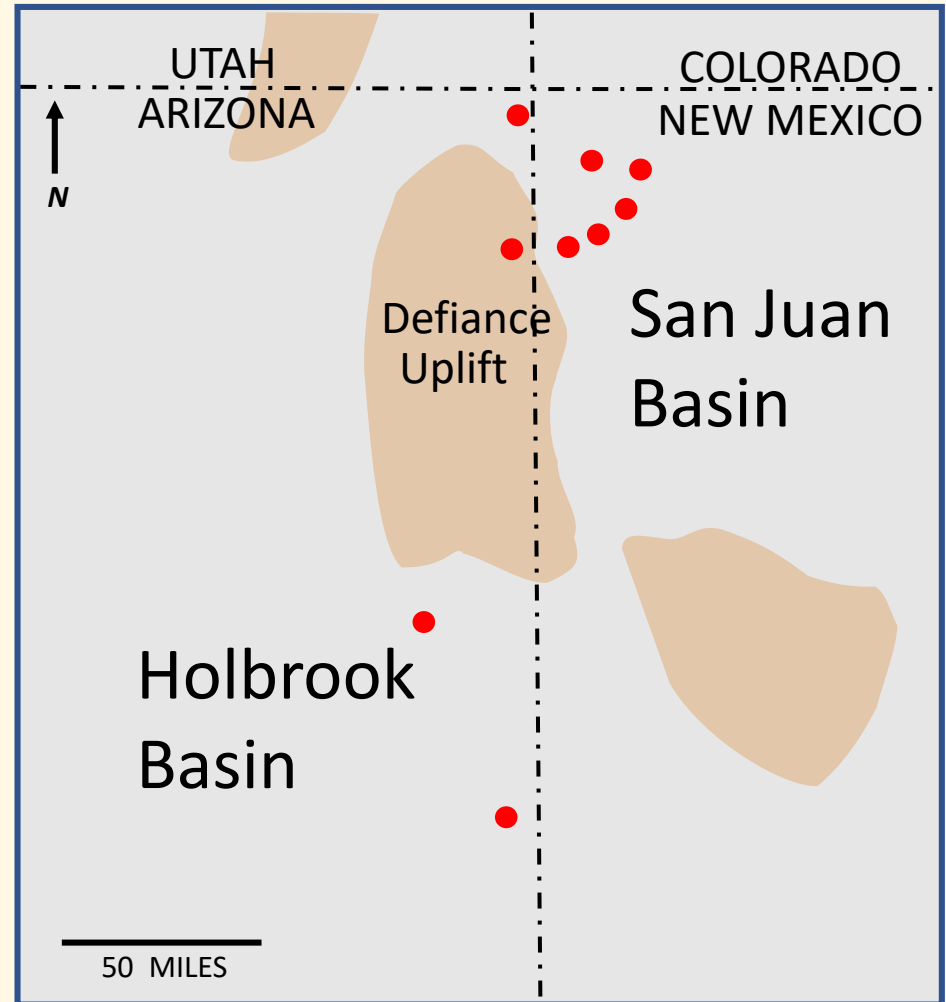
AAPG Rocky Mountain Section, September 15 – 18 2019, Cheyenne Wyoming

Helium in General

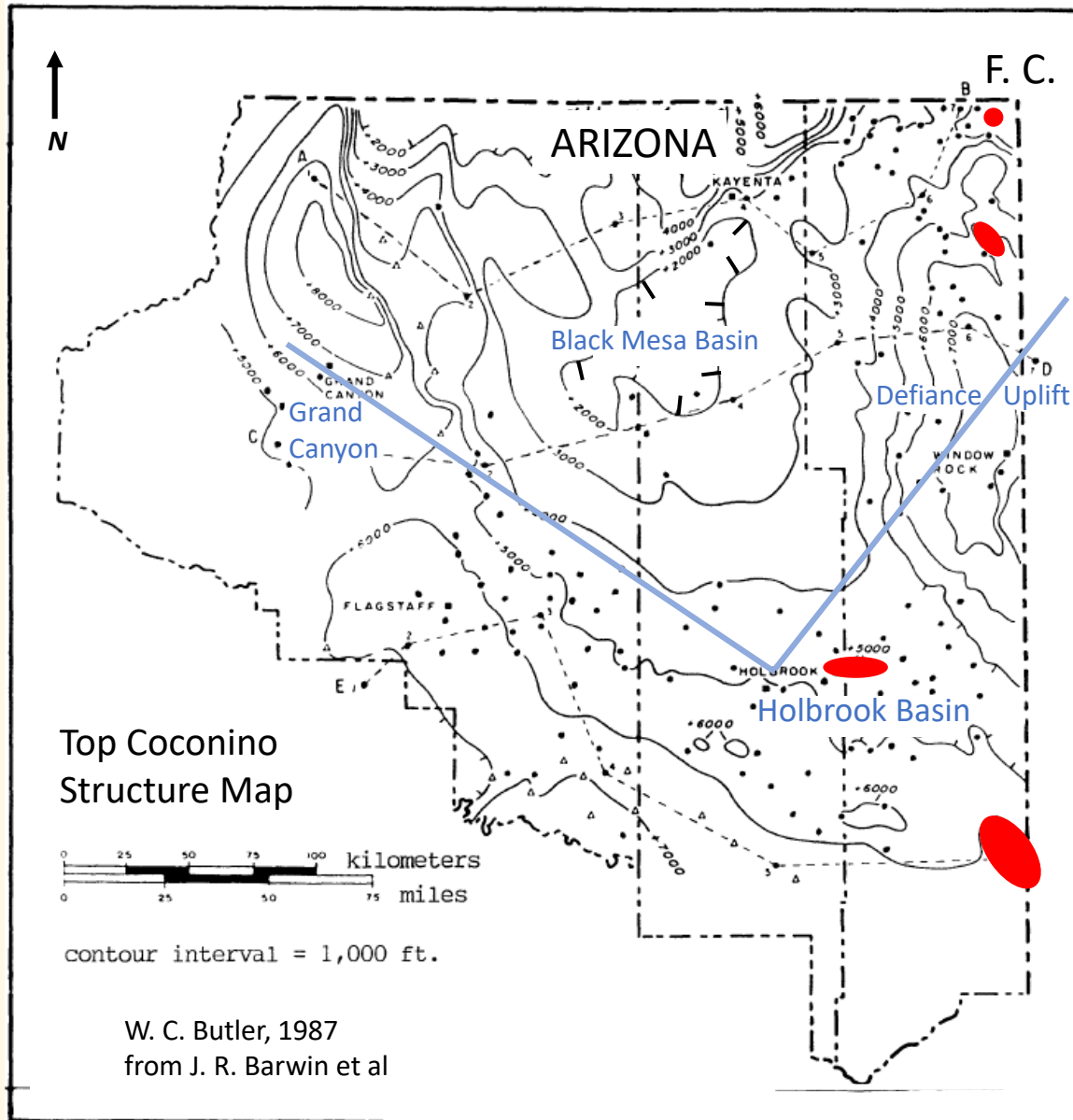
- Has exotic sources - the decay of uranium in igneous rocks, from the mantle, etc.
- Once it reaches the near surface (faults/fractures/diatremes), it is found in the same kind of traps as natural gas. Drilling, logging, completions... the same. Facilities are different.
- Helium production is largely from low concentrations in natural gas (e.g. 0.7% at Hugoton field), but concentrations over 5% are found in Arizona and New Mexico.
- U.S.A. is a large producer and exports helium, but production is in decline. The price has gone way up (over \$100 an mcf).

Helium in Arizona and New Mexico

- In the Four Corners region of the Colorado Plateau
- Fields are located around the Defiance Uplift (basement reverse faults and diatremes).
- In the north, helium is mixed with hydrocarbons.
- In the Holbrook basin, nitrogen and CO₂ are more common.



For New Mexico see R.F. Broadhead, 2004
For Arizona see S.L. Rauzi, 2003



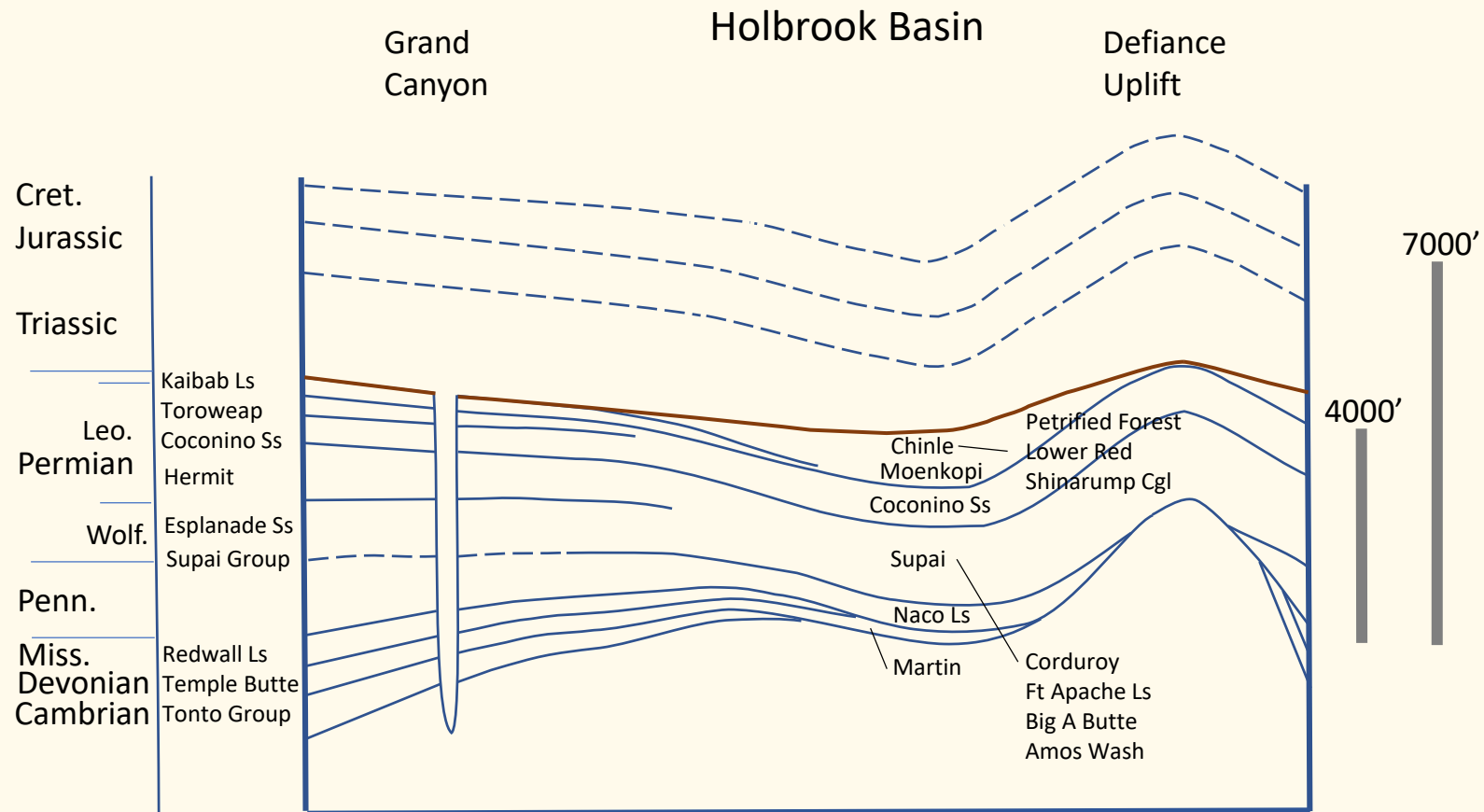
- Note location of the Four Corners and the helium fields in Arizona.
- The Holbrook basin is within a regional NW plunging syncline that includes the Black Mesa basin.
- Helium is present over part of the SW flank, and is prospective along the NE flank.
- The blue line locates a cross section; Grand Canyon - Holbrook Basin - Defiance Uplift.

NW

SE

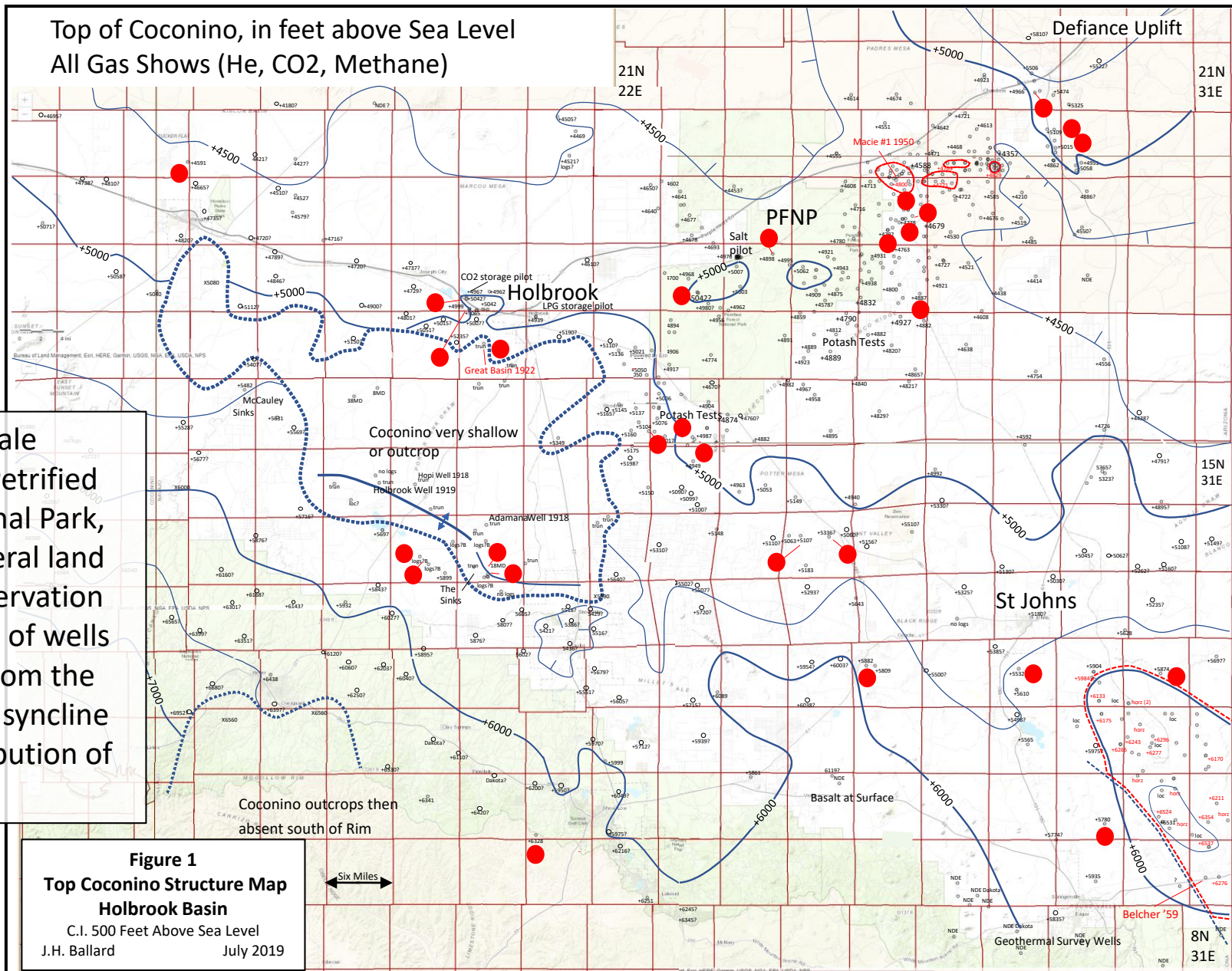
SSW

NNE



- Ground level is brown, Holbrook stratigraphy is similar to the Grand Canyon.
- Note Coconino aeolian sandstone (produced the most helium), Shinarump conglomerate above and the Supai evaporites-red beds-carbonates below.
- Structures formed in the Cordilleran orogeny (Defiance was also a Penn. high).
- Holbrook basin is 4000' deep, a Mesozoic section briefly brought it to 7000'.

Top of Coconino, in feet above Sea Level All Gas Shows (He, CO₂, Methane)



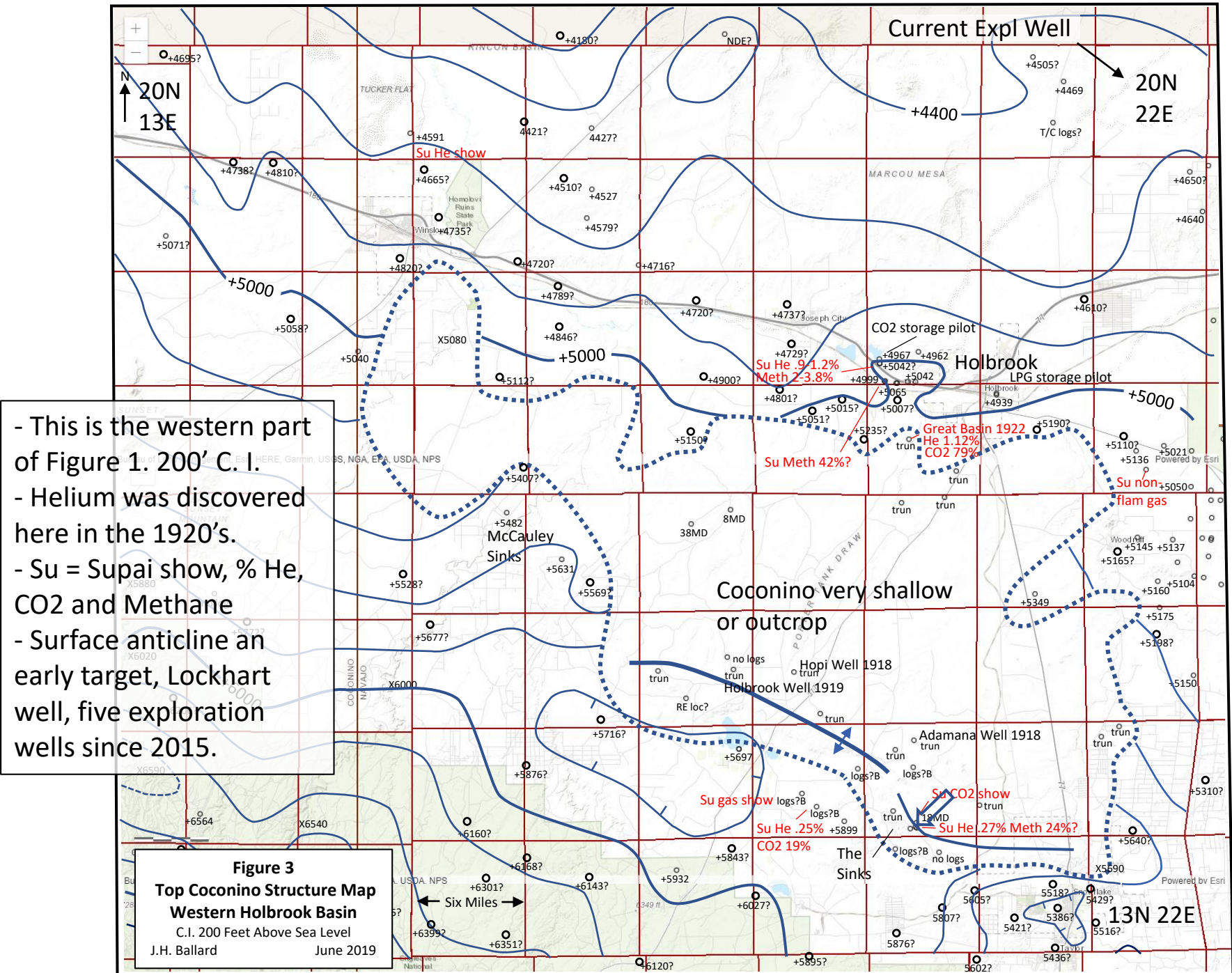
- Note the scale
- Holbrook, Petrified Forest National Park, Green = Federal land Brown = Reservation
- Many types of wells
- Dip is NE, from the "Rim" to the syncline
- Wide distribution of gas shows

Basemaps, well locations and elevations, are from the AOGCC website, 2019

Figure 2
Depth to Top Coconino
Holbrook Basin
 C.I. 500 Feet from Ground Level
 J.H. Ballard
 July 2019

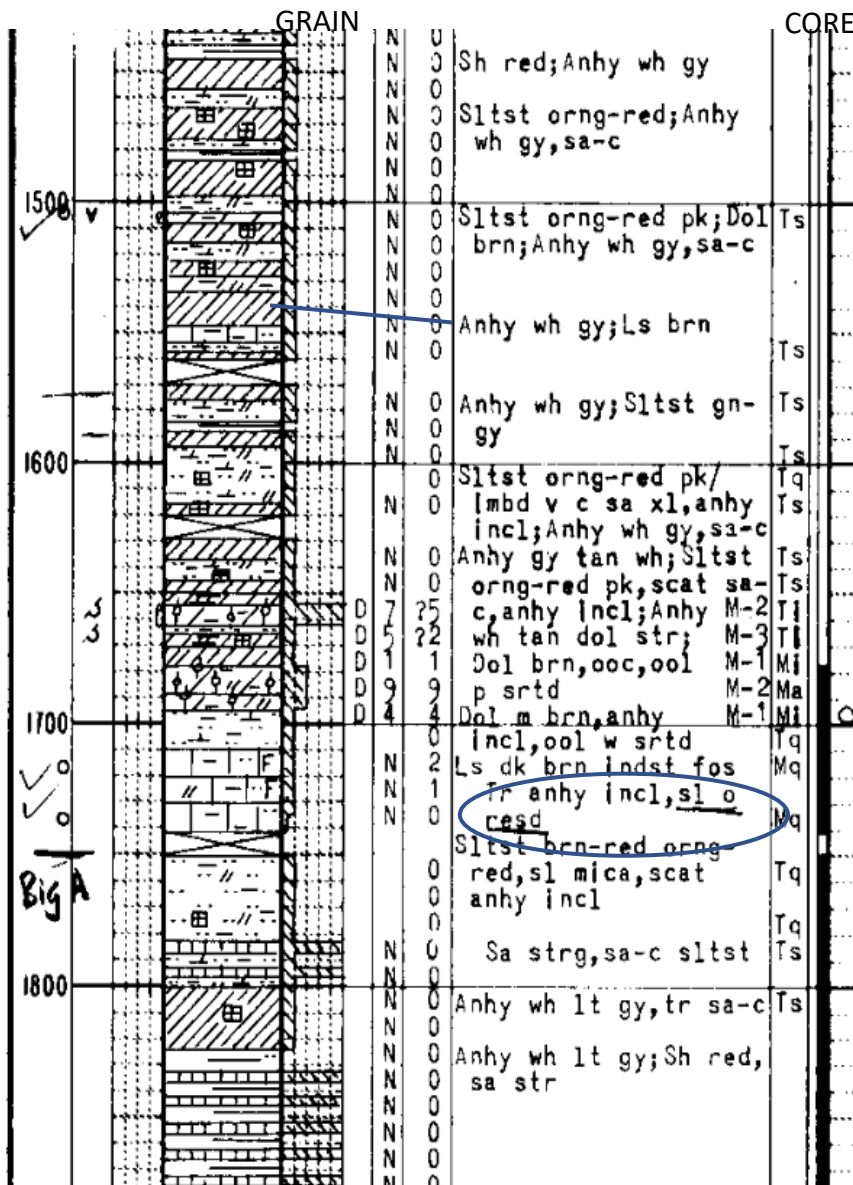
- Outcrop to 2000'
- Shallow drilling
- Shows are mostly below 1000', above 500' lacks seal.
- Other shows on Fig. 1 mostly Supai, up to 2000' deeper.
- Still shallow drilling

Figure 2
Depth to Top Coconino
Holbrook Basin
C.I. 500 Feet from Ground Level
J. Ballard July 2019



Lockhart '49 14N 20E Sec 33

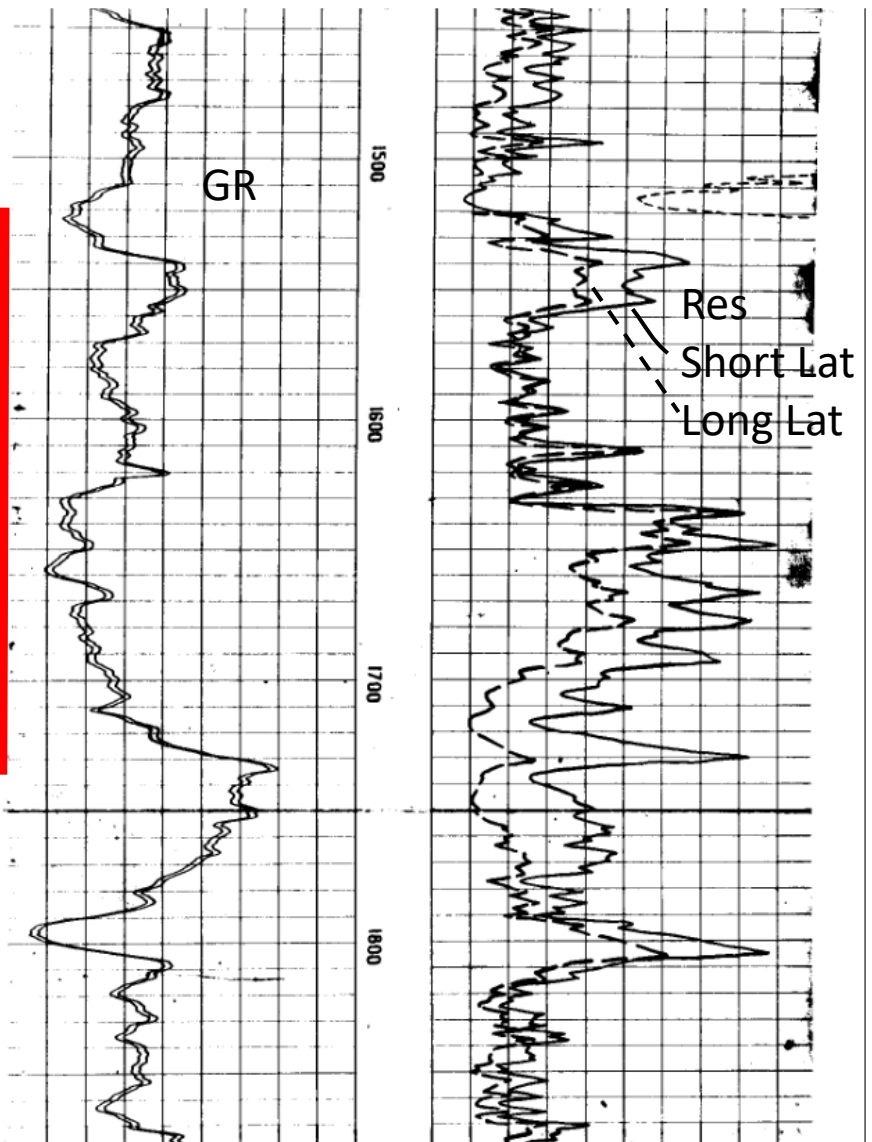
Am Strat



Supai, Fort Apache Member

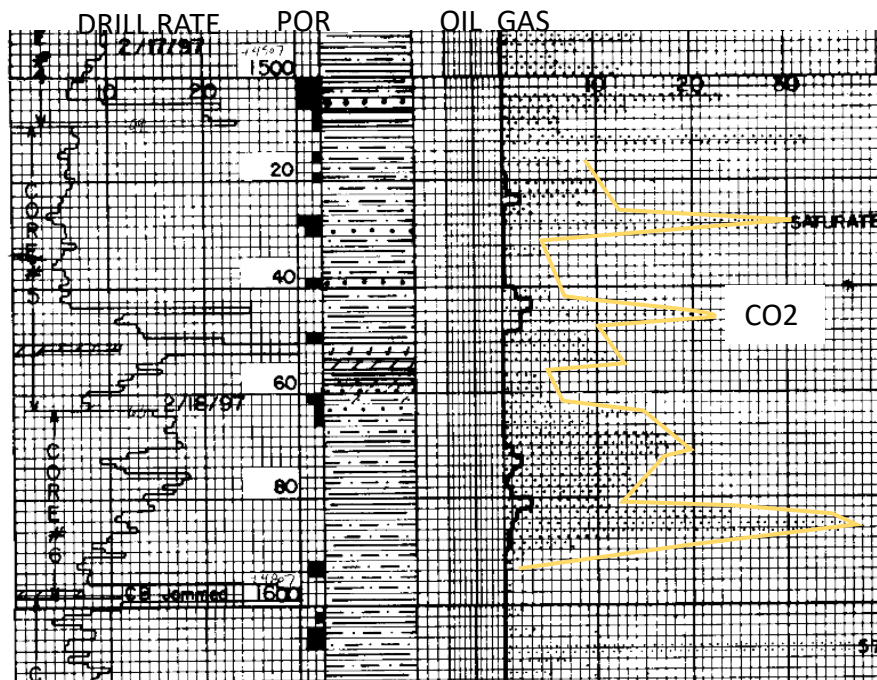
Nitro shot, recovered gas; Nitrogen 70%

Methane 24% (some C1+), Helium 0.27%



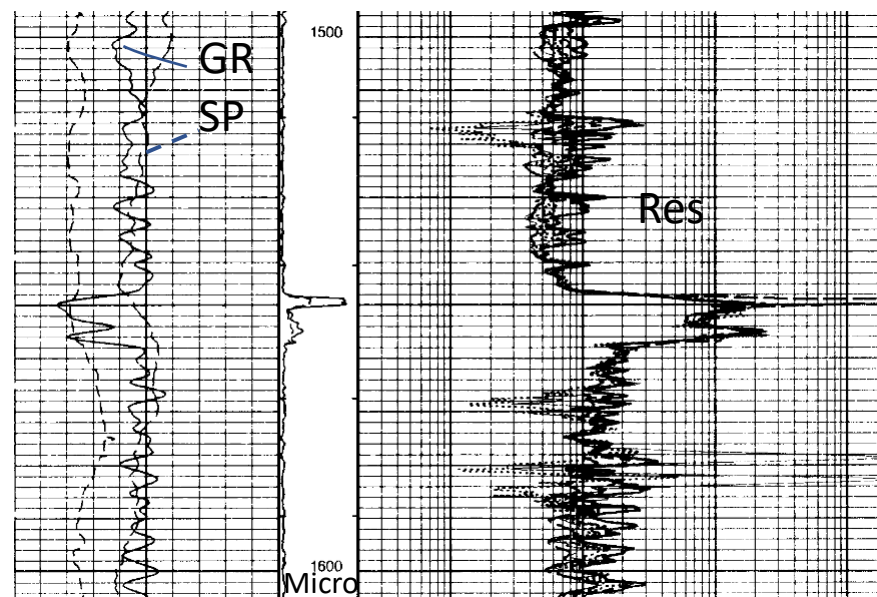
Ridgeway '97 12N 29E Sec 22

Mud Logs with CO2 Tracks

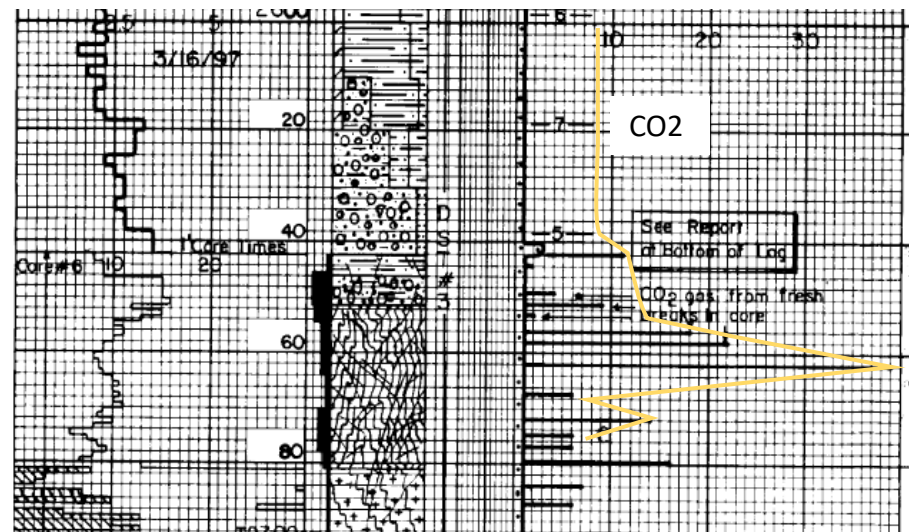


Supai, Amos Wash Member

Sand frac, tested 1.8 mmcf/d CO2 90% He 0.66%

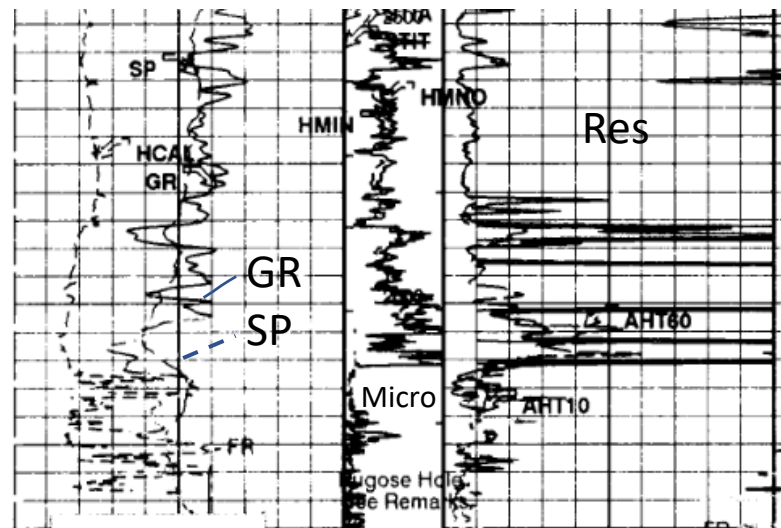


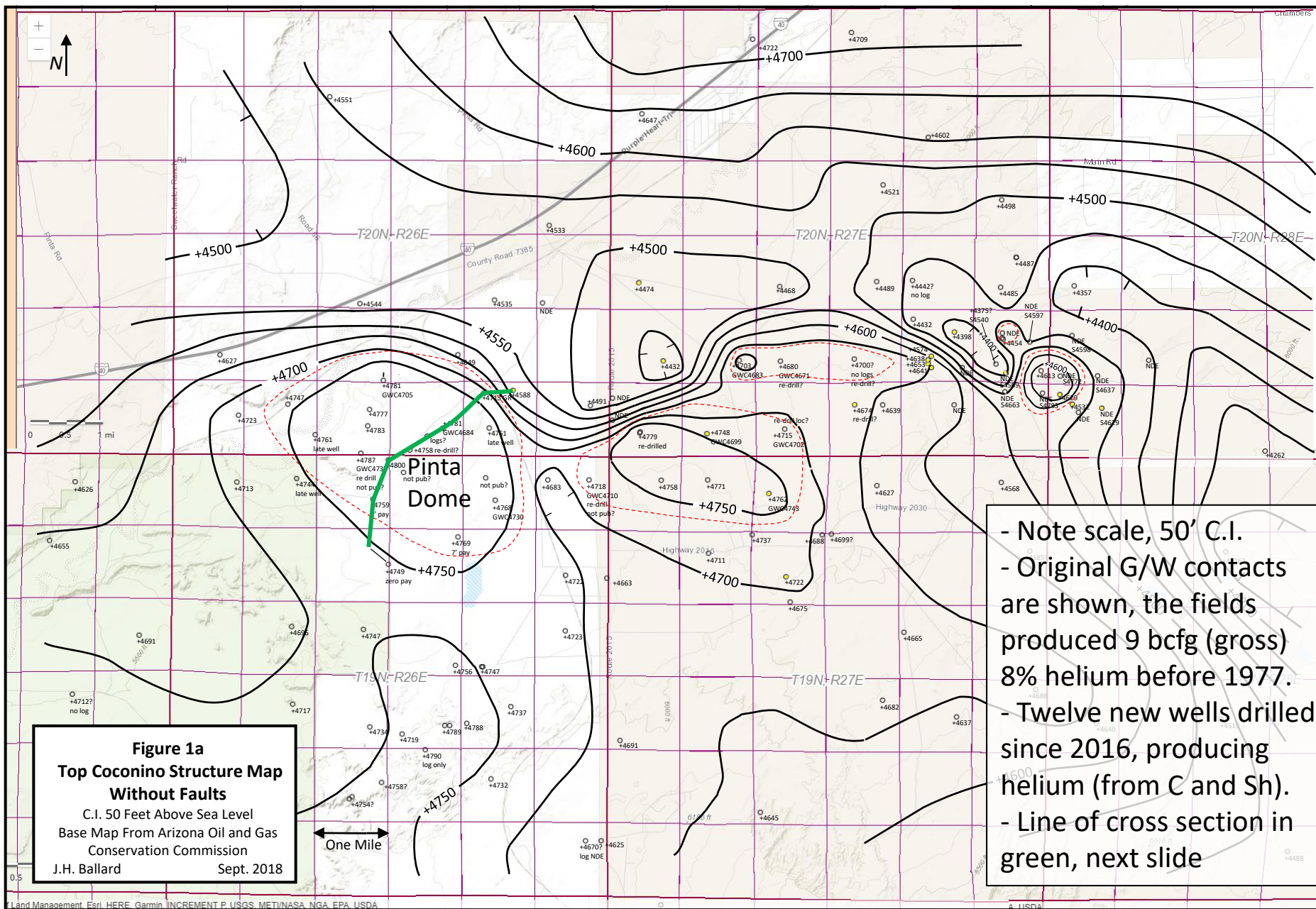
Ridgeway '97 9N 31E Sec 21



Supai, lower Amos Wash and Basement

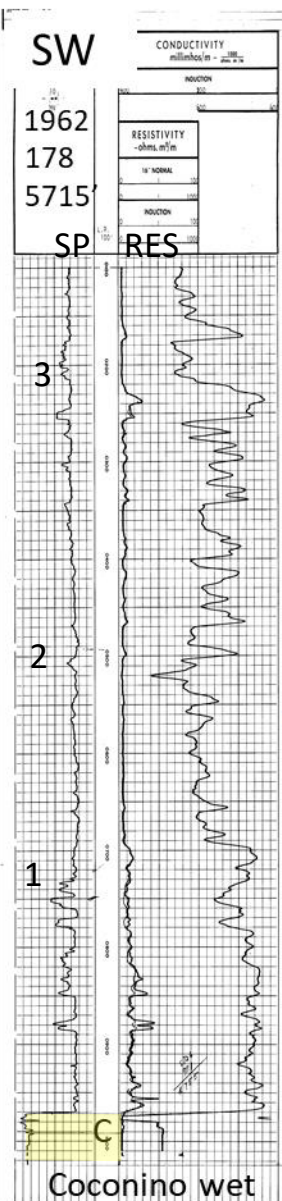
Sand frac, tested 1.1 mmcf/d CO2 99% He 0.07%



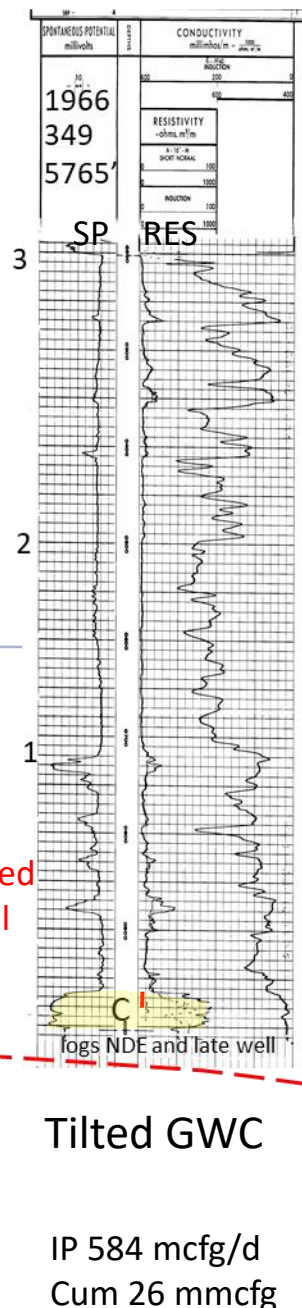
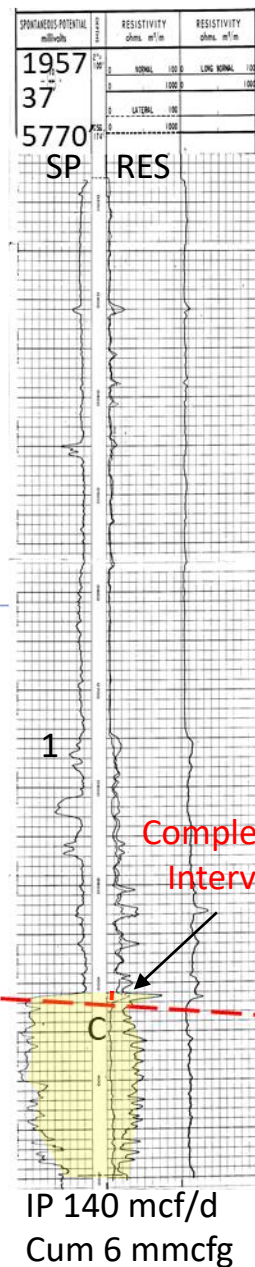


Cross Section 1 Pinta Dome Field (1961-1976)

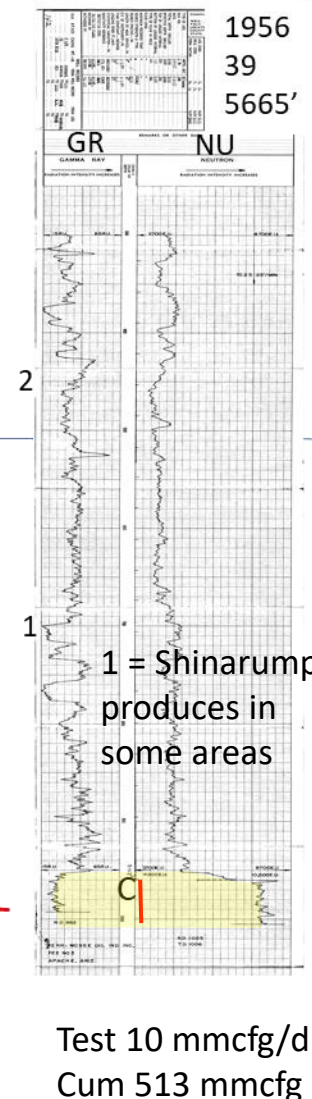
NE



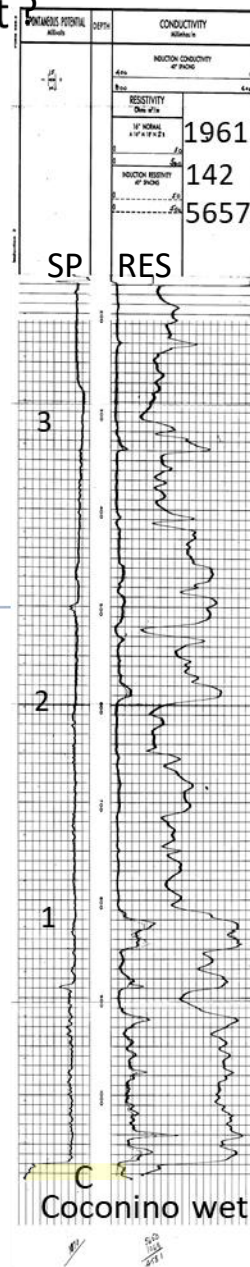
Datum: Sea Level
No Horz Scale



C = Coconino sandstone
300' Por 14% Perm 150md
90% N 8% He, <1% CO2, Meth



Fault?



Yr

Elev

Holbrook Helium

- Coconino sandstone is the best quality reservoir, have to consider seal and hydrodynamics. Supai carbonates also proven, may need stimulation.
- Where there are enough data points we see structures. Few wells outside potash/salt areas. Very limited seismic.
- High He% (with nitrogen) near Defiance Uplift. Lower He% with CO₂ to southeast, and with (some) methane to the southwest.
- Low cost drilling (shallow), small operations possible with new He upgrader technology.

References

Arizona Oil and Gas Conservation Commission, 2019, Oil and Gas Viewer, ogviewer.azdeq.gov.

Ballard, J.H., 2018, Faulting in helium producing structures, Holbrook basin, Arizona: Project - Holbrook Basin, Arizona Helium Production Potential, on researchgate.net.

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