Arkoma Basin PowerPoint References

(Note: All Oklahoma Geological Survey references are online and available for free download at http://www.ogs.ou.edu/pubs.php)

1. Title Slide – Arkoma Basin Petroleum – Past, Present, and Future. By Neil H. Suneson for OCGS and OGS Geology Workshop, March 7, 2012

2. Acknowledgements

3. Thrust belts and foreland basins of NA. Coleman, J.L., Jr., 2008, Petroleum systems of the Ouachita thrust belt and foreland basins (with emphasis on the Arkoma Basin): Oklahoma Geological Survey Circular 112B, p. 2.

4. Mid-continent tectonic features. From USGS presentation. Black Warrior – Arkoma – Fort Worth – Kerr Basins. Petroleum producing.

5. Features/characteristics of a foreland basin.

6. Different kinds of foreland basins – idealized cross section. AB is peripheral.

7. Plate tectonic model for Ouachita subduction zone – model for Arkoma Basin. (reversed to match previous and next slides) Wickham, J., Roeder, D., and Briggs, G., Plate tectonics models for the Ouachita foldbelts: Geology, v. 4, p. 173-176.

8. Foreland basin system. Many people equate foreland basin w/ foredeep. DeCelles, P.G., and Giles, K.A., 1996, Foreland basin systems: Basin Research, v. 8, p. 105-123.

9. Same slide, but says similar stratigraphic setting of Ouachita turbidites and Arkoma Basin middle-Atokan strata.

10. Geologic provinces of OK. Therefore, my interest "classic Arkoma Basin" and Ouachitas. Northcutt, R.A., and Campbell, J.A., 1995, Geologic provinces of Oklahoma: Oklahoma Geological Survey Open-File Reports OF5-95, scale 1:750,000. Also available at http://www.ogs.ou.edu/geolmapping/Geologic_Provinces_OF5-95.pdf

11. Gas (and oil) fields of Arkoma Basin and Ouachita Mtns. Boyd, D.T., 2002, Oklahoma oil and gas fields (distinguished by GOR and conventional vs. coalbed methane): Oklahoma Geological Survey Map GM-36. Also available at http://www.ogs.ou.edu/fossilfuels/MAPS/GM-36.pdf

12. How to define “classic” Arkoma Basin? Major structural elements - Mulberry Fault, Desmoinesian hinge line, edge of Seminole Uplift, Choctaw Fault. (same base map as above)

13. Or presence of broad, open folds. Branan, C.B., Jr., 1968, Natural gas in Arkoma Basin of Oklahoma and Arkansas: AAPG Memoir 9, v. 2, p. 1616 – 1635.

14. Not all the folds have the same origin - compressional vs. drape. Arbenz, J.K., 2008, Structural framework of the Ouachita Mountains, in Suneson, N.H., ed., Stratigraphic and structural evolution of the Ouachita Mountains and Arkoma Basin, southeastern Oklahoma and west-central Arkansas: applications to petroleum exploration: 2004 field symposium. The Arbenz – Misch/Oles volume: Oklahoma Geological Survey Circular 112A, p. 1-40.

15. Ideal compressional structure – Washburn Anticline. http://www.ogs.ou.edu/MEETINGS/Presentations/USGS%20Arkoma%20Nov%2009/USGS3_ShelfBasin.pdf. Ref: Bartlett, C.S., Jr., 1968, Washburn Anticline gas fields, Arkansas: AAPG Memoir 9, p. 1658-1667.

16. Northern boundary based on hinge line. Thickening of unit, descent into basin. Boyd, D.T., 2005, The Booch gas play in southeastern Oklahoma: regional and field-specific petroleum geological analysis: Oklahoma Geological Survey Special Publication 2005-1, p. 16.

17. Another cross-section showing thickening, descent. Visher, G.S., Saitta, S.B., and Phares, R.S., 1971, Pennsylvanian delta patterns and petroleum occurrences in eastern Oklahoma: AAPG Bulletin, v. 55, p. 1210-1211.

18. Map view of hinge line (isopach of McAlester Fm). Busch, D.A., 1974, Deltas, in Stratigraphic traps in sandstones – exploration techniques: AAPG Memoir 21, p. 128.

19. Arkoma Basin reservoir names. http://www.ogs.ou.edu/fossilfuels/pdf/StratChartfr.pdf

20. Reservoirs – northern part of Arkoma Basin. Most are fluvial-dominated deltaic. Andrews, R.A., 1997, Fluvial-dominated deltaic (FDD) oil reservoirs in Oklahoma: the Red Fork play: Oklahoma Geological Survey Special Publication 97-1, p. 16.

21. Log character of really good FDD reservoir – channel fill. Suneson, N.H., 1998, Geology of the Hartshorne Formation, Arkoma Basin, Oklahoma: Oklahoma Geological Survey Guidebook 31, p. 51

22. Photograph of Hartshorne channel outcrop.

23. Reservoirs – southern part of Arkoma Basin. Suneson, N.H., and Hemish, L.A., 1994, Geology and resources of the eastern Ouachita Mountains frontal belt and southeastern Arkoma Basin, Oklahoma: Oklahoma Geological Survey Guidebook 29, p. 51. http://www.ogs.ou.edu/pubsscanned/guidebooks/GB_29.pdf

24. Production map showing commingled production from multiple reservoirs in same well – Panola Field. How many of these were discovered by accident vs. good geology? Andrews, R.D., 2008, Panola field – multiple Atoka sandstone gas reservoirs in T. 5 N., RS. 19-20 E., Latimer County, Oklahoma: Oklahoma Geological Survey Circular 112B, p. 31 – 50.

25. Log of deep-water reservoirs, Panola Field. Key to further exploration – restore thrust plates to original position, then look at facies of individual reservoir sandstones. Same ref as above.

26. Log of Spiro – Wapanucka w/ sub-Spiro shale (Morr-Atokan boundary). Suneson, N.H., et al., 2005,Stratigraphic and structural evolution of the Ouachita Mountains and Arkoma Basin, southeastern Oklahoma and west-central Arkansas: applications to petroleum exploration: Oklahoma Geological Survey Guidebook 34, p. 103.

27. Ouachita orogenic belt completions – stratigraphic units.

28. Ouachita oil and gas fields. Base Map: Boyd, D.T., 2002, Oklahoma oil and gas fields (distinguished by GOR and conventional vs. coalbed methane): Oklahoma Geological Survey Map GM-36. Also available at http://www.ogs.ou.edu/fossilfuels/MAPS/GM-36.pdf

29. Ouachita reservoirs/fields. Same base map as above.

30. Channel sandstone, Jackfork Group, McKinley Rocks. Not all turbidites are created equal – need for facies analysis after subtracting structure.

31. **History of H/C Exploration and Development in AB and OMs. Seven "periods."**

32. **"Solids are Good, Pre-1910 Early History"**

33. Historical photos of asphaltite pits and mines. Hutchinson, L.L., 1911, Preliminary report on the rock asphalt, asphaltite, petroleum and natural gas in Oklahoma: Oklahoma Geological Survey Bulletin No. 2, p. 83.

34. More historical photos. Same reference as above.

35. **“Anticlines are Good (1910-1935)”**

36. Location map of early Poteau-Gilmore Field. Smith, C.D., 1912, Structure of the Fort Smith – Poteau gas field, Arkansas and Oklahoma: U.S. Geological Survey Bulletin 541, pt. 2, p. 23-33.

37. Early announcement of Poteau Field discovery from 1910 Oil and Gas Journal.

38. 1915 USGS map of OK oil and gas fields. From OSU online map library – McCaslind collection.

39. 1916 USGS map – Poteau and Red Oak Fields appear (Red Oak discovered in 1912). OSU online map library – McCaslind collection.

40. Old cable tool rig abandoned at Redden Field (discovered in 1914).

41. Old oil well at Redden Field. Do not forget the Stanley!!!

42. Map of Arkoma Basin anticlines. Branan, C.B., Jr., 1968, Natural gas in Arkoma Basin of Oklahoma and Arkansas: AAPG Memoir 9, v. 2, p. 1616 – 1635.

43. “Classic” Arkoma Basin anticline w/ steep north limb. Drawn on relatively shallow Hartshorne, unfaulted. (Note Cavanal Syncline totally bogus.) Six, D.A., 1968, Red Oak – Norris gas field, Brazil Anticline, Latimer and LeFlore Counties, Oklahoma: AAPG Memoir 9, v. 2, p. 1644-1657.

44. Better, deeper data – Arkoma Basin anticlines typically thrust-cored. Same reference as above.

45. More data – anticlines, faults complex. Same reference as above.

46. Early cross-section through Arkoma Basin and Ouachitas. Not bad, but some fundamental flaws – like no attempt to balance. Six, D.A., 1968, Red Oak – Norris gas field, Brazil Anticline, Latimer and LeFlore Counties, Oklahoma: AAPG Memoir 9, v. 2, p. 1644-1657.

47. **“Geologic Maps Are Good Period (1935 – 1950)”**
Period of geological mapping by USGS, focused on coal resources. Hendricks, especially, added to knowledge of structural geology of Ouachitas.

48. Geological map of Ouachitas. Much mapping by USGS, also as theses and dissertations. Ref: OGS Hydrologic Atlas 3 (Ardmore-Sherman sheet), 9 (McAlester-Texarkana sheet).

49. **"Deeper Drilling is Good Period (1950 – 1980)"**
Also period of new sed-strat concepts, especially paper by Busch on deltas and Cline on turbidites.

50. Booch deltas. Busch, D.A., 1971, Genetic units in delta prospecting: AAPG Bulletin, v. 55, p. 1137-1154.

51. Most of principal reservoirs in northern part of Arkoma Basin are FDDs. But note – some (e.g., Booch) have significant tidal influence. Andrews, R.A., 1997, Fluvial-dominated deltaic (FDD) oil reservoirs in Oklahoma: the Red Fork play: Oklahoma Geological Survey Special Publication 97-1, p. 16.

52. Early Atokan paleogeographic map. Note that advancing thrust front (wedge top of slide 6) is high enough to funnel turbidite fans, but not high enough to contribute sediments – entirely subaqueous. Unpub. guidebook prepared for Amoco by MASERA.

53. Principal reservoirs in southern part of Arkoma Basin and thrust-faulted part of northern Ouachita Mtns. Mostly middle Atokan reservoirs. Ref: Suneson, N.H., and Hemish, L.A., 1994, Geology and resources of the eastern Ouachita Mountains frontal belt and southeastern Arkoma Basin, Oklahoma: Oklahoma Geological Survey Guidebook 29, p. 51.
http://www.ogs.ou.edu/pubsscanned/guidebooks/GB_29.pdf

54. Oil in frac'd chert – Isom Springs Field. Talk given by Jim Coleman, USGS. http://www.ogs.ou.edu/MEETINGS/Presentations/USGS%20Arkoma%20Nov%2009/USGS4_OuachitasReel.pdf.

55. Morrison abstract (from 1980 AAPG) re: oil production from fractured cherts. AAPG Bulletin, v. 64, no. 5, p. 754.

56. **"Thrust Plates Are Good Period (1980 – 1990)"**

57. Modern concepts of transition zone – triangle zones, duplex structures. http://www.ogs.ou.edu/MEETINGS/Presentations/USGS%20Arkoma%20Nov%2009/USGS2_Regi_Set.pdf. Ref: Arbenz, J.K., 2008, Structural framework of the Ouachita Mountains, in Suneson, N.H., ed., Stratigraphic and structural evolution of the Ouachita Mountains and Arkoma Basin, southeastern Oklahoma and west-central Arkansas: applications to petroleum exploration: 2004 field symposium. The Arbenz – Misch/Oles volume: Oklahoma Geological Survey Circular 112A, p. 1-40

58. Modern concepts applied on more local level. Duplex structures. From Cemen, I., Sagnak, A., and Akthar, S., 2001, Geometry of the triangle zone and duplex

structure in the Wilburton Gas Field area of the Arkoma Basin, southeastern Oklahoma: Oklahoma Geological Survey Circular 104, p. 87-98.

59. Same slide, but with Woodford highlighted. How far does Woodford extend beneath thrust sheets, both as potential reservoir and source? Same reference as above.

60. Photo of Woodford at Bengal, albeit in allochthonous stratigraphic and structural position.

61. Also began to understand growth faulting in Arkoma Basin, especially once able to remove effect of thrust faulting. Middle Atokan growth faulting at advancing edge of foreland basin. http://www.ogs.ou.edu/MEETINGS/Presentations/USGS%20Arkoma%20Nov%2009/USGS3_ShelfBasin.pdf. Houseknecht, D.W., 1986, Evolution from passive margin to foreland basin: the Atoka Formation of the Arkoma Basin, south-central USA, *in* Allen, P.A.; and Homewood, P., eds., Foreland basins: International Association of Sedimentologists Special Publication 8, p. 327-345. Also McGilvery, T.A., and Houseknecht, D.W., 2000, Depositional systems and diagenesis of slope and basin facies, Atoka Formation, Arkoma Basin, *in* Johnson, K.S., ed., Marine clastics in the southern Midcontinent, 1997 symposium: Oklahoma Geological Survey Circular 90, p. 129-140.

62. Cross section of growth faults – both basement-involved and listric. Roberts, M.T., 1994, Geologic relations along a regional cross section from Spavinaw to Broken Bow, eastern Oklahoma: Oklahoma Geological Survey Guidebook 29, p. 137-160.

63. And once able to account for thrust faults and growth faults (schematic cross section of growth faults) were able to develop a clearer understanding of some of facies relationships observed (e.g., Red Oak sand). http://www.ogs.ou.edu/MEETINGS/Presentations/USGS%20Arkoma%20Nov%2009/USGS3_ShelfBasin.pdf. ).

64. Facies model of Red Oak sand deposition. Same reference as 2 above.

65. With the recognition of different facies, could begin to put together paleogeographic models of this foreland basin system. One thing to like about this model – very little contribution into foreland basin from S (orogenic front). Most coming in from east. http://www.ogs.ou.edu/MEETINGS/Presentations/USGS%20Arkoma%20Nov%2009/USGS2_Regi_Set.pdf. Houseknecht, D.W., and Kacena, J.A., 1983, Tectonic and sedimentary evolution of the Arkoma foreland basin, in Houseknecht, D.W., eds., Tectonic-sedimentary evolution of the Arkoma Basin: Society of Economic Paleontologists and Sedimentologists Midcontinent Section, v. 1, p. 3-33.

66. One of best, early paleogeographic models (i.e., pre-Blakey) from Sutherland. Note –even in late Morrowan, orogenic front had not arrived in Oklahoma. Only some southern sourcing. Sutherland, P.K., 1988, Late Mississippian and Pennsylvanian depositional history in the Arkoma Basin area, Oklahoma and Arkansas: Geological Society of America Bulletin, v. 100, p. 1787-1802.

67. Continued. Finally ……. Uplift of Ouachitas. (Slightly too late based on recent work in Arkoma Basin by Newman.) Same reference as above.

68. Wilburton Deep discovered. Discovery wells all close by. Ref: Suneson, N.H., and others, 2005, Stratigraphic and structural evolution of the Ouachita Mountains and Arkoma Basin, southeastern Oklahoma and west-central Arkansas: applications to petroleum exploration: Oklahoma Geological Survey Guidebook 34, p. 115.

69. Cross section through Wilburton Deep field. Same ref as above.

70. **"Horizontal Wells Are Good Period (1990 – Present)"**

71. Histogram of CBM drilling in Arkoma Basin. Intially vertical, then went horizontal. Real dropoff in last 3 years. http://www.ogs.ou.edu/coal/pdf/2010TSOPRankRev.pdf. Courtesy of Brian Cardott

72. What makes a good CBM well? This slide - relation of lateral length to IP. Additional questions – relation of IP to cum; reason for lower IP in longest wells. http://www.ogs.ou.edu/coal/pdf/2010TSOPRankRev.pdf

73. CBM wells by coal bed. Most are in Hartshorne, long known for gassiness. http://www.ogs.ou.edu/coal/pdf/2010TSOPRankRev.pdf Courtesy of Brian Cardott

74. More recent themes – the Woodford Shale. It and other gas shales – huge huge potential in North America. http://www.ogs.ou.edu/MEETINGS/Presentations/USGS%20Arkoma%20Nov%2009/USGS5_Shale_G_Intro.pdf.

75. Advances in completion techniques – hydro frac'ing horizontal Woodford wells. Reason that most wells are NS due to present-day stress regime. Ideally, wells should be oriented N15W, but land considerations. http://dc-app3-14.gfz-potsdam.de/pub/poster/World_Stress_Map_Release_2008.pdf

76. 2011 activity map. Most activity in Woodford. From Boyd's 2011 OK drilling activity report in March-Apr 2012 Shale Shaker.

77. **THE FUTURE** but will ignore 2 killers – prices and infrastructure

78. Plays, concepts, and unknowns. To ignore some (shale plays). Also tight gas sands in thrust belt, Bigfork Chert (which might be similar to Ark. Nov.)

79. Horizontal wells drilled in Pittsburg Co. – CBM, gas shale, thrust belt. Map from IHS. CBM – natural fractures; gas shale – present-day stress direction; thrust belt – drilling into thrust sheets.

80. Understanding facies relations of middle Atoka deep-water reservoirs á la the Red Oak sand. Suneson, N.H., and Hemish, L.A., 1994, Geology and resources of the eastern Ouachita Mountains frontal belt and southeastern Arkoma Basin, Oklahoma: Oklahoma Geological Survey Guidebook 29, p. 51. http://www.ogs.ou.edu/pubsscanned/guidebooks/GB_29.pdf

81. Understanding transition zone structure to east. From Cemen, I., Sagnak, A., and Akthar, S., 2001, Geometry of the triangle zone and duplex structure in the Wilburton Gas Field area of the Arkoma Basin, southeastern Oklahoma: Oklahoma Geological Survey Circular 104, p. 87-98.

82. Map (IHS) of wells in Latimer Co. vs Le Flore County. Thermal maturity an issue or lack of data (i.e., no wells).

83. Extent of Woodford beneath thrusts. Same reference as 81.

84. Morrowan and pre-Morrowan shelf edge – juxtaposition of source rocks and reservoir rocks. http://www.ogs.ou.edu/MEETINGS/Presentations/USGS%20Arkoma%20Nov%2009/USGS4_OuachitasReel.pdf. Original ref – Gatewood, L.E., and Fay, R.O., 1991, The Arbuckle/Ouachita facies boundary in Oklahoma, *in* Johnson, K.S., ed., Late Cambrian – Ordovician geology of the southern midcontinent, 1989 symposium: Oklahoma Geological Survey Circular 92, p. 171-180.

85. Map of Ouachitas featuring Potapo Creek Anticline. OGS Hydrologic Atlas maps.

86. Cross section of Potapo Creek Anticline. From Misch, P., and Oles, K.F., 2008, Stratigraphic and structural studies in the Ouachita Mountains, Oklahoma and Arkansas (1956), *in* Suneson, N.H., ed., Stratigraphic and structural evolution of the Ouachita Mountains and Arkoma Basin, southeastern Oklahoma and west-central Arkansas: applications to petroleum exploration: 2004 field symposium. The Arbenz – Misch/Oles volume: Oklahoma Geological Survey Circular 112A, Plate IVa (on CD-ROM).

87. Cross section through frontal belt highlighting Jackfork fields. http://www.ogs.ou.edu/MEETINGS/Presentations/USGS%20Arkoma%20Nov%2009/USGS4_OuachitasReel.pdf. Ref: Arbenz, J.K., 2008, Structural framework of the Ouachita Mountains, *in* Suneson, N.H., ed., Stratigraphic and structural evolution of the Ouachita Mountains and Arkoma Basin, southeastern Oklahoma and west-central Arkansas: applications to petroleum exploration: 2004 field symposium. The Arbenz – Misch/Oles volume: Oklahoma Geological Survey Circular 112A, pl. 6B (on CD-ROM)

88. Photo of McKinley rocks – strat traps in Jackfork

89. Stanley oil and gas field in Ouachitas. Boyd, D.T., 2002, Oklahoma oil and gas fields (distinguished by GOR and conventional vs. coalbed methane): Oklahoma Geological Survey Map GM-36. Also available at http://www.ogs.ou.edu/fossilfuels/MAPS/GM-36.pdf

90. Strat column showing correlation of Woodford Shale and Arkansas Novaculite. http://www.ogs.ou.edu/MEETINGS/Presentations/USGS%20Arkoma%20Nov%2009/USGS2_Regi_Set.pdf. Original reference – Arbenz, 2008, OGS Circ. 112A, pl. 2 (on CD-ROM). See full reference below.

91. Arbenz Geologic/Structure map of Ouachitas with Novaculite play area highlighted. http://www.ogs.ou.edu/MEETINGS/Presentations/USGS%20Arkoma%20Nov%2009/USGS4_OuachitasReel.pdf. Talk given by Jim Coleman. Ref: Arbenz, J.K., 2008, Structural framework of the Ouachita Mountains, *in* Suneson, N.H., ed., Stratigraphic and structural evolution of the Ouachita Mountains and Arkoma Basin, southeastern Oklahoma and west-central Arkansas: applications to petroleum exploration: 2004 field symposium. The Arbenz – Misch/Oles volume: Oklahoma Geological Survey Circular 112A, pl. 2. (on CD-ROM).