

# The Southern Oklahoma Aulacogen: It's a classic

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## INTRODUCTION

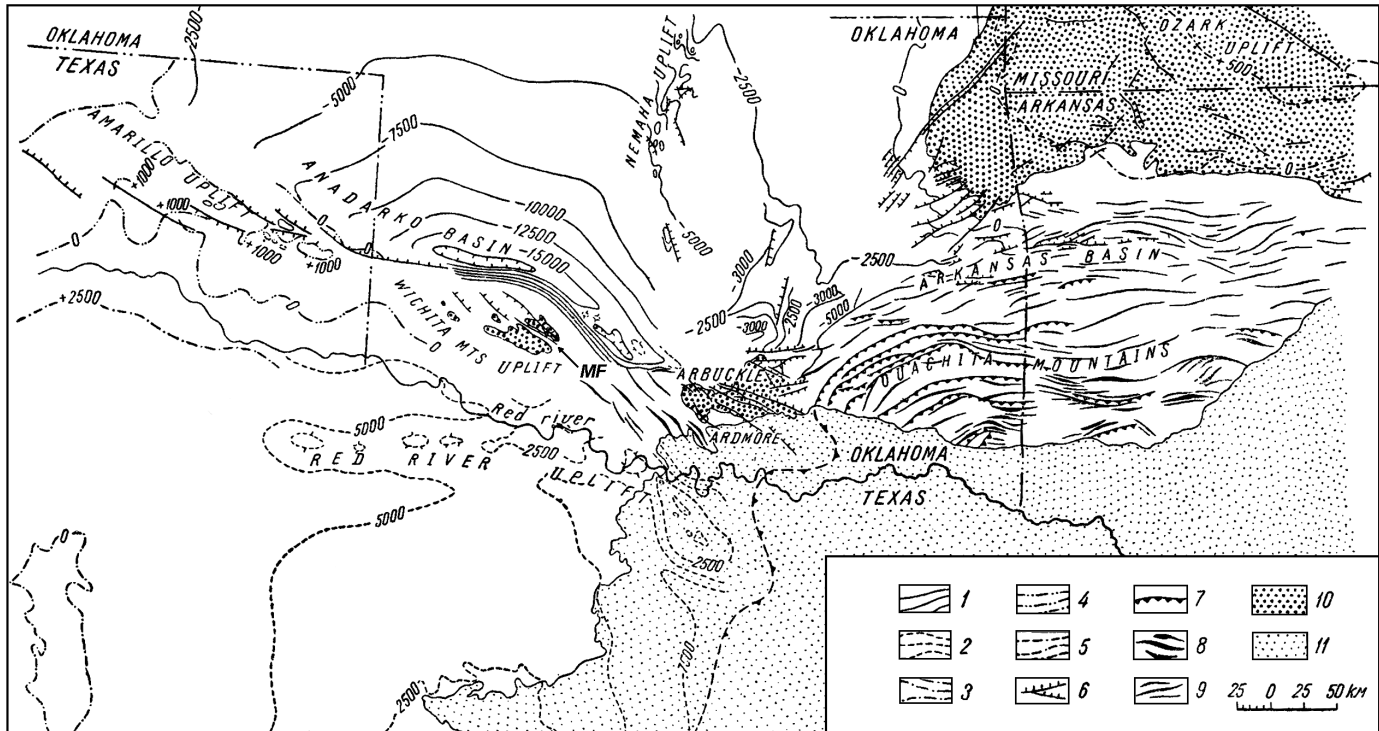
Southern Oklahoma has long been recognized as the home to a series of very large and complex intraplate structures that are exposed in the Wichita and Arbuckle Mountains. These features are the result of early Paleozoic extension and late Paleozoic compression. Strike-slip movements probably played a role both phases of deformation. Today, the resulting features are together referred to as the Southern Oklahoma Aulacogen (SOA). This classic feature was recognized as a major intraplate structure by the famous Russian geologist Nikolay S. Shatsky (also spelled Nicholas Shatski). The Shatsky Rise in the north Pacific was named after him, and he was awarded the Lenin Prize in 1958 for his compilation of the first tectonic map of Russia. In 1946, he published a paper comparing the tectonic history of southern Oklahoma with the Dniepr-Donets Basin region of the Ukraine. His impressive index map from this paper is shown in Figure 1.

In terms of continental tectonics, rifts that do not succeed in breaking a continent apart are often referred to as having “failed.” The classic failed rift or aulacogen is one that intersects a rifted continental margin at a high angle as part of a triple junction (e.g., Burke and Dewey, 1973; Hoffman et al., 1974). Failed rifts usually are the sites of post-rift subsidence and sedimentation that provide important records of continental evolution and usually contain petroleum resources. In the case of the Southern Oklahoma Aulacogen, one would think that the main magmatic modification of the crust would be centered under the post-rift basin. However, this does not appear to be the case given the extensive magmatic modification of the upper crust observed by the UTEP/UTD seismic experiment integrated with seismic and drilling data (e.g., Keller and Stephenson, 2007; Buckey, 2012; also this guidebook). This poses just one of several questions about the structure and evolution of the SOA. Another is the relative role of thrusting versus strike-slip faulting during the late Paleozoic inversion; this has been the subject of considerable debate because there are many northwest-striking faults that have a significant left-lateral, strike-slip component of movement (e.g., Mc-

Connell, 1989; Granath, 1989). In some places, oblique slip involves approximately equal amounts of strike-slip and dip-slip movement (Granath, 1989). Thomas (this guidebook) also stresses the importance of strike-slip in the in the initial Cambrian phase of tectonism.

However, the SOA is widely viewed as a classic example of an aulacogen and consists of a linear alignment of structures that have been extensively inverted and that begins at the rifted margin of Laurentia (ancient core of North America) in northeast Texas and extends northwestward at least to southern Colorado (Fig. 1). The main structures commonly associated with the SOA are the Amarillo-Wichita Uplift and the Anadarko Basin. Because of extensive petroleum exploration, the late Paleozoic history of this part of the SOA is well known and summarized by Ham et al. (1964) and Ham and Wilson (1967). However, many other significant structures are involved, and the aulacogen has been interpreted to extend as far to the northwest as the Paradox Basin and Uncompahgre Uplift in Utah (Larson et al., 1985).

The large late Paleozoic faults and the large upper crustal load represented by the Cambrian mafic intrusions in the Wichita Uplift show that it should be no surprise for the region to have experienced significant Holocene movement along faults in the aulacogen (Crone and Luza, 1990). In fact, the Meers Fault is the southernmost element of the complex and massive (10-15 km of throw) frontal fault zone that forms the boundary between the Anadarko Basin and the uplifted igneous rocks of the Wichita Mountains (Fig. 1). The Meers Fault is the best-exposed and -documented Quaternary fault scarp east of Colorado (e.g., Crone and Luza, 1990). The most recent movement occurred in the late Holocene (1100-1300 yr ago) with an earlier movement 2,000-2,900 yr ago. During faulting, the Quaternary soils along the fault were folded as well as ruptured, and the scarp has dammed small gullies where fine-grained alluvium has collected that has been used in dating efforts (Crone and Luza, 1990). There is as much as 5 m vertical and possibly appreciably more left-lateral strike slip displacement on the fault. Motion on the Meers Fault represents continued activity on one of the largest structural features in North America.



**Figure 1. Index map of tectonic features in the southern Mid-Continent region. Modified from Shatski (1946). MF – Meers Fault. 1 – Top of Mississippian; 2 – Base of Mississippian; 3 – Top of Permian; 4 – Top of Panhandle Big Lime; 5 – Top of Cambrian; 6 – Normal fault; 7 – Thrust fault; 8 – Strongly folded anticline; 9 – Broad anticline; 10 – Pre-Pennsylvanian outcrop in Ozark Dome; 11 – Mesozoic cover.**

In summary, we are left with a picture of the southeastern part of the SOA in which pervasive magmatic modification of the upper crust occurred in the Cambrian; cooling and subsidence followed that was in turn followed by a huge (up to 15 km) amount of structural inversion in the late Paleozoic. The scale of this magmatism and deformation is impressive. The result is the 15-km-deep Anadarko Basin that is floored by igneous and basement rocks that crop out in adjacent uplifts. To the northwest in New Mexico and Colorado, Mesozoic and Cenozoic tectonism has obscured SOA structures, but evidence for substantial Cambrian mafic magmatism and late Paleozoic structural uplifts across northeastern New Mexico is strong. In Colorado, the Wet Mountains appear to be cored by Cambrian mafic rocks (Pardo, 2009). Together, the evidence documents the presence of a major intracratonic structure that is ~1500 km long and has experienced very recent tectonic reactivation.

#### REFERENCES CITED

- Buckey, A., 2012, An integrated geophysical analysis of crustal structure in the Wichita Uplift region of southern Oklahoma: *Shale Shaker*, v. 62, p. 432-452.
- Burke, K., and Dewey, J.F., 1973, Plume-generated triple junctions: Key indicators in applying plate tectonics to old rocks: *Journal of Geology*, v. 81, p. 406-433.
- Crone, A.J., and Luza, K.V., 1990, Style and timing of Holocene surface faulting on the Meers Fault, southwestern Oklahoma: *Geological Society of America Bulletin*, v. 102, p. 1-17.
- Granath, J.W., 1989, Structural evolution of the Ardmore Basin, Oklahoma: Progressive deformation in the foreland of the Ouachita collision: *Tectonics*, v. 8, p. 1015-1036.
- Ham, W.E., Denison, R.E., and Merritt, C.A., 1964, Basement Rocks and Structural Evolution of Southern Oklahoma: *Oklahoma Geological Survey Bulletin* 95, 302p.
- Ham, W.E., and Wilson, J.L., 1967, Paleozoic epeirogeny and orogeny in the central United States: *American Journal of Science*, v. 265, p. 332-407.
- Hoffman, P., Dewey, J.F., and Burke, K., 1974, Aulacogens and their genetic relations to geosynclines, with a Proterozoic example from Great Slave Lake, Canada, in Dott, R. J., Jr., and Shaver, R. H., eds., *Modern and Ancient Geosynclinal Sedimentation*: Society of

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- Economic Paleontologists and Mineralogists Special Publication 19, p. 38-55.
- Keller, G.R., and Stephenson, R.A., 2007, The Southern Oklahoma and Dniepr-Donets Aulacogens: A comparative analysis, *in* Hatcher, R. D., Jr., Carlson, M. P., McBride, J.H., and Martínez Catalán, J.R., eds., *The 4D Framework of Continental Crust: Geological Society of America Memoir 200*, p. 127-143.
- Larson, E.E., Patterson, P.E., Curtis, G., Drake, R., Mutschler, F.E., 1985, Petrologic, paleomagnetic, and structural evidence of a Paleozoic rift system in Oklahoma, New Mexico, Colorado, and Utah: *Geological Society of America Bulletin*, v. 96, p. 1364-1372.
- McConnell, D.A., 1989, Determination of offset across the northern margin of the Wichita Uplift, southwest Oklahoma: *Geological Society of America Bulletin*, v. 101, p. 1317-1332.
- Pardo, J., 2009, An integrated geophysical study of the Wet Mountains, Colorado [M.S. thesis]: Norman, Oklahoma, University of Oklahoma, 86p.
- Shatski, N.S., 1946, The great Donets Basin and the Wichita system; comparative tectonics of ancient platforms: *Akademiya Nauk SSSR Izvestiya, Seriya Geologicheskaya*, v. 6, p. 57-90.