



# WESTCARB Annual Business Meeting

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## Geologic Evaluation for Potential CO<sub>2</sub> storage in Arizona's Cenozoic sedimentary basins: The Safford Basin, southeastern Arizona

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# Outline

- AZGS project objectives
- Initial screening of 88 Cenozoic sedimentary basins in the Basin and Range province
- Preliminary evaluation of Arizona's largest basin, the Safford basin, with 2,300 km<sup>3</sup> below 800m depth
  - Methods and difficulties
  - Stratigraphy and structure
  - Storage and sealing conditions
  - Salinity
- Conclusions and recommendations

# AZGS WESTCARB Phase III Objectives

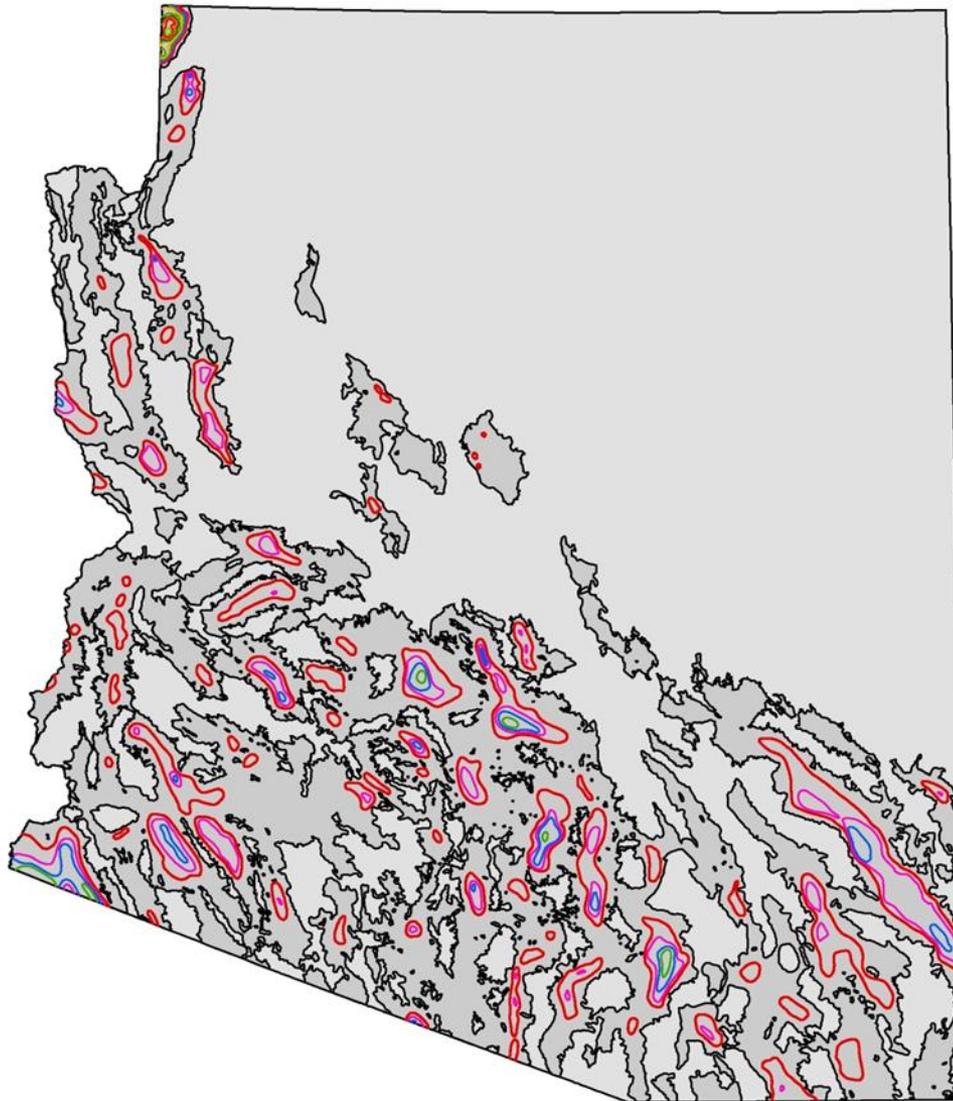
- Identify and assess subsurface geologic formations in the Colorado Plateau and Basin and Range Provinces of Arizona for CO<sub>2</sub> storage potential
- Determine where subsurface salinities approach 10,000 milligrams per liter (mg/l) of total dissolved solids (TDS) for areas identified as having potential for CO<sub>2</sub> storage



# Arizona Physiographic Provinces



- Water
- Rock
- Surficial deposits and basin fill

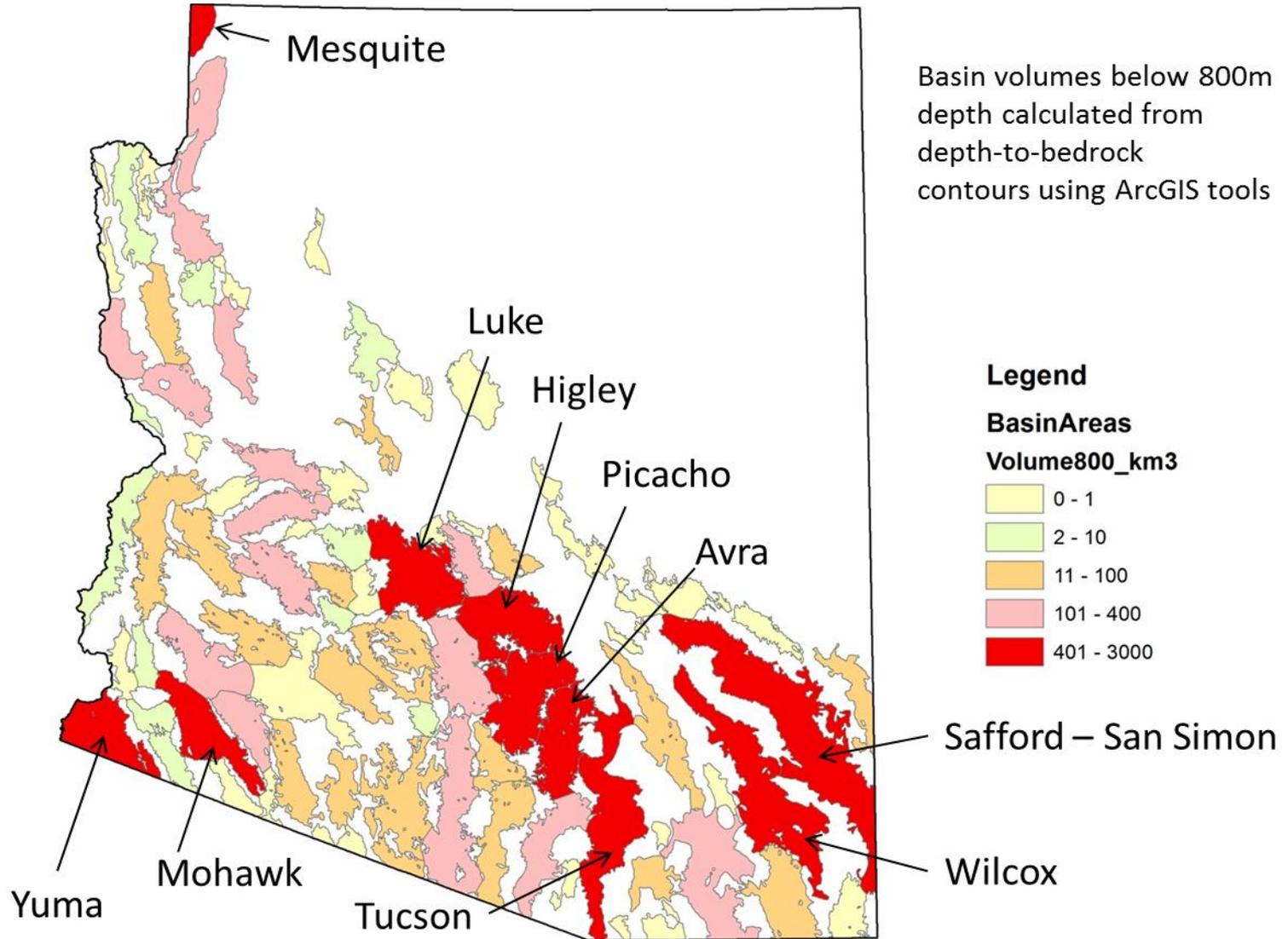


**Legend**

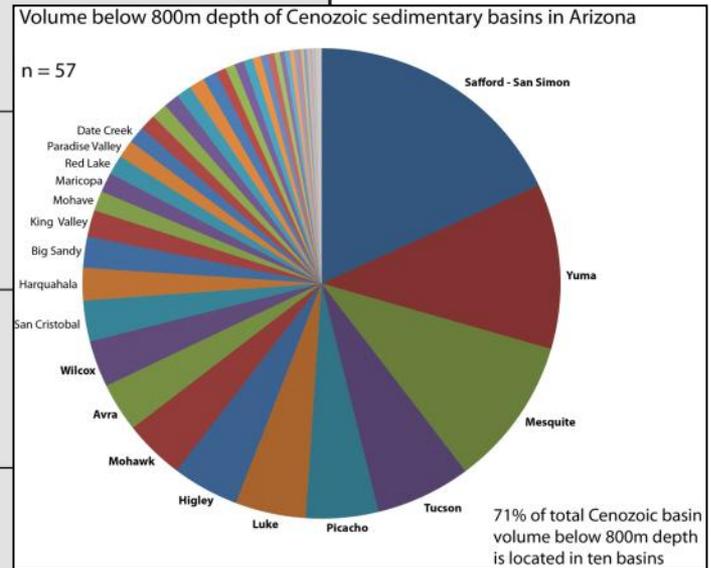
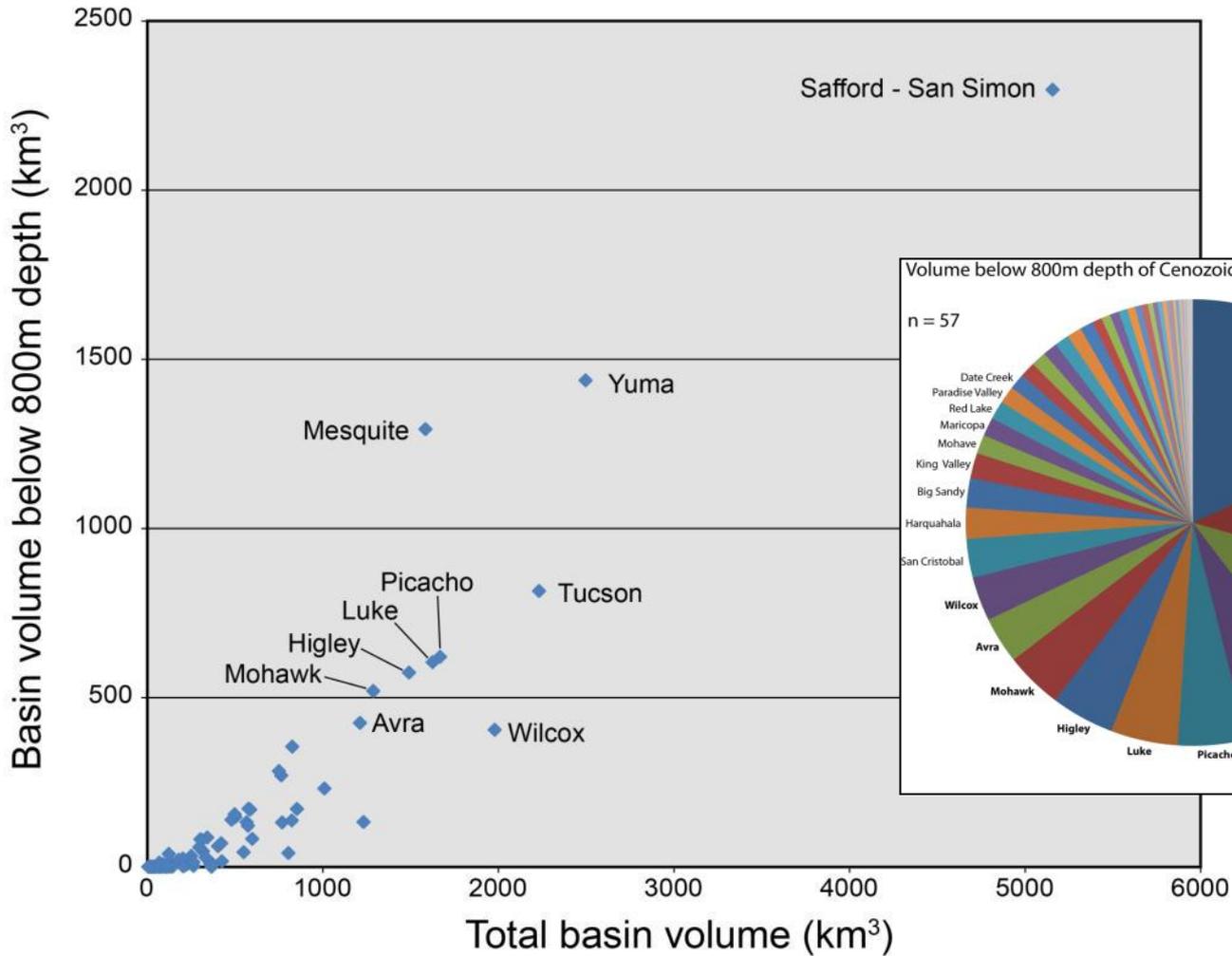
Depth-to-bedrock contours (meters)

- 0
- 800
- 1600
- 2400
- 3200
- 4000
- 4800
- 5600
- 6400
- 7200
- 8000

Depth-to-bedrock in Cenozoic basins of Arizona calculated from gravity and well data

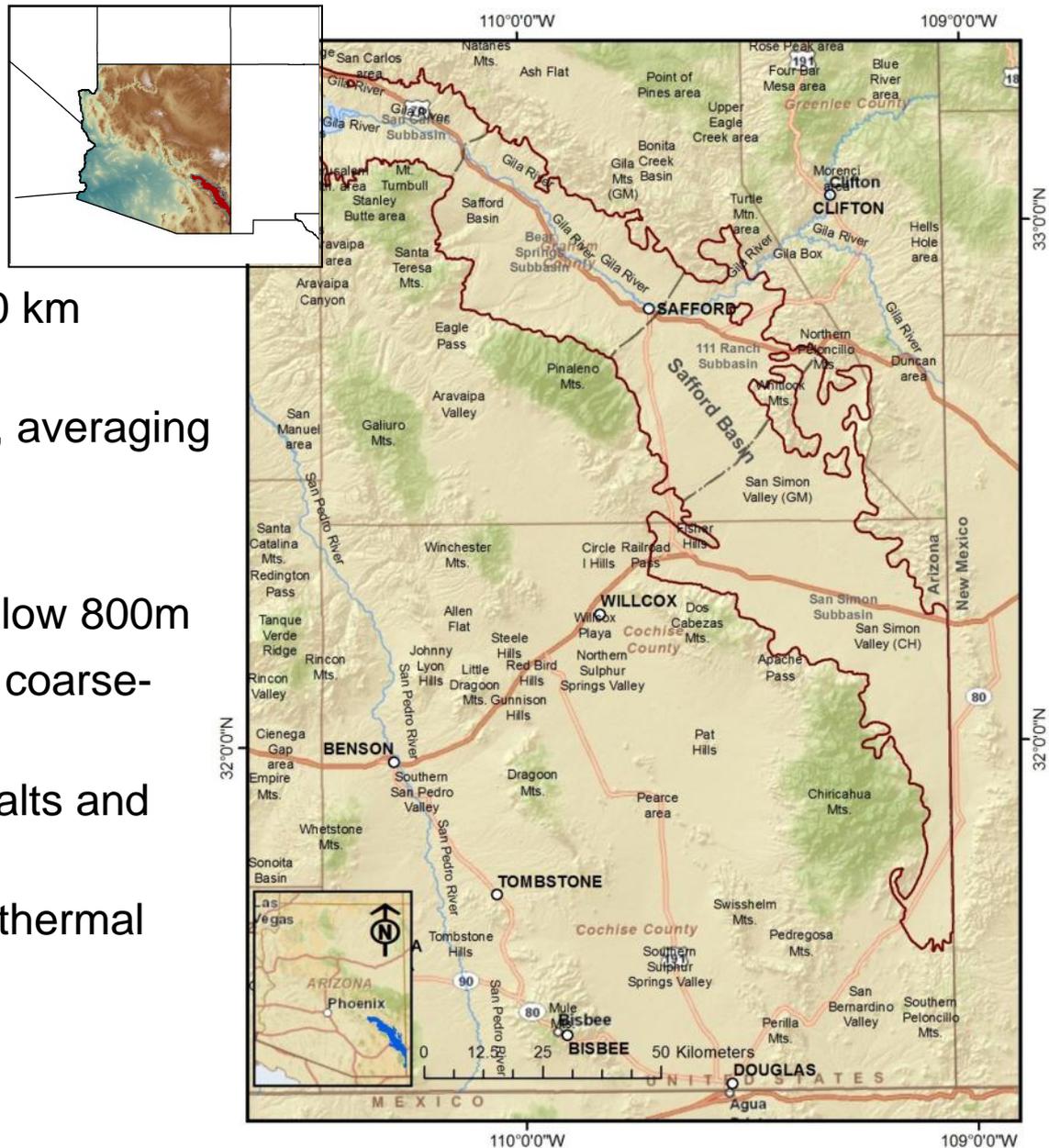


# Arizona Cenozoic basins: Volume vs. volume below 800m depth



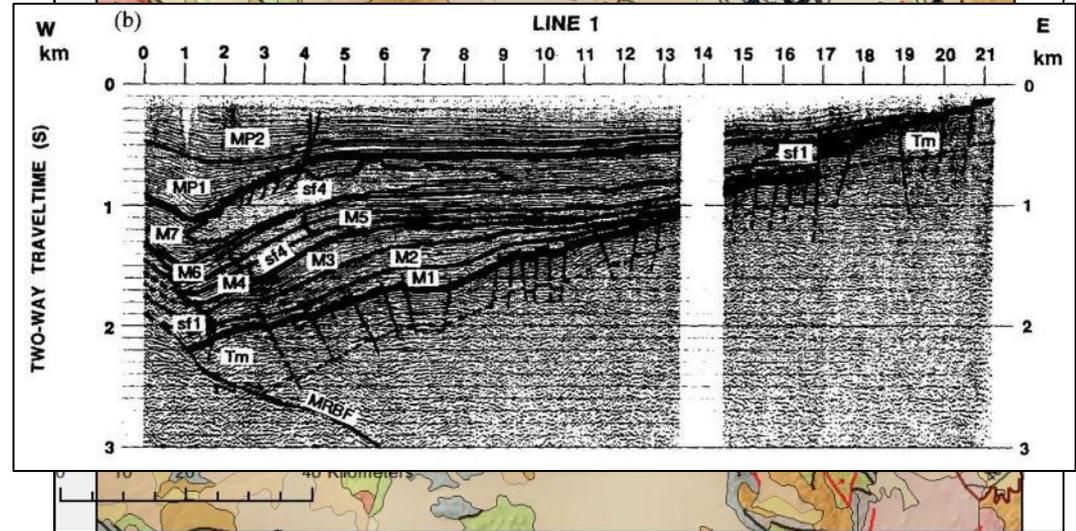
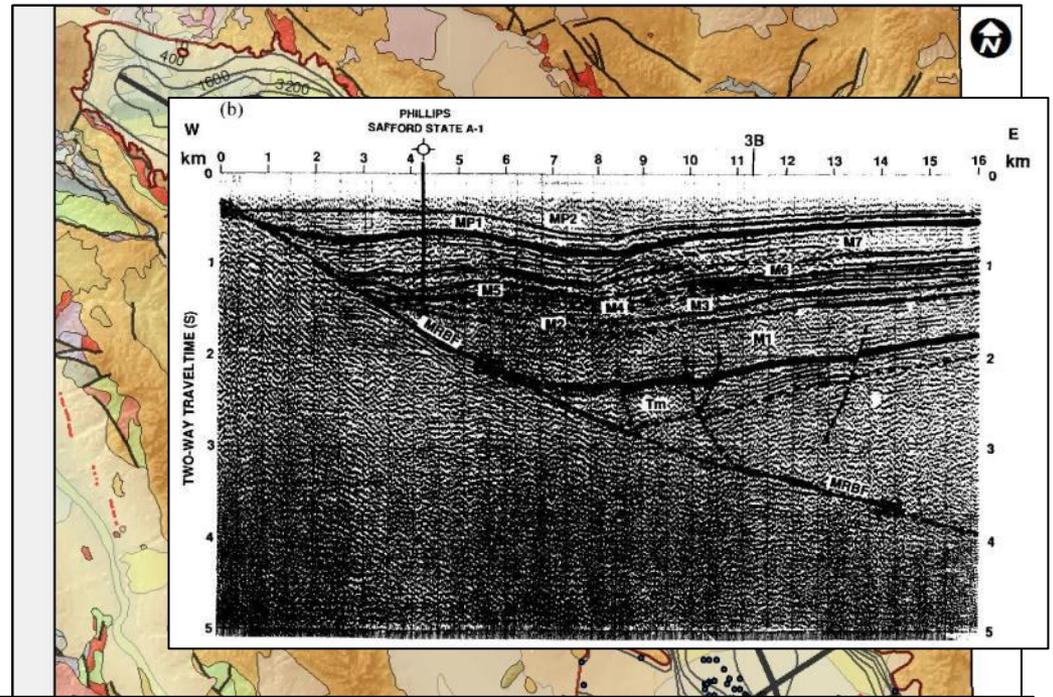
# Safford Basin

- 245 km (155 mi) long, 20 km (12 mi) wide
- 3,500m (11,500 ft) deep, averaging 2,000 to 3,000m
- Fault bounded at depth
- 2,300 km<sup>3</sup> of basin fill below 800m
- Potential targets include coarse-grained facies
- Potential seals include salts and clay bodies
- Saline, artesian and geothermal conditions are present



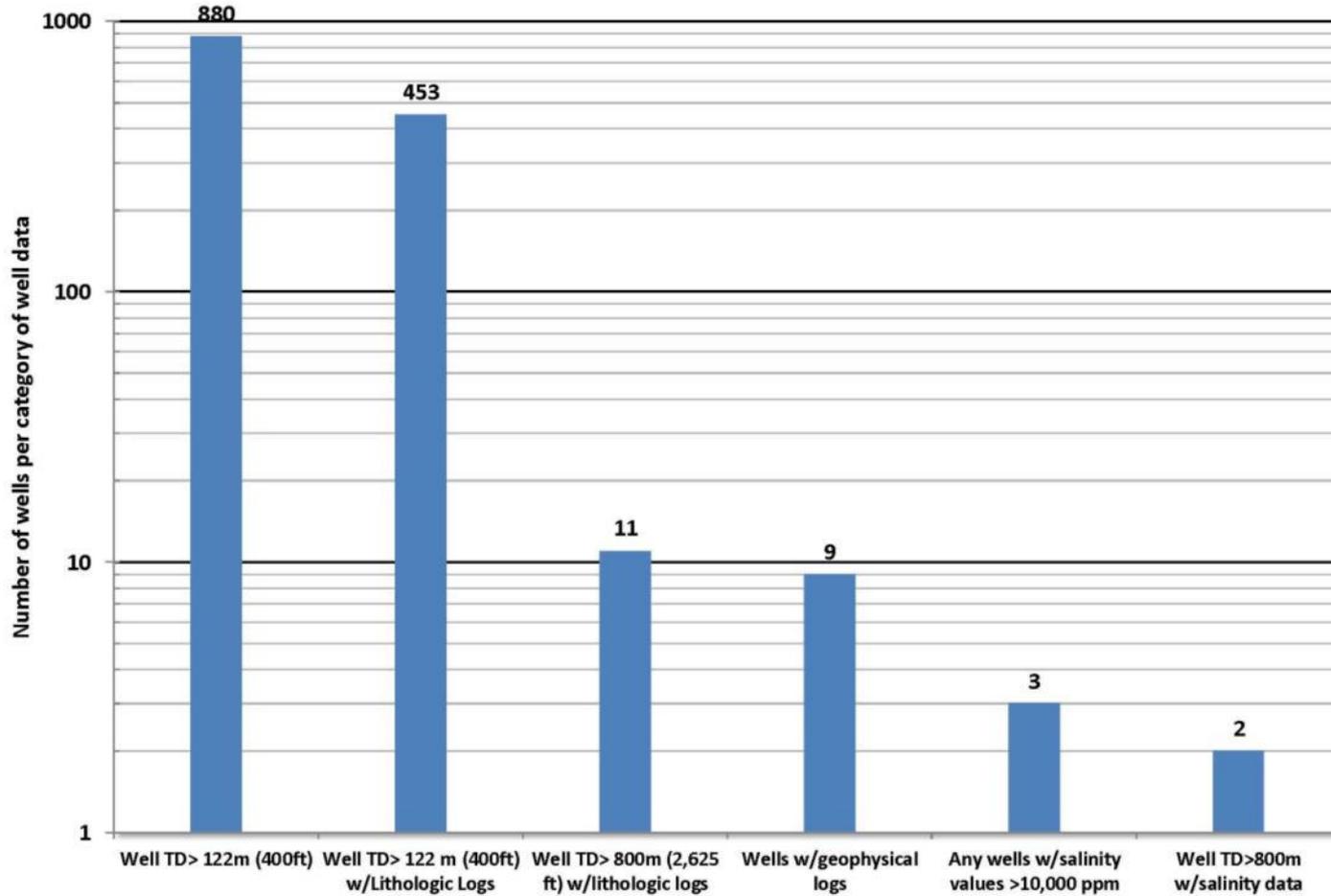
# Methods and Difficulties

- ArcGIS
- Borehole data
- Gravity
- Vintage seismic
- Surficial geologic maps
- Aquaveo for cross-sections



# Well Data

Criteria and categories of well data for the Safford Basin

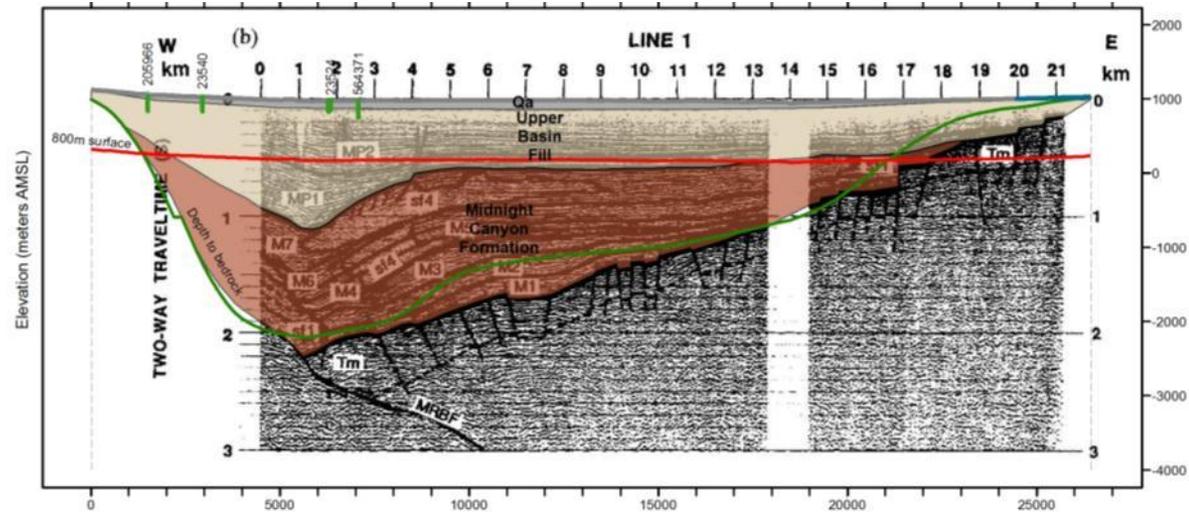
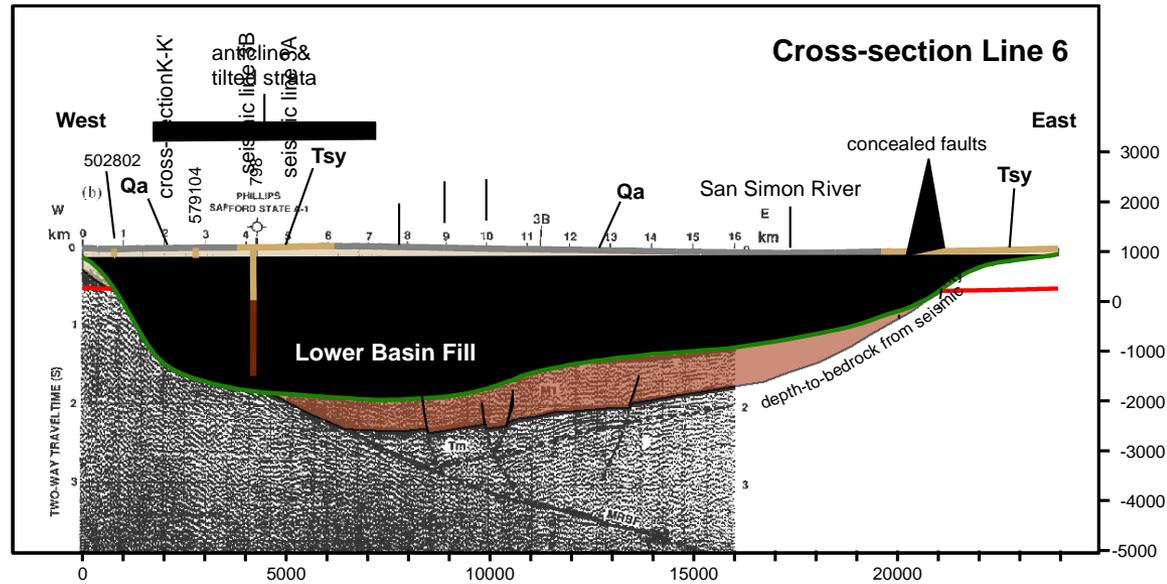


# Stratigraphy

Geologic Unit	Description	Age (Ma)	Thickness (m)
Gila River alluvium	Alluvial and fluvial deposits derived from the modern Gila River drainage network.	0 to 2	0 to 25
Upper Basin Fill	<ul style="list-style-type: none"> <li>• <u>Unconsolidated</u></li> <li>• Coarse and fine siliciclastics, evaporites and limestone</li> <li>• Alluvial, fluvial and lacustrine environments</li> <li>• Basalt flows interbedded with lower portion of this unit</li> <li>• <u>Generally undeformed</u></li> <li>• Unconformable with underlying basin fill unit</li> </ul>	2.3 to 8	0 to 2,000
Lower Basin Fill	<ul style="list-style-type: none"> <li>• <u>Semi-consolidated to indurated</u></li> <li>• Coarse and fine siliciclastics, evaporites and limestone</li> <li>• Alluvial, fluvial and lacustrine environments</li> <li>• Basalt flows interbedded in the lowermost portions</li> <li>• <u>More deformation apparent (folds, faults, fractures)</u></li> <li>• Unconformable with underlying bedrock.</li> </ul>	8 to 12	0 to 2,300
Bedrock	<ul style="list-style-type: none"> <li>• Consolidated</li> <li>• Proterozoic igneous and metamorphic rocks</li> <li>• Paleozoic sedimentary rocks</li> <li>• Cenozoic igneous rocks including andesite and basalt flows</li> </ul>	17 to 1,400	n/a

# Structure

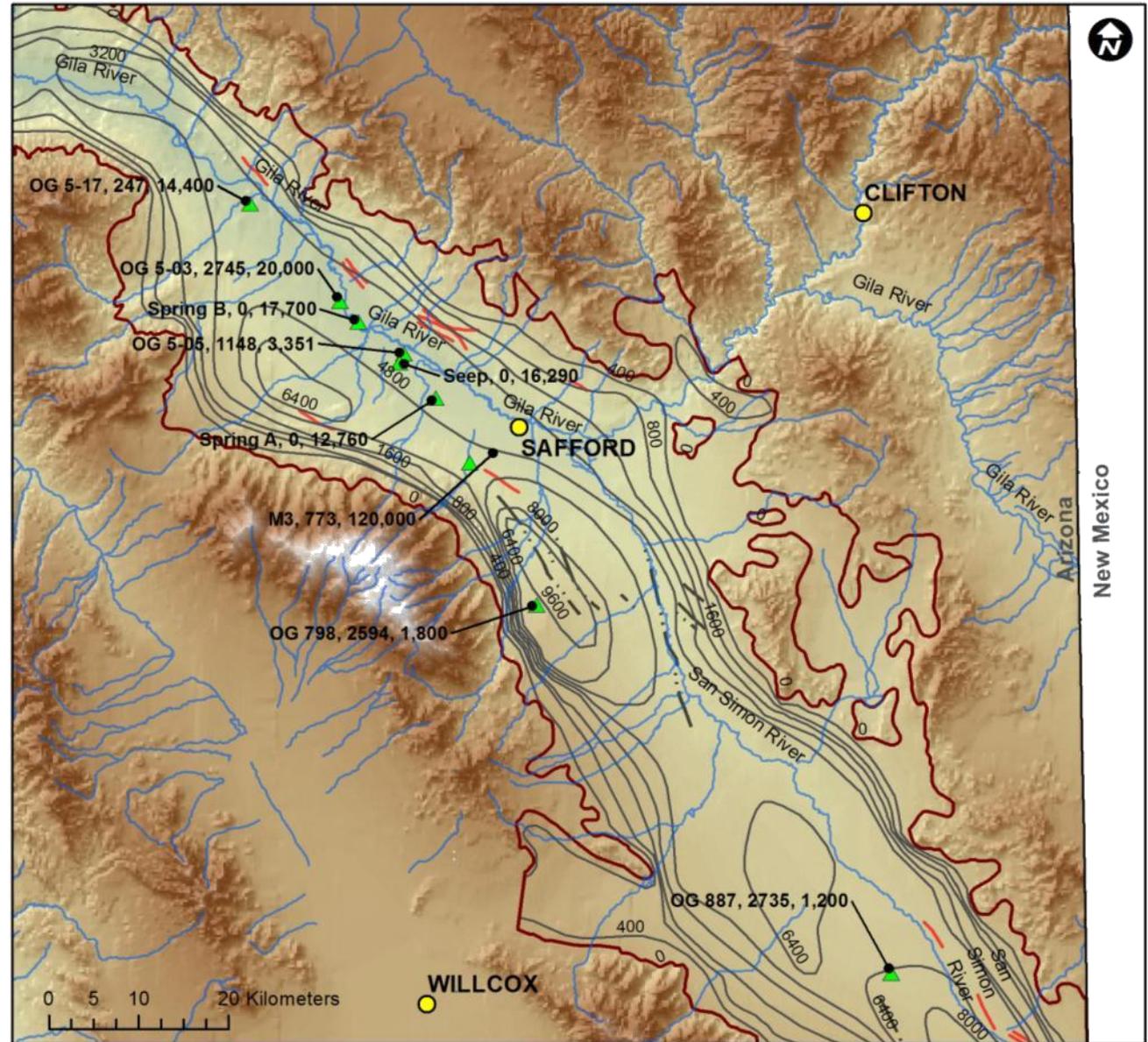
- Closed-basin in a half-graben, hinged-facies model
- Generally more deformation in the lower unit (folds, tilted bedding and faults)
- Fault activity present from late Miocene to late Pleistocene





# Salinity

- Limited to six wells and 3 springs
- Ranges from 300 to 120,000 ppm
- Only one well >800m depth at 14,000 ppm
- Confining and geothermal conditions
- No iso-salinity contours



# Conclusions

- Depth, storage and sealing conditions favorable for CO<sub>2</sub> storage are present in Arizona's Cenozoic sedimentary basins.
- Results of the Safford Basin evaluation:
  - 2,296 km<sup>3</sup> of sediments below 800m depth
  - Siliciclastics, evaporites and limestone present
  - Lower Basin Fill unit considered the target formation
  - Both lower and upper basin-fill units have sealing conditions present
  - Elevated saline conditions present, although lack of data precludes iso-salinity contours for further volume estimates

# Recommendations

- Cost-effective measures:
  - Acquire vintage seismic reflection data
  - Conduct salinity/conductivity profiles in existing deep wells
  - Conduct porosity/permeability tests on existing core
  - Showcase a GIS-interactive viewer of AZGS-WESTCARB data to facilitate awareness
- Conduct new seismic reflection work
- Drill additional exploration/characterization wells in the gravity-low areas where wells are absent

# Acknowledgments

- AZGS WESTCARB Team Jon Spencer, Steve Rauzi, Diane Love and Michael Mahan
- Elizabeth Keller (CEC)
- Arizona Department of Water Resources (ADWR)
- Arizona Department of Environmental Quality (ADEQ)

# Additional Slides

[westcarb.org](http://westcarb.org)



WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP

LM-04 CA-9



Salinity Point ID	UTMX	UTMY	Sample Date	Land Elevation (ft)	Well Depth (m)	Well Depth (ft)	Total Dissolved Solids (ppm)	Basin Fill Unit at Total Depth	Remarks
M3: Safford Golf Course well; Water Well #8 (Witcher, 1982, AZ-259)	614372	3629509	n/a	3,068	773 (5)	2,536	115,000 (3) to 120,000 (4)	UBF	Considerable salt encrustation from 1,465 to 1,780 feet depth bls. Chloride of 168,200 ppm recorded (4).
OG 5-05: Mary Mack Well	608061	3642477	11/30/1933	2,780	1,148	3,767	3,351 (1)	LBF (?)	
			10/30/1940				3,530 (2)	LBF (?)	
			10/27/1943				3,400 (2)	LBF (?)	
			5/8/1952				3,440 (3)	LBF (?)	
OG 5-17: R.S. Knowles well	590899	3659453	11/22/1933	2,769	247	810	14,035 (1)	UBF	
			4/24/1941				14,290 (2)	UBF	
			1/6/1944				14,400 (2)	UBF	
OG 5-03: Gila Oil Syndicate #1	600906	3648398	12/15/2000	2730	806	2,645	20,000 (6)	UBF	From depth interval between 630 to 1025 ft (6)
			12/15/2000				5,500 (6)	UBF	From depth of well, reported to be 2,400 feet depth (6)
OG 798: Phillips Petroleum A1 Safford State	622815	3614079	4/11/1982	3,562	2,594	8,509	600 to 1,800* (6)	UBF and (?) LBF	Chloride data not reliable of formation salinity
OG 887: Arzon Corporation No. 1 State	662242	3572465	7/28/1995	3,600	2,735	8,974	300 to 1,200* (6)	UBF and (?) LBF	Chloride data not reliable of formation salinity
Spring at Terrace Scarp	611564	3637447	12/1/1940	2,907	0	0	12,760 (2)	UBF and (?) LBF	From Hem (1950; sample no. 1592)
Unnamed spring (ADWR, 2009, Map Key 19)	603000	3646098	8/7/1943	2,740	0	0	17,700 (2)	UBF and (?) LBF	From Hem (1950; sample no. 1730). Location from ADWR (2009)
Seep from Terrace Gravel	607553	3641434	11/29/1940	2,845	0	0	16,290 (2)	UBF and (?) LBF	Location from Hem (1950; sample 2597) to the nearest 1/4, 1/4 of section 13, T6S, R24E

Table 2. Salinity data for wells and springs with depths greater than 800m-bls or salinity above 10,000 ppm for the Safford basin.

Notes: n/a = not available; UBF = Upper Basin Fill; LBF = Lower Basin Fill; \* = value represents chloride concentration; 1=Knechtel (1938); 2=Hem (1950); 3=Witcher (1982); 4=Rauzi (2002); 5=Conley et al. (2005); 6=Harris (2004).

# Core from 8,506 feet depth in OG well 798 (Tertiary conglomerate below the lower basin fill unit)

