

Rift Related Basalts in the Arbuckle Mountains of Oklahoma: A Deep Drilling Penetration into Rift Fill Volcanics*

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*Adapted from oral presentation at AAPG Mid-Continent Section meeting, Oklahoma City, Oklahoma, October 1-4, 2011. Please see closely related article, “Cambrian Early Rift-Fill Sediments in the Southern Oklahoma Aulacogen: A “Granite Wash” Analog in the Subsurface of the Arbuckle Mountains Area”, Search and Discovery article #30211.

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Abstract

Bimodal volcanism and interbedded volcanic and rift fill sedimentary rocks are characteristics of continental rifts. Although rhyolites are present, mafic volcanic rocks and rift fill sedimentary rocks are not exposed in the outcrops of the Southern Oklahoma Aulacogen. Drilling penetration of basalt has been limited to a maximum of 300 m in southwestern Oklahoma. Although basalt extrusion is thought to have been widespread, most of these rocks have apparently been removed by erosion or deeply buried by Paleozoic sedimentation and tectonics. This paper describes the geologic section encountered in a deep exploratory well in the Arbuckle area in south central Oklahoma that penetrated 4,800 m of over-thrust Cambrian igneous rocks, including 2,813 m of basalt and altered basalt. This section occurs in the hanging wall of the Washita Valley Fault, a Cambrian normal fault bounding the aulacogen which was re-activated as a regional thrust fault in Pennsylvanian time. Also present is a lower section of 1000 m of apparently interbedded rhyolite and rift fill sedimentary rocks.

Although alternative structural interpretations for the lower section must be considered, the lithologic evidence strongly favors a rift fill origin. The sedimentary rocks contain a total of 155 m of dolomite and lithic dolomitic conglomerate. The lithic clasts in the conglomerate were derived from 1.4 Ga Southern Granite Rhyolite Province granites exposed on the craton. Thirty four boreholes penetrate the overthrust along a 42 km band to the northwest along strike with regional faulting. Magnetic survey evidence indicates a significant basalt accumulation which is confirmed by sample examination of these wells. The presence of these basalt accumulations has important implications for seismic interpretation in structurally complex areas in southern Oklahoma.

References

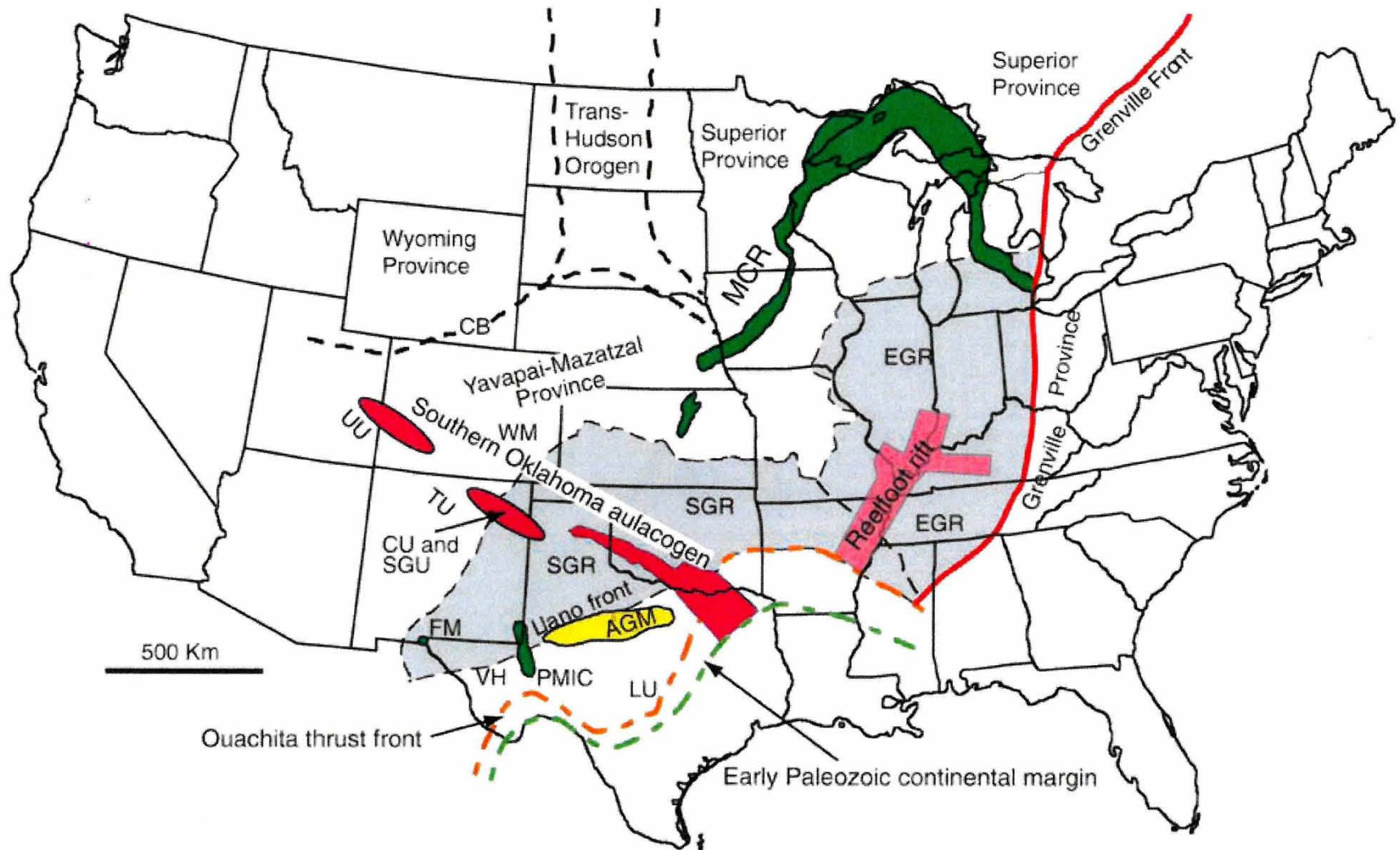
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Rift Related Basalts in the Arbuckle Mountains of Oklahoma

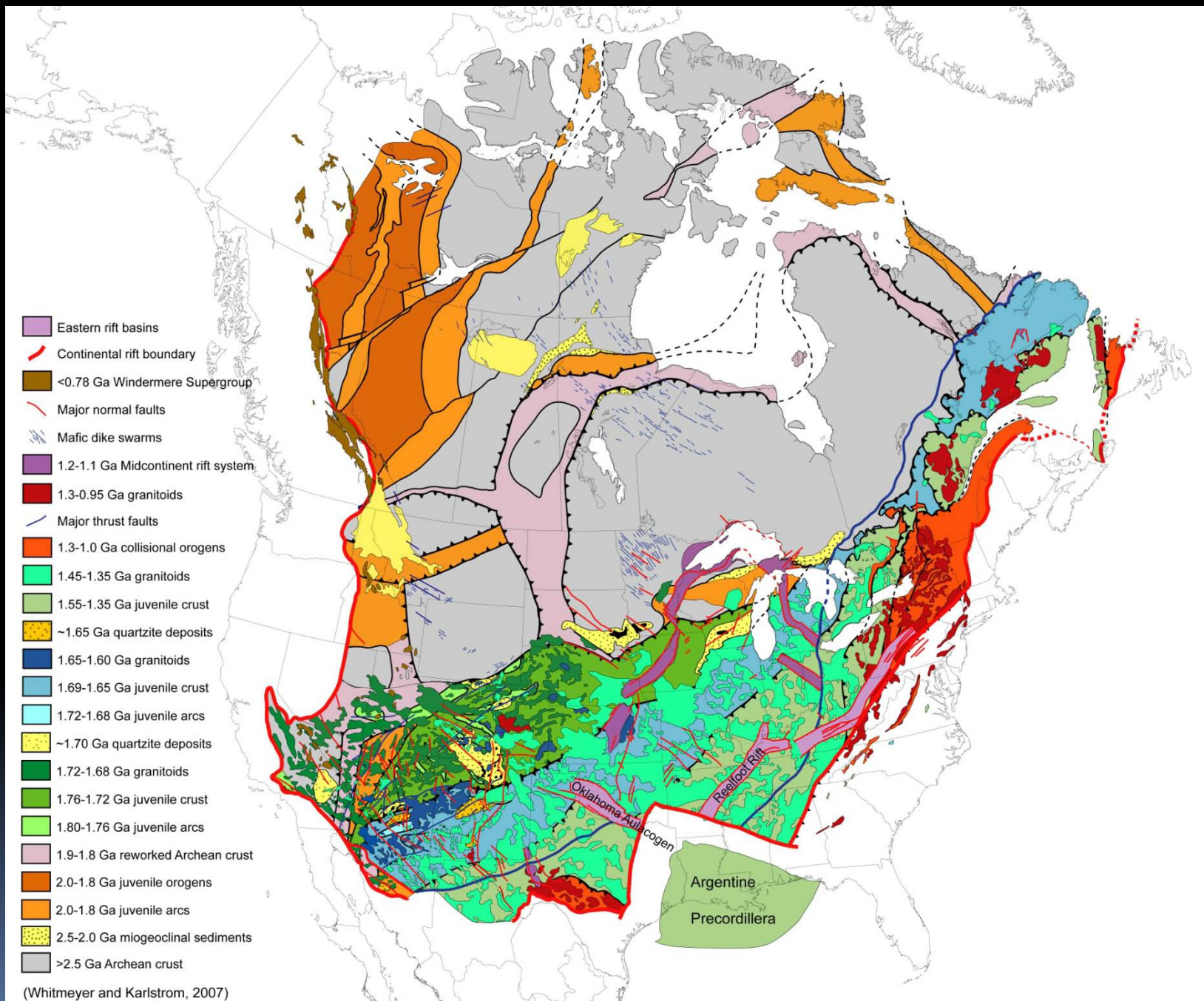
A deep drilling penetration into rift
fill volcanics

Bob Puckett, Oklahoma City

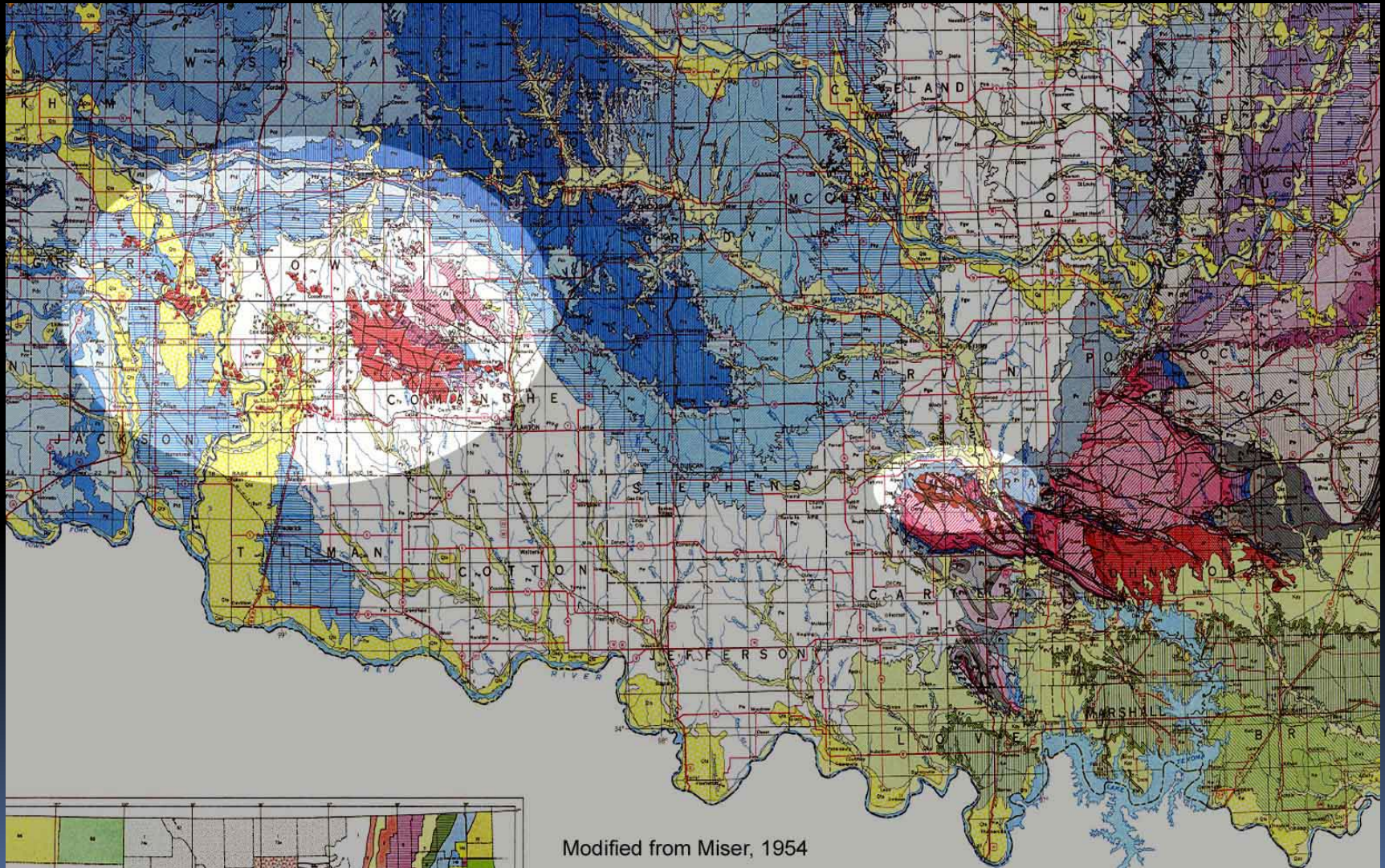
Southern Oklahoma Aulacogen



From Keller and Stephnson, 2007

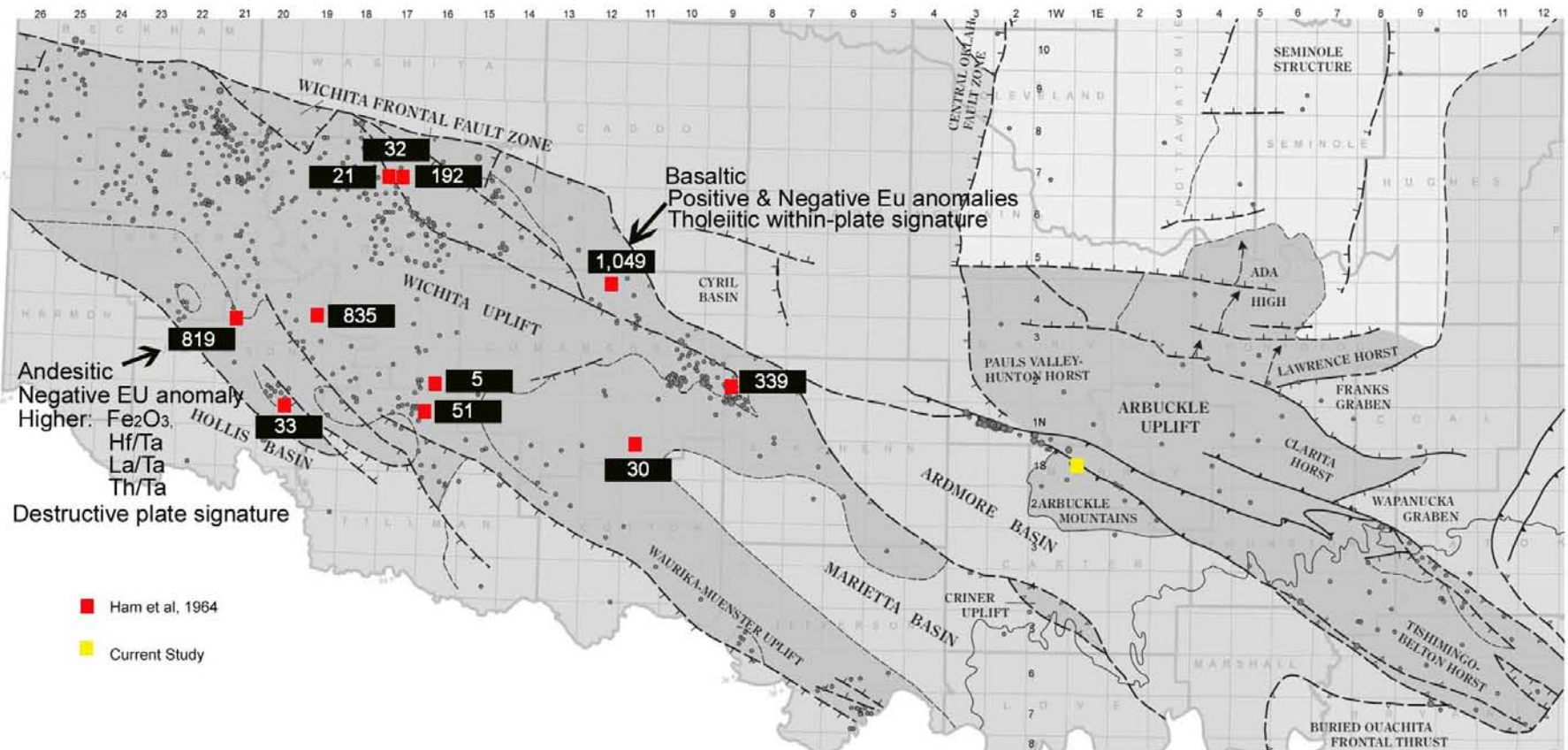


Cambrian Igneous Rock Outcrops – Southern Oklahoma



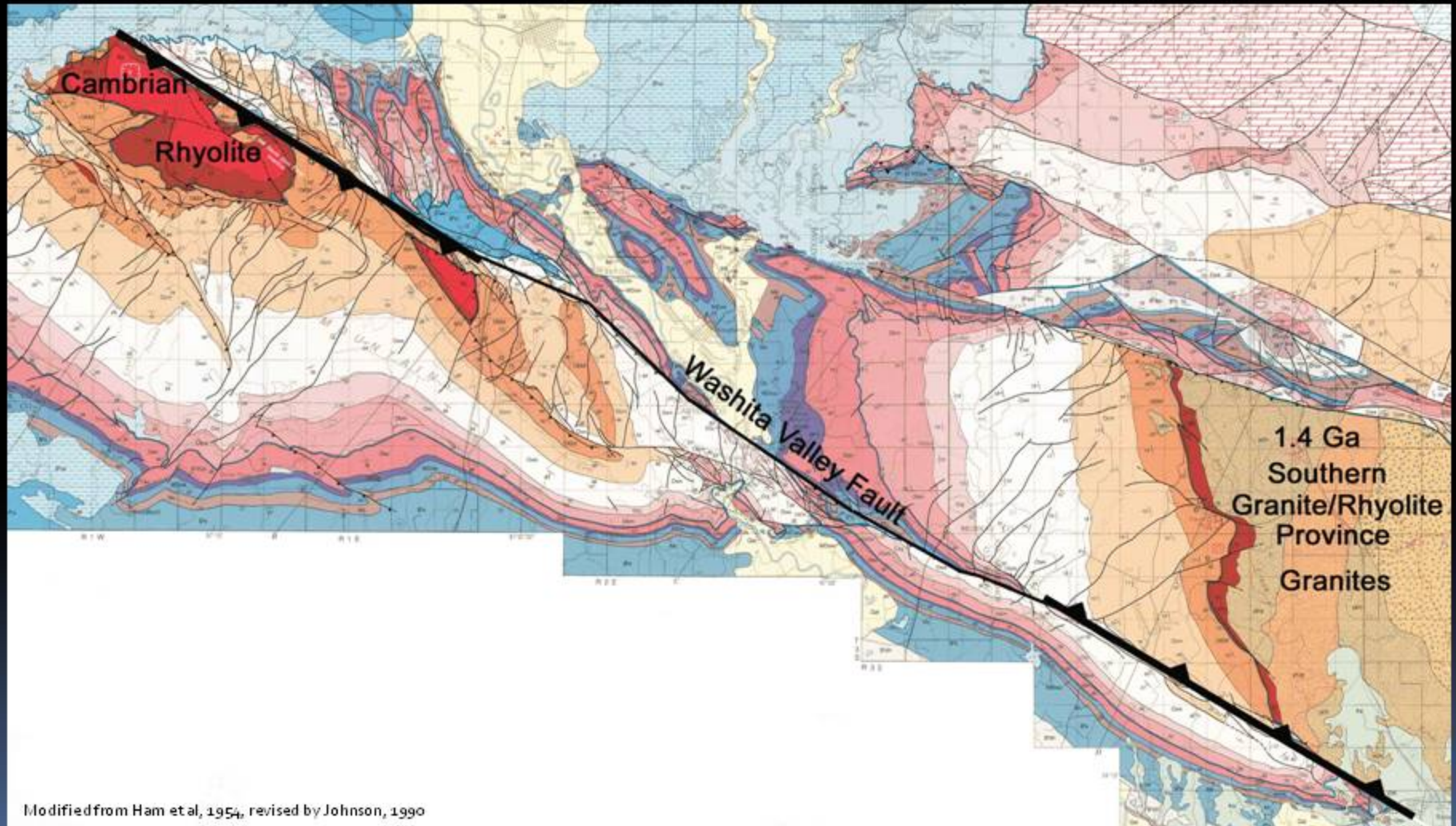
Documented Basalt Penetrations – Southern Oklahoma

Basement Penetrations - Southern Oklahoma

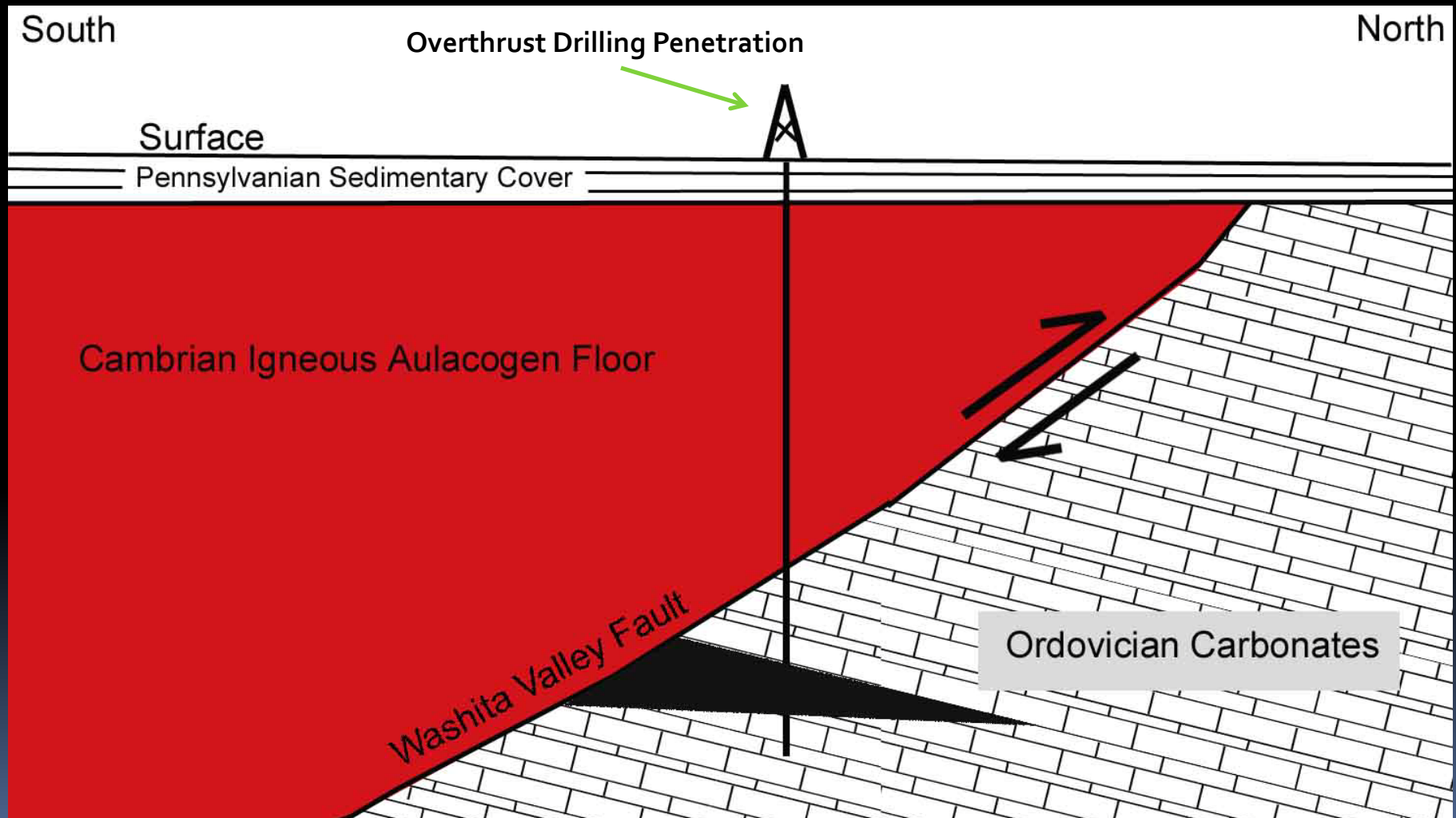


Modified from Campbell and Weber, 2006
Geochemical data from Aquilar, 1988

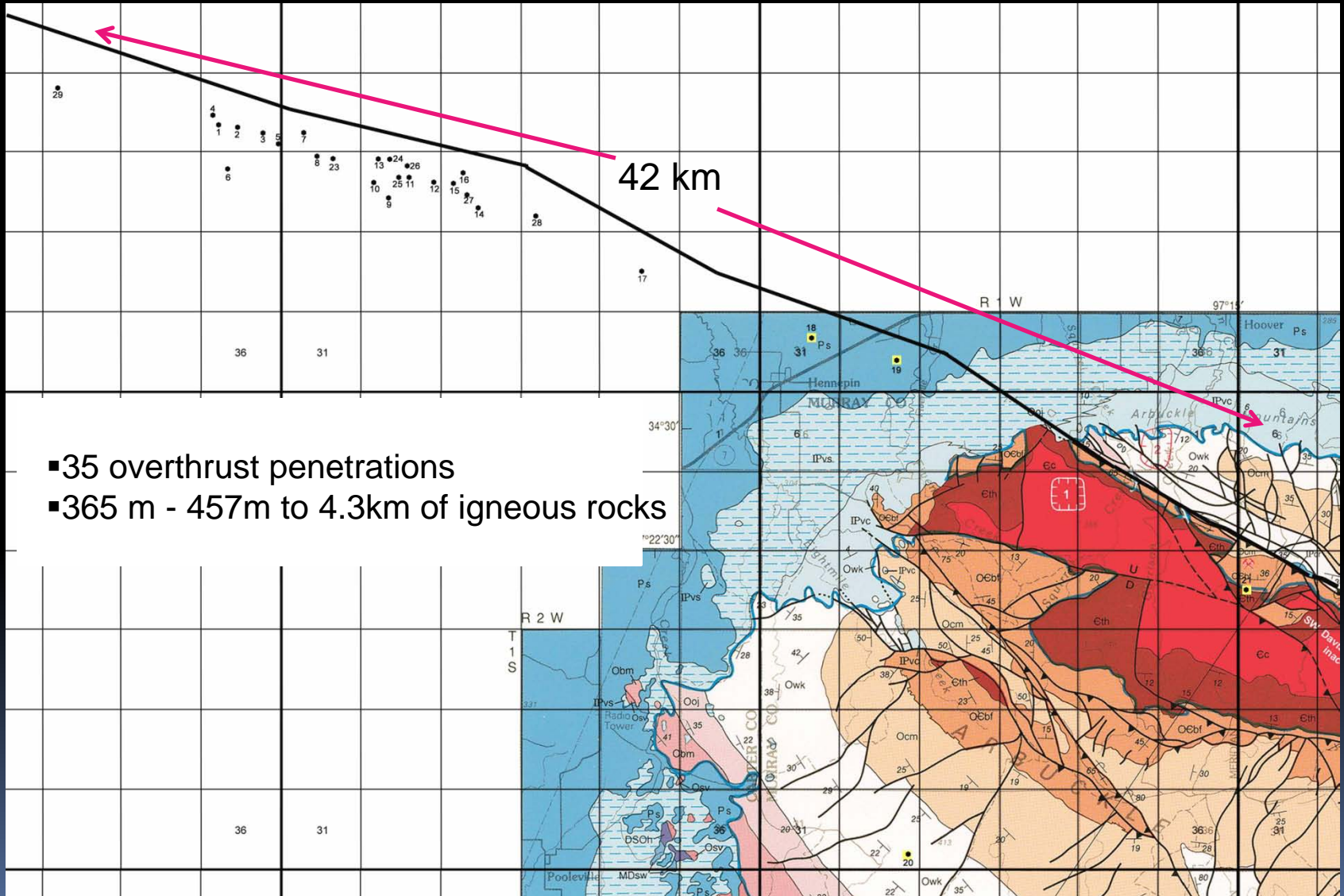
The Washita Valley Fault in the Arbuckle Mountains Area



Overthrust Penetration Wells Schematic Cross Section



Overthrust Penetrations – Western Arbuckles



[illegible]

Modified from Johnson, 1990

Stratigraphic Section

Hamilton Brothers
1-18 Turner Falls

Rhyolite

Drilled Thickness 2,130 ft./ 650 m

Corrected Thickness 1,704 ft./ 520 m

Granite & Microgranite

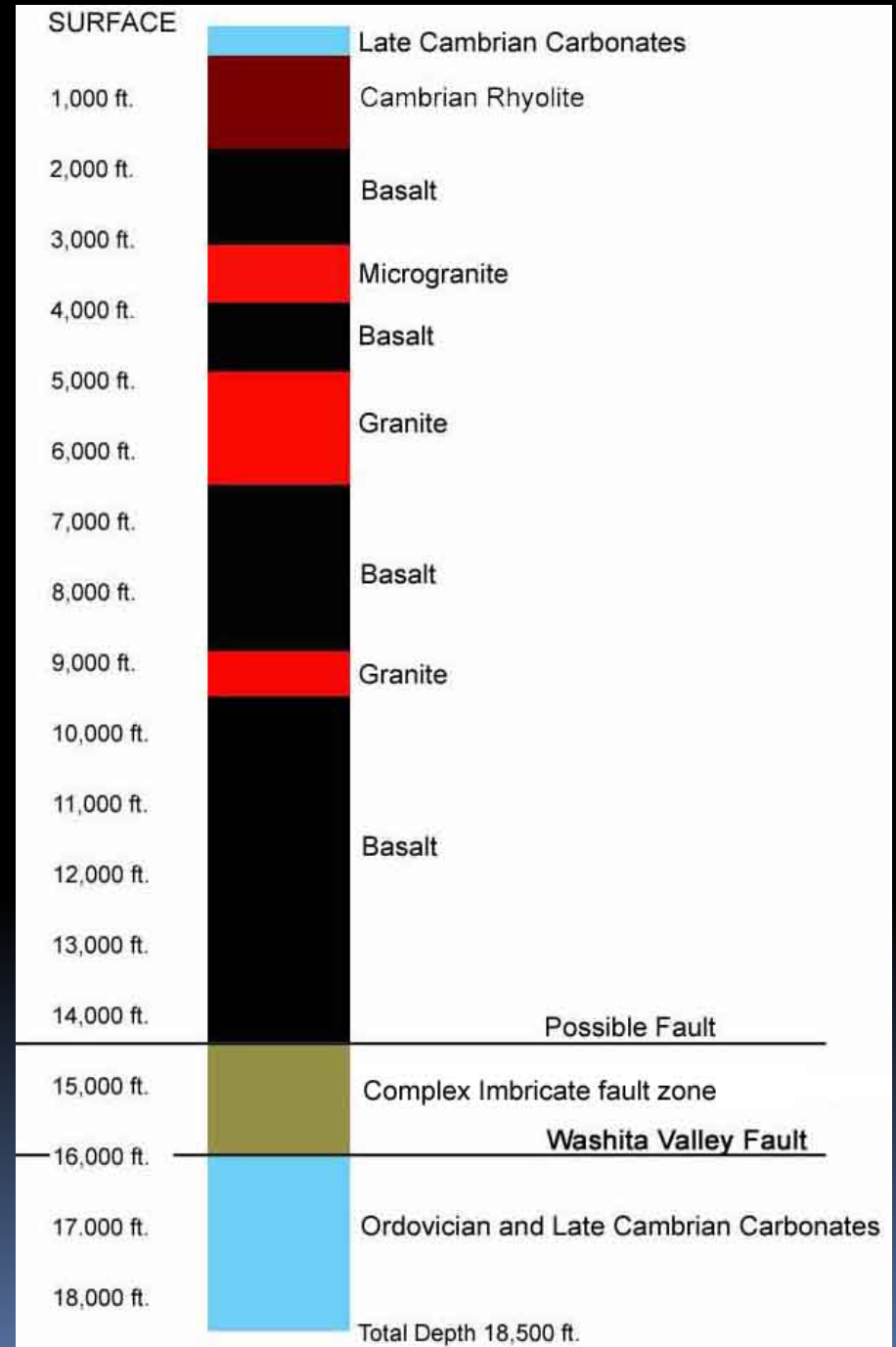
Drilled Thickness 3,630 ft./ 1,106 m

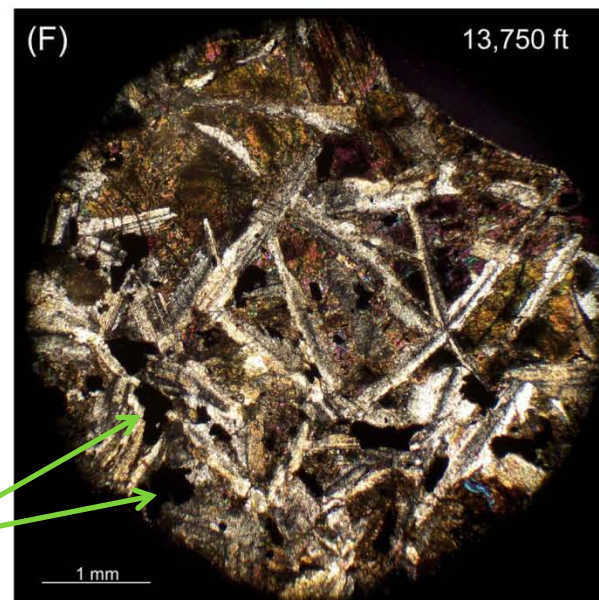
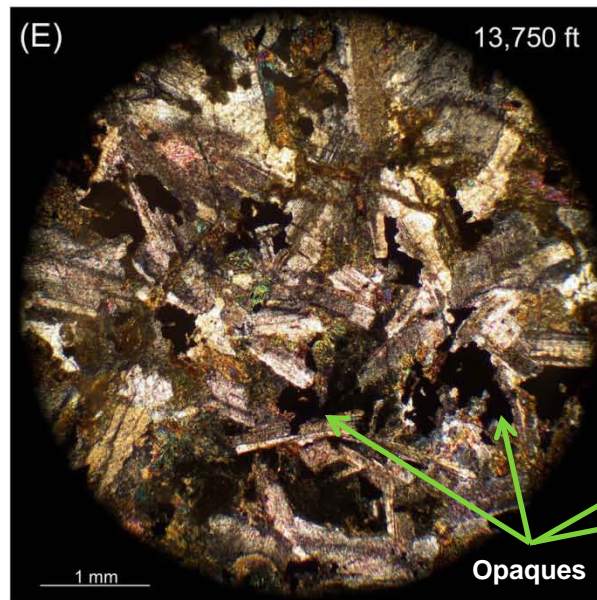
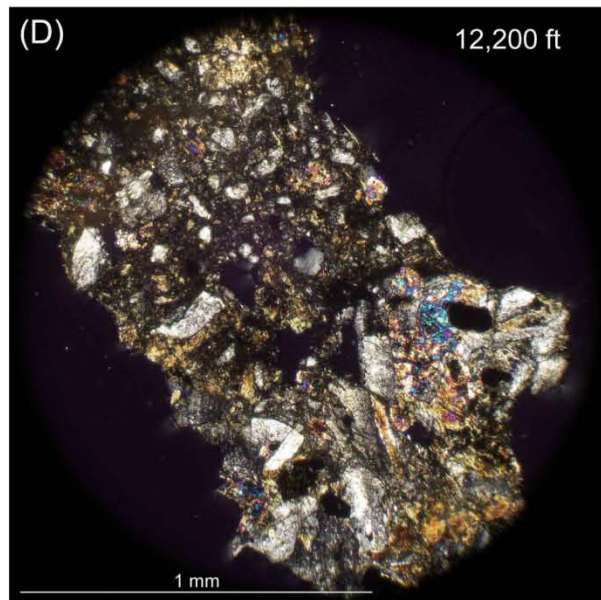
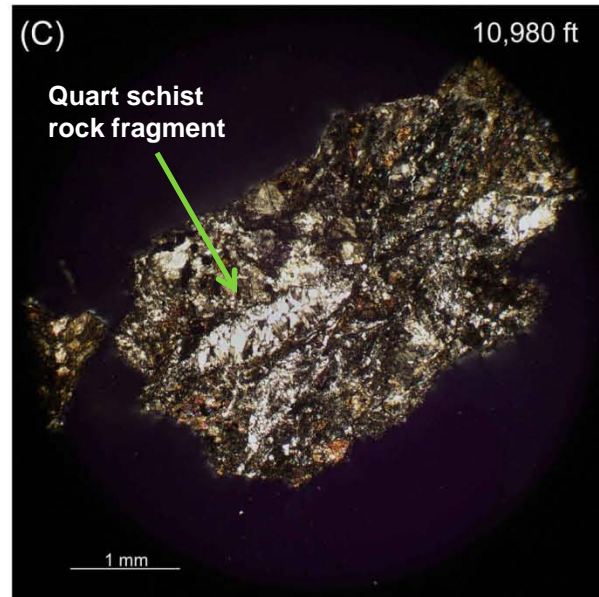
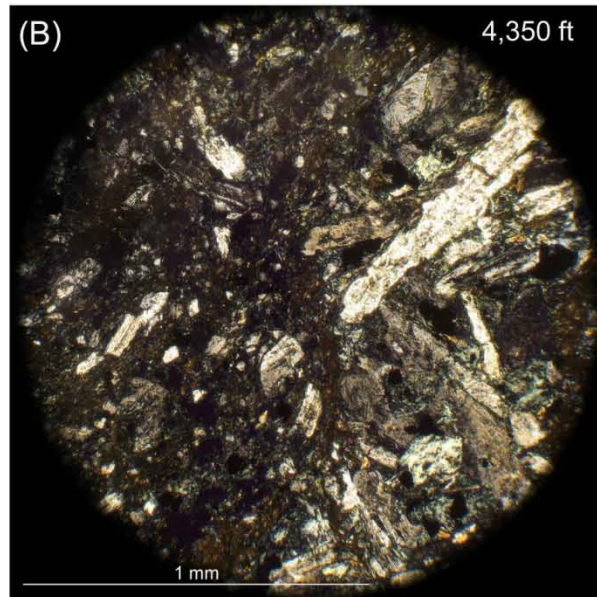
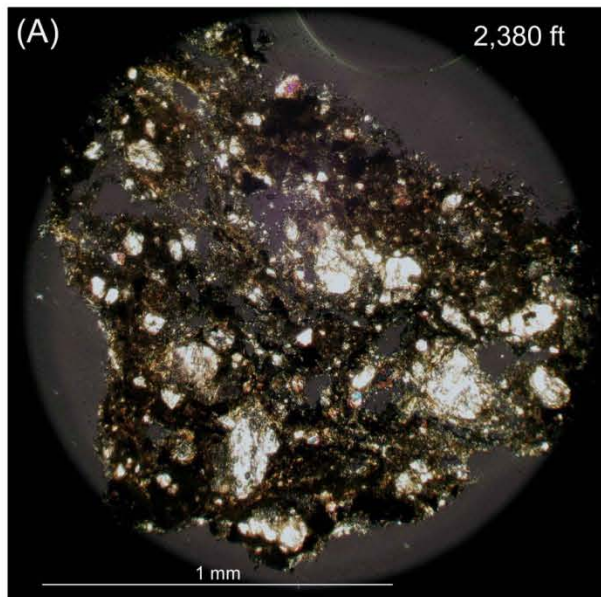
Corrected Thickness 2,904 ft./ 885 m

Basalt

Drilled Thickness 9,230 ft./ 2,814 m

Corrected Thickness 7,384 ft./ 2,251 m



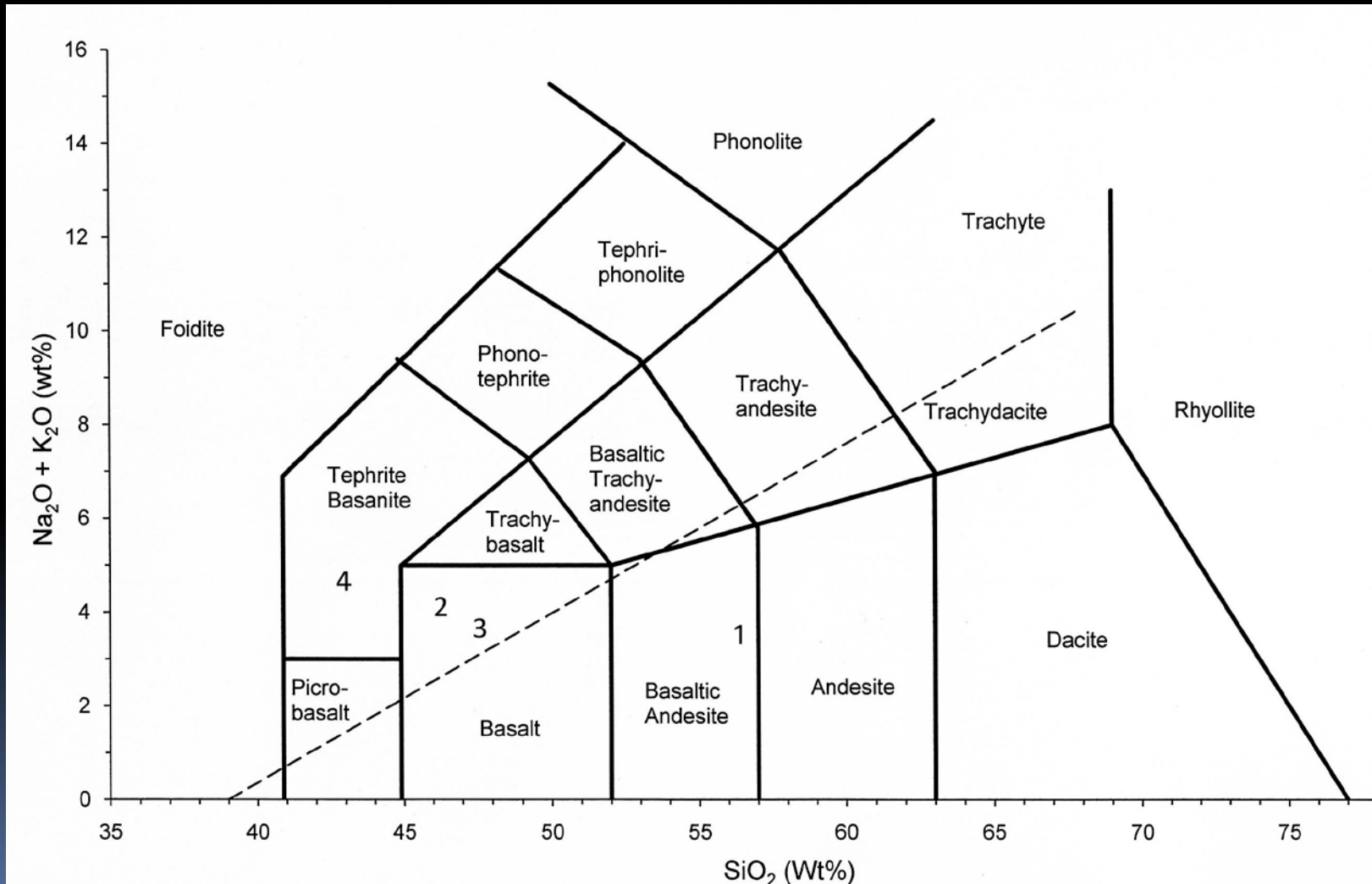


Opagues

Major Oxide Analysis of Southern Oklahoma Basalts

Source	Ham et al	Ham et al	Puckett	Puckett	Puckett	Gray, 1989
Location	9-3N-21W	24-2N-9W	18-1S-1W	18-1S-1W	18-1S-1W	10-1S-1W
Depth (Ft.)	3,260	10,136	13,750	13,750	13,750	83
TAS data point	1	2	3	3	3	4
SiO ₂	56.42	46.27	47.40	47.54	47.71	42.89
Al ₂ O ₃	17.17	18.28	14.52	14.34	14.36	13.32
Fe ₂ O ₃ (T)	4.81	11.42	12.44	12.64	12.34	14.94
MnO	n.d.	n.d.	0.19	0.20	0.19	0.15
MgO	7.94	4.73	6.89	7.10	6.90	4.64
CaO	5.68	6.21	8.91	9.81	9.04	4.85
Na ₂ O	2.14	3.98	2.72	2.75	2.68	3.68
K ₂ O	1.50	0.07	1.06	1.13	1.14	1.18
TiO ₂	0.73	3.72	2.00	2.13	2.06	3.4
P ₂ O ₅	n.d.	n.d.	0.41	0.42	0.42	0.53
Cr ₂ O ₃			0.06	0.05	0.05	
LOI			2.86	3.05	2.91	

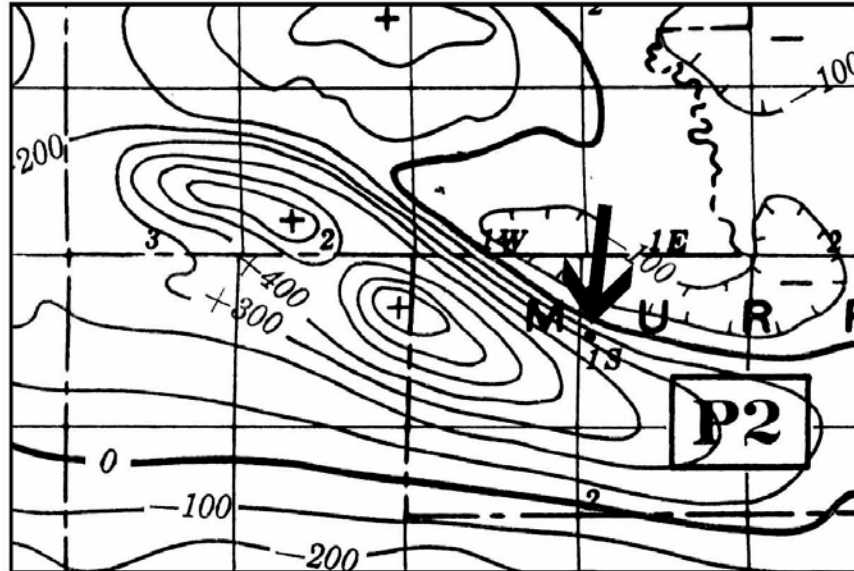
Total Alkalis vs. Silica Plot – IUGS Classification



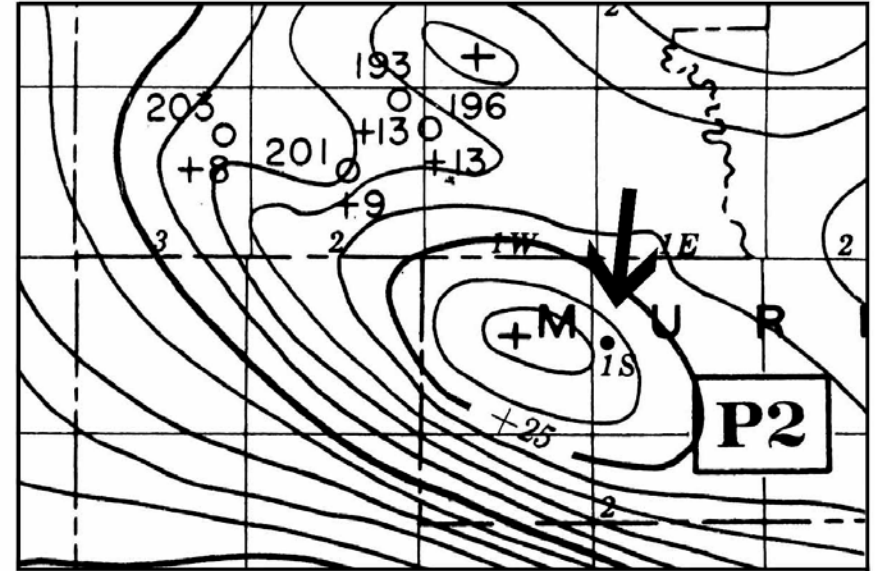
Basalt Normative Mineralogy

Mineral	Weight % Norm	Volume % Norm
Quartz	2.80%	3.20%
Plagioclase	48.15%	54.21%
Orthoclase	6.86%	8.11%
Diopside	8.72%	8.20%
Hypersthene	14.19%	13.38%
Ilmenite	0.45%	0.29%
Hematite	13.03%	7.51%
Apatite	1.00%	0.94%
Sphene	4.82%	4.17%

These volumes of mafic rocks imply a volcanic field of considerable extent.

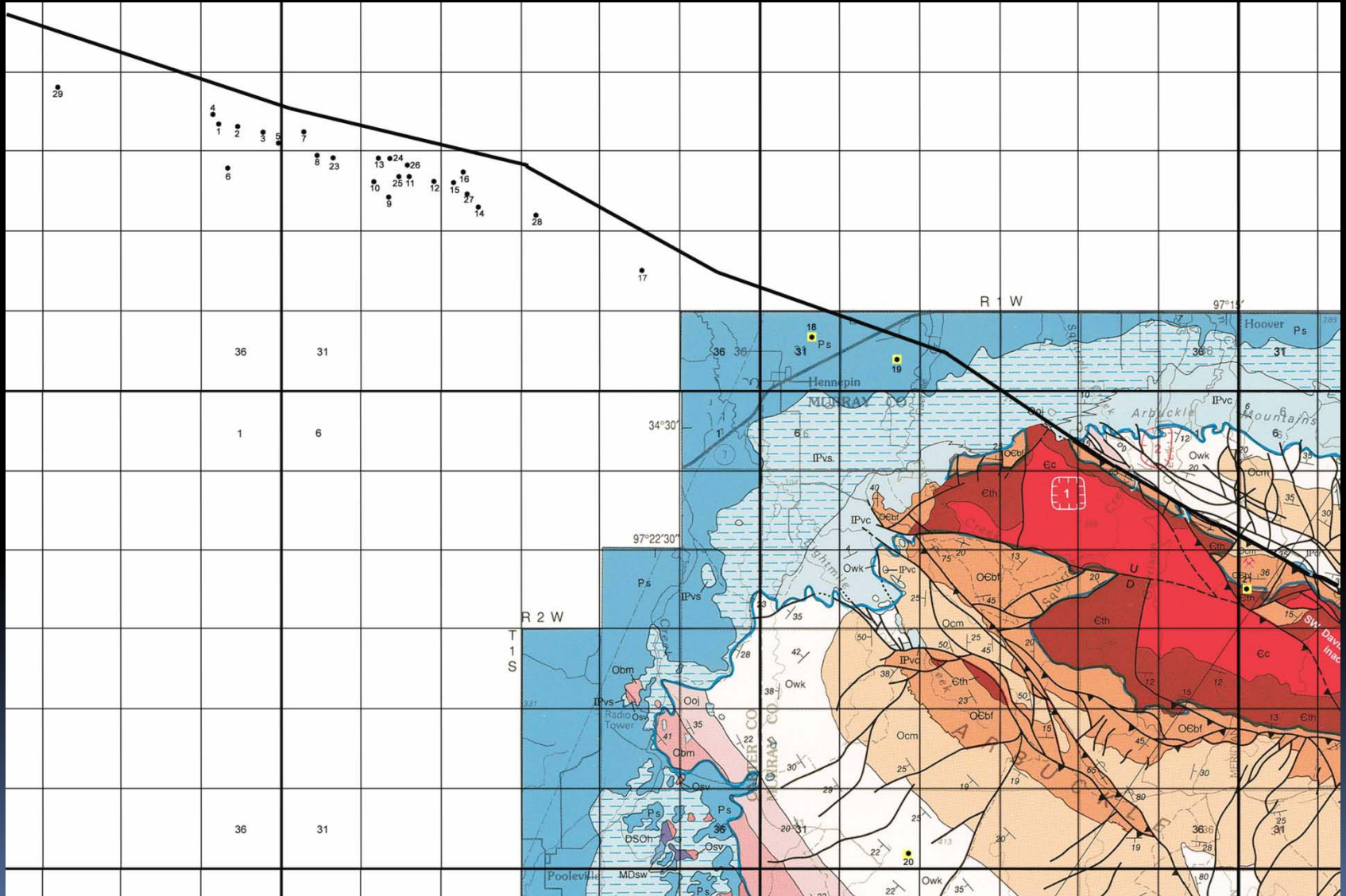


A. Vertical Intensity Magnetic Map



B. Bouguer Gravity Anomaly Map

Overthrust Penetrations – Western Arbuckles



Stratigraphic Section

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1-18 Turner Falls

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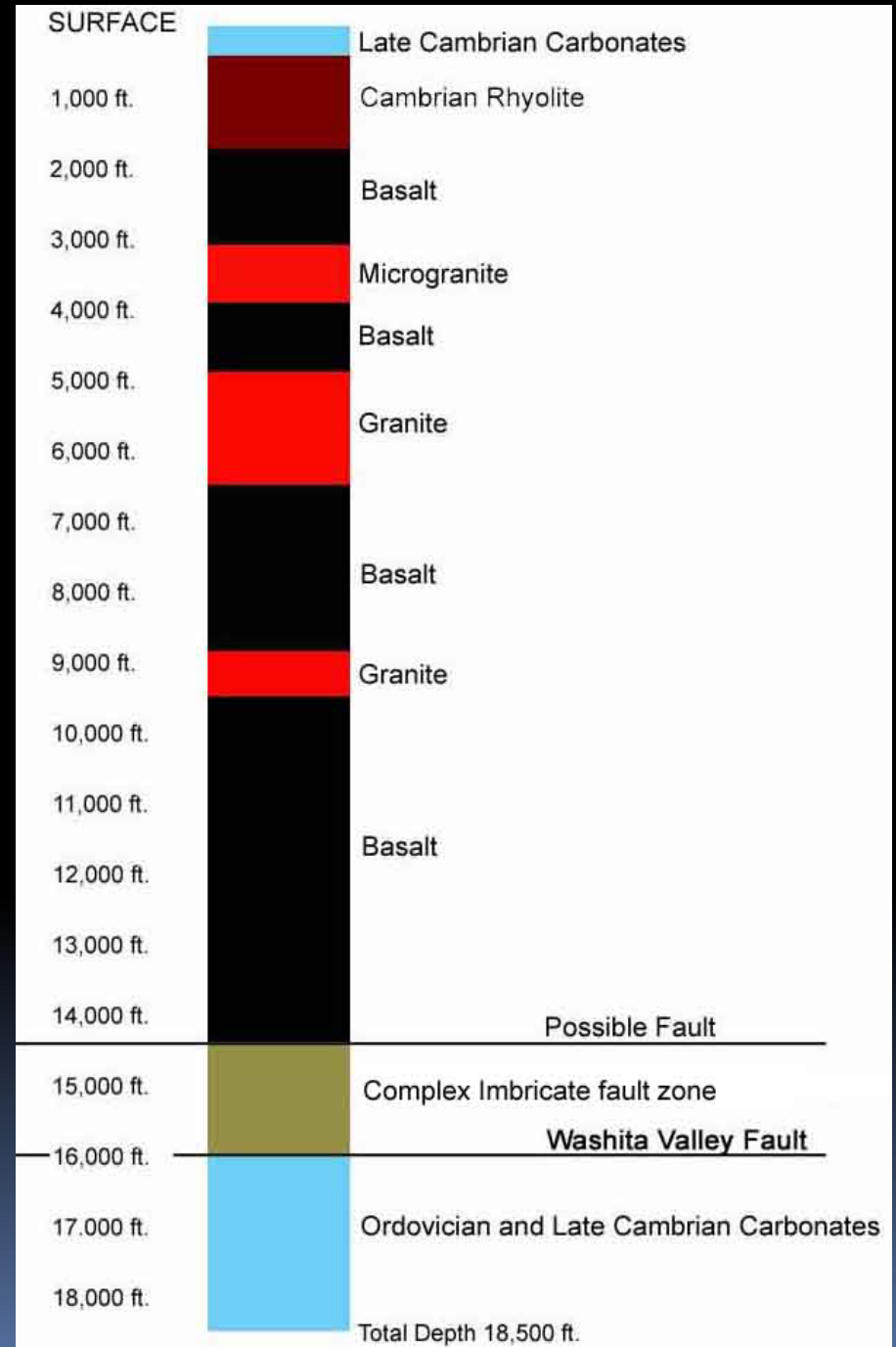
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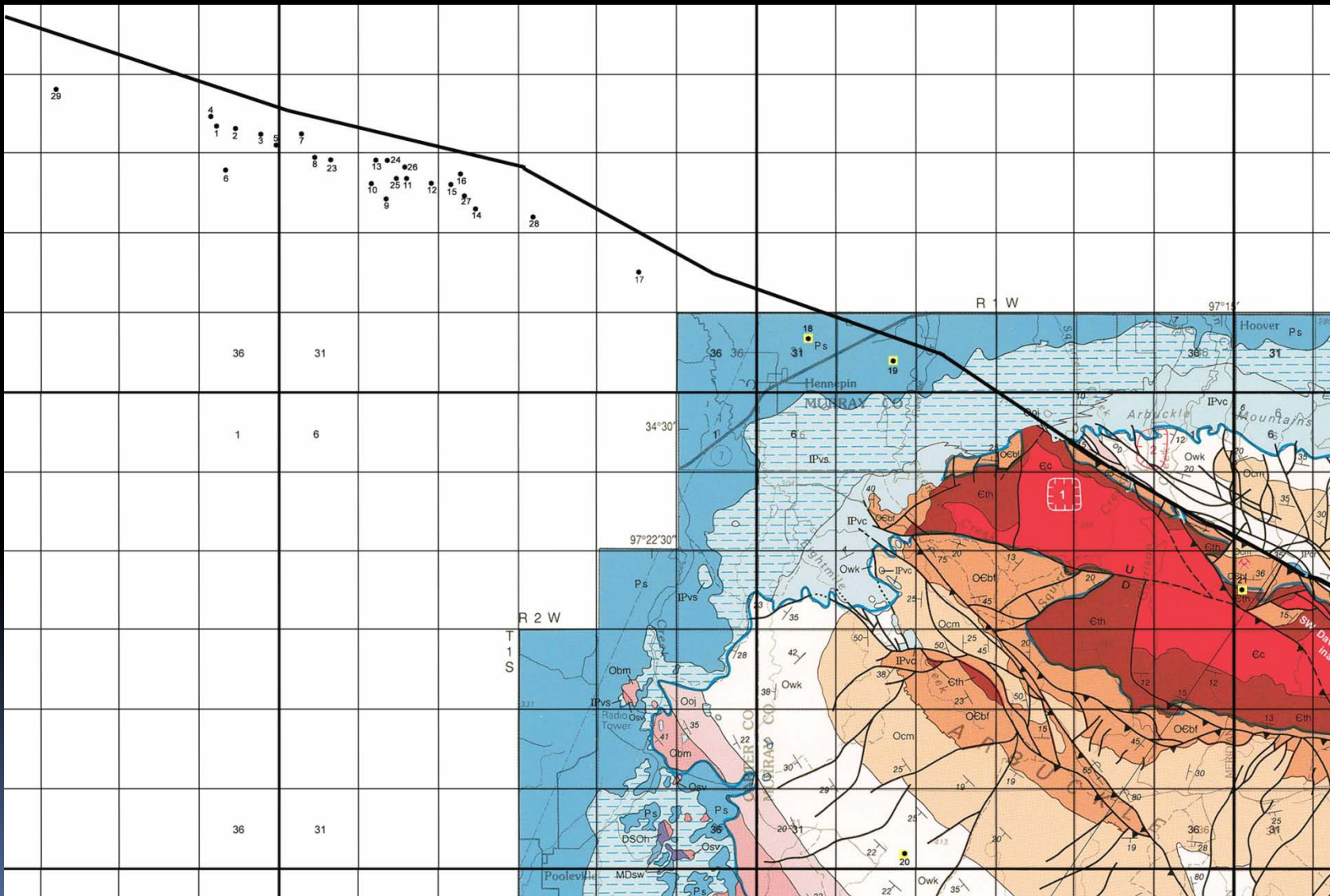
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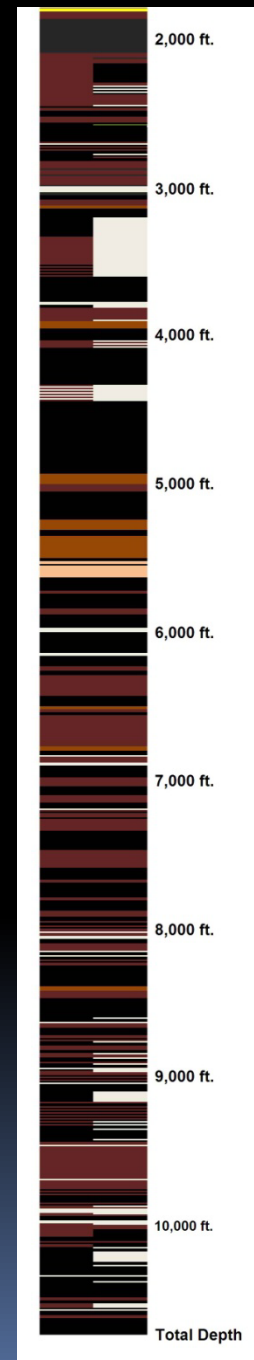
Overthrust Penetrations – Western Arbuckles



8,931 ft. of Complexly Intercalated Rhyolite, Basalt, & Pyroclastic deposits

Pan American Oil Company
Newberry #1

NW NE NW Sec 24-T1N-R3W
Drilled 1970
Total Depth 10,741 ft.



Summary

- Voluminous silicic volcanics are present in southern Oklahoma – the Carlton Rhyolite Group – estimated original volume of 40,000 km³.
- A thick sequence of rift related mafic volcanism is present in the subsurface and may involve a considerable areal extent and volume.

Questions

1. Age and Stratigraphic Relationships – How do we resolve the varying Rhyolite/Basalt stratigraphy within this volcanic field and how does this area relate to western Oklahoma?
2. Do the basalts indicate the presence of a large intrusive mafic body in the lower crust that will affect seismic studies?

Current Research

- Continued examination of drill cuttings in the overthrust igneous section
- Dr. Richard Hanson – TCU – Geochemistry of subsurface rhyolites, directing a Masters Thesis doing detailed mapping and geochemistry of rhyolite outcrops in the Arbuckles.
- Dr. Matt Brueseke – Kansas State – Directing a Masters Thesis doing geochemistry and dating of subsurface basalts and surface/subsurface diabase dikes