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PRESENTS:

A Geological Report of the Hydrocarbon Potential of the Holbrook Basin and Southern Black Mesa Basin in Navajo and Coconino Counties, Arizona

by

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PETROLEUM LEADS IN PARTS OF THE HOLBROOK BASIN AND SOUTHERN BLACK MESA BASIN IN COCONINO AND NAVAJO COUNTIES, ARIZONA

EXECUTIVE SUMMARY

Seven lead areas for petroleum (oil, natural gas and helium) exploration drilling are identified in the Holbrook Basin and adjoining southern Black Mesa Basin in Coconino and Navajo Counties, Arizona (see attached map). The primary potential reservoir objective in these leads is porous dolomite in the Devonian, locally with secondary up-hole potential in shallower units (notably the Permian Supai Formation). Identification of the leads was based on subsurface mapping (structure and thickness maps), reported petroleum and helium shows and tests, and published Bouguer gravity-anomaly data.

A number of exploratory oil and gas wells have been drilled in the Holbrook Basin in last 90 years, and considerably fewer wells in the southern Black Mesa Basin. The majority were drilled only into the Supai Formation or shallower, and the remainder reached TD variously in the Pennsylvanian, Mississippian, Devonian or Precambrian. None of these wells resulted in commercial production, although shows of oil and/or gas were reported in many of them. Surface structures in this area are related to deformation of overlying strata resulting from the dissolution of subsurface evaporites in the Supai Formation, and they do not reflect deeper structure. Previous operators who mainly drilled such structures did not drill optimal locations for petroleum traps and did not identify viable reservoir-trap objectives. Likewise, maps of shallow horizons do not reflect structure on the Devonian.

Most of the leads for Devonian dolomites are on separate fault blocks that compartmentalize potential reservoir systems such that dry holes on one fault block do not condemn exploratory drilling on other fault blocks. The exploration for potential Devonian reservoirs in this area is based largely on several inter-related lines of geological evidence: (i) evaluation of Devonian structure and relationship of that to underlying Precambrian structure and gravity anomalies, (ii) Devonian thickness, (iii) petroleum shows, and (iv) analysis of the internal stratigraphy of the Devonian section, which is subdivided on the basis of log characteristics into several porosity sub-zones and related marker beds. ***Lead #1*** is on a structural high on a discrete fault block in T13N-R19E, T13N-R20E, and T14N-R20E in Navajo County and is ranked highest because of associated compelling shows of oil, natural gas and helium in surrounding wells. There is also potential here in the Mississippian Redwall Limestone, the Pennsyvanian Naco Formation, and the Permian Supai Formation. ***Lead #2*** is on a structural high in T17N-

R13E and 14E and T18N-R13E and 14E, in Coconino County. It has good potential for reservoirs based on compelling shows of oil and gas in the Devonian and the Supai Formation in adjoining wells. ***Lead #3*** is on a structural high on a discrete fault block in T20N-R9E and 10E and T21N-R9E and 10E, in Coconino County. Shows of oil and the best porosity zones in the Devonian section were mostly un-tested, and there also is a possibly of reservoirs present in the overlying Supai Formation. ***Lead #4*** is on a fault-bounded structural high in T18N-R22E and T19N-R22E and part of T18N-R23E, in Navajo County. This lead requires 2-D seismic and evaluation of oil potential in a nearby lease (once information is released to the state) prior to acquiring seismic or drilling. ***Lead #5*** is on a gravity high in T24-27N in R7-10E in Coconino with some shows of oil in the Devonian in nearby structurally low wells. There may also be potential from reservoirs in the Supai Formation. ***Leads #6 and 7*** are rank wildcats based solely on the presence of gravity highs. They are in T22-23N in R12½-13E in Coconino County (#6), and T23-24N in R14-15E in Coconino and Navajo Counties (#7). Structural setting and reservoir thickness at these leads are favorable attributes of potential traps for Devonian (and Supai) reservoirs.

Respectfully submitted,

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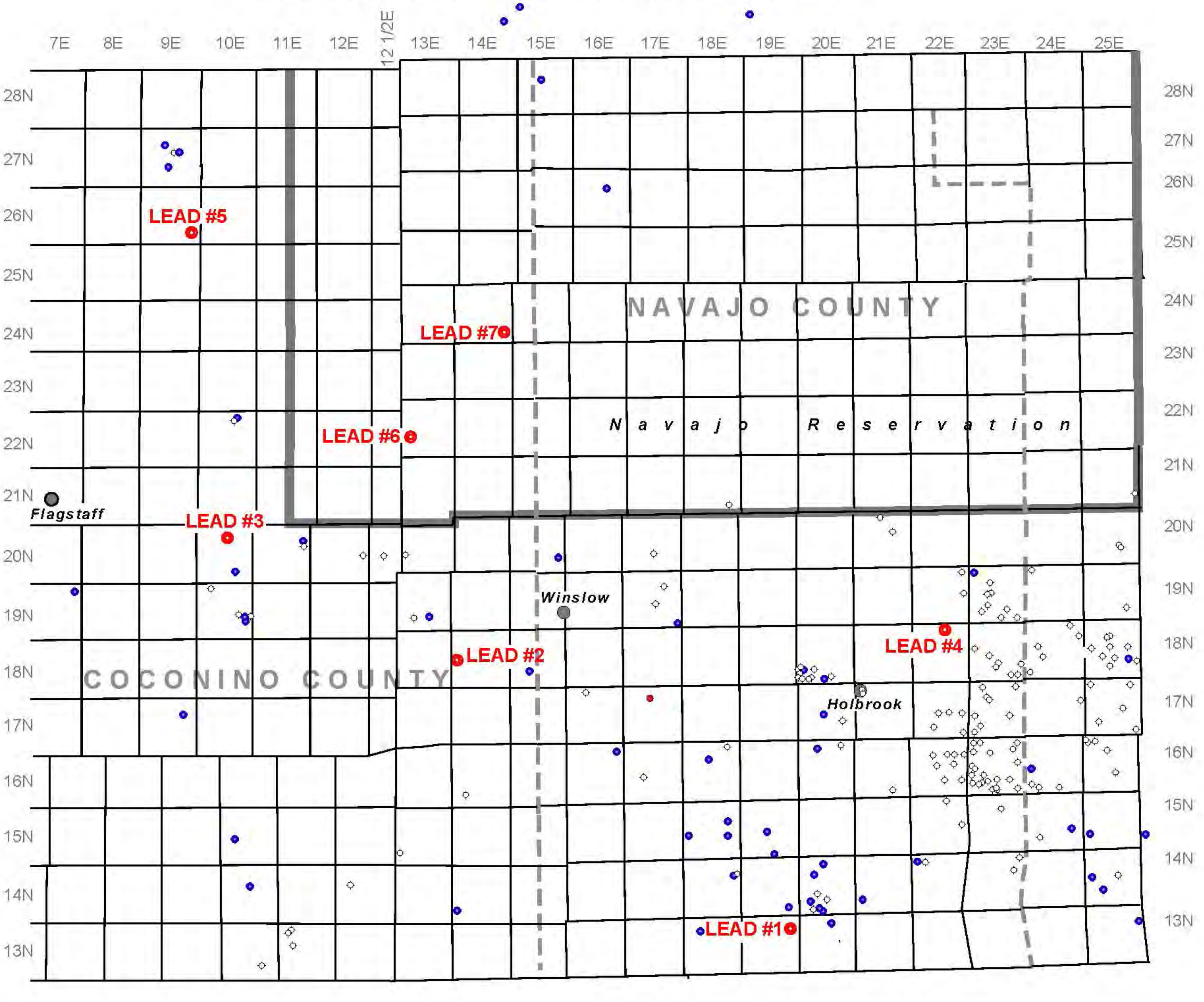
LOCATIONS OF LEADS
HOLBROOK-SOUTHERN BLACK MESA BASIN



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REGIONAL SETTING

The petroleum leads (oil, natural gas and helium) described in this report are in the central and western parts of the Holbrook Basin and adjoining southern part of the Black Mesa Basin in Coconino and Navajo Counties, Arizona (see *Exhibit 1*). These basins formed and subsided mainly during the late Pennsylvanian and Permian. There have been many shows of oil, natural gas and helium reported in wells drilled in these areas but to date no commercial fields have been discovered here. However, a number of very prolific oil fields are present to the northeast of this area on the Defiance Uplift, the Four Corners Platform, and in the Paradox Basin. The Dineh-bi-Keyah Field on the Defiance Uplift, for example, produces oil and helium-rich natural gas from Tertiary rocks, and cumulative production from this field is in excess of 1.2 MMBO and 653 MMCFG. Major helium reserves have been produced in the eastern part of the Holbrook Basin (see Exhibit 1) at the Pinta Dome-Navajo Springs-East Navajo Springs fields in Apache County.

STRATIGRAPHY AND POTENTIAL RESERVOIRS

The stratigraphy of the Holbrook and Black Mesa Basins is shown in *Exhibit 2*. Precambrian rocks here are overlain locally by the Cambrian Tapeats Sandstone, which y has shows of oil in some wells in the southern part of the Black Mesa Basin. For the most part, however, the Tapeats Sandstone generally is not present over most of the area considered herein. The Precambrian, or the Tapeats Sandstone where it is present, are overlain unconformably by the Devonian-age Martin Formation and its lithologic equivalents (the Temple Butte Formation of the Elbert Formation), ***which are the main potential reservoir objectives in this area.*** The Martin, Temple Butte and Elbert Formations are dominantly dolomite, but they also contain varying amounts of interbedded sandstone and shale. Shows of oil and gas have been reported in these formations in a number of wells. The Martin Formation (and its equivalents) are not present is some areas, however, because of later Devonian and/or early Mississippian erosion. In places the Martin Formation is underlain by a thin section of the Devonian Aneth Formation (dominantly dolomite) and overlain by a thin section of the Devonian Ouray Limestone. These formations generally are not reservoir objectives here. The Devonian is overlain unconformably by a thin section of the Mississippian-age Redwall Limestone, which consists primarily of limestone with some dolomite and interbedded shales. The formation locally is absent because of pre-Pennsylvanian erosion. The

Redwall may be a possible reservoir objective in one or more of the leads described herein because it locally contains porous rocks and some shows of oil.

The Pennsylvanian-age Naco Formation overlies either the Devonian or Mississippian, depending on the extent of later Devonian to early Mississippian and pre-Pennsylvanian erosion. The formation comprises a relatively thick section of thin-bedded limestones, siltstones and shales locally with some sandstones and dolomites. It is considered to be a possible reservoir objective in some of the leads considered herein because of the presence of porous rocks with oil shows. The overlying Supai Formation is mainly of Permian age, although the basal part of the formation is of upper Pennsylvanian age. The formation comprises a thick section of dominantly red shales, siltstones and sandstones and associated evaporites (gypsum, anhydrite and halite, salt) and silty limestones and dolomites. The Supai consists of a relatively thick section of halite, gypsum, anhydrite and potash in the eastern two-thirds of the Holbrook Basin (see *Exhibit 3*). The thin Ft. Apache Member of the Supai Formation is roughly in about the middle of the formation, and it consists of interbedded porous dolomite and some sandstone, red shale and siltstone, and evaporites. It is underlain in turn by the Big A Butte and Amos Wash Members of the formation (see *Exhibit 2*), which also consist mainly of red siltstones and shales and accessory limestone, dolomite, sandstone, and evaporites. Oil and gas shows, including helium, have been reported in these members in many wells in the Holbrook Basin, particularly in the Ft. Apache Member. Accordingly, they are considered to be secondary reservoir objectives in this area.

Overlying strata include the thick, Permian Coconino Sandstone, which is the main helium-bearing reservoir in the Pinta Dome-Navajo Springs-East Navajo Springs fields in the eastern part of the Holbrook Basin, and succeeding it, the erosionally thin to absent Kaibab Limestone. These rocks are unconformably overlain by various Triassic formations (see *Exhibit 2*). Whereas the Coconino Sandstone may be a reservoir for natural gas and/or helium at some of the leads considered herein, the youngest Permian Kaibab Limestone and overlying Triassic rocks offer no potential for oil or gas accumulations in this area.

HISTORY OF PAST DRILING FOR OIL AND GAS

Aside from in the Pinta Dome-Navajo Springs-East Navajo Springs fields, there have been a number of exploratory oil and gas wells drilled in the Holbrook Basin, and considerably fewer wells in the southern Black Mesa Basin. The majority of these wells were drilled only into the Supai Formation or shallower, and the remainder reached TD variously in the Naco, Redwall or Martin Formations or in the subjacent Precambrian crystalline-rock basement. Based on available records, the oldest oil or gas exploration well drilled in Coconino and Navajo Counties was the Arizona Sunshine #1 Sunshine well in Section 13 T20N-R12½E in Coconino County. It was drilled in 1920 into the Coconino Formation and reached TD at 1470'. The first deep well was the Holbrook #1 Government well in Section 23 T15N-R18E in Navajo County. It was drilled in 1922 and deepened in 1924 to the Devonian, and reached TD at 3775'. The nearby Adamana Oil #1 Government well in Section 4 T14N-R20E in Navajo County was drilled in 1926 reached TD at 3387' in the Redwall Limestone(?), and it blew out 48° gravity oil at TD.

Influence of Surface Structures on Previous Drilling – There are a number of anticlines exposed at the surface in the Holbrook Basin and southern Black Mesa Basin as shown in *Exhibit 4* (based on the work of Scurlock, 1971 and Rauzi, 1996), the most prominent of which is the Holbrook Anticline. It and the other long anticlines here trend mostly in a northwest-to-southeast direction, and shorter ones trend in the same direction or to the northeast-southwest. In addition to some small domes, several short normal faults also are present locally, and they mostly trend in northwest-southeast and also north-northeast—south-southwest directions. With some exceptions, most of the exploratory wells in the area were drilled on or close to these surface structures. Old well files indicate that some of the wells that seemingly were not drilled on a mapped structure actually were drilled on surface structures that are not shown in *Exhibit 4*. None of these wells resulted in commercial petroleum production, although some shows of oil and/or gas were reported in them. Most of the many shallow wells east of the city of Holbrook, between the easternmost anticline and the one to the immediate west-southwest, were drilled into the Supai Formation solely to evaluate the subsurface extent of potash in the formation. Those shallow wells around the Pinta Dome-Navajo Springs-East Navajo Springs fields were drilled into the Coconino Sandstone in the search for helium.

According to Bahr (1962) and some later workers, the surface structures in this area are not related to tectonic activity, but rather, to deformation of overlying strata resulting from the dissolution of subsurface evaporites in the Supai Formation. *I will show below that these surface structures clearly do not reflect deeper structure on either the Devonian Martin Formation or the shallower Supai Formation, which are the primary and secondary reservoir objectives, respectively, in this area. Accordingly, insofar as commercial oil or natural gas production has not been established in this area (other than in the Pinta Dome-Navajo Springs-East Navajo Springs fields) by past drilling on surface structures, it is my contention that previous operators who drilled such structures obviously did not drill in optimal locations for petroleum traps. Furthermore, the geologic nature of likely traps for oil and/or gas in the Devonian and other possible reservoir objectives had not been identified by previous operators in this area. Evaluation of likely trap types present in any area lowers risk and allows for targeted drilling for oil and gas reserves.*

STRUCTURE AND THICKNESS MAPS AND INFERENCES

Accordingly, I prepared a series of maps and geologic cross sections to systematically identify the nature of likely traps for petroleum in Devonian and shallower strata and to assist me in evaluating the structural attitude, thickness, and distribution of potential reservoirs in this area. I was particularly concerned with determining if there were any shallow maps that I could use as a proxy for identifying Devonian structure and potential traps.

Precambrian Structure – The structure on the top of the Precambrian basement in the area is shown in *Exhibit 5A*. In addition to several structural highs and lows, the map also shows a number of normal faults that cut the Precambrian. These faults are geologically important because they compartmentalize the Precambrian into separate fault blocks.

Note on *Exhibit 5B*, on which previously identified surface structures are superimposed, that there is no coincidence between surface structures and these faults. Also, aside from that portion of the Holbrook Anticline that corresponds to a broad structural high on the Precambrian south and west of Winslow along the Coconino-Navajo County line, there also is no coincidence between surface structures and structural attitude on the top of the Precambrian.

Devonian Structure – *Exhibit 6A* is a structure map on the top of the Devonian (Martin and equivalent formations) that also shows the Devonian subcrop (which specific formation is present within the Devonian) and where these rocks are not present because of pre-Mississippian erosion. Note that the same faults that are present on the Precambrian structure map (*Exhibit 5A*) are similarly present on the Devonian structure map, which indicates that the potential Devonian reservoirs also are physically compartmentalized on separate fault blocks. *This is an important observation because it implies that dry holes in the Devonian on one fault block do not necessarily condemn exploration on other fault blocks.* When previously mapped surface structures are superimposed on this map, they show that, like the Precambrian map, there is no coincidence between Devonian structures and surface structures (Exhibit 6B). *Hence, surface structures are not a proxy for deeper structure, and exploratory drilling on surface structures does not necessarily identify optimum locations for Devonian petroleum traps.*

Supai Structure – *Exhibit 7A* is a structure map on the top of the Supai Formation. It shows that (i) several of the faults that are present in the Devonian and Precambrian cut up into the Supai Formation, (ii) the existence of some faults that are present only in the Supai, and (iii) some structurally low and high areas on the Devonian and Precambrian are similarly reflected in the Supai structure. It also shows a number of "dissolution sinks" (low areas) that resulted from the dissolution of evaporites within the formation and subsequent collapse of overlying strata. Note that these low areas are not reflected on the deeper Devonian and Precambrian structure maps. *Exhibit 7B* is this same Supai structure map but with superimposed surface structures. It shows that most of the shallow structures are not reflected on the structure mapped on the top of the Supai Formation. *Hence, surface structures are not a proxy for slightly deeper structure, and exploratory drilling on surface structures does not necessarily identify optimal locations for petroleum traps in the Supai or Devonian formations. Furthermore, structure on the top of the Supai Formation also does not necessarily reflect that on the Devonian.*

Supai to Top of Devonian (or Precambrian) Thickness – *Exhibit 8* is a thickness (isopach) map of the section from the top of the Supai Formation to the top of the Devonian (or top of the Precambrian where the Devonian is not present because of erosion). I prepared this map to determine if there was any mappable coincidence between thickness of part of the section overlying potential Devonian reservoirs and structure on the top of the Devonian. The map shows that the Supai to Devonian thickness generally increases from the northwest to the southeast in the area, *and that there is no mappable coincidence to structure at the top of the Devonian (or to top of the Supai Formation). Rather, the map reflects the salt basin (see Exhibit 3) that formed as a* *result of increased subsidence in the eastern part of the Holbrook Basin during Pennsylvanian and Permian time.*

LEAD AREAS FOR EXPLORATORY DRILLING

The inferences listed above led me to conclude that the exploration for potential Devonian reservoirs as the primary objective in this area must be based largely on: (i) evaluation of Devonian structure and relationship of that to underlying Precambrian structure based on my map (*Exhibit 5A*) and a previously published (by Aiken and Sumner, 1972) Bouguer Gravity anomaly map (*Exhibit 10*), (ii) Devonian thickness (*Exhibit 11*), (iii) petroleum shows, and (iv) analysis of the internal stratigraphy of the Devonian section along regional reference cross section AA' (*Exhibit 12*) rather than to maps of shallower horizons or surface structures. That is because there are no proxies at shallow depths that reflect deeper Devonian structure. Perhaps there might have been more success in the past in finding oil/gas fields in the Devonian if previous operators had realized this and not drilled solely on the basis of surface structures.

Exhibit 9 is the same Devonian structure map as in *Exhibit 6A* but it includes reported oil and gas shows, several reference cross sections, and 7 identified lead areas (numbered 1 through 7 in order of decreasing rank) that are prospective for petroleum. Regional reference cross section AA' (*Exhibit 12*) shows that, over much of the area, the Devonian section can be subdivided on the basis of log characteristics into several sub-zones defined by correlative markers "A", "B" and "C" and intervening porosity zones 1-4 (wherein porosity is not uniformly developed across the area). The section also shows that marker "A" and overlying porosity zone 1 locally are not present in some wells because of later Devonian and/or pre-Mississippian erosion. This is important because it indicates that the top of the Devonian in one well may not be the same stratigraphic interval as in another well, which implies that correlative potentially-productive zones may not have been properly evaluated by past operators. That is to say, strata at the top of the Devonian in one well may not be the same strata as the top of the Devonian in an adjoining well.

Lead #1 – This lead is in parts of T13N-R19E, T13N-R20E, and T14N-R20E in Navajo County. It is ranked highest of all of the leads presented herein because of associated shows of oil and gas in surrounding wells. Structure on the Devonian (*Exhibit 9*) shows a structural nose trending to the west-southwest in T13N-R19E and R20E, with the Devonian getting higher in that direction; and there is a corresponding gravity high on the Precambrian in this area (*Exhibit 10*). I mapped a similar high on my Precambrian structure map (*Exhibit 5A*). The lead is on a discrete fault block bounded by two normal faults. The Devonian thickness map (*Exhibit 11*) suggests that the Devonian should be 100 ft thick or more here. Cross section BB' (*Exhibit 13*) illustrates structural and stratigraphic relationships in this lead, and it shows that the Devonian is porous in this area. I recommend drilling a first well in the NE/4 of T13N-R19E (specific location to be provided later).

The Lockhart #1 Aztec well in Section 33 T14N-R20E is a key well in this lead (*Exhibit 13*). It was drilled in 1949 to a TD of 3734' into the Precambrian, and subsequently plugged. According to the mudlog report it had *"good shows of oil"* in samples of porous dolomite in the Devonian Martin Formation at 3674-79' and in the overlying porous Mississippian Redwall Limestone at 3659-61'. Oil in these zones comprised 26-67% of collected samples, the remainder being water. The Lockhart #1 Aztec had the only show of oil in the Mississippian in the area, and it may be a secondary reservoir objective in this lead. The Martin and Redwall Formations were perforated, but unfortunately, no information on recovery was provided. The well also had intermittent shows of oil in samples of porous limestones in the Pennsylvanian Naco Formation at 3178-3425' associated with gas bubbles and fair odor. This unit also may be a secondary reservoir objective here. There likewise were shows of oil and significant shows of gas in samples of porous dolomites in and immediately above the Ft. Apache Member of the Supai Formation. The section 1522-1745' was perforated and reportedly tested 250 MCFG/day; a DST at 1678-1743' recovered 170' gas-cut mud. Oil saturation reportedly was 19% in the section 1678-1730'. Finally, there were some shows of gas and oil, in samples of either porous dolomite or sandstone, in the underlying Amos Wash Member of the Supai Formation. All of these aforementioned zones in the Supai are secondary reservoir objectives in this lead.

Some immediately surrounding wells also had significant shows in the Supai Formation, which further bolster the potential of this lead. The Johnson #2 Aztec well, for example, also in Section 33, was drilled in 1959 and reached TD at 1540' in the Supai Formation. It reportedly tested 780 MCFG/day at 1511-1523' in the Ft. Apache Member, with 6% helium. The Johnson #1 Aztec well in Section 33 was drilled in 1958 and reached TD at 3737' in the Precambrian. It reportedly tested 2 MMCFG/day at 1017' somewhere in the Supai Formation (specific depth not indicated) either in porous sandstone or dolomite, and the operator reported (an unknown percentage of) helium in the Ft. Apache Member. Hence in addition to oil, this lead also has the potential to produce natural gas and helium.

The tract of acreage in the SE/4 of T14N-R20E that is part of this lead area may be potential for oil within the Supai Formation and the Redwall Limestone. This area offsets the Adamana #1 Government well in Section 4 in this T-R, which was drilled in 1926 and reached TD at 3387' in the Redwall Limestone. It reported shows of oil in samples at 1740-50', shows of oil and gas in samples at 1940-50', and "oil sands" at 2260-2300' and 2480-92', all in the Supai Formation. There also were shows of oil in samples at 3387' in the Redwall Limestone, and the well reportedly blew out at TD spewing 48^{o} oil. Insofar as structurally higher wells to the immediate southwest in this T-R did not encounter such shows, there instead may be a trap along the bounding fault to the immediate east (*Exhibit 9*).

Lead #2 – This lead is in parts of T17N-R13E and 14E and T18N-R13E and 14E, in Coconino County. Structure on the Devonian (*Exhibit 9*) shows the Devonian gets higher to the southwest on an areally extensive south-trending ridge and along the edge of a gravity high (*Exhibit 10*). My mapping indicates that a structural high on the Precambrian runs diagonally across this lead (*Exhibit 5A*). The Devonian thickness map (*Exhibit 11*) suggests that the Devonian should be 300-400 ft thick here. Structural and stratigraphic relationships in this lead are illustrated on cross section AA' (*Exhibit 12*), and it shows that the Devonian is porous in this area. I recommend drilling a first well along the west side of T18N-R14E (specific location to be provided later).

The Townsend-Berry-Holbrook #26-1 State well in Section 26 T19N-R13E is a key well in this lead because of oil shows (*Exhibit 12*). It was drilled initially in 1995 to a TD of 2960' into the Pennsylvanian Naco Formation, re-entered in 1999 by Gus Berry and deepened to 3900' into the Precambrian, and finally re-entered again by Berry in 2004 to again evaluate the Supai and Devonian sections. The Devonian section here is 380' thick, composed mainly of dolomite, and it is subdivided into several marker beds ("A", "B", and "C") and intervening porosity zones. There were shows of oil in samples in porosity zones 1, 3 and 4 (the latter = marker bed "C"). Although porosity zones 3 and 4 are the thickest such units in the section and appear to have the best porosity (they drilled at 4 min/ft and 2 min/ft, respectively), for some reason only porosity zone 1 was tested. A report sent to Gus Berry by consultant Mike Morford in December 1999 stated *"I think the best chance for production in the Devonian section is in the 3724' to 3754' zone* (sic, my porosity zone 4). *The resistivity curves and the caliper both indicate good permeability. My best estimate of water saturation is 40%."*. However, what instead was tested is a non-porous to only slightly porous part of porosity zone 1 at the very top of the Devonian that was perforated at 3724-28' and was swabbed dry (no recovery reported). Then, the section 3724-54', which included some porosity in porosity zone 1 was acidized and had a show of gas and associated 25.7^{o} condensate; no additional information was reported. All of the shows in the Devonian section are good enough to warrant an initial exploratory well in this lead at a location structurally higher than the Townsend-Berry-Holbrook #26-1 well, especially considering that the Devonian was never truly evaluated!

There also were oil shows in samples in the overlying Ft. Apache and the Big A Butte members of the Supai Formation, and shows of gas in the latter member (*Exhibit 12*). The Ft. Apache was perforated at 1635-45'and swabbed dry (no recovery indicated). The operator then flushed 1 BO from 1640'. The Big A Butte Member was perforated at 1752-57', acidized, and also swabbed dry (no recovery indicated). All of these shows suggest that the Supai Formation also may be productive in this lead as a secondary reservoir objective. Although there are porous zones in the Pennsylvanian Naco Formation in the Townsend-Berry-Holbrook #26-1 well (*Exhibit 12*) that might also be present in this lead, no shows were reported in this formation in this well.

Lead #3 – This lead is in parts of T20N-R9E and 10E and T21N-R9E and 10E, in Coconino County. Structure on the Devonian (*Exhibit 9*) shows the Devonian gets higher northward from the Steinberg #1-A Babbitt well in Section 24 T19N-R10E on this discrete fault block. My Precambrian structure map (*Exhibit 5A*) likewise shows a high northward from the Steinberg #1-A Babbitt well, and there is a corresponding gravity high on the Precambrian as well (*Exhibit 10*). The Devonian thickness map (*Exhibit 11*) suggests that the Devonian should be in excess of 300 ft thick here. Structural and stratigraphic relationships in this lead are illustrated on cross section AA' (*Exhibit 12*), which shows that the Devonian is porous in this area. I recommend drilling a first well in the N/2 of T20N-R10E (specific location to be provided later).

The Pickett #1 Padre Canyon-State well in Section 26 T20N-R10E is a key well in this lead because of oil shows (*Exhibit 12*). It was drilled in 1963 to a TD of 3596' into the Precambrian. The Devonian section here is 361' thick, composed mainly of dolomite, and as in the Lead #2 area, it likewise is subdivided into marker beds "A", "B", and "C" and intervening porosity zones. Porosity zones 2, 3 and 4 have porosity, although the thickest and best-developed porosity is in zone 3. There were shows of oil in samples in the "B" marker and the top of porosity zone 3, and also in porosity zone 4. The only test in this well, however, was a DST in marker "B" and the upper part of porosity zone 3, and it recovered mud. The best porosity zone in the Devonian section (zone 3) and the oil show in porosity zone 4 were not evaluated.

Based on the mudlog report there are porous limestones in the overlying Pennsylvanian Naco Formation and also beds of reef-building phylloid algae at the top of the formation (*Exhibit 12*), although there were no shows in the formation. Nonetheless, such rocks might be potential secondary oil reservoirs in this lead. There were no shows of oil or gas reported in the overlying Supai Formation in this well. However, there was a show of gas in the Supai in the down-dip Helium Resources #1 Walters well in Section 24 T-19N-R10E which might indicate the possibility of production from this formation in the lead area.

Lead #4 – This lead is in T18N-R22E and T19N-R22E and part of T18N-R23E, in Navajo County. Structure on the Devonian (*Exhibit 9*) shows the Devonian gets higher eastward across the lead area, and abuts a northeast-trending down-to-west fault to the immediate west of the General Petroleum #14-6 Creager State well in Section 6 T19N-R23E. The key elements in this prospect are: (i) to define the exact location of the mapped fault here with 2-D seismic (one shot in a NE-SW direction across the lead area to the General Petroleum #14-6 well, and the other in a NNW-SSE direction on the downthrown side of the fault once it is located); and (ii) determination of whether there are good oil shows or oil production in the Devonian, as currently is tentatively indicated on the nearby, structurally lower Pugliani lease in T20N-R21E pending imminent release of well data to the state.

The Devonian structure mapped on the down-thrown side of the fault in this lead (*Exhibit 9*) corresponds to a gravity high on the Precambrian (*Exhibit 10*). My Precambrian structure map (*Exhibit 5A*) also shows the Precambrian getting higher in the lead area. The Devonian thickness map (*Exhibit 11*) suggests that the Devonian section should be between 100-200 ft thick or more here. Structural and stratigraphic relationships in this lead are illustrated on cross section CC' (*Exhibit 14*), which shows that the Devonian is absent by erosion on the up-thrown side of the fault, in the General Petroleum #14-6 Craeger State well. The closest deep well to this lead is the Cree #1 Scorse Fee in Section 33 T18N-R20E (*Exhibit 14*). Although porous, there were no oil or gas shows or tests in the Martin Formation in this well, although it is so far from the lead area that it really implies nothing about oil potential in the lead other than the porosity in the section might persist northeastward into the structurally higher lead area. It is for that reason the status of the Pugliani lease in T20N-R21E is crucial to this lead. If there are shows in the Devonian or production from the Devonian on the Pugliani lease, then I recommend shooting 2-D seismic lines across the lead and then drilling a first well possibly in the N/2 of T18N-R22E (specific location to be provided later). There were shows of gas at the top of the Big A Butte Member of the Supai Formation in the Cree #1 Scorse Fee well (*Exhibit 14*), which might indicate the potential for production from this zone in the lead area, especially if it is determined that there are hydrocarbons present in this section on the Pugliani lease.

Lead #5 – This lead is in adjoining parts of T24-27N in R7-10E in Coconino County, and it is based largely on gravity data (*Exhibit 10*) because there are only a few deep wells here and I can not definitively map the Devonian and Precambrian. Structure on the Devonian (*Exhibit 9*) and Precambrian (*Exhibit 5A*), for example, suggest that these horizons get lower to the immediate south-southwest of the cluster of wells in T27N-R9E, but the gravity map (*Exhibit 10*) suggests a reversal of dip farther south onto a structural high on the Precambrian in the lead area. The Devonian thickness map (*Exhibit 11*) suggests that the Devonian section should be around 250 ft thick in this area.

Structural and stratigraphic relationships in this lead are illustrated on cross section DD' (*Exhibit 15*). The Lockhart #1 Babbitt well in Section 21 T27N-R9E was drilled in 1948 and reached TD at 3624' into the Precambrian. Available files indicate that there was a show of oil in fractures in the Devonian dolomite section (Temple Butte Formation, the equivalent of the Martin Formation). The Clayton Williams #1 Babbitt well in Section 15 of the same T-R was drilled in 2003 and reached TD at 4350' into the Precambrian. According to well records, the reservoir objective in this well was the Cambrian Tapeats Sandstone because there supposedly was a show of oil in the Lockhart #1 Babbitt well. The Tapeats was perforated and acidized, however, and found to be tight. According to the well file, there was *"good reservoir rock in the Supai Formation"* although there were no tests of this section.

Structure, thickness, and shows are favorable attributes of potential traps for Devonian (and Supai) reservoirs. I recommend drilling a wildcat well in the SE/4 of T26N-R9E (specific location to be provided later) to specifically evaluate these rocks.

Leads #6 and 7 – These leads are rank wildcats that are based solely on gravity data (*Exhibit 10*). Lead #6 is in adjoining parts of T22-23N in R12½-13E in Coconino County, and Lead #7 is in adjoining parts of T23-24N in R14-15E in Coconino and Navajo Counties. There are no nearby wells, and accordingly, I could not map the Devonian and Precambrian in these leads nor could I provide a reference cross section. The gravity map (*Exhibit 10*), however, suggests the presence of a relatively large, northeast-trending structural ridge on the Precambrian, and the two leads are located on the highest parts of this ridge. Thickness of the Devonian section here might be 400 ft or more (*Exhibit 11*). These are favorable attributes of potential traps for Devonian (and Supai) reservoirs.

Hydrocarbon Indications Surveys

Remote detection ('sensing') of hydrocarbons seeped into surficial soils from reservoirs at depth by aerial or satellite surveys is a well-known method of exploration in little-drilled, frontier areas (e.g., Tian, 2012), although it is not always 100% reliable. There are such surveys in and around some of the seven leads discussed in this report. The survey on Lead #1 (Exhibit 16C), for example, covers only the eastern half of the area of interest. Although this survey suggests mostly limited to moderate, and in some places high, indications of hydrocarbons there nonetheless were compelling shows of oil and gas in some of the wells in this area as discussed above. Most of the survey hydrocarbon shows are, in fact, to the immediate west of the fault bounding the eastern edge of the area of interest here. The survey on Lead #2 (Exhibit 16A) suggests moderate to high indication of hydrocarbons in the northern half of the lead area, in and around the Townsend-Berry-Holbrook #26-1 well, and in the southeastern part of the area of interest. These indications appear to be to the immediate east of the normal fault that bounds the western part of the area of interest. There was no survey for the Lead #3 area (Exhibit 16C). The survey over Lead #4 suggests low to moderate to locally high suggestions of hydrocarbons (Exhibit 16B). Lead #5, on a gravity high, suggests a high possibility for hydrocarbons over much of the northern part of the area of interest (Exhibit 16C). There is no satellite survey for Lead #6 (Exhibit 16C). The survey for Lead #7, also on a gravity high, suggests variously low to locally high indications of hydrocarbons over much of the area of interest (Exhibit 16C).

References Cited

Aiken, C.L.V., and J.S. Sumner, 1972, A study of regional geophysical data in the Holbrook area, Arizona; Arizona Geological Survey, Oil and Gas Publication OG-23, 15 p.

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Rauzi, S.L., and L.D. Fellows, 2003, Arizona has helium; Arizona Geology, v. 33, no. 4, 4 p.

Ryder, R.T., 1983, Petroleum potential of wilderness lands in Arizona; U.S. Geological Survey Circular 902-C.

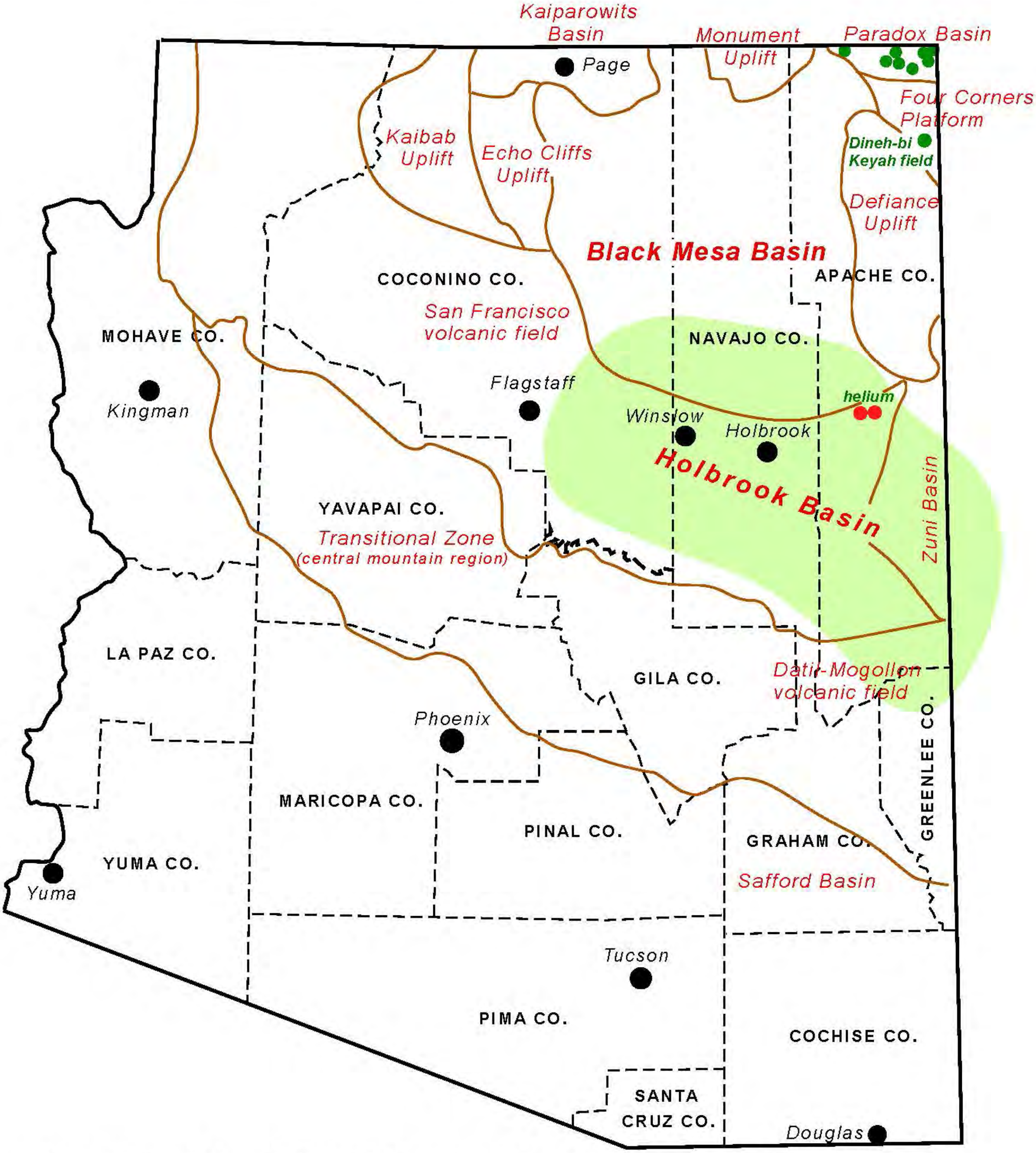
Tian, Q., 2012, Study on oil-gas reservoir detecting methods using hyperspectral remote sensing; International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, v. 39-B7, p. 157-162.

Respectfully submitted,

S. J. Mazzullo, PhD

S. J. Mazzullo, PhD
Petroleum Geological Consultant
June, 2014

EXHIBIT 1



Location of the Holbrook Basin and adjoining Black Mesa Basin in northeastern Arizona (from Ryder, 1983).

EXHIBIT 2

STRATIGRAPHY OF THE HOLBROOK AND SOUTHERN BLACK MESA BASINS

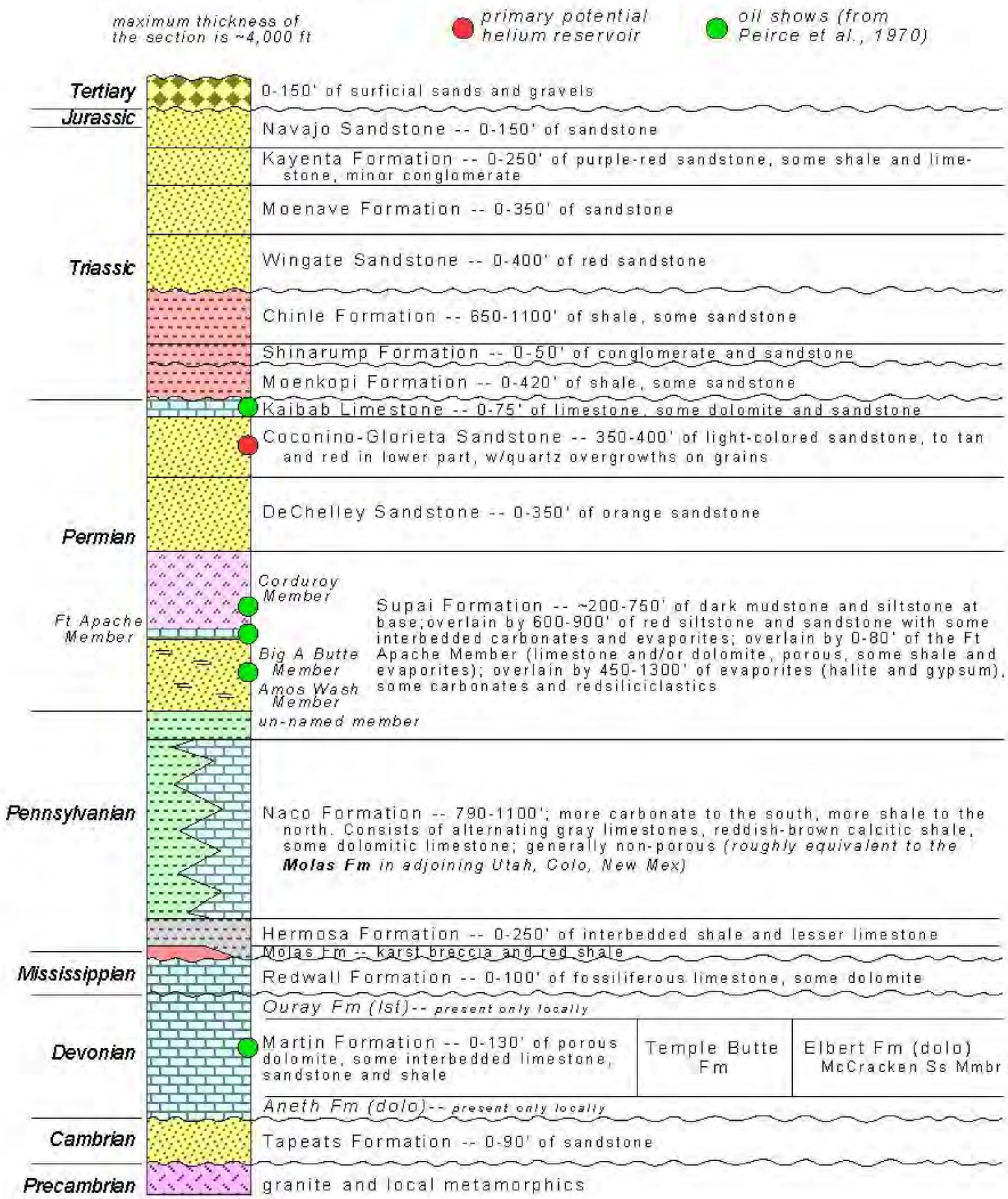
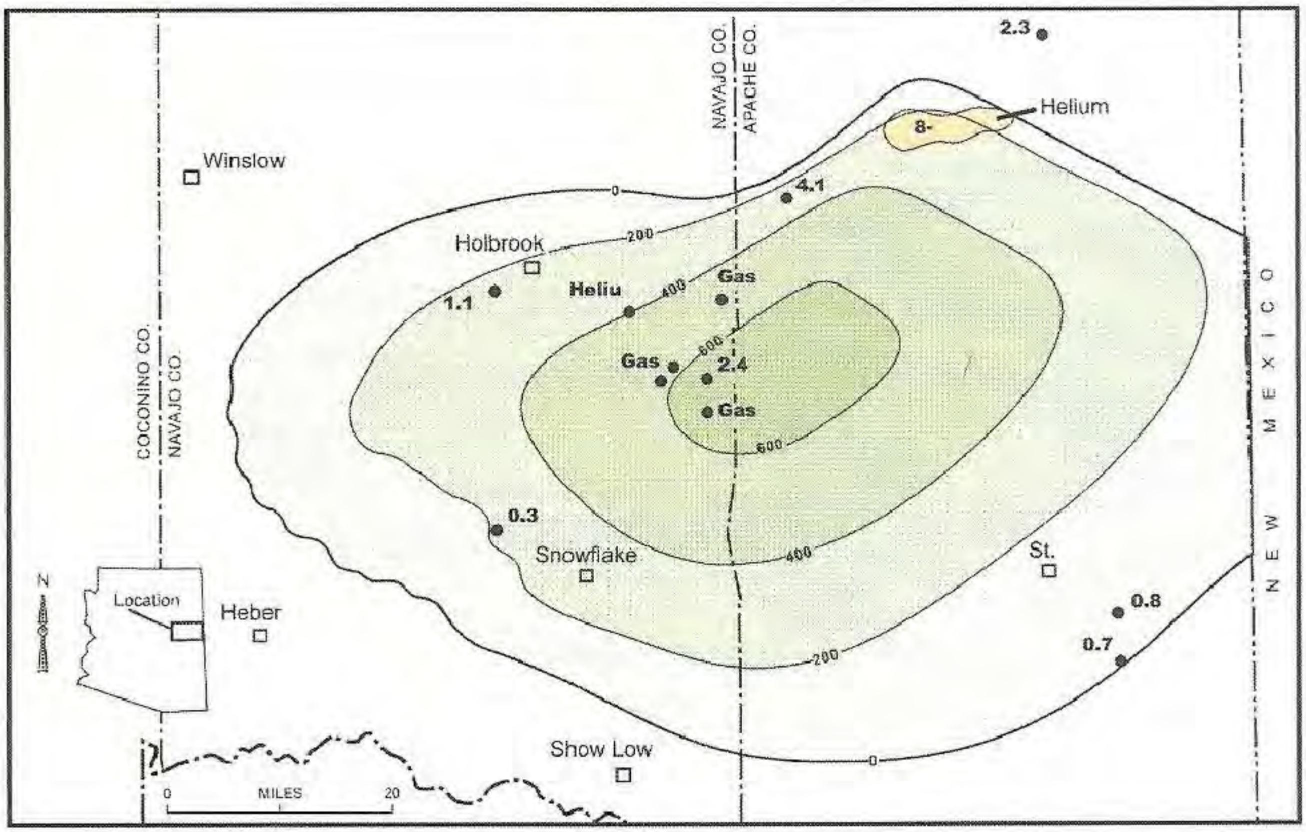


EXHIBIT 3



Holbrook Salt Basin showing thickness of salt (in feet) andhelium content (percent) of selected wells (from Rauzi and Fellows, 2003).

EXHIBIT 4

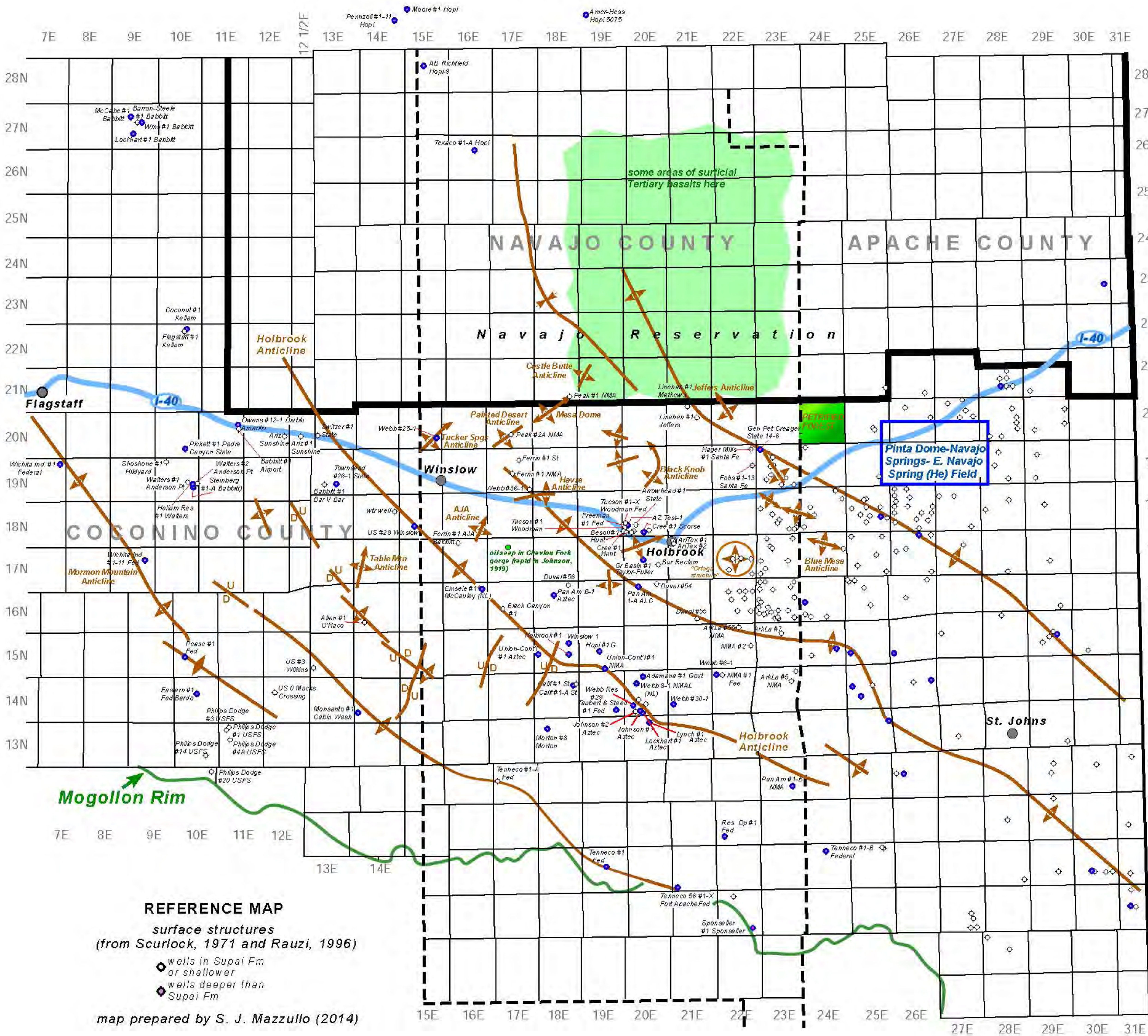
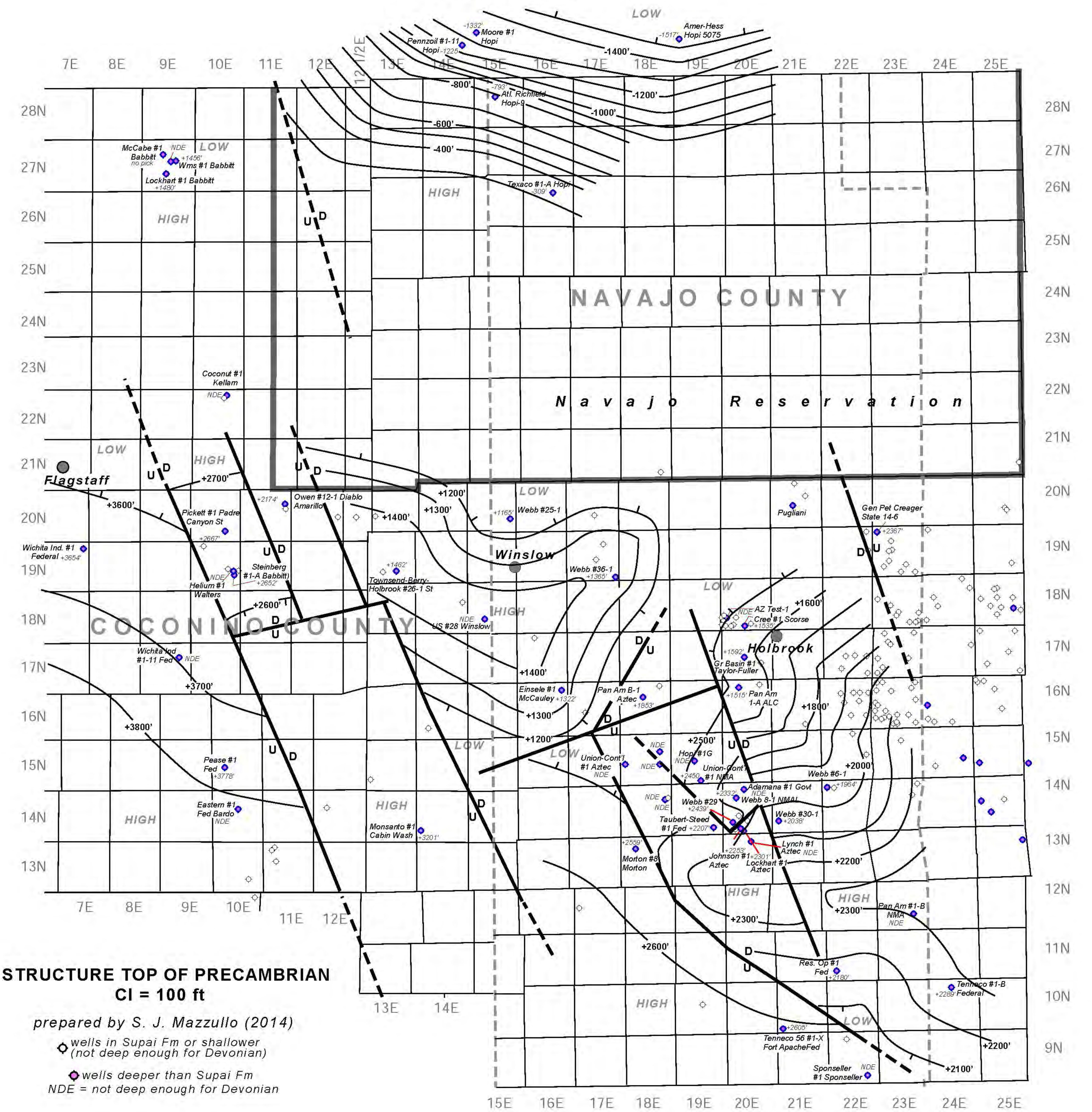

NAVAJO COUNTY
APACHE COUNTY
COCONINO COUNTY
Navajo Reservation
some areas of surficial Tertiary basalts here
I-40
Flagstaff
Winslow
Holbrook
St. Johns
Mogollon Rim
Pinta Dome-Navajo Springs- E. Navajo Spring (He) Field
Holbrook Anticline
Castle Butte Anticline
Jeffers Anticline
Painted Desert Anticline
Mesa Dome
Tucker Spgs Anticline
Black Knob Anticline
Hayes Anticline
AJA Anticline
Table Mtn Anticline
Mormon Mountain Anticline
Blue Mesa Anticline
oil seep in Chevlon Fork gorge (reptd in Johnson, 1919)
REFERENCE MAP
surface structures (from Scurlock, 1971 and Rauzi, 1996)
wells in Supai Fm or shallower
wells deeper than Supai Fm
map prepared by S. J. Mazzullo (2014)

EXHIBIT 5A



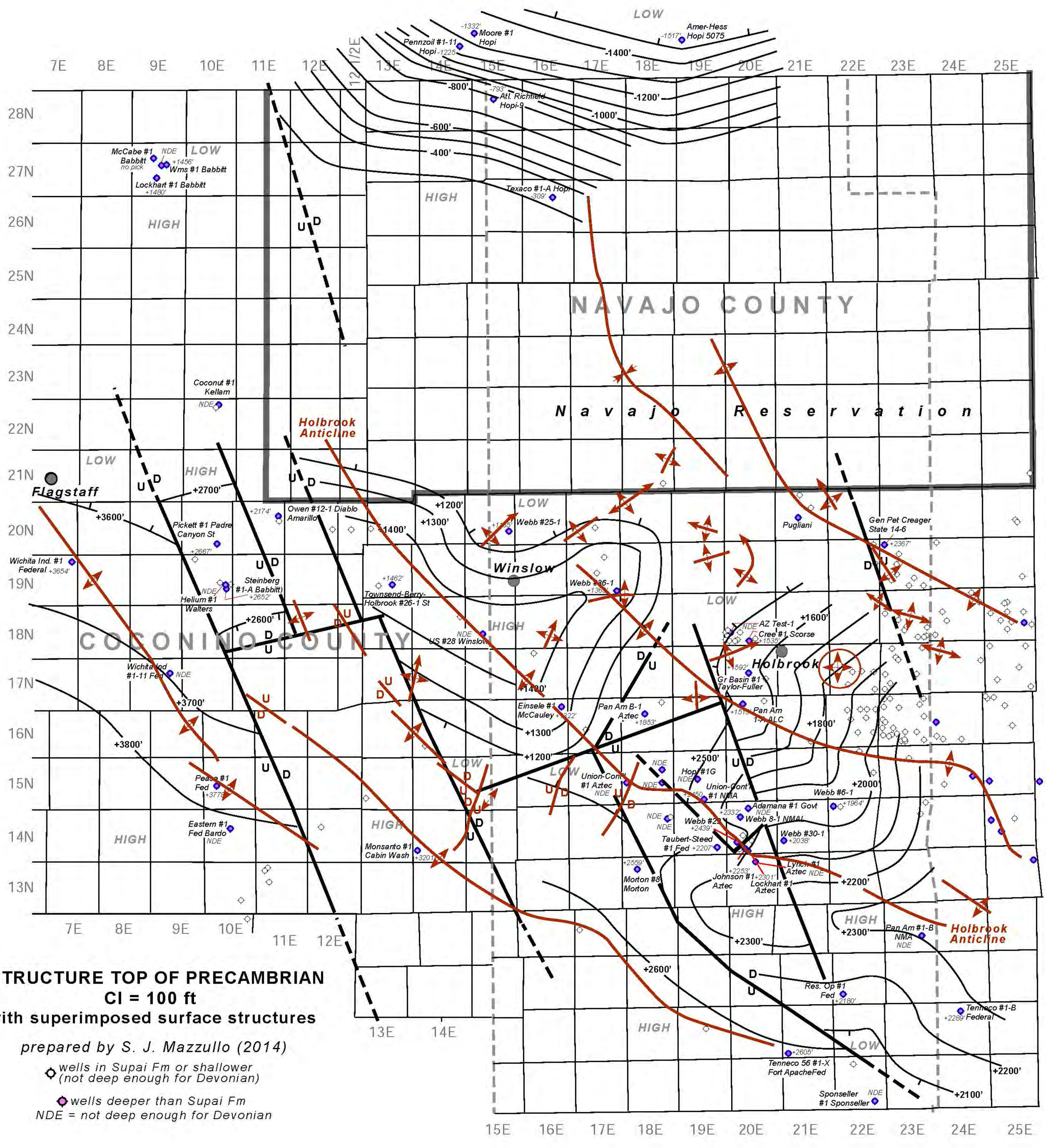
STRUCTURE TOP OF PRECAMBRIAN
CI = 100 ft

prepared by S. J. Mazzullo (2014)

wells in Supai Fm or shallower (not deep enough for Devonian)

wells deeper than Supai Fm
NDE = not deep enough for Devonian

EXHIBIT 5B



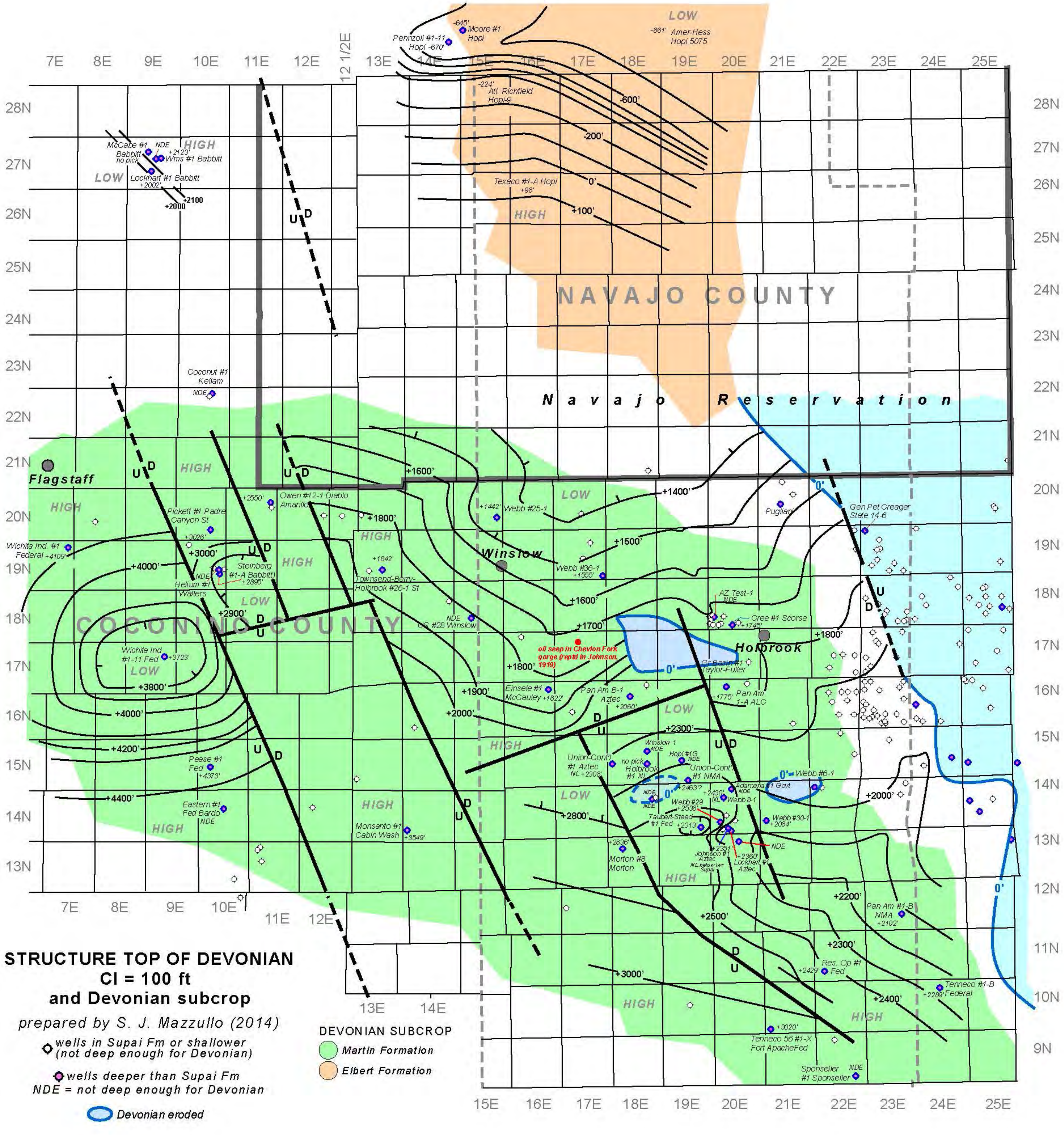
STRUCTURE TOP OF PRECAMBRIAN
CI = 100 ft
with superimposed surface structures

prepared by S. J. Mazzullo (2014)

wells in Supai Fm or shallower (not deep enough for Devonian)

wells deeper than Supai Fm
NDE = not deep enough for Devonian

EXHIBIT 6A


STRUCTURE TOP OF DEVONIAN
CI = 100 ft
and Devonian subcrop
prepared by S. J. Mazzullo (2014)
wells in Supai Fm or shallower (not deep enough for Devonian)
wells deeper than Supai Fm
NDE = not deep enough for Devonian
Devonian eroded
DEVONIAN SUBCROP
Martin Formation
Elbert Formation
NAVAJO COUNTY
COCONINO COUNTY
Navajo Reservation
Flagstaff
Winslow
Holbrook
HIGH
LOW
7E
8E
9E
10E
11E
12E
12 1/2E
13E
14E
15E
16E
17E
18E
19E
20E
21E
22E
23E
24E
25E
28N
27N
26N
25N
24N
23N
22N
21N
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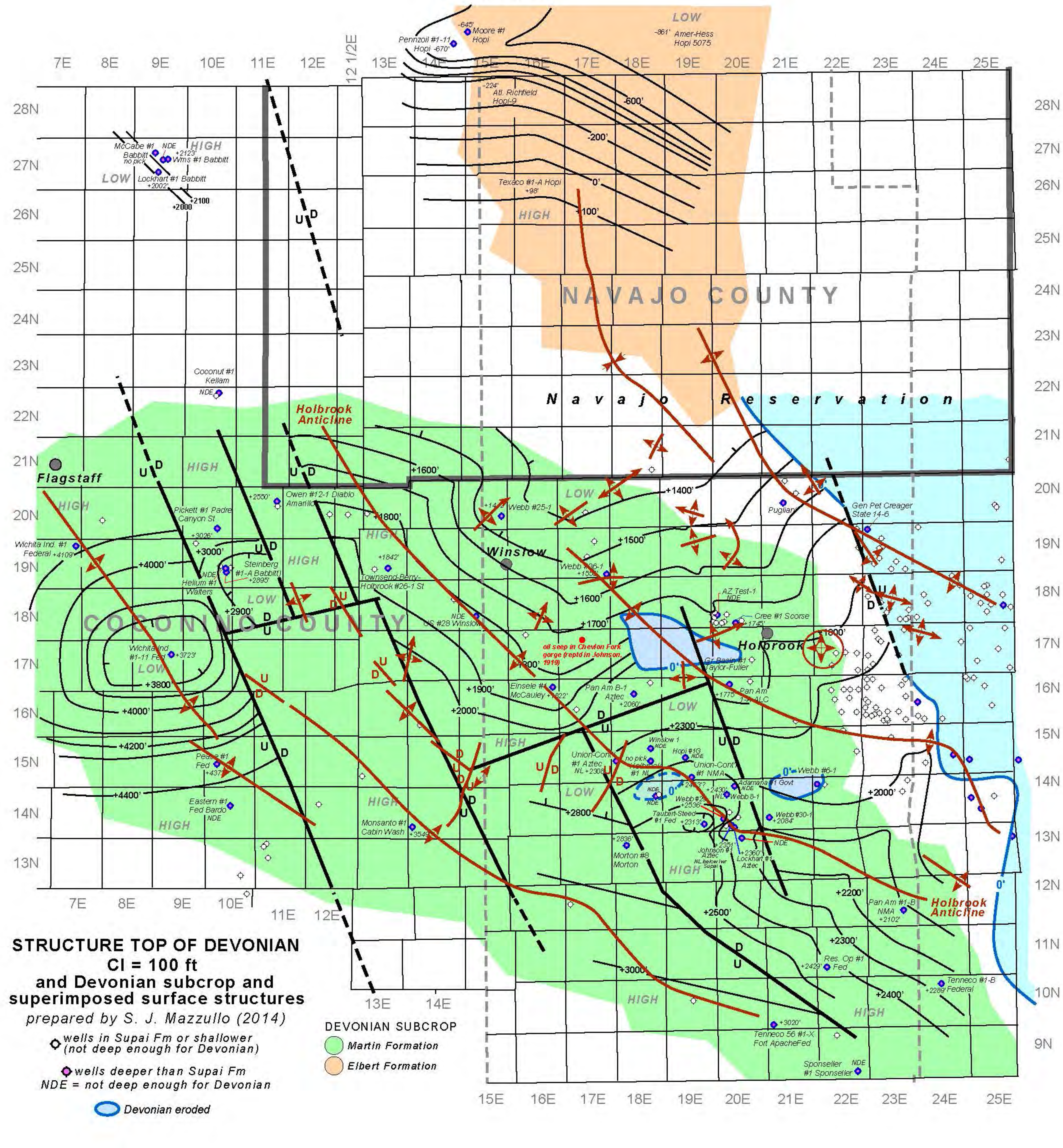
19N
18N
17N
16N
15N
14N
13N
12N
11N
10N
9N

EXHIBIT 6B



NAVAJO COUNTY
Navajo Reservation
COCONINO COUNTY
Flagstaff
Winslow
Holbrook
Holbrook Anticline
STRUCTURE TOP OF DEVONIAN
CI = 100 ft
and Devonian subcrop and
superimposed surface structures
prepared by S. J. Mazzullo (2014)
wells in Supai Fm or shallower
(not deep enough for Devonian)
wells deeper than Supai Fm
NDE = not deep enough for Devonian
Devonian eroded
DEVONIAN SUBCROP
Martin Formation
Elbert Formation
oil seep in Chevlon Fork gorge (rept'd in Johnson, 1919)

EXHIBIT 7A

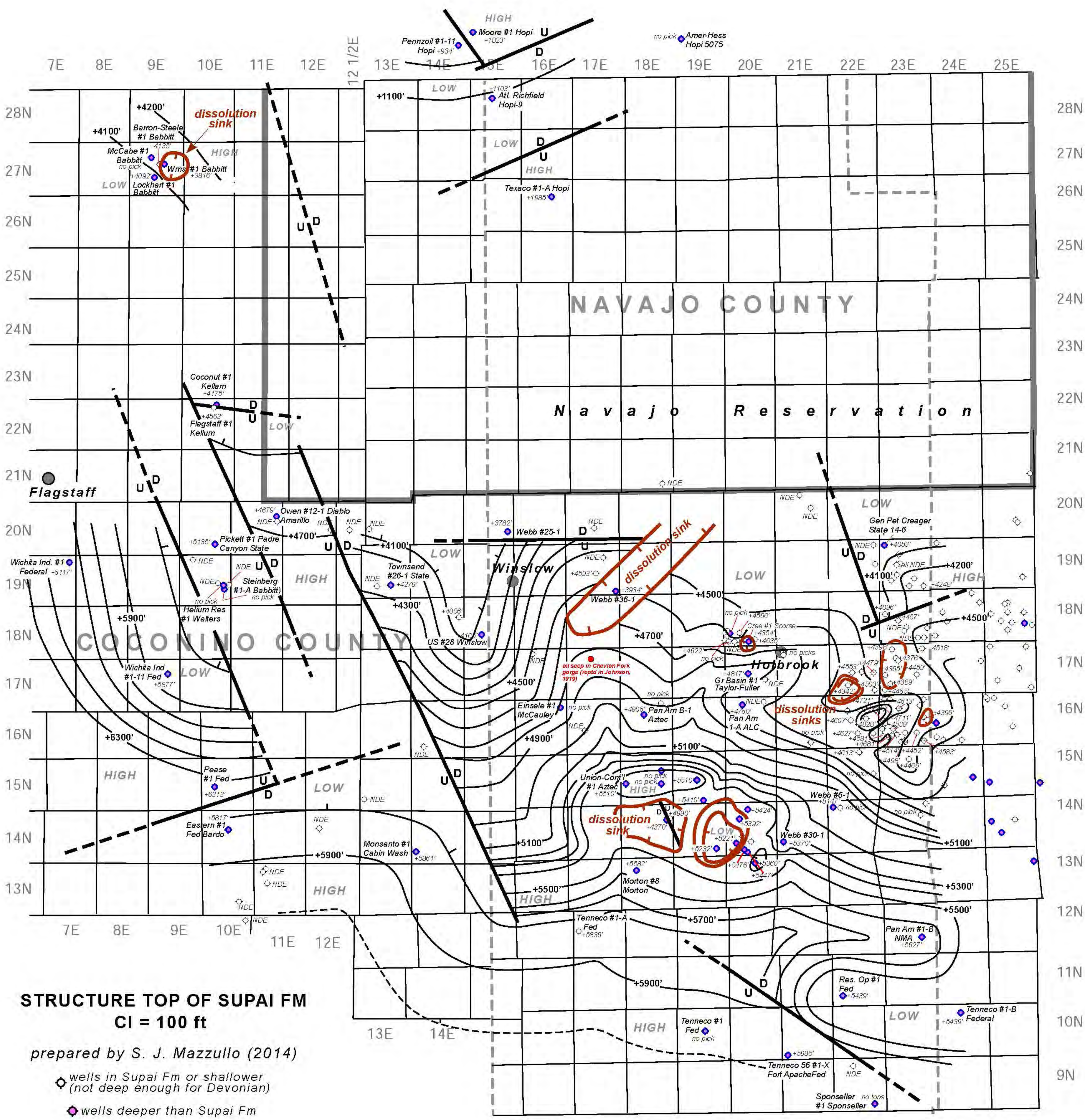
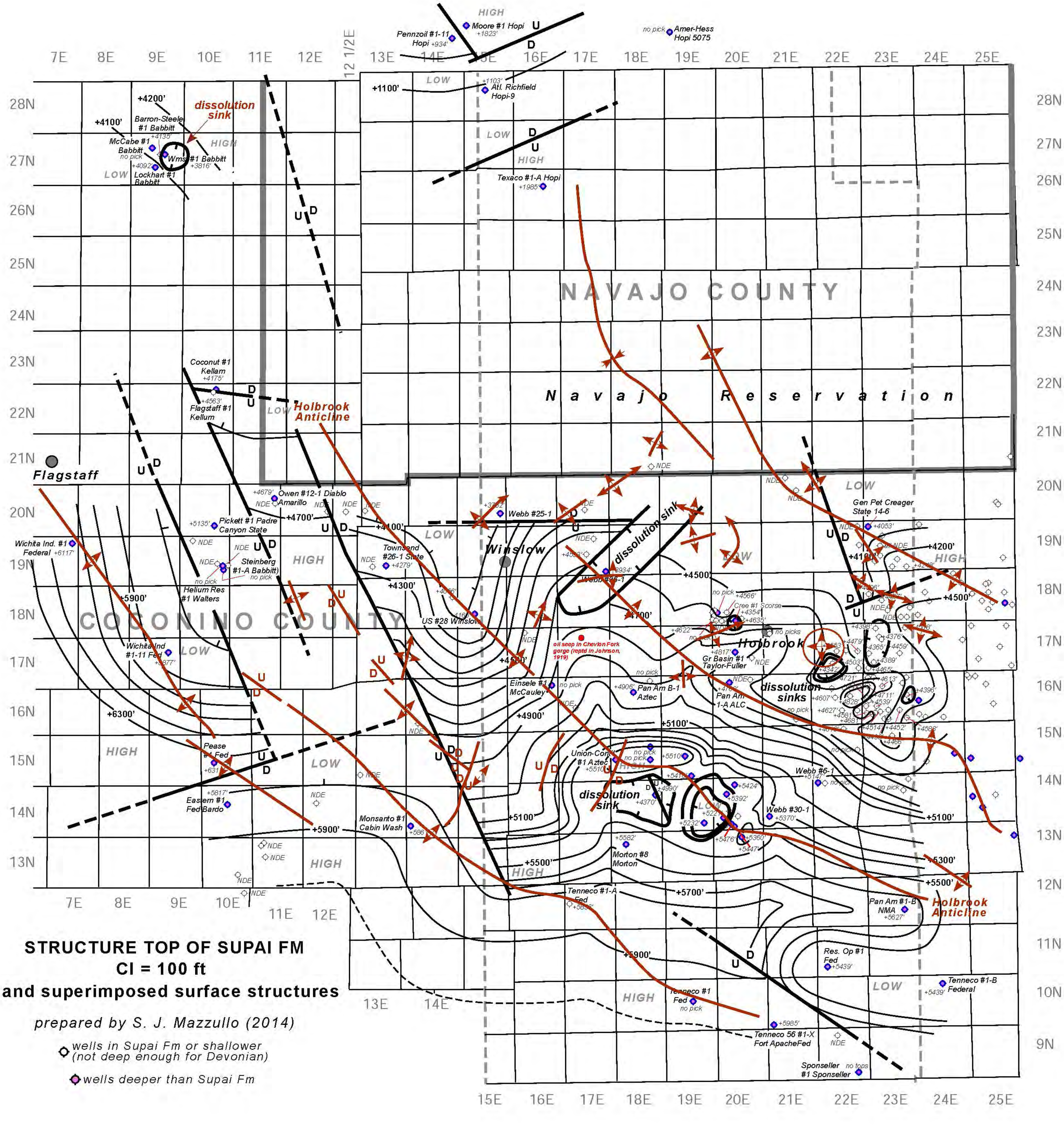

STRUCTURE TOP OF SUPAI FM
CI = 100 ft
prepared by S. J. Mazzullo (2014)
wells in Supai Fm or shallower (not deep enough for Devonian)
wells deeper than Supai Fm
NAVAJO COUNTY
Navajo Reservation
COCONINO COUNTY
Flagstaff
Winslow
Holbrook
dissolution sink
dissolution sinks
oil seep in Chevlon Fork gorge (reptd in Johnson, 1919)
7E
8E
9E
10E
11E
12E
12 1/2E
13E
14E
15E
16E
17E
18E
19E
20E
21E
22E
23E
24E
25E
9N
10N
11N
12N
13N
14N
15N
16N
17N
18N
19N
20N
21N
22N
23N
24N
25N
26N
27N
28N
HIGH
LOW
+4100'
+4200'
+4300'
+4500'
+4700'
+4900'
+5100'
+5300'
+5500'
+5700'
+5900'
+6300'
+1100'
Moore #1 Hopi
Pennzoil #1-11 Hopi
Amer-Hess Hopi 5075
Atl. Richfield Hopi-9
Texaco #1-A Hopi
Barron-Steele #1 Babbitt
McCabe #1 Babbitt
Wms. #1 Babbitt
Lockhart #1 Babbitt
Coconut #1 Kellam
Flagstaff #1 Kellum
Owen #12-1 Diablo Amarillo
Pickett #1 Padre Canyon State
Steinberg #1-A Babbitt
Helium Res #1 Walters
Wichita Ind. #1 Federal
Wichita Ind #1-11 Fed
Townsend #26-1 State
US #28 Winslow
Webb #25-1
Webb #36-1
Cree #1 Scorse
Gen Pet Creager State 14-6
Gr Basin #1 Taylor-Fuller
Pan Am 1-A ALC
Pan Am B-1 Aztec
Einsele #1 McCauley
Union-Cont'l #1 Aztec
Webb #6-1
Webb #30-1
Morton #8 Morton
Pease #1 Fed
Eastern #1 Fed Bardo
Monsanto #1 Cabin Wash
Tenneco #1-A Fed
Pan Am #1-B NMA
Res. Op #1 Fed
Tenneco #1-B Federal
Tenneco #1 Fed
Tenneco 56 #1-X Fort ApacheFed
Sponseller #1 Sponseller

EXHIBIT 7B

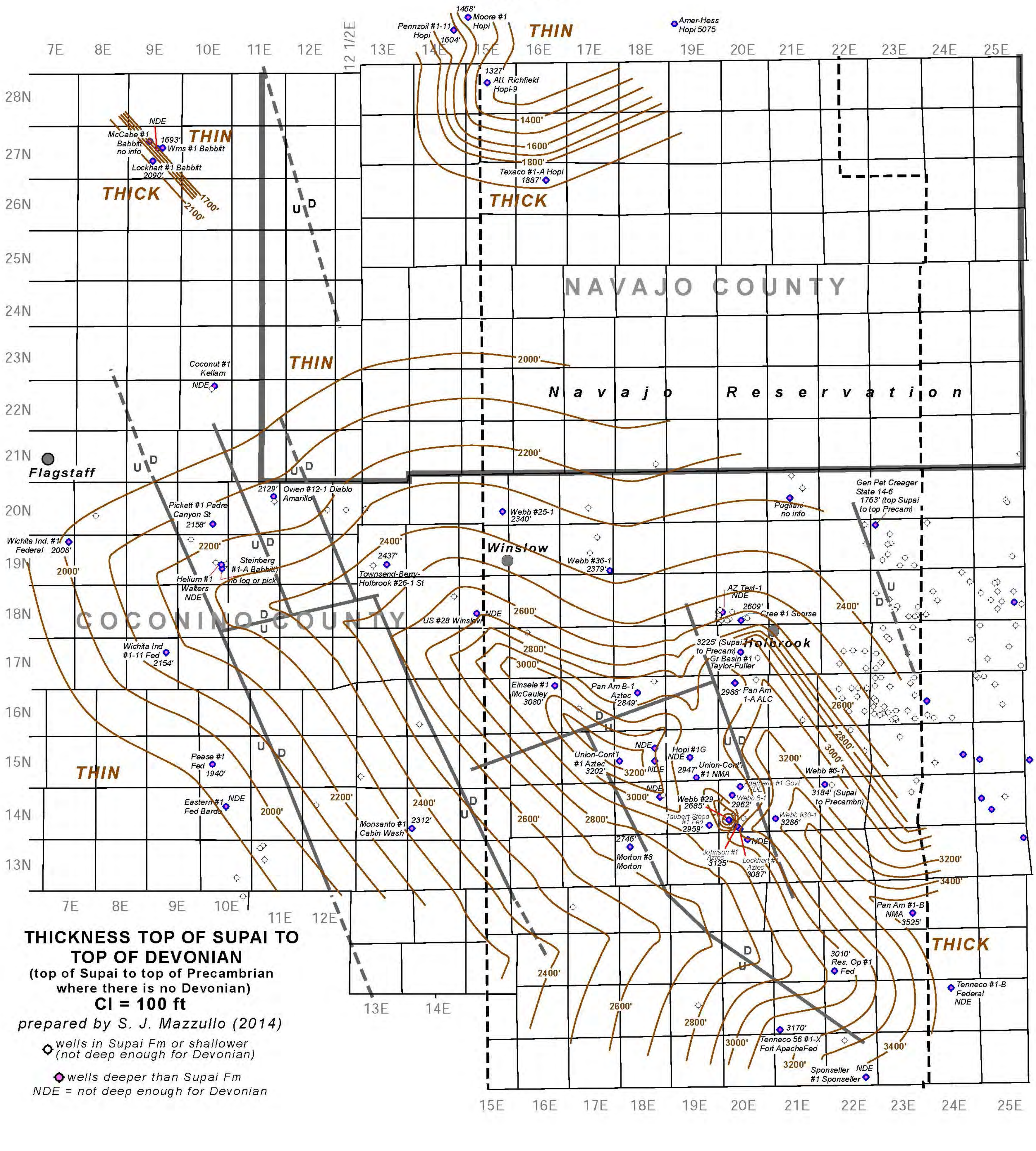


STRUCTURE TOP OF SUPAI FM
CI = 100 ft
and superimposed surface structures

prepared by S. J. Mazzullo (2014)

- wells in Supai Fm or shallower (not deep enough for Devonian)
- wells deeper than Supai Fm

EXHIBIT 8



THICKNESS TOP OF SUPAI TO TOP OF DEVONIAN
(top of Supai to top of Precambrian where there is no Devonian)
CI = 100 ft

EXHIBIT 9

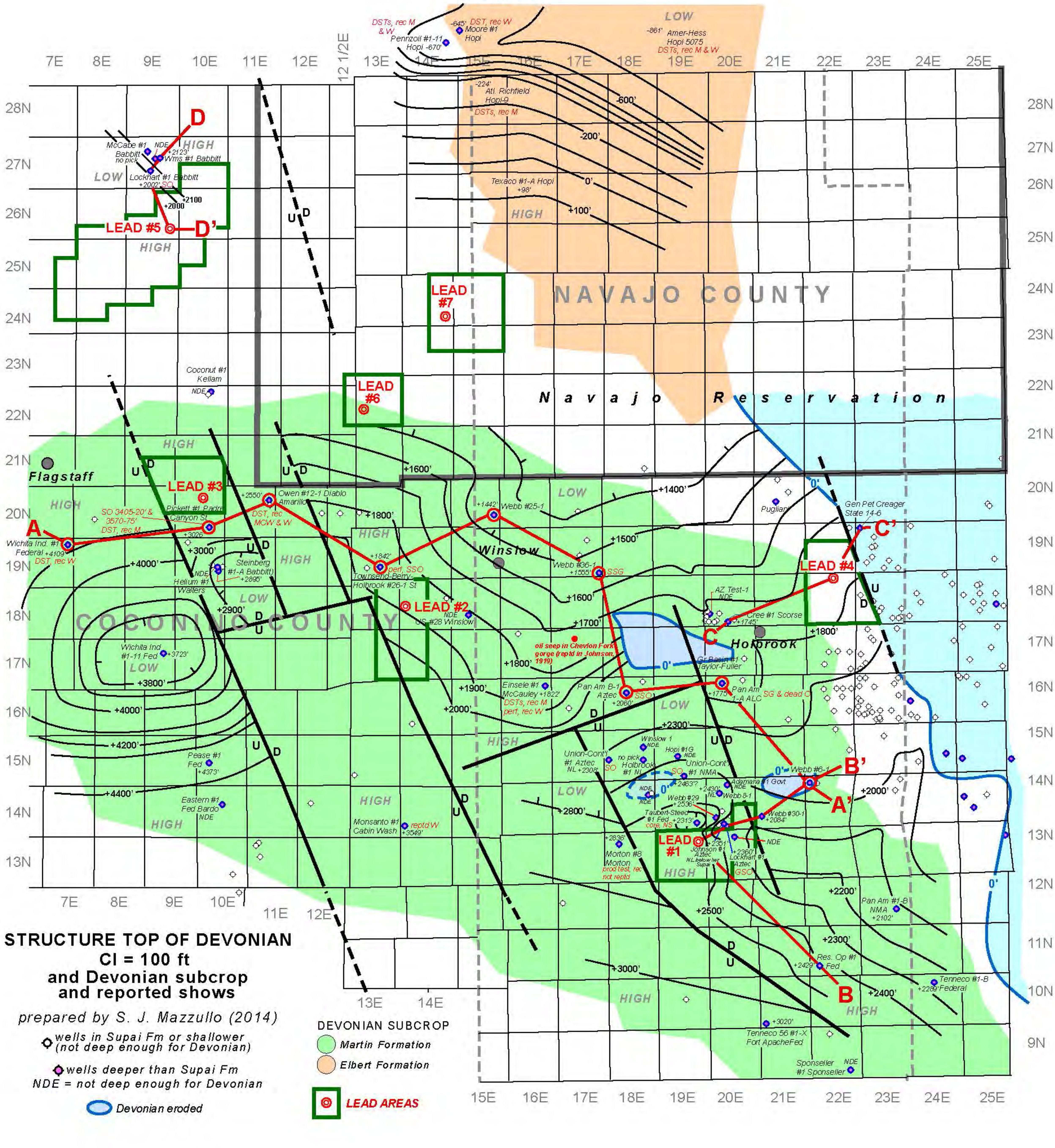
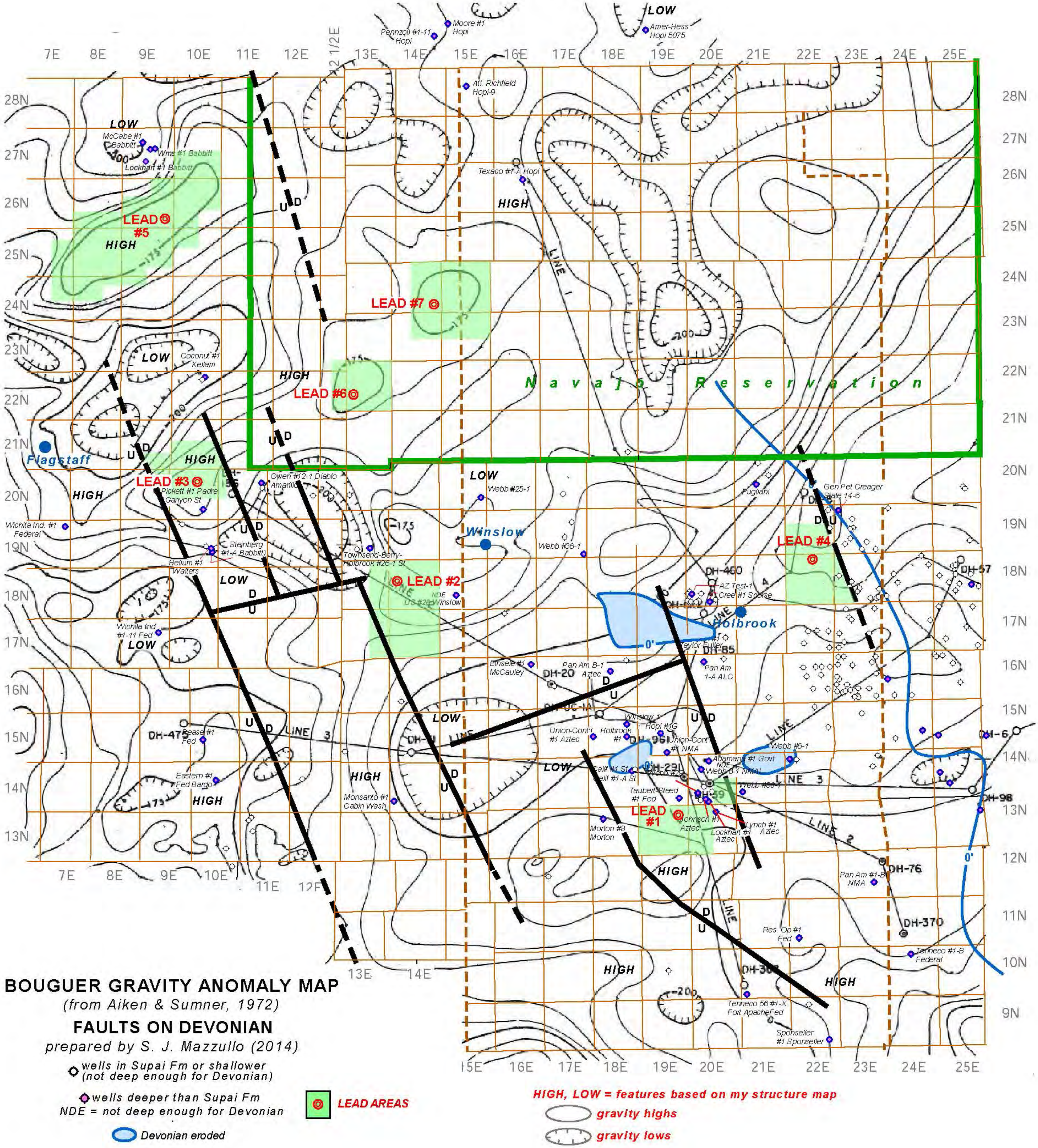

STRUCTURE TOP OF DEVONIAN
CI = 100 ft
and Devonian subcrop
and reported shows
prepared by S. J. Mazzullo (2014)
wells in Supai Fm or shallower (not deep enough for Devonian)
wells deeper than Supai Fm
NDE = not deep enough for Devonian
Devonian eroded
DEVONIAN SUBCROP
Martin Formation
Elbert Formation
LEAD AREAS
NAVAJO COUNTY
COCONINO COUNTY
Navajo Reservation
Flagstaff
Winslow
Holbrook
LEAD #1
LEAD #2
LEAD #3
LEAD #4
LEAD #5
LEAD #6
LEAD #7
oil seep in Chevlon Fork gorge (reptd in Johnson, 1919)

EXHIBIT 10


BOUGUER GRAVITY ANOMALY MAP
(from Aiken & Sumner, 1972)
FAULTS ON DEVONIAN
prepared by S. J. Mazzullo (2014)
wells in Supai Fm or shallower (not deep enough for Devonian)
wells deeper than Supai Fm
NDE = not deep enough for Devonian
Devonian eroded
LEAD AREAS
HIGH, LOW = features based on my structure map
gravity highs
gravity lows
LEAD #1
LEAD #2
LEAD #3
LEAD #4
LEAD #5
LEAD #6
LEAD #7
Navajo Reservation
Flagstaff
Winslow
Holbrook
LINE 1
LINE 2
LINE 3
HIGH
LOW
U
D
7E
8E
9E
10E
11E
12E
12 1/2E
13E
14E
15E
16E
17E
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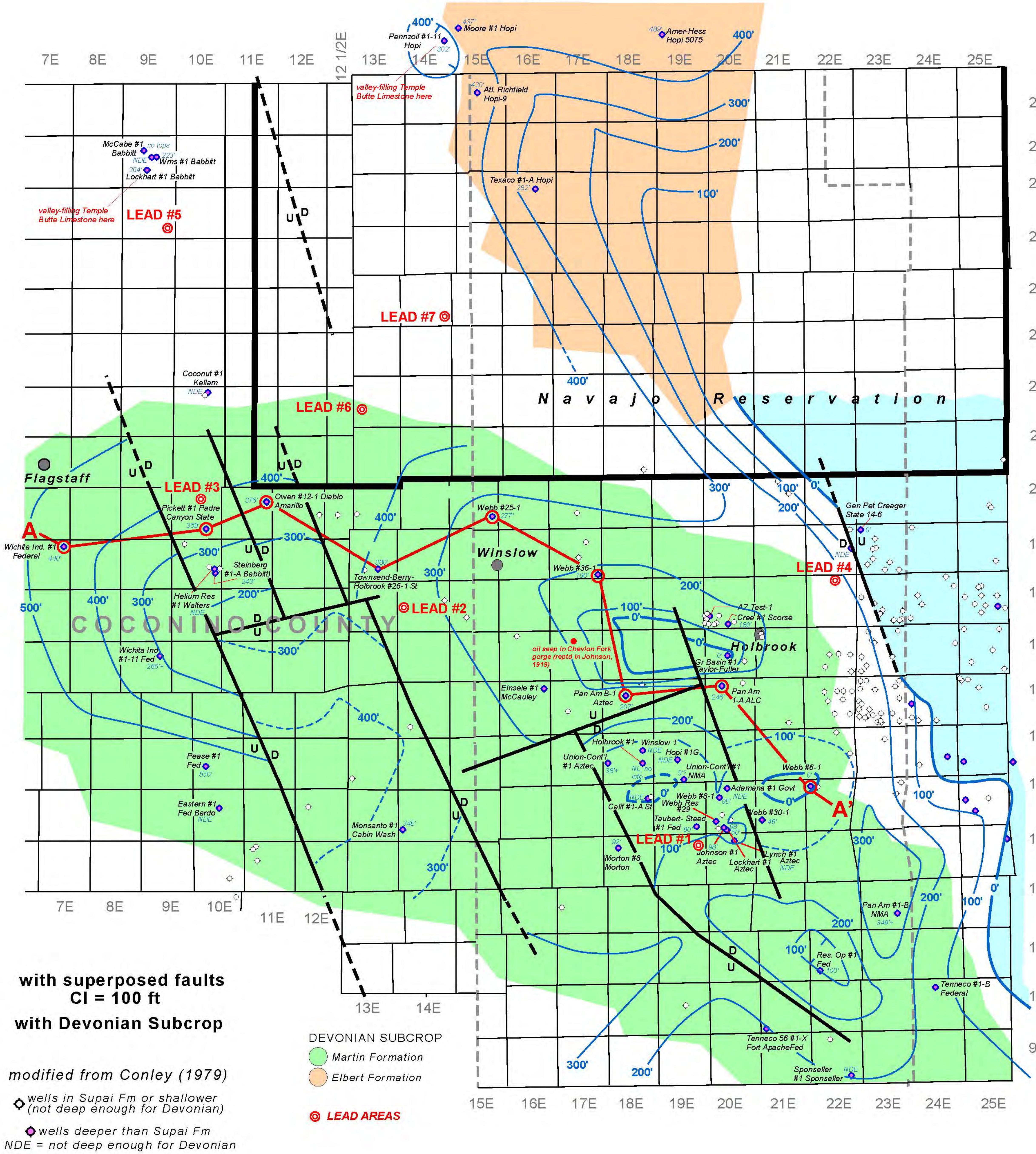
23N
24N
25N
26N
27N
28N
-175
-200
0'
Moore #1 Hopi
Pennzoil #1-11 Hopi
Amer-Hess Hopi 5075
Atl. Richfield Hopi-9
Texaco #1-A Hopi
McCabe #1 Babbitt
Wms #1 Babbitt
Lockhart #1 Babbitt
Coconut #1 Kellam
Pickett #1 Padre Canyon St
Owen #12-1 Diablo Amarillo
Wichita Ind. #1 Federal
Steinberg #1-A Babbitt
Helium #1 Walters
Townsend-Berry-Holbrook #26-1 St
Webb #25-1
Webb #36-1
Wichita Ind #1-11 Fed
Pease #1 Fed
Eastern #1 Fed Bargo
Monsanto #1 Cabin Wash
Einsele #1 McCauley
Pan Am B-1 Aztec
Pan Am 1-A ALC
Union-Cont'l #1 Aztec
Hopi #1G
Union-Cont'l #1 NMA
Webb #6-1
Taubert-Steed #1 Fed
Johnson #1 Aztec
Lockhart #1 Aztec
Lynch #1 Aztec
Morton #8 Morton
AZ Test-1
Cree #1 Source
Gen Pet Creager State 14-6
Pugliani
Pan Am #1-B NMA
Res. Op #1 Fed
Tenneco #1-B Federal
Tenneco 56 #1-X Fort Apache Fed
Sponseller #1 Sponseller
DH-20
DH-460
DH-57
DH-6
DH-98
DH-76
DH-370
DH-47
DH-230
DH-59
DH-85

EXHIBIT 11



7E
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12 1/2E
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21E
22E
23E
24E
25E
28N
27N
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23N
22N
21N
20N
19N
18N
17N
16N
15N
14N
13N
12N
11N
10N
9N
Moore #1 Hopi
Pennzoil #1-11 Hopi
Amer-Hess Hopi 5075
Atl. Richfield Hopi-9
valley-filling Temple Butte Limestone here
McCabe #1 Babbitt
no tops
Wms #1 Babbitt
Lockhart #1 Babbitt
Texaco #1-A Hopi
LEAD #5
LEAD #7
LEAD #6
LEAD #3
LEAD #2
LEAD #4
LEAD #1
Coconut #1 Kellam
N a v a j o R e s e r v a t i o n
Flagstaff
Winslow
Holbrook
COCONINO COUNTY
A
A'
Wichita Ind. #1 Federal
Pickett #1 Padre Canyon State
Owen #12-1 Diablo Amarillo
Townsend-Berry-Holbrook #26-1 St
Webb #25-1
Webb #36-1
Steinberg #1-A Babbitt
Helium Res #1 Walters
Wichita Ind #1-11 Fed
Pease #1 Fed
Eastern #1 Fed Bardo
Monsanto #1 Cabin Wash
Gen Pet Creager State 14-6
AZ Test-1
Cree #1 Scorse
Gr Basin #1 Taylor-Fuller
oil seep in Chevlon Fork gorge (reptd in Johnson, 1919)
Einsele #1 McCauley
Pan Am B-1 Aztec
Pan Am 1-A ALC
Holbrook #1
Winslow 1
Hopi #1G
Union-Cont'l #1 Aztec
Union-Cont'l #1 NMA
NL, no info
Calif #1-A St
Adamana #1 Govt
Webb #6-1
Webb #8-1
Webb Res #29
Webb #30-1
Taubert- Steed #1 Fed
Johnson #1 Aztec
Lockhart #1 Aztec
Lynch #1 Aztec
Morton #8 Morton
Pan Am #1-B NMA
Res. Op #1 Fed
Tenneco #1-B Federal
Tenneco 56 #1-X Fort ApacheFed
Sponseller #1 Sponseller
NDE
U
D
400'
300'
200'
100'
0'
500'
with superposed faults
CI = 100 ft
with Devonian Subcrop
modified from Conley (1979)
wells in Supai Fm or shallower (not deep enough for Devonian)
wells deeper than Supai Fm
NDE = not deep enough for Devonian
DEVONIAN SUBCROP
Martin Formation
Elbert Formation
LEAD AREAS

EXHIBIT 12

HOLBROOK BASIN, ARIZONA

CROSS SECTION SHOWING UNIT CORRELATIONS, POTENTIAL PAY ZONES, OIL/GAS SHOWS, AND INTRA-DEVONIAN CORRELATIONS

EXHIBIT 12

CROSS SECTION SHOWING UNIT CORRELATIONS, POTENTIAL PAY ZONES, OIL/GAS SHOWS, AND INTRA-DEVONIAN CORRELATIONS

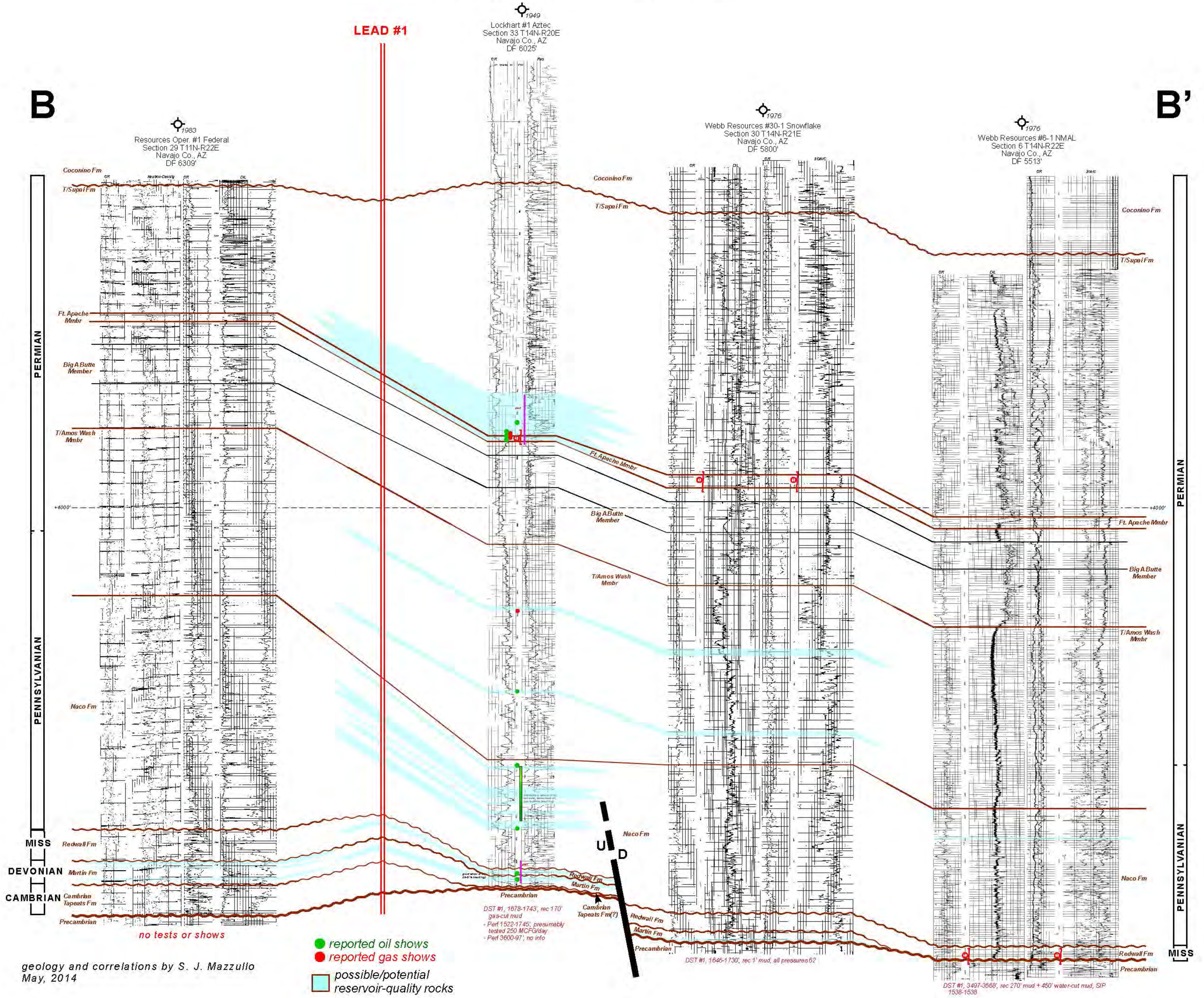
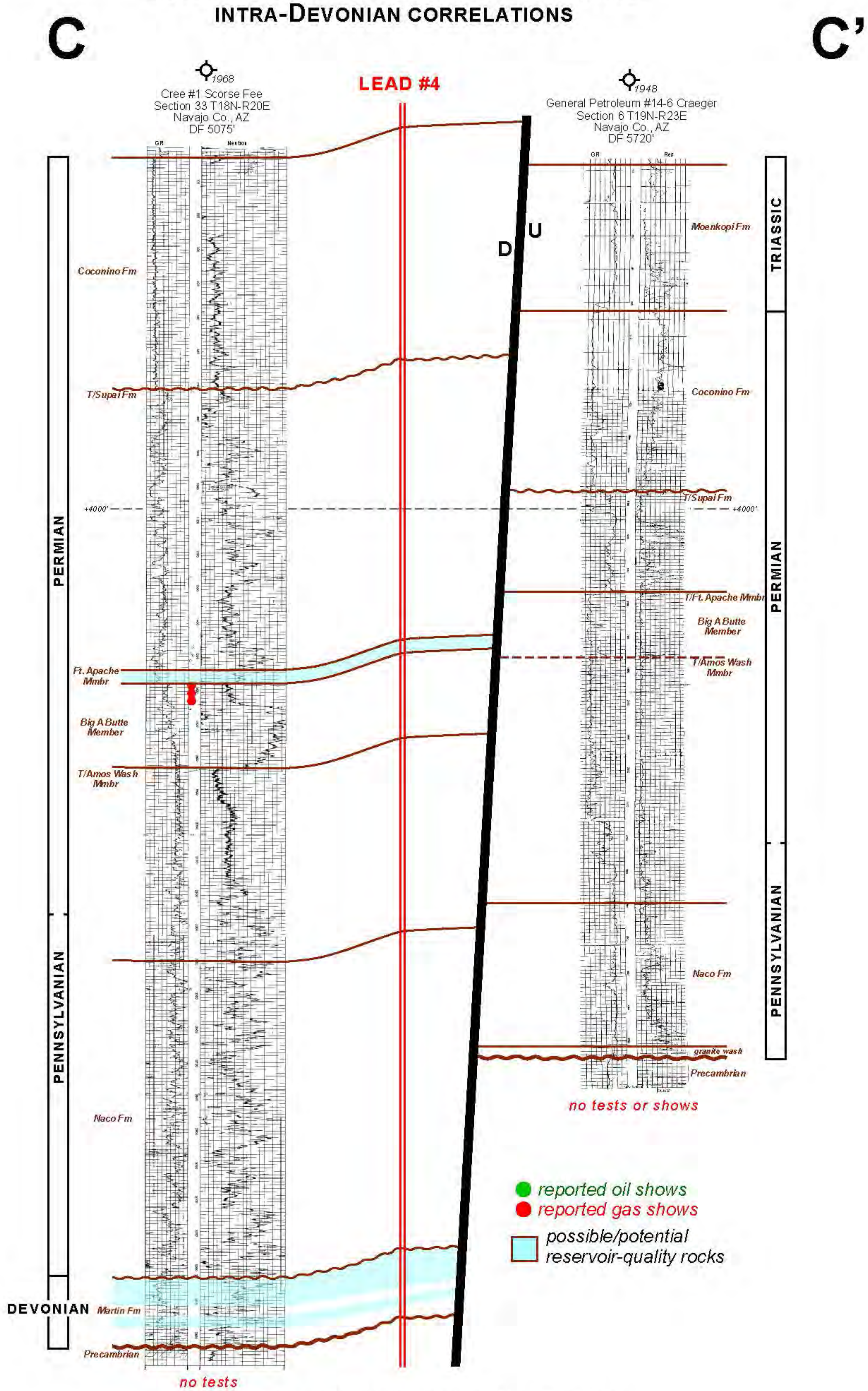


EXHIBIT 14

CROSS SECTION SHOWING UNIT CORRELATIONS, POTENTIAL PAY ZONES, OIL/GAS SHOWS, AND INTRA-DEVONIAN CORRELATIONS



geology and correlations by S. J. Mazzullo
June, 2014

EXHIBIT 15

CROSS SECTION SHOWING UNIT CORRELATIONS, POTENTIAL PAY ZONES, OIL/GAS SHOWS, AND INTRA-DEVONIAN CORRELATIONS

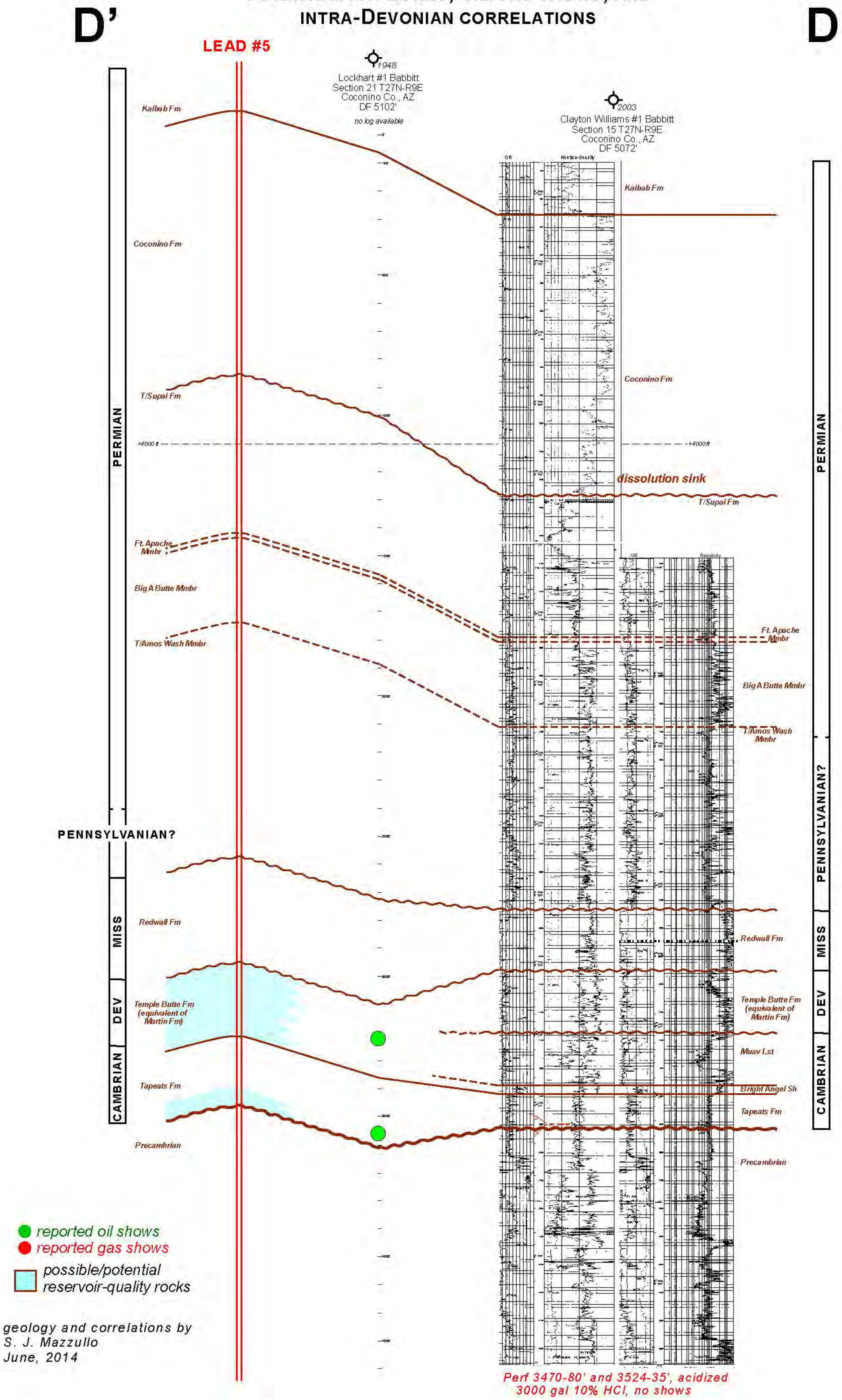
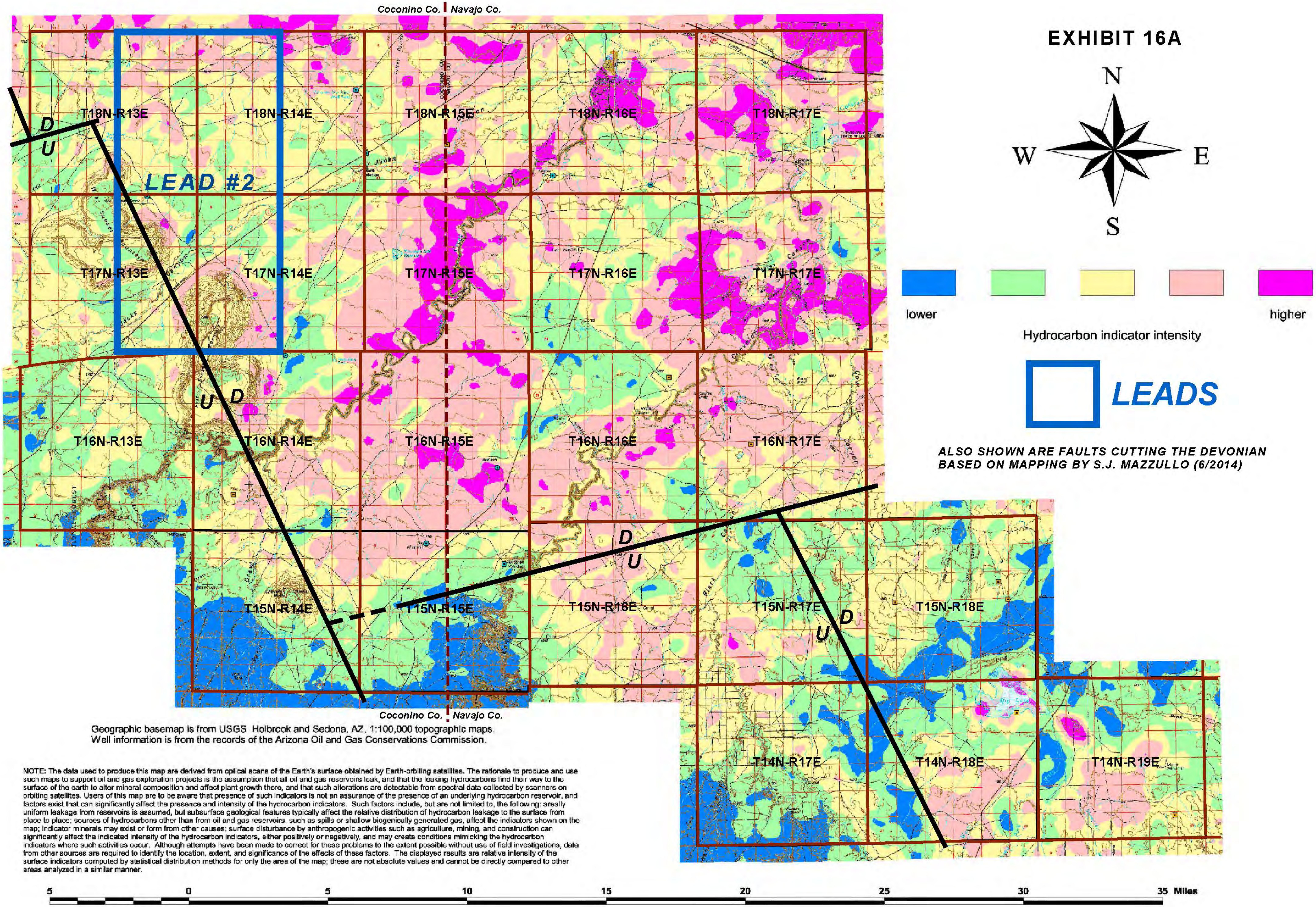


EXHIBIT 16A



Geographic basemap is from USGS Holbrook and Sedona, AZ, 1:100,000 topographic maps.
Well information is from the records of the Arizona Oil and Gas Conservations Commission.

NOTE: The data used to produce this map are derived from optical scans of the Earth's surface obtained by Earth-orbiting satellites. The rationale to produce and use such maps to support oil and gas exploration projects is the assumption that all oil and gas reservoirs leak, and that the leaking hydrocarbons find their way to the surface of the earth to alter mineral composition and affect plant growth there, and that such alterations are detectable from spectral data collected by scanners on orbiting satellites. Users of this map are to be aware that presence of such indicators is not an assurance of the presence of an underlying hydrocarbon reservoir, and factors exist that can significantly affect the presence and intensity of the hydrocarbon indicators. Such factors include, but are not limited to, the following: areally uniform leakage from reservoirs is assumed, but subsurface geological features typically affect the relative distribution of hydrocarbon leakage to the surface from place to place; sources of hydrocarbons other than from oil and gas reservoirs, such as spills or shallow biogenically generated gas, affect the indicators shown on the map; indicator minerals may exist or form from other causes; surface disturbance by anthropogenic activities such as agriculture, mining, and construction can significantly affect the indicated intensity of the hydrocarbon indicators, either positively or negatively, and may create conditions mimicking the hydrocarbon indicators where such activities occur. Although attempts have been made to correct for these problems to the extent possible without use of field investigations, data from other sources are required to identify the location, extent, and significance of the effects of these factors. The displayed results are relative intensity of the surface indicators computed by statistical distribution methods for only the area of the map; these are not absolute values and cannot be directly compared to other areas analyzed in a similar manner.

Satellite spectral analysis of parts of Coconino and Navajo counties, Arizona

Satellite spectral analysis of parts of Coconino and Navajo counties, Arizona

EXHIBIT 16B

Geographic basemap is from USGS Winslow, Flagstaff, Sedona, Holbrook and Saint Johns, AZ, 1:100,000 topographic maps.
Well information is from the records of the Arizona Oil and Gas Conservations Commission.

NOTE: The data used to produce this map are derived from optical scans of the Earth's surface obtained by Earth-orbiting satellites. The rationale to produce and use such maps to support oil and gas exploration projects is the assumption that all oil and gas reservoirs leak, and that the leaking hydrocarbons find their way to the surface of the earth to alter mineral composition and affect plant growth there, and that such alterations are detectable from spectral data collected by scanners on orbiting satellites. Users of this map are to be aware that presence of such indicators is not an assurance of the presence of an underlying hydrocarbon reservoir, and factors exist that can significantly affect the presence and intensity of the hydrocarbon indicators. Such factors include, but are not limited to, the following: areally uniform leakage from reservoirs is assumed, but subsurface geological features typically affect the relative distribution of hydrocarbon leakage to the surface from place to place; sources of hydrocarbons other than from oil and gas reservoirs, such as spills or shallow biogenically generated gas, affect the indicators shown on the map; indicator minerals may exist or form from other causes; surface disturbance by anthropogenic activities such as agriculture, mining, and construction can significantly affect the indicated intensity of the hydrocarbon indicators, either positively or negatively, and may create conditions mimicking the hydrocarbon indicators where such activities occur. Although attempts have been made to correct for these problems to the extent possible without use of field investigations, data from other sources are required to identify the location, extent, and significance of the effects of these factors. The displayed results are relative intensity of the surface indicators computed by statistical distribution methods for only the area of the map; these are not absolute values and cannot be directly compared to other areas analyzed in a similar manner.

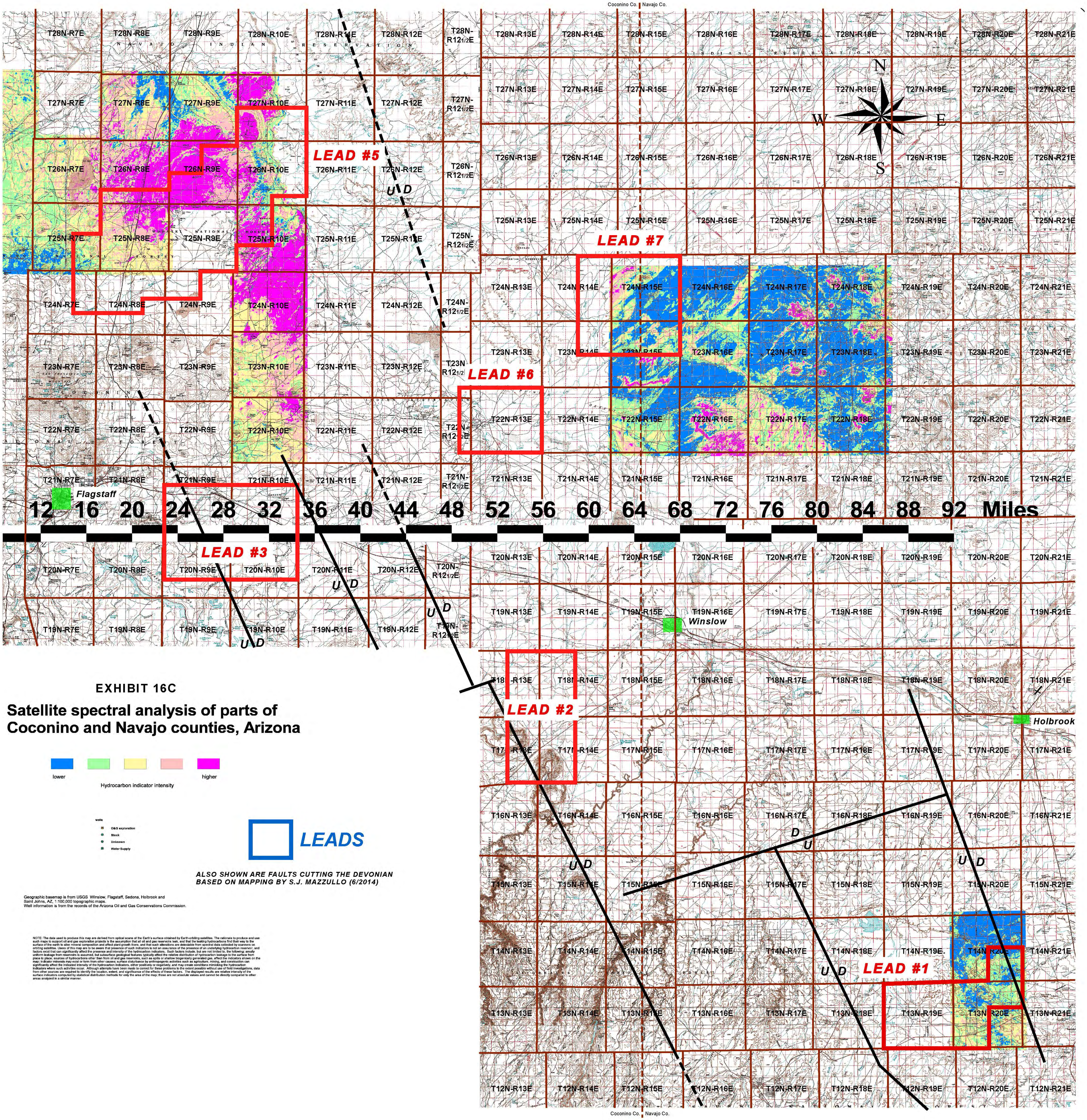


EXHIBIT 16C

Satellite spectral analysis of parts of Coconino and Navajo counties, Arizona

lower — higher

Hydrocarbon indicator intensity

wells

- O&G exploration
- Stock
- Unknown
- Water Supply

LEADS

ALSO SHOWN ARE FAULTS CUTTING THE DEVONIAN BASED ON MAPPING BY S.J. MAZZULLO (6/2014)

Geographic basemap is from USGS Winslow, Flagstaff, Sedona, Holbrook and Saint Johns, AZ, 1:100,000 topographic maps.
Well information is from the records of the Arizona Oil and Gas Conservations Commission.

NOTE: The data used to produce this map are derived from optical scans of the Earth's surface obtained by Earth-orbiting satellites. The rationale to produce and use such maps to support oil and gas exploration projects is the assumption that all oil and gas reservoirs leak, and that the leaking hydrocarbons find their way to the surface of the earth to alter mineral composition and affect plant growth there, and that such alterations are detectable from spectral data collected by scanners on orbiting satellites. Users of this map are to be aware that presence of such indicators is not an assurance of the presence of an underlying hydrocarbon reservoir, and factors exist that can significantly affect the presence and intensity of the hydrocarbon indicators. Such factors include, but are not limited to, the following: areally uniform leakage from reservoirs is assumed, but subsurface geological features typically affect the relative distribution of hydrocarbon leakage to the surface from place to place; sources of hydrocarbons other than from oil and gas reservoirs, such as spills or shallow biogenically generated gas, affect the indicators shown on the map; indicator minerals may exist or form from other causes; surface disturbance by anthropogenic activities such as agriculture, mining, and construction can significantly affect the indicated intensity of the hydrocarbon indicators, either positively or negatively, and may create conditions mimicking the hydrocarbon indicators where such activities occur. Although attempts have been made to correct for these problems to the extent possible without use of field investigations, data from other sources are required to identify the location, extent, and significance of the effects of these factors. The displayed results are relative intensity of the surface indicators computed by statistical distribution methods for only the area of the map; these are not absolute values and cannot be directly compared to other areas analyzed in a similar manner.

RESUME OF PETROLEUM GEOLOGY*

SALVATORE J. MAZZULLO

***Note:** *This resume includes only petroleum geology-related entries in my career. Company names are the original pre-merger names in existence in the time-frame to which I refer to them (e.g., Texaco then is now Chevron-Texaco, Mobil and Exxon then are now Exxon-Mobil, etc)*

PRESENT POSITION: Petroleum explorationist and consultant geologist. Formerly Professor, Department of Geology, Wichita State University, Wichita, Kansas

EDUCATION:
BS, Brooklyn College (1969), Geology; MS, Brooklyn College (1971), Geology; PhD, Rensselaer Polytechnic Institute (1974)

PROFESSIONAL PETROLEUM GEOLOGY EXPERIENCE:

- Senior Research Geologist, Texaco Research & Technical Dept., Houston, TX (1975) – *involved in characterizing the geology of giant stratigraphic-type fields around the world as models for further petroleum exploration*

- Petroleum geological consultant (1975-78) – *consulted on various petroleum exploration and production concerns for companies such as Union Texas Petroleum, American Trading and Production, Phillips Petroleum, and Gulf Oil*

- Senior Staff Stratigrapher (1978-79) and Manager of Stratigraphic Exploration, Union Texas Petroleum Corp., Midland and Houston, TX (1978-81) – *I managed a staff of 5 geologists and a support staff of 2 technicians-secretaries as the company's director of exploration for stratigraphic petroleum traps in the US*

- Consulting geologist, 1981 to present – *studies of (i) reservoirs in existing fields (depositional facies, diagenesis, clay minerals in sandstones, pore geometry utilizing thin-sections and scanning electron microscopy) based on cores and cuttings samples; (ii) definition of plays and trends based on subsurface mapping, studies of cores and/or cuttings, and relationship to seismic; and (iii) reservoir analyses on basin-wide scales, notably in the Permian Basin. I did such work for a number of domestic and international companies on exploration in the Permian Basin of west Texas-New Mexico, Anadarko Basin of Oklahoma, Kansas, and elsewhere in the world, including:* Woolsey Operating Co. (Wichita, KS), Murfin Drilling Co. (Wichita, KS), Trans-Pacific Oil (Wichita, KS), Palomino Petroleum (Newton, KS), Nat-Gas (CEP Holdings out of Kansas City, KS), Texaco, Exxon, Tenneco, Mobil Oil, Superior Oil, Anadarko Prod. Co. (Midland, TX), Burlington Resources (Midland, TX), Spectrum 7 (Midland, TX), American Trading and Production Co. (Midland, TX), John Edmonson & Associates (Midland, TX); Amerind (Lubbock, TX), Permian Exploration (Midland, TX), Nearburg Prod. Co. (Midland, TX), Paladin Exploration (Dallas, TX), Meridian Oil (Midland, TX), Chevron, Gulf Oil, Estacado Oil, Deminex (Dallas, TX), Santa Fe Energy (Midland, TX), Anschutz, Abercrombie Drilling (Midland, TX), National Oil & Gas Commission of India, Nakoma Exploration (San Antonio, TX), R.M. Hill, Inc (Graham, TX), REPSOL (Madrid, Spain)

- **Exploration geologist, 1981 to present:** *since 1981 I have generated many oil or gas prospects for a number of companies, and have had many of them drilled. I have found significant oil/gas in Texas for a number of companies, and in Kansas as well. In my exploration effort I utilize subsurface mapping, seismic when available, and analogy to other fields and modern depositional-diagenetic models in carbonate and siliciclastic deposition.*

Areas in Kansas in which I've mapped and generated prospects include:

- Ness and Hodgeman Counties (for Mississippian, Cherokee sand, and Fort Scott Limestone)
- northern Barber, southern Pratt, and easternmost Kiowa Counties (for Arbuckle, Simpson, Viola, Mississippian, Lansing-Kansas City, Douglas sands, and Indian Cave Sand)
- Cowley, eastern Sumner, and southern Butler Counties (for Arbuckle, Mississippian, Lansing-Kansas City, Douglas sands and Indian Cave Sand)
- southern Saline, McPherson, Harvey, and NE Kingman Counties (for Simpson, Viola, Hunton, Mississippian, Lansing-Kansas City, and Douglas sands)
- part of Rawlins County (for Lansing-Kansas City)
- part of Lane County (for Lansing-Kansas City)
- adjoining parts of northern Butler, NE Sedgwick, and eastern Harvey Counties for Mississippian and Cherokee sands)
- parts of Rush County (for Arbuckle)

-Related Skills: I can (I) generate and promote prospects; and obviously I can read, understand, interpret, and correlate well logs and know what the information recorded on scout cards means and how to utilize it; (ii) evaluate submitted prospects; (iii) evaluate and map plays and existing fields; (iv) direct/work with other exploration or development geologists and geophysicists; (v) sit wells as a well-site geologist (I don't do so, however); (vi) geologically supervise a drilling well; (vii) take and understand daily drilling reports; (viii) interpret drill-stem tests and know what to do with them; (ix) integrate 2-D and 3-D seismic data and subsurface data; (x) directly apply academic studies of reservoirs to actual exploration and/or production

- I have authored a fully-illustrated book on cuttings analysis in carbonates after having run hundreds of thousands of feet of cuttings samples throughout the Permian Basin, in Ellenburger (Arbuckle equivalent) through Permian strata, for clients listed above

- I have authored a reference (mainly for students) on well-log interpretation entitled "Well Log Analysis" (35 p.)

PROFESSIONAL MEMBERSHIPS:

- Fellow (1990), Geological Society of America – *the membership category "fellow" is reserved for those who have made important contributions in geology*
- Honorary Life Member (1991), Permian Basin Section SEPM (Society for Sedimentary Geology) – *this status is in recognition of those who have made significant contributions to knowledge of the petroleum geology of the Permian Basin of west Texas and New Mexico*
- International Association of Sedimentologists
- American Association of Petroleum Geologists (national, Southwest Section, and Midcontinent Section)
- SEPM (Society for Sedimentary Geology) - national
- West Texas Geological Society

- Kansas Geological Society
- Honorary Founding Member, Andrews Geological Society

PETROLEUM COURSES I'VE TAUGHT FOR PROFESSIONAL GEOLOGISTS

- a 2-day course on cuttings and core analysis in carbonates that I've taught numerous times for the Permian Basin Graduate Center (in Midland, Texas) and for a number of majors and independent companies throughout the SW US and in India.
- a 2-day course on basin analysis and stratigraphy in the Permian Basin that I've taught numerous times for the Permian Basin Graduate Center (in Midland, Texas) and for a number of majors and independent companies throughout the SW US
- a 2-day course on porosity evolution in limestones and dolomites that I've taught numerous times for the Permian Basin Graduate Center (in Midland, Texas) and for a number of majors and independent companies throughout the SW US
- a 3-hour video-taped course (for distribution by the Kansas Geological Society) on facies models and porosity evolution in limestones
- a 2-day course on dolomitization and porosity in reservoirs that I've offered several times through WSU at the Downtown Center
- a 2-day course on stratigraphic plays in Ordovician to Permian carbonates in the Permian Basin that I've taught for the Permian Basin Graduate Center and numerous oil companies
- numerous 7-day courses in Belize to examine modern analogs of carbonate petroleum reservoirs (offered this courses independently as well as through the Permian Basin Section SEPM)

GRANTS/CONTRACTS/FUNDS RECEIVED FOR PETROLEUM RESEARCH AT WSU:

- Co-investigator on Texas A&M University faculty grant for studies of Upper Permian sandstone-carbonate deposition in the Permian Basin of west Texas (1985), $11000
- From Texaco, $60,000 for research on origin of Holocene dolomite in Belize (1987-90) -- *I supported 2 graduate students and one undergraduate with this money*
- From Petroleum Research Fund-American Chemical Society, $60,000 for continuing research on Holocene dolomitization in Belize (1999-2001) – *I supported 4 graduate students with this money*
- From Conoco, Ponca City, OK, donation of an ISI Super III-A scanning electron microscope (1989), value $56000 – *for the department and its students/faculty*
- From Shell Oil Co., Houston, TX, for research on reservoir development in the northern Midland Basin (1993), $20,000 – *which supported 3 graduate students*
- From Paladin Exploration Corp., Dallas, TX, to study reservoir development in Pennsylvanian carbonates, NM (1993), $8000 – *supported 1 undergraduate student*
- From Paladin Exploration Corp., Dallas, TX, to study porosity formation in Lower Permian basinal carbonate reservoirs in the Permian Basin (1994), $1800
- From Paladin Exploration Corp., Dallas, TX, to study reservoir potential in Pennsylvanian and Permian carbonates in New Mexico (1994), $20,900 – *supported 1 undergraduate student*
- From GEOGRAPHIX Corp., state-of-the-art computer software for geoscience education, valued at $36,000 (1996) – *for the department and its students/faculty*
- From Watkins Petroleum, $650 for research on Cretaceous reservoirs, Mississippi (1996)
- From Palomino Petroleum, $5000 for research on Mississippian reservoirs in Kansas (2001) – *supported 1 undergraduate and 1 graduate student*

- From Woolsey Petroleum, Wichita, $4000 for research on Mississippian reservoirs in Rhodes Field, Barber Co., KS (2003-2004) – *supported 1 graduate student*
- From Woolsey Petroleum, Wichita, $5000 for research on Mississippian reservoirs in Oakes Field, Barber Co., KS (2005-2006) – *supported 1 undergraduate student*
- From Permian Exploration Corp., Roswell, NM, to support modern carbonate research in Belize (1987-88), $2000 – *supported several undergraduate students*
- From Amerind Oil Corp., Midland, TX, to support modern carbonate research in Belize (1987-88), $250 – *supported 1 undergraduate student*
- From Dr. A.M. Reid, Geological Consultant, Midland, TX, to support modern carbonate research in Belize (1988), $300 – *supported 1 undergraduate student*
- From Meridian Oil Corp., Midland, TX, for research on sedimentology and diagenesis of Permian reef reservoirs, Permian Basin (1988), $8000
- From Core Laboratories, Dallas, TX, to study diagenesis of basinal carbonate reservoirs in the Permian Basin (1988), $2000 for kerogen and vitrinite reflectance analyses of shale – – *supported 1 graduate student*
- From Nearburg Prod. Co., Dallas, TX, to study micrite diagenesis in Belize (1989), $900 – *supported several undergraduate students*
- From Meridian Oil Co., Houston, TX, for research on stratigraphy of Pennsylvanian, coal-bearing strata in Alabama (1989), $10,000 – *supported several undergraduate students*
- From various petroleum company sources for support of modern carbonate research in Belize: 1991-92, $750; 1992-93,$300; 1993-94, $1400; 1995, $650; 1996, $1000; 1997, $300; 1998, $300 – *supported several graduate and undergraduate students*
- Estacado Oil Co., Lubbock, TX: $300 for support of Permian Basin research (1995) – *supported 1 undergraduate student*
- $2000 worth of Landsat images from Belize and Yucatan coast of Mexico in support of research in Belize, from Chevron Oil Co. (1995)
- From Paladin Exploration, $5000 for personal computer upgrade (1995)
- From petroleum company sources for support of modern carbonate research in Belize (1995-1996), $450 – *supported 1 undergraduate student*

Grants to Students with My Sponsorship/Supervision for Petroleum-Related Research at WSU

- to Tom Wingate: $1500 in fusulinid identifications from Dr. A.M. Reid, Midland, TX, in support of MS thesis research
- to Jim Rough: $1700 from the American Association of Petroleum Geologists for MS thesis research on depositional facies in Belize as modern analogs of petroleum reservoirs (1991)
- to Ye (Mike) Qiucheng: $2000 in isotopic analyses for support of MS thesis research from Texaco (1991) on dolomite and porosity formation in some Permian Basin oil reservoirs
- to Chellie Teal: $300 from the South-Central Section of the Geological Society of America in support of undergraduate research in Belize (1992); and $1000 from the Kansas Geological Foundation in support of same (1993 and 1994); and $4000 from Paladin Exploration Corp., Dallas, Texas, in support of an undergraduate scholarship to study petroleum geology in the Permian Basin, New Mexico (1994); and $1000 from the SIPES Foundation for thesis research on the Cangrejo Shoals mudbank in Belize as modern analogs of petroleum reservoirs
- to Cynthia Burtnett: $300 from the South-Central Section of the Geological Society of America in support of undergraduate research in Belize (1994); and $500 from the Kansas Geological Foundation for same (1994) as modern analogs of petroleum reservoirs

- to David Lowe: $1000 from the Geological Society of America to support MS thesis research in Belize (1994); and $2000 from the American Association of Petroleum Geologists for same (1994); and $60 from the Delano Maggard Foundation for same (1994) as modern analogs of petroleum reservoirs
- to Cynthia Burtnett: $2000 for support of thesis research on Lower Permian stratigraphy in Kansas from the American Association of Petroleum Geologists (1997) as an outcrop analog of subsurface gas reservoirs in Kansas
- to Brian Wilhite: $1500 for support of thesis research on sedimentation and diagenesis of modern foram sand shoals in Belize from the Geological Society of America (1998); $1000 for same from Society of Independent Earth Scientists (1998); $300 from Delano Maggard program for same (1998) as modern analogs of petroleum reservoirs
- to Kimberly Dimmick: $500 for support of McNair undergraduate research on marine dolomitization in Belize from South-Central Section Geological Society of America (1998) as modern analog of petroleum reservoirs
- to Krysti Weed: $500 for support of thesis research on Pleistocene facies in Belize from Kansas Geological Society Foundation (1998); $750 for same from Sigma Xi (1999); $1000 for same from SIPES to understand porosity evolution in carbonates
- to Joseph Hall: $600 and $400 for support of thesis research on the Carlton Dolomite (Permian) in Kansas from Kansas Geological foundation (2 separate grants, 2003 and 2004) as an outcrop analog of subsurface gas reservoirs in Kansas
- to Daryl Lederhos: $500 in support of thesis research on subsurface Mississippian carbonates, SE Kansas, from Kansas Academy of Science (2005); $1000 for same from Kansas Geological Society Foundation (in 2006); and $1250 from SIPES for same (in 2006), as models for prolific Mississippian oil and gas reservoirs in Kansas
- to Loveness Mpange: $1250 for support of thesis research from AAPG student grants program to study cores of Lansing-Kansas City oil reservoirs in O'Connor Oil Field, Stafford Co., Kansas

PETROLEUM GEOLOGY-RELATED AWARDS:

- ***Four*** A.I. Levorsen Best Paper Awards – three from the Southwest Section American Association of Petroleum Geologists (1983, 1986, 1994) and one from the Midcontinent Section AAPG (2013) – *a most coveted award to speakers of best oral presentations and subjects on the petroleum geology of the southwest US*
- ***Three*** Planalp Awards from the Midcontinent Section AAPG for best poster session presentations
- Diploma of Honor from Pi Epsilon Tau (National Petroleum Engineering Honor Society (1987) – *specifically for applied scientific contributions to petroleum geology*
- Monroe Cheney Science Award from Southwest Section American Association of Petroleum Geologists (1989) – *a most prestigious award for significant, long-term, applied scientific contributions to the petroleum geology of the southwest region*
- Best Speaker Award from Permian Basin Section SEPM (Society for Sedimentary Geology)(1989) – *for the petroleum geology of the Permian Basin*
- Honorary Life Member of Permian Basin Section SEPM (Society for Sedimentary Geology)(1991) – *for significant, long-term, applied scientific contributions to the geology of the Permian Basin*
- Best Paper Award from West Texas Geological Society (1994) – *for the petroleum geology of the Permian Basin*

- Gold Medal of Honor (Kapitsa Medal) from Russian Academy of Science (1995) – *for applied scientific contributions to petroleum geology around the world. I am one of only a handful of non-Russians to receive this award*
- Distinguished Service Award from Kansas Geological Society (1996, 2004, 2005) – *for applied scientific contributions to promoting the petroleum geology of Kansas*
- Distinguished Educator Award from Southwest Section American Association of Petroleum Geologists (2002) – *for applied scientific contributions to promoting the science of application of such to petroleum geology*

PETROLEUM GEOLOGY-RELATED PUBLICATIONS

Asterisks (*) denote publications with students, whose names are italicized

Articles in Refereed Journals

Mazzullo, S.J., and J.M. Cys, 1978, *Archaeolithoporella*-boundstones and marine cementation, Capitan reef, New Mexico and Texas USA; Neues Jahrbuch fur Geologie und Palaeontologie Abh., v. 10, p. 600-611 (INVITED).

Cys, J.M., and S.J. Mazzullo, 1978, Lithofacies and sedimentation of Lower Permian carbonates of the Leonard Mountain area, Glass Mountains, western Texas: a discussion; Journal of Sedimentary Petrology, v. 48, p. 1363-1368 (reprinted in Symposium and Guidebook, Marathon-Marfa Region of West Texas: Permian Basin Section SEPM Publ. No, 81-20, p. 163-168).

Mazzullo, S.J., and J.M. Cys, 1979, Marine aragonite sea-floor growths and cements in Permian phylloid algal mounds, Sacramento Mountains, New Mexico; Journal of Sedimentary Petrology, v. 49, p. 917-936.

Mazzullo, S.J., 1980, Calcite pseudospar replacive of marine, acicular cements, and implications for aragonite diagenesis; Journal of Sedimentary Petrology, v. 50, p. 409-422.

Mazzullo, S.J., 1981, Facies and burial diagenesis of a carbonate reservoir: Chapman Deep (Atoka) field, Delaware Basin, Texas; American Association of Petroleum Geologists Bulletin, v. 65, p. 850-865 (INVITED).

Mazzullo, S.J., 1982, Stratigraphy and depositional mosaics of Lower Clear Fork and Wichita Groups (Permian), Northern Midland Basin, Texas; American Association of Petroleum Geologists Bulletin, v. 66, p. 210-226.

**Judice, P.W.*, and S.J. Mazzullo, 1982, The Gray Sandstones (Jurassic) in Terryville Field, Louisiana: basinal deposition and exploration model; Transactions Gulf Coast Association of Geological Societies, v. 32, p. 23-43 (INVITED).

Mazzullo, S.J., and A.M. Reid, 1986, Belize, Central America: geologic models for certain Paleozoic reservoirs in the Permian Basin; West Texas Geological Society Bulletin, v. 25, no. 6, p. 4-11 (INVITED).

Mazzullo, S.J., 1986, Mississippi Valley-type sulfides in Lower Permian dolomites, Delaware Basin, Texas: implications for basin evolution; American Association of Petroleum Geologists Bulletin, v. 70, p. 943-952.

Mazzullo, S.J., 1986, Stratigraphic approaches to hydrocarbon exploration and exploitation; Geological Journal, v. 21, p. 265-281 (INVITED).

Mazzullo, S.J., A.M. Reid, and L.J. Mazzullo, 1987, Basinal Lower Permian facies, Permian Basin: Part I - Stratigraphy of the Wolfcampian-Leonardian boundary; West Texas Geological Society Bulletin, v. 26, no. 7, p. 5-9 (INVITED).

Mazzullo, S.J., and A.M. Reid, 1987, Basinal Lower Permian facies, Permian Basin: Part II - Depositional setting and reservoir facies of Wolfcampian-Leonardian basinal carbonates; West Texas Geological Society Bulletin, v. 26, no. 8, p. 5-10 (INVITED).

Reid, A.M., and S.J. Mazzullo, 1988, The Pennsylvanian-Permian boundary in shelf areas of the North Platform of the Midland Basin; West Texas Geological Society Bulletin, v. 27, p. 5-8.

Reid, A.M., and S.J. Mazzullo, 1988, Paint Rock and Paint Rock Southwest fields, Concho County, Texas: Strawn analogue of modern shelf island systems; West Texas Geological Society Bulletin, v. 27, p. 5-10.

*Mazzullo, S.J., *W.E. Hipke, T.H. Weidemeier, T.P. Wingate, M.G. Gaylord*, and A.M. Reid, 1989, Dynamic stratigraphy of the Tubb and Dean Formations (Lower Permian), northern Midland Basin, Texas; West Texas Geological Society Bulletin, v. 29, no. 1, p. 5-11.

Mazzullo, S.J., and J.M. Gregg, 1989, Mississippi Valley-type sulfide mineralization and relationships to carbonate diagenesis; Carbonates and Evaporites, v. 4, no. 2, p. 131-135 (INVITED).

Mazzullo, S.J., 1990, Karst-controlled reservoir heterogeneity in Ellenburger Group carbonates in west Texas: discussion; American Association of Petroleum Geologists Bulletin, v. 74, p. 1119-1123.

Mazzullo, S.J., and P.M. Harris, 1992, Mesogenetic dissolution: its role in porosity development in carbonate reservoirs; American Association of Petroleum Geologists Bulletin, v. 76, p. 607-620.

**Ye, Q.*, and S.J. Mazzullo, 1993, Dolomitization of Lower Permian platform facies, Wichita Formation, North Platform, Midland Basin, Texas; Carbonates and Evaporites, v. 8, p. 55-70.

Mazzullo, S.J., 1994, Dolomitization of periplatform carbonates (Lower Permian, Leonardian), Midland Basin, Texas; Carbonates and Evaporites, v. 9, p. 95-112.

Mazzullo, S.J., 1994. Models of porosity evolution in Permian periplatform carbonate reservoirs (debris-flows and turbidites) in the Permian Basin; West Texas Geological Society Bulletin, v. 34, no. 1, p. 5-12.

Mazzullo, S.J., 1994. Diagenesis in a sequence stratigraphic setting: porosity evolution in periplatform carbonate reservoirs, Permian Basin, Texas and New Mexico; Journal of Petroleum Science and Engineering, v. 11, p. 311-322 (INVITED)

Mazzullo, S.J., 1994, Lithification and porosity evolution in Permian periplatform limestones, Midland Basin, Texas; Carbonates and Evaporites, v. 9, p. 151-171.

*Mazzullo, S.J., W.D. Bischoff, and *C.S. Teal* 1996, Dolomitization of shallow subtidal sediments by normal seawater in the Holocene Cangrejo shoals mudbank, Belize; Bulletin West Texas Geological Society, v. 35, no. 5, p. 5-13.

Mazzullo, S.J., 1997, Permian "Wolfcamp" limestone reservoirs: Powell Ranch field, eastern Midland Basin: Discussion; AAPG Bulletin, v. 81, p. 1750-1753.

Mazzullo, S.J., 1998, Stratigraphic architecture of Lower Permian, cyclic carbonate reservoirs (Chase Group) in the mid-continent USA, based on outcrop studies; AAPG Bulletin, v. 82, p. 464-483.

Mazzullo, S.J., 2004, Overview of porosity evolution in carbonate reservoirs; published in two parts in Kansas Geological Society Bulletin – v. 79 no. 1, p. 22-28 (part 1) and v. 79 no. 2, p. 22-27 (part 2). Reprinted 2004 as paper #40134 in AAPG's on-line journal "Search and Discovery" by invitation of editor Ted Beaumont.

Mazzullo, S.J., 2005, Classification of carbonate rocks in well cuttings and cores: a directed approach toward recognition and correlation of carbonate reservoirs based on depositional and diagenetic attributes; Kansas Geological Society Bulletin, v. 80, no. 1, p. 16-19.

Mazzullo, S.J., 2005 Subunconformity plays in Mississippian strata in Kansas; Kansas Geological Society Bulletin, v. 80, no. 3, p. 12-17.

Mazzullo, S.J., 2005, Outcrop of the Indian Cave Sandstone (Lower Permian) in Greenwood County, Kansas; Kansas Geological Society Bulletin, v. 80, no. 4, p. 12-20.

Mazzullo, S.J., 2005, Relating the sequence stratigraphy of basal Cherokee strata (based on two cores from Barber County) to the exploration for Cherokee sandstone reservoirs in Kansas; Kansas Geological Society Bulletin, v. 80, no. 5, p. 12-20.

*_Wilhite, B.W., Dimmick-Wells, K._ and Mazzullo, S.J., 2005, Modern carbonate depositional settings in Belize, Central America: analogs for modeling and exploring for stratigraphic traps in Lansing-Kansas City reservoirs; Kansas Geological Society Bulletin, v. 80, no. 6, p. 12-22.

Mazzullo, S.J., 2006, Late Pliocene to Holocene platform evolution in northern Belize, and comparison with coeval deposits in southern Belize and the Bahamas; Sedimentology, v. 53, p. 1015-1047.

Mazzullo, S.J., 2006, Geo-Scenes: modern river sands and ancient soils & transgressive marine surfaces; Kansas Geological Society Bulletin, v. 81 no. 6, p. 11-12.

*Mazzullo, S. J., Boardman, D., Grossman, E.L., and _Dimmick-Wells, K._, 2007, Oxygen-carbon isotope stratigraphy of Upper Carboniferous to Lower Permian marine deposits in Midcontinent U.S.A. (Kansas and NE Oklahoma): implications for seawater chemistry and depositional cyclicity; Carbonates and Evaporites, v. 22, p. 55-72.

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