

Curriculum Vitae
RONALD F. BROADHEAD
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Citizenship: U.S.

PROFESSIONAL EXPERIENCE:

Emeritus Principal Senior Petroleum Geologist New Mexico Bureau of Geology and Mineral Resources	April 2020 - present
Principal Senior Petroleum Geologist, New Mexico Bureau of Geology (formerly Mines and Mineral Resources	July 2003-March 2020
Principal Senior Petroleum Geologist and Associate Director For Industry Liason, New Mexico Bureau of Mines and Mineral Resources	December 1998-June 2003
Senior Petroleum Geologist and Assistant Director New Mexico Bureau of Mines and Mineral Resources	1994-1998
Senior Petroleum Geologist, Head Library of Subsurface Data New Mexico Bureau of Mines and Mineral Resources	1992-1994
Petroleum Geologist, Head Petroleum Section New Mexico Bureau of Mines and Mineral Resources	1988-1992
Faculty Adjunct, Earth and Environmental Sciences Department New Mexico Institute of Mining and Technology	1983-present
Petroleum Geologist New Mexico Bureau of Mines and Mineral Resources	1981-1988
Petroleum Geologist, Cities Service Oil Company Tulsa and Oklahoma City	1979-1981

EDUCATION:

M.S. in Geology, University of Cincinnati Thesis: Gas-bearing Ohio Shale along Lake Erie Advisor: Professor Paul Edwin Potter	1979
Duke University Marine Laboratory Pivers Island, North Carolina	1977 (summer)
B.S. in Geology, New Mexico Institute of Mining and Technology (with Highest Honors)	1977

HONORS AND AWARDS:

2016 **Career Achievement Award** from the New Mexico Oil & Gas Association

2015 **Distinguished Service Award** from American Association of Petroleum Geologists

2014 **Charles H. Taylor Fellow**, American Association of Petroleum Geologists

2009 **Distinguished Service Award** from West Texas Geological Society

Honors and Awards (continued)

2008 **Honorary Membership** from Roswell Geological Society

2004 **Long Service Award** from the House of Delegates of the American Association of Petroleum Geologists

2002 **Monroe G. Cheney Science Award** from
Southwest Section American Association of Petroleum Geologists

2002 **A.J. Levorsen Award** for best paper presented at Southwest Section American Association of Petroleum Geologists annual convention, Ruidoso New Mexico

1977 **Union Oil Company Summer Fellowship in Marine Geology**

1977 **Estwing Award** for Outstanding Geoscience Graduate, New Mexico Institute of Mining and Technology

PROFESSIONAL AFFILIATIONS:

American Association of Petroleum Geologists (member since 1978; Editor Search and Discovery, 2011-2018; House of Delegates, 1986-2004; Membership Committee, 1987-1993; Technical Program Chair for Rocky Mountain Section meeting in Albuquerque, 2000)

SEPM, the Society for Sedimentary Geology (member since 1979)

New Mexico Geological Society (President, 1993; Vice President, 1992; Treasurer, 1991; Secretary, 1990)

Roswell Geological Society (member)

West Texas Geological Society (member)

Four Corners Geological Society (member)

Albuquerque Geological Society (member)

Sigma Xi (President, New Mexico Tech Chapter, 1989-1990)

Potential Gas Committee of the Potential Gas Agency (member)

CIVIC AFFILIATIONS:

Friends of the Socorro Public Library (Vice President, 2005).

SYNERGISTIC ACTIVITIES (selected)

- Editor of Search and Discovery, the online exploration and production journal of the American Association of Petroleum Geologists, 2011 – 2018.
- Co-advisor, New Mexico Tech AAPG Imperial Barrel Award Team, 2016 & 2017.
- Instructor, Earth Science 460 (Subsurface and Petroleum Geology), 1982-2013.
- Advisor New Mexico Tech Student Chapter of AAPG, 1997-2001 (NMT Student Chapter won Best Student Chapter Award in 1999).
- Technical program chair, Rocky Mountain Section AAPG annual meeting, 2000.
- President New Mexico Geological Society, 1993.
- Member of Rocky Mountain Membership Committee of AAPG, 1987-1993.
- Member House of Delegates of AAPG, 1986-2004.
- President, New Mexico Tech Chapter of Sigma Xi, 1989-1990.

MAJOR PROJECTS AT NEW MEXICO BUREAU OF GEOLOGY AND MINERAL RESOURCES:

- **Petroleum, helium and CO₂ potential of New Mexico.** Project performed in conjunction with the Petroleum Recovery Research Center and funded by the New Mexico State Land Office.
- **Evaluation of the oil & gas resources of the Secretary of Interior's Potash Area, Eddy County, New Mexico.** This ongoing project, performed in conjunction with the Petroleum Recovery Resource Center, the NMT Petroleum Engineering Dept., and the NMT Management Dept. is funded by a consortium of oil companies with the goal of providing a current and independent estimate of the oil and gas resources within the Secretary's Potash Area.
- **Induced seismicity resulting from injection of produced oilfield water in New Mexico.** This work grew out of a public workshop conducted at New Mexico Tech during August 2014. Cooperating scientists are Mark Person and Sue Bilek of the NMT Earth and Environmental Sciences Dept.
- **Petroleum geology and plays on the Mancos Shale in the San Juan Basin.** This work grew out of work performed for the NMT-sponsored San Juan Basin Energy Conference, March 2013.
- **Natural gas potential of north-central New Mexico** (funded by New Mexico State Land Office). Principal Investigator. Mapped and analyzed distribution of CO₂-rich gases throughout New Mexico.
- **Carbon dioxide in New Mexico: geologic distribution of natural occurrences:** (funded by New Mexico State Land Office). Principal Investigator. Mapped distribution of hydrocarbon production and shows, subsurface structure and stratigraphy, and assessed petroleum source rocks in the Las Vegas, Raton and San Luis Basins and assessed potential for undiscovered natural gas resources.
- **Mississippian of southeastern New Mexico** (multiple projects funded by New Mexico State Land Office). Principal Investigator. Mapped and analyzed the structure and stratigraphy of Mississippian strata in southeastern New Mexico. Grouped currently productive reservoirs into 4 stratigraphically and structurally defined plays and described those plays.
- **Helium resources of New Mexico** (funded by New Mexico State Land Office and New Mexico Commissioner of Public Lands). Principal Investigator. Mapped and analyzed distribution of helium-rich gases in New Mexico and developed models for helium exploration.
- **Development of a Fuzzy Expert System for the Reduction of Risk in Petroleum Exploration** (in conjunction with the New Mexico Petroleum Recovery Research Center and the Computer Science Department of New Mexico Institute of Mining and Technology). **Co-Principal Investigator.** \$2.9 million contract awarded end of 1998 by U.S. Department of Energy, commenced work 1999.
- **Petroleum Geology of Frontier Basins in New Mexico.** Evaluated the petroleum potential of frontier basins in New Mexico. This work has involved extensive subsurface mapping of nonproductive to marginally productive frontier basins in the state. Mapping involved a combination of well data, biostratigraphic data, gravity and magnetic field data, and 2-dimensional seismic lines. Structure and stratigraphic data were integrated with lithofacies studies, petrographic studies, and hydrocarbon source-rock analyses to form an integrated picture of the petroleum geology and petroleum systems in these basins. Work has involved extensive collaboration and interaction with the petroleum industry in New Mexico. Evaluated basins include the Tucumcari Basin of east-central New Mexico, the Estancia Basin of central New Mexico, the Carrizozo Basin of central New Mexico, the Tularosa Basin – Orogrande Basin area of south-central New Mexico, and Pennsylvanian age elevator basins in central and northeast New Mexico (elevator basins are deep narrow grabens characterized by deposition of both source facies and reservoir rocks and are self-contained petroleum systems). 1986-present.
- **Mineral and Energy Resource Assessment of the McGregor Range, Otero County, New Mexico.** \$300K project funded by the U.S. Army Corps of Engineers through TRC-Mariah Associates, Inc. Served as **Principal Investigator** coordinating research and budgets of other workers and performed the oil and gas assessment work. The McGregor Range encompasses approximately 1,000 mi² in Otero County, south-central New Mexico. It is used by the U.S. Army as a practice and target range for conducting military exercises, especially bombardment with projectiles and air-to-ground weapons, as well as for the testing of experimental weaponry. The project involved assessing recoverable mineral and energy resources on the McGregor bombing and artillery range. The project was required by federal law in order to comply with federal regulations regarding continued withdrawal and military use of the McGregor Range by the U.S. Army. This project involved extensive field and laboratory work

on the restricted access lands of the McGregor Range and involved coordination of the work of more than 20 scientists and technicians from the New Mexico Bureau of Mines and Mineral Resources, the Earth Data Analysis Center of the University of New Mexico, the New Mexico State University, and the University of Texas at El Paso. The project also involved liaison with U.S. Army security forces for purposes of gaining access to this militarily restricted area. The final product was a comprehensive report of more than 500 pages that is presently held confidential by the U.S. Army. 1997.

- **Evaluation of Mineral Resources at the Waste Isolation Pilot Plant (WIPP) Site.** Funded by Westinghouse Electric Corporation. Served as lead scientist in evaluation of oil and gas resources of 16 square mile WIPP Land Withdrawal Area and adjacent lands. Integrated comprehensive subsurface geological study and petroleum engineering study which evaluated oil and natural gas resources producible through primary and secondary (waterflood) recovery. 1994-1995.
- **Atlas of Major Rocky Mountain Gas Reservoirs.** \$1.5 million project funded principally by Gas Research Institute and U.S. Department of Energy. **Project CoDirector. Project Director** for last year of project. Roles as Project CoDirector and Director involved supervising and coordinating efforts and budgets of 36 professional personnel at New Mexico Bureau of Mines and Mineral Resources, Colorado Geological Survey, Utah Geological Survey, Geological Survey of Wyoming, Intera Information Technologies, Inc., Methane Resources Group, Ltd., and Barlow and Haun Associates, as well as writing 12 sections of atlas. 1991-1993.
- **New Mexico Library of Subsurface Data.** **Supervisor** from 1988 to present. Duties include supervising one to two full-time staff members and a variable number of student assistants organizing New Mexico Library of Subsurface Data, and routinely answering service requests for information from industry, the general public, and government agencies. Most requests concern the oil and gas industry in the state, but many requests are also received regarding groundwater resources and data useful to the minerals industries. Initiated program to computerize drilling records, well logs, and other information on the 90,000 oil and natural gas wells that have been drilled in New Mexico. The New Mexico Library of Subsurface Data is affiliated with the U.S. Department of Energy Regional Petroleum Technology Transfer Center located at New Mexico Tech since 1994. Subsurface library staff recently completed digital maps of oil and gas fields in New Mexico which are available to the public over the internet and are linked to the state's computerized database of oil and gas production. Currently raising private-sector funds to permit construction of additional core archival facilities.
- **New Mexico Petroleum Source Rock Project.** Cooperative project funded by New Mexico Bureau of Mines and Mineral Resources, New Mexico Oil Conservation Division, New Mexico Energy Research and Development Institute, and private industry (more than 20 contributing companies). **Project Manager.** Source-rock analyses of more than 100 key oil and gas exploration wells and outcrop sections in New Mexico. 1987-present (ongoing). A computer database of data generated by this project has been completed and reproduced on CD-ROM as a New Mexico Bureau of Mines and Mineral Resources product.
- **Geology of gas-producing Abo red beds, southeastern New Mexico.** This project involved a subsurface and surface analysis of the nonmarine red beds of the Abo Formation (Permian) in southeastern New Mexico. Gas was discovered in the Abo in the late 1970's and a drilling boom began to exploit this gas in the early-mid 1980's. This project was undertaken in concurrence with the drilling boom in an effort to more fully understand the geologic controls on gas distribution. Resulted in several publications as well as a two-day field trip jointly sponsored by the New Mexico Bureau of Mines and Mineral Resources and the Roswell Geological Society (a largely industry-supported group).
- **Mineral Resource Potential of Cibola, McKinley, Rio Arriba, San Juan, Sandoval, and Valencia Counties, New Mexico.** Cooperative project with U.S. Bureau of Land Management and several New Mexico Bureau of Mines and Mineral Resources staff. Evaluated petroleum, carbon-dioxide, and helium potential of these counties. 1984-1986.

EDUCATIONAL ACTIVITIES AT NEW MEXICO TECH

- **Geology 572-05, Shales.** I co-taught this course with Jolante Van Wijk of the NMT EES Department during the Fall semester of 2019. 8 students.
- **Tech-Trek 2019.** Tech-Trek, funded by Halliburton, brought middle school female science students to Tech for a week during the summer of 2019. The topic of this year's Tech-Trek was porosity in rocks. My part involved presenting a workshop on porosity in cores.
- **Geology 572-03, Petroleum Source Rock Geology.** I co-taught this course with Jolante Van Wijk and Ryan Leary of the NMT EES Department during the Fall semester of 2018
- **Geology/Geophysics 571 – AAPG IBA Competition.** I co-taught this course (with Jolante Van Wijk) which involved lectures and extensive advising for the NMT AAPG Imperial Barrel Award Team. Spring 2016, 2017.
- **Earth Science 460 (3 credits, lecture + lab course, formerly Geology 460 and 464), Subsurface and Petroleum Geology.** Lecture and laboratory course. Taught this course 24 times from 1982 until 2013 (annually from 1997 through 2013. Course is required for petroleum engineering majors and passed ABET review. This course was essentially taught largely on my own time and was essentially uncompensated. A total of 328 students passed my course through the years with 40 students completing the course in 2013.
- **Geology 581, Directed study in petroleum source rocks.** Taught on demand, 2000-2001.
- **Advise and direct M.S. research projects.** Matriculated graduate research advisees are Heidi Justman, Jason Lennane, and Jake Sharp. Have also served on numerous M.S thesis committees at New Mexico Tech including Jenna Donatelli, Ken Lemley, Curtis McKallip, Weiqiang Wu, Greg Little, Maqsood Ali, and Fawzia Begum of the Earth and Environmental Sciences Department and Kelsey Seals, Shigao Ren, Ketil Hareland, Steven Sanchez, Xi Xiaokui and Ryan Robinson of the Petroleum Engineering Department.
- **High School Minicourse in Petroleum Technology.** This week-long course was offered by the NMT Petroleum Engineering Department for several years in the mid-1990's. I taught the geology part.
- **MST Course in Petroleum Technology.** This course was offered during the summers of 1990 and 1991. I taught the geology part.
- **Mentor NMT Petroleum Engineering Senior Design Students,** approx. 2000-present.

NEW MEXICO TECH INSTITUTIONAL SERVICE

- NMT Search Committee for Vice President for Academic Affairs, 2016
- NMT Presidential Search Committee, 2015-2016
- NMT Search Committee for Vice President for Academic Affairs, 2013
- Search Committee for Director of New Mexico Bureau of Geology and Mineral Resources, 2012
- New Mexico Bureau of Geology and Mineral Resources Petroleum Geologist Search Committee (Chair), 2001
- New Mexico Bureau of Geology and Mineral Resources Petroleum Geologist Search Committee (Chair), 1999
- New Mexico Bureau of Geology and Mineral Resources Petroleum Geologist Search Committee, 1995
- NMT Institute Space Committee, 1990-1991.
- New Mexico Bureau of Geology and Mineral Resources Petroleum Geologist Search Committee, 1989
- NM Bureau of Geology tenure committees (1989-2004; 1995-1999; 1999-2003; 2001-2003)

SELECTED PUBLICATIONS

(complete list of 203 publications listed in Appendix A of this CV):

- Broadhead, R.F., 2019, Carbon dioxide in the subsurface of northeastern New Mexico, *in* Ramos, F.C., Zimmerer, M.J., Zeigler, K.E., and Ulmer-Scholle, D.S., eds., *Geology of the Raton-Clayton area: New Mexico Geological Society, Guidebook to 70th field conference*, p. 101-108.
- Broadhead, R.F., 2017, *Petroleum geology of New Mexico: New Mexico Bureau of Geology and Mineral Resources, Memoir 50A and New Mexico Geological Society Special publication 13A*, 90 p.
- Broadhead, R.F., 2015, The Upper Mancos Shale in the San Juan Basin: Three plays, conventional and unconventional: American Association of Petroleum Geologists, Search and Discovery, Document No. 10791, 39 p.
- Broadhead, R.F., 2015, Petroleum geology of the Las Vegas Basin: an overview, *in* Lindline, J., Petronis, M., and Zebrowski, J., eds., *Geology of the Las Vegas region: New Mexico Geological Society, Guidebook 66*, p. 253-260.
- Broadhead, R.F., 2012, Hydrocarbon-water and CO₂-water systems in the pre-Cretaceous section in the New Mexico part of the Raton Basin: *The Mountain Geologist*, v. 49, no. 2, p. 55-74.
- Broadhead, R.F., 2010, The Woodford Shale in southeastern New Mexico: distribution and source rock characteristics: *New Mexico Geology*, v 32 no 3, p. 79-90.
- Broadhead, R.F., 2009, Mississippian strata of southeastern New Mexico: distribution, structure, and hydrocarbon plays: *New Mexico Geology*, v 31 no 3, p. 65-76.
- Broadhead, R.F., Mansell, M., and Jones, G., 2009, Carbon dioxide in New Mexico: Geologic distribution of natural occurrences: New Mexico Bureau of Geology and Mineral Resources, Open file report 514, 131 p., 20 plates, 1 database, CD-ROM.
- Broadhead, R., 2009, Oil and natural gas potential of the Albuquerque Basin, *in* Price, L.G., Bland, D., Johnson, P.S., and Connell, S.D., eds., *Water, natural resources, and the urban landscape, The Albuquerque region: New Mexico Bureau of Geology and Mineral Resources, Decision Makers Field Conference 2009*, p. 80-86.
- Broadhead, R.F., 2008, The natural gas potential of the Raton and Las Vegas Basins, Colfax and Mora Counties, north-central New Mexico, *in* Bowden, C.E., Raines, M.A., and Hinterlong, G.D., *The Permian Basin: Geological models to the world: West Texas Geological Society, Publication 08-120 (CD-ROM)*, paper is 45 pages.
- Broadhead, R.F., 2008, Interpretive stratigraphic contouring, *in* Leetaru, H., (ed.), *AAPG Teaching sets in petroleum geology: American Association of Petroleum Geologists: AAPG Datapages, CD-ROM*.
- Broadhead, R.F., 2005, Helium in New Mexico – geologic distribution, resource demand, and exploration possibilities: *New Mexico Geology*, v. 27, no. 4, p. 93-101.
- Broadhead, R.F., 2005, Helium in New Mexico: Geologic distribution and exploration possibilities, *in* Lufholm, P.H., and Cox, D., eds., *Unconventional reservoirs technology and strategies – alternate perspectives for the Permian Basin: West Texas Geological Society, Publication 05-115*, p. 85-98.
- Dutton, S.P., Kim, E.M., **Broadhead, R.F.**, Raatz, W.D., Breton, C.L., Ruppel, S.C., and Kerans, C., 2005, Play analysis and leading-edge oil-reservoir development methods in the Permian Basin; increased recovery through advanced technologies: American Association of Petroleum Geologists, *Bulletin*, v. 89, p. 553-576.
- Broadhead, R.F., 2004, Oil, natural gas and helium potential of the Chupadera Mesa area, Lincoln and Socorro Counties, New Mexico, *in* Trentham, R.C., ed., *Banking on the Permian Basin: Plays, field studies, and techniques: West Texas Geological Society, Publication 04-112*, p. 81-104.
- Broadhead, R.F., 2003, Remaining oil and natural gas resources of New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open-file report 474, CD-ROM. This was a report prepared for the New Mexico State Legislature.
- Broadhead, R.F., 2002, Petroleum geology of the McGregor Range, Otero County, New Mexico: New Mexico Geological Society, *Guidebook to 53rd field conference*, pp. 331-338.
- Broadhead, R.F., 2002, Petroleum geology of the McGregor Range, Otero County, New Mexico, *in* Transactions Southwest Section AAPG Convention: Roswell Geological Society, pp. 40-55.
- Broadhead, R., 2002, The origin of oil and gas, *in* Brister, B.S., and Price, L.G., eds., *New Mexico's*

- energy, present and future: policy, production, economics, and the environment: New Mexico Bureau of Geology and Mineral Resources, pp. 41-43.
- Broadhead, R.F., 2002, Tucumcari Basin potential borne out in new source rock studies: *Oil and Gas Journal*, v. 99, no. 38, pp.
- Broadhead, R.F., and Justman, H.A., 2000, Regional controls on oil accumulations, lower Brushy Canyon Formation, southeast New Mexico, *in* DeMis, W.D., Nelis, M.K., and Trentham, R.C., *The Permian Basin: proving ground for tomorrow's technologies*: West Texas Geological Society, Publication 00-109, pp. 9-18.
- Justman, H.A., and **Broadhead, R.F.**, 2000, Source rock analysis for the Brushy Canyon Formation, Delaware Basin, southeastern New Mexico, *in* DeMis, W.D., Nelis, M.K., and Trentham, R.C., *The Permian Basin: proving ground for tomorrow's technologies*: West Texas Geological Society, Publication 00-109, pp. 211-220.
- Read, A., **Broadhead, R.**, Lopez, A., Fleming, E., and Watrous, J., 2000, New Mexico oil and gas pool maps: New Mexico Bureau of Mines and Mineral Resources, Circular 209, 1 CD ROM.
- Broadhead, R.F., 1999, Underdeveloped oil fields in Upper Pennsylvanian and Lower Permian carbonates of southeast New Mexico: initial development missed major reserves: *The Leading Edge*, September 1999, pp. 1012-1017.
- Broadhead, R.F., 1999, Underdeveloped oil fields – Upper Pennsylvanian and Lower Wolfcampian carbonate reservoirs of southeast New Mexico: *Carbonates and Evaporites*, v. 14, no. 1, pp. 84-105.
- New Mexico Tech, Geology 460 Class (N. Derrick, D. Hart, H. Justman, D. Leiphart, D. Medford, R. Robinson, T. Sande, A. Trivitt, **R. Broadhead**), 1999, Kenmnitz Morrow, *in* Worthington, R.E., and Brown, M., eds., *A symposium of the oil and gas fields of southeastern New Mexico*, 1999 supplement, *Pennsylvanian gas fields*: Roswell Geological Society, pp. 204-207.
- Broadhead, R.F., Luo, F., and Speer, S.W., 1998, Oil and gas resources at the Waste Isolation Pilot Plant (WIPP) site, Eddy County, New Mexico, *in* *Hydrocarbon resources at WIPP site, New Mexico*: New Mexico Bureau of Mines and Mineral Resources, Circular 206, pp. 3-72.
- Broadhead, R.F., Wilks, M., Morgan, M., and Johnson, R.E., 1998, New Mexico petroleum source rock database: New Mexico Bureau of Mines and Mineral Resources, 1 CD-ROM.
- Broadhead, R.F., 1997, Subsurface and petroleum geology of Estancia Basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 157, 54 pp.
- Broadhead, R.F., and Luo, F., 1996, Oil and gas resources in the Delaware Mountain Group at the WIPP site, Eddy County, New Mexico, *in* Demis, W.D., and Cole, A.G., eds., *The Brushy Canyon play in outcrop and subsurface: concepts and examples*: Permian Basin Section SEPM, Publication 96-38, pp. 119-130.
- Broadhead, R.F., 1993, Petrography and reservoir geology of Upper Devonian shales, northern Ohio: U.S. Geological Survey, Bulletin 1909, chapter H, pp. H1-H15.
- Broadhead, R.F., 1990, Bravo dome carbon dioxide gas field, *in* E.A. Beaumont and N.H. Foster, eds, *Treatise of petroleum geology, Atlas of oil and gas fields, structural traps I*: American Association of Petroleum Geologists: pp. 213-232.
- Broadhead, R.F., 1990, Petroleum source rocks in the Tucumcari Basin, east-central New Mexico: *West Texas Geological Society, Bulletin*, v. 29, no 8, pp. 5-16.
- Broadhead, R.F., and King, W.E., 1988, Petroleum geology of Pennsylvanian and Lower Permian strata, Tucumcari Basin, east-central New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 119, 75 pp.
- Budding, A.J., and **Broadhead, R.F.**, 1987, Geology and geochemistry of Santa Rosa tar sands: American Association of Petroleum Geologists, *Studies in geology* no. 25, pp. 293-299.
- Broadhead, R.F., 1984, Stratigraphically controlled gas production from Abo red beds (Permian), east-central New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 183, 36 pp.
- Broadhead, R.F., Kepferle, R.C., and Potter, P.E., 1982, Stratigraphic and sedimentologic controls of gas in shale -- example from Upper Devonian of northern Ohio: American Association of Petroleum Geologists, *Bulletin*, v. 66, pp. 10-27.

INVITED PRESENTATIONS, SELECTED
(complete list of 66 invited presentation listed in Appendix B of this CV):

- Helium: Geology of accumulations and relation to other gases in the reservoir, presented to Albuquerque Geological Society, Albuquerque NM, February 6, 2019
- Relationship of helium and CO₂ to other gases in New Mexico reservoirs, presented at American Association of Petroleum Geologists Annual Conference and Exhibition, Salt Lake City UT, May 2018.
- Marine Mancos Shale core, San Juan Basin, New Mexico. This was a 3-day core display presented at the American Association of Petroleum Geologists Annual Conference and Exhibition, Salt Lake City UT, May 2018.
- Petroleum geology of New Mexico: An overview and recent developments, presented at Society of Professional Independent Earth Scientists Annual meeting, Santa Fe NM, June 12, 2018.
- Oil and gas at the southeastern end of the San Juan Basin: Recent resurgence due to horizontal drilling in the Upper Mancos Shale, presented to Roswell Geological Society dinner meeting, Roswell NM, October 9, 2018.
- Helium: Geology of accumulations and relationship to other natural gases in the reservoir. Presented to American Association of Petroleum Geologists Geoscience Technology Workshop, Houston TX, October 2016.
- Carbon dioxide and helium gases in New Mexico: Distribution and relation to other gases in the reservoir, presented to Geological Society of America Annual Meeting, Denver CO, September 2016.
- Overview of selected shale plays in New Mexico, presented at Rocky Mountain Association of Geologists Luncheon meeting, August 6, 2014.
- Shale plays in New Mexico: Independent Petroleum Association of New Mexico annual meeting, Albuquerque NM, August 9, 2013.
- Petroleum geologic framework of the Tucumcari Basin, east-central New Mexico, with a synopsis of recent exploratory activity: Society of Independent Professional Earth Scientists, 47th annual meeting, Colorado Springs CO, June 2010.
- Petroleum geology framework of the Tucumcari Basin, presented to West Texas Geological Society luncheon program, August 11, 2009.
- Core workshop and field trip – examples and analogues for the Tucumcari Basin, given for Shell Oil Company Western U.S. Tight Sands Exploration Team, October 20-22, 2008, Socorro NM.
- Underdeveloped oil fields in Upper Pennsylvanian and Lower Permian carbonate reservoirs of southeastern New Mexico: Initial development missed major reserves. Presented to American Association of Petroleum Geologists, 2006 Annual Convention, Houston TX, April 12, 2006.
- Helium in New Mexico: geologic distribution and exploration possibilities, presented to:
Tulsa Geological Society, October 10, 2006.
Roswell Geological Society, Roswell NM, November 8, 2005.
- Petroleum source rocks and structure of the Tucumcari Basin, east-central New Mexico. Presented to Tulsa Geological Society, Tulsa OK, May 24, 2005.
- Oil, natural gas, and helium potential of Chupadera Mesa, central New Mexico. Presented to Midland, TX Chapter of the Society of Independent Professional Earth Scientists, Midland TX, May 18, 2005.
- Underdeveloped oil fields in Upper Pennsylvanian and Lower Wolfcampian carbonates of southeast New Mexico, presented to:
Mid-Continent Section Meeting of American Association of Petroleum Geologists, Wichita, Kansas, August 29, 1999.
Southwest Section Meeting of American Association of Petroleum Geologists, Abilene, Texas, March 2, 1999.
Albuquerque Geological Society, September 1997.
- Petroleum source rocks in late Paleozoic elevator basins: the Tucumcari, Estancia, Vaughn, and Carrizozo Basins, presented to:
Four Corners Geological Society, Farmington, New Mexico, January 22, 1999.
Roswell Geological Society, Roswell, New Mexico, January 12, 1999.
Permian Basin Section SEPM, Midland, Texas, December 1998.
- Abo sands in subsurface, southeast New Mexico: presented to:
Permian Basin Section SEPM, Midland, TX, March 1985
Albuquerque Geological Society, Albuquerque, NM, June 1985.

LEGISLATIVE PRESENTATIONS (New Mexico Legislature)

Broadhead, R.F., 2017, Oil and natural gas activities at the New Mexico Bureau of Geology and Mineral Resources. Presented to New Mexico House of Representatives Water & Natural Resources Interim Committee, Socorro NM, October 12, 2017.

Broadhead, R.F., 2013, Geology of oil & gas in Mancos Shale, San Juan Basin: Presented to New Mexico House of Representatives Water & Natural Resources Interim Committee, Farmington NM, August 29, 2013.

Broadhead, R.F., 2013, Overview of hydraulic fracturing in New Mexico: Presented to joint meeting of New Mexico House of Representatives Energy & Natural Resources Committee and Agriculture & Water Resources Committee, Santa Fe NM, February 11, 2013.

Broadhead, R.F., 2012, New Mexico Oil and Gas Production, presented to New Mexico House of Representatives Energy and Natural Resources Committee, Santa Fe NM, February 3, 2012.

EXTERNALLY FUNDED PROJECTS at NMBGMR (total funding to Bureau = \$3,057,403)

Project name	Funding organization	Cooperative Investigators/Scientists	Role	Start year	End year
Oil & gas resource assessment of Sandoval County and its relationship to groundwater	Sandoval County	Alex Rinehart	PI	2017	2018
BLM mineral potential of land parcels proposed for exchange with NM SLO	U.S. Bureau of Land Management	Martha Cather (PRRC), Virginia McLemore (NMBGMR)	geologist	2017	2018
NM SLO mineral potential of land parcels proposed for exchange with US BLM	New Mexico State Land Office	Martha Cather (PRRC), Virginia McLemore (NMBGMR)	geologist	2017	2018
New analysis of oil & gas potential of Secretary of Interior's Potash Area	Industry consortium (Bopco, OXY USA, Chevron, Devon, XTO)	R. Balch, M. Cather (PRRC), T. Engler (NMT Petroleum Engineering Dept.), Y. Yuan, NMT Management Dept.)	geologist	2015	2016
National Geothermal Data System - New Mexico Contribution	U.S. Department of Energy	S. Kelley (NMBGMR) D. Ulmer-Scholle (NMT)	geologist	2010	2013
New Mexico saline aquifer database	U.S. Geological Survey	D. Ulmer-Scholle (NMT)	PI	2010	2011
National Geologic & Geophysical Preservation Program	U.S. Geological Survey	A. Trivitt-Kracke, A. Lopez (NMBGMR)	PI	2010	2011
National Geologic & Geophysical Preservation Program	U.S. Geological Survey	A. Trivitt-Kracke, A. Lopez (NMBGMR)	PI	2009	2010
National Geologic & Geophysical Preservation Program	U.S. Geological Survey	A. Trivitt-Kracke, A. Lopez (NMBGMR)	PI	2008	2009
Carbon dioxide accumulations in New Mexico	New Mexico State Land Office		PI	2008	2009

Project name	Funding organization	Cooperative Investigators/Scientists	Role	Start year	End year
Natural gas potential of north-central New Mexico	New Mexico State Land Office		PI	2007	2008
National Geologic & Geophysical Preservation Program	U.S. Geological Survey	A. Trivitt-Kracke, A. Lopez (NMBGMR)	PI	2007	2008
Barnett Shale in southeastern New Mexico	New Mexico State Land Office		PI	2006	2007
Mississippian strata of southeastern New Mexico	New Mexico State Land Office		PI	2005	2006
Geologic trends of oil & gas production in potash area	U.S. Bureau of Land Management	Patrick Walsh (NMBGMR)	PI	2005	2006
Helium in New Mexico	New Mexico State Land Office		PI	2004	2005
Permian Basin structure maps	New Mexico State Land Office		PI	2003	2004
Oil, gas & mineral resources of Laguna Bonitas area	New Mexico Energy, Minerals and Natural Resources Dept.	Ginger McLemore (NMBGMR)	geologist	2003	2003
Play analysis of major oil reservoirs in Permian Basin	U.S. Department of Energy	Shirley Dutton and 4 other geologists and engineers at Bureau of Economic Geology (at Univ. of Texas); Bill Raatz (NMBGMR)	PI (NM part only)	2002	2004
Oil, natural gas & helium potential of Chupadera Mesa area	New Mexico State Land Office		PI	2002	2003
Roadmap for unconventional natural gas technology	Gas Technology Institute	Tom Engler (NMT Petroleum Engineering Dept) Martha Cather (PRRC) Bill Raatz (NMBGMR)	geologist	2002	2002
Petroleum potential of Sin Nombre area	New Mexico State Land Office		PI	2001	2002
Tucumcari Basin source rocks and structure	New Mexico State Land Office		PI	2000	2001
Exploration risk reduction with fuzzy expert tool	U.S. Department of Energy	Bill Weiss & Bob Balch (PRRC)	co-PI	1999	2005
Mineral and energy assessment of McGregor Range	U.S. Army Corp of Engineers through TRC-Mariah, Inc.	G. Austin, V. McLemore, J. Barker (NMBGMR; J. Witcher of New Mexico State University	PI	1994	1995
Atlas of Major Rocky Mountain Gas Reservoirs	Gas Research Institute	N. Whitehead, J. Robertson, F. Luo of New Mexico Bureau of Geology; S. Speer of Roswell NM; 31 geologists and engineers from Geol Surveys of Wyoming, Colorado, Utah, Barlow & Haun, Inc., Methane Resources Group, Ltd., Intera Inc.	PI	1991	1993

CITIES SERVICE (Oil) COMPANY, 1979-1981

I spent my first 3 months in the Basin Studies Group, an applied research unit in Tulsa. In this group I was part of a team that was developing a computer-based exploration tool based on principal components analysis of geologic data. From there, I attended the 6 month Exploration Training Program in Tulsa. After that I was transferred to the Oklahoma City Office where I developed drilling prospects, evaluated acreage positions, and did wellsite duty which encompassed recommendations on testing and completing wells vs. plug and abandonment, picking core points, etc. Primary areas of responsibility for prospect evaluation and acreage evaluation included the Arkoma Basin of Oklahoma and Arkansas, the central Oklahoma uplift area, extreme southwestern Oklahoma and the Texas panhandle, and the Ouachita thrust belt. Wellsite duties included wells drilled in the Arkoma Basin, the Oklahoma panhandle and western Kansas.

Ron Broadhead, Curriculum Vitae (November 2019)

Appendix A – Publications Listed by Basin or Other Topic

NEW MEXICO (GENERAL) PUBLICATIONS:

Broadhead, R.F., 2017, Petroleum geology of New Mexico: New Mexico Bureau of Geology and Mineral Resources Memoir 50A and New Mexico Geological Society Special publication 13A, 90 p.

PERMIAN BASIN PUBLICATIONS:

Scholle, P.A., **Broadhead, R.**, and McLemore, V., in press, The Permian Basin, *in* The geology of southern New Mexico's parks, monuments, and public lands, p. 276-287.

Broadhead, R.F., 2012, The Woodford Shale in southeastern New Mexico: Distribution and source rock characteristics, *in* Bowden, C.E., ed., Hidden treasures in our own backyard: West Texas Geological Society, Publication No. 11-124, pages not consecutively numbered.

Broadhead, R.F., 2011, The Woodford Shale in southeastern New Mexico: Distribution and source rock characteristics: American Association of Petroleum Geologists, Search and Discovery Article 80163.

Broadhead, R.F., 2010, The Woodford Shale in southeastern New Mexico: distribution and source rock characteristics: New Mexico Geology, v 32 no 3, p. 79-90.

Justman, H., and Broadhead, R., 2010, Petroleum source rock data for the Brushy Canyon Formation, Delaware Basin, southeastern New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open file report 528, CD-ROM.

Justman, H., and Broadhead, R., 2010, Petroleum source rock data for the Bone Spring Formation, Delaware Basin, southeastern New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open file report 529, CD-ROM.

Broadhead, R.F., 2009, Mississippian strata of southeastern New Mexico: distribution, structure, and hydrocarbon plays: New Mexico Geology, v 31 no 3, p. 65-76.

Broadhead, R.F., 2008, The Barnett Shale in southeastern New Mexico: Distribution, thickness and source rock characterization: West Texas Geological Society, Publication 07-119, DVD.

Broadhead, R.F., and Gillard, L., 2007, The Barnett Shale in southeastern New Mexico: Distribution, thickness, and source rock characterization: New Mexico Bureau of Geology and Mineral Resources, Open file report 502, CD-ROM.

Broadhead, R.F., 2006, Mississippian strata of southeastern New Mexico: Distribution, structure and hydrocarbon plays, *in* Raines, M.A., ed., Resource plays in the Permian Basin: Resources to reserves: West Texas Geological Society, Publication 06-117, p. 12-28.

Broadhead, R.F., 2006, Mississippian strata in southeastern New Mexico, including the Barnett Shale: Thickness, structure and hydrocarbon plays: New Mexico Bureau of Geology and Mineral Resources, Open file report 497, CD-ROM.

Broadhead, R.F., 2006, Underdeveloped oil fields in Upper Pennsylvanian and Lower Permian carbonate reservoirs of southeastern New Mexico: Initial development missed major reserves (abstract): American Association of Petroleum Geologists, 2006 Annual Convention Abstracts, CD-ROM.

Dutton, S.P., Kim, E.M., Ruppel, S.C., Kerans, C., **Broadhead, R.F.**, Raatz, W.D., and Breton, C.L., 2006, Oil-play analysis of the Permian Basin: A tool for increasing recovery from a mature oil-producing province (abstract): American Association of Petroleum Geologists, 2006 Annual Convention Abstracts, CD-ROM.

Dutton, S.P., Kim, E.M., **Broadhead, R.F.**, Raatz, W.D., Breton, C.L., Ruppel, S.C., and Kerans, C., 2005, Play analysis and leading-edge oil-reservoir development methods in the Permian Basin; increased recovery through advanced technologies: American Association of Petroleum Geologists, Bulletin, v. 89, p. 553-576.

Permian Basin publications (continued):

- Dutton, S.P., Kim, E.M., **Broadhead, R.F.**, Breton, C.L., Raatz, W.D., Ruppel, S.C., and Kerans, C., 2005, Play analysis and digital portfolio of major oil reservoirs in the Permian Basin: Bureau of Economic Geology, The University of Texas at Austin, Report of Investigations No. 271, CD-ROM.
- Broadhead, R.F., 2005, Regional aspects of the Wristen petroleum system, southeastern New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open-file report 485, CD-ROM.
- Broadhead, R.F., Gillard, L., and Engin, N., 2005, Structure contours on Abo Formation (Lower Permian), Northwest Shelf of Permian Basin: New Mexico Bureau of Geology and Mineral Resources, Open-file report 487, CD-ROM.
- Broadhead, R.F., and Gillard, L., 2005, Structure contours on Bone Spring Formation (Lower Permian), Delaware Basin: New Mexico Bureau of Geology and Mineral Resources, Open-file report 488, CD-ROM.
- Broadhead, R.F., and Gillard, L., 2005, Structure contours on Tubb sandstone member of Yeso Formation (Lower Permian), Central Basin Platform, southeastern New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open-file report 489, CD-ROM.
- Dutton, S.P., Kim, E.M., Breton, C.L., **Broadhead, R.F.**, Raatz, W.D., Ruppel, S.C., and Kerans, C., 2004, Digital portfolio of oil plays in the Permian Basin (abstract), *in* Trentham, R.C., ed., Banking on the Permian Basin: Plays, field studies, and techniques: West Texas Geological Society, Publication 04-112, p. 7.
- Broadhead, R.F., and Hall, A., 2004, Regional aspects of the Wristen petroleum system, southeast New Mexico (abstract), *in* Trentham, R.C., ed., Banking on the Permian Basin: Plays, field studies, and techniques: West Texas Geological Society, Publication 04-112, p. 107-108.
- Baldonado, D., and **Broadhead, R.**, 2003, Preliminary investigation of the regional stratigraphy of Siluro-Devonian carbonates, Tobosa Basin, New Mexico (abstract): Transactions Southwest Section AAPG Convention, Fort Worth, Texas, CD-ROM.
- Baldonado, D., and **Broadhead, R.**, 2002, Preliminary investigation of the regional stratigraphy of Siluro-Devonian carbonates, Tobosa Basin, New Mexico, *in* The Permian Basin: preserving our past – securing our future: West Texas Geological Society, Publication No. 02-111, pp. 55-69.
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- Balch, R.S., Hart, D.M., Weiss, W.W., and **Broadhead, R.F.**, 2002, Using artificial intelligence to predict drilling success using regional data, Brushy Canyon Formation, Delaware Basin, New Mexico, *in* Transactions Southwest Section AAPG Convention: Roswell Geological Society, pp. 244-254.
- Broadhead, R.F., and Justman, H.A., 2002, Regional controls on oil accumulations and regional sand trends, lower Brushy Canyon Formation (abstract): talk presented to Roswell Geological Society, Roswell New Mexico, February 12, 2002.
- Balch, R.S., Hart, D.M., Weiss, W.W., and **Broadhead, R.F.**, 2002, Using artificial intelligence to predict drilling success using regional data, Brushy Canyon Formation, Delaware Basin, New Mexico, *in* Transactions Southwest Section AAPG Convention: Roswell Geological Society, pp. 244-254.
- Broadhead, R.F., 2001, Redevelopment of old fields in the Upper Pennsylvanian and Lower Permian of southeast New Mexico: Rejuvenation of underdeveloped fields yields major reserves; *in* Johnson, K.S., ed., Pennsylvanian and Permian geology and petroleum in the southern midcontinent, 1998 symposium: Oklahoma Geological Survey, Circular 104, pp. 119-122.
- Broadhead, R.F., and Justman, H.A., 2000, Regional controls on oil accumulations, lower Brushy Canyon Formation, southeast New Mexico, *in* DeMis, W.D., Nelis, M.K., and Trentham, R.C., The Permian Basin: proving ground for tomorrow's technologies: West Texas Geological Society, Publication 00-109, pp. 9-18.

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- Justman, H.A., and **Broadhead, R.F.**, 2000, Source rock analysis for the Brushy Canyon Formation, Delaware Basin, southeastern New Mexico, *in* DeMis, W.D., Nelis, M.K., and Trentham, R.C., The Permian Basin: proving ground for tomorrow's technologies: West Texas Geological Society, Publication 00-109, pp. 211-220.
- Broadhead, R.F., 2000, Petroleum systems in Pennsylvanian elevator basins of New Mexico (abstract): American Association of Petroleum Geologists, Bulletin, v. 84, p. 1236.
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- Justman, H.A., and **Broadhead, R.**, 2000, An evaluation of the source rock, reservoir rock, and sequence stratigraphy for the Brushy Canyon Formation's hydrocarbon accumulations of the Delaware Basin, southeastern New Mexico (abstract): American Association of Petroleum Geologists, Bulletin, v. 84, p. 1241.
- Weiss, W.W., **Broadhead, R.**, and Sung, A., 2000, Risk reduction with a fuzzy expert exploration tool (abstract): American Association of Petroleum Geologists, Bulletin, v. 84, p. 1246.
- Broadhead, R.F., 1999, Underdeveloped oil fields in Upper Pennsylvanian and Lower Permian carbonates of southeast New Mexico: initial development missed major reserves: The Leading Edge, September 1999, pp. 1012-1017.
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- New Mexico Tech, Geology 460 Class (N. Derrick, D. Hart, H. Justman, D. Leiphart, D. Medford, R. Robinson, T. Sande, A. Trivitt, **R. Broadhead**), 1999, Kenmnitz Morrow, *in* Worthington, R.E., and Brown, M., eds., A symposium of the oil and gas fields of southeastern New Mexico, 1999 supplement, Pennsylvanian gas fields: Roswell Geological Society, pp. 204-207.
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- Broadhead, R.F., 1998, Underdeveloped fields in southeast New Mexico: major primary reserves remain after initial development, *in* Cox, D., ed., Upper Pennsylvanian and Wolfcampian mixed carbonate-siliciclastic systems, Sacramento Mountains, New Mexico: Permian Basin Section SEPM, Publication 98-104, pp. 159-170.
- Broadhead, R., 1998, Upper Pennsylvanian and Lower Permian carbonate reservoirs of southeast New Mexico: examples of underdeveloped oil fields, *in* Proceedings volume for Frontier and underexplored basins of New Mexico: Petroleum Technology Transfer Council, pages not consecutively numbered.
- Broadhead, R., 1998, Redevelopment of old fields – Upper Pennsylvanian and Lower Permian of southeast New Mexico: Rejuvenation of underdeveloped fields yields major reserves (abstract): *in* abstract volume for Pennsylvanian and Permian Geology and Petroleum in the Southern Midcontinent – a workshop: Oklahoma Geological Survey and U.S. Department of Energy, p. 19.
- Broadhead, R.F., 1997, Redevelopment of old fields – Upper Pennsylvanian and Lower Permian of southeast New Mexico (abstract): American Association of Petroleum Geologists, Official program for 1997 annual convention, p. A15.

Permian Basin publications (continued):

- Broadhead, R.F., Luo, F., and Speer, S.W., 1996, Oil and gas resources at the WIPP site, Eddy County, New Mexico (abstract): American Association of Petroleum Geologists, Proceedings of Southwest Section Annual Meeting, El Paso, Texas, p. 18.
- Broadhead, R.F., and Luo, F., 1996, Oil and gas resources in the Delaware Mountain Group at the WIPP site, Eddy County, New Mexico, *in* Demis, W.D., and Cole, A.G., eds., The Brushy Canyon play in outcrop and subsurface: concepts and examples: Permian Basin Section SEPM, Publication 96-38, pp. 119-130.
- Broadhead, R.F., Luo, F., and Speer, S.W., 1996, Oil and gas resources at the WIPP site, Eddy County, New Mexico (abstract): American Association of Petroleum Geologists, Proceedings of Southwest Section Annual Meeting, El Paso, Texas.
- Broadhead, R.F., Luo, F., and Speer, S.W., 1995, Chapter XI: Oil and gas resource estimates, in Evaluation of mineral resources at the Waste Isolation Pilot Plant (WIPP) Site: New Mexico Bureau of Mines and Mineral Resources, Report to Westinghouse Electric Corporation, Waste Isolation Division, 135 pp. + 7 oversize plates.
- Broadhead, R.F., and Speer, S.W., 1995, Oil and gas in the New Mexico part of the Permian Basin: Roswell Geological Society, Symposium of oil and gas fields of southeastern New Mexico, 1995 supplement, pp. 32-49.
- Broadhead, R.F., 1993, PB, Permian Basin Permian plays, *in* Atlas of major Rocky Mountain gas reservoirs: New Mexico Bureau of Mines and Mineral Resources, p. 138.
- Broadhead, R.F., 1993, PB-1, Upper Guadalupian platform, *in* Atlas of major Rocky Mountain gas reservoirs: New Mexico Bureau of Mines and Mineral Resources, p. 139-140.
- Broadhead, R.F., 1993, PB-2, Delaware Mountain basinal sandstone, *in* Atlas of major Rocky Mountain gas reservoirs: New Mexico Bureau of Mines and Mineral Resources, p. 141.
- Broadhead, R.F., 1993, PB-3, San Andres and Grayburg platform, *in* Atlas of major Rocky Mountain gas reservoirs: New Mexico Bureau of Mines and Mineral Resources, p. 142-143.
- Broadhead, R.F., 1993, PB-4, Glorieta and upper Yeso platform, *in* Atlas of major Rocky Mountain gas reservoirs: New Mexico Bureau of Mines and Mineral resources, p. 144.
- Broadhead, R.F., 1993, PB-5, Bone Spring basinal sediments, *in* Atlas of major Rocky Mountain gas reservoirs: New Mexico Bureau of Mines and Mineral Resources, p. 145.
- Broadhead, R.F., 1993, PB-6, Yeso platform, *in* Atlas of major Rocky Mountain gas reservoirs: New Mexico Bureau of Mines and Mineral Resources, 146-148 .
- Broadhead, R.F., 1993, PB-7, Abo platform carbonate, *in* Atlas of major Rocky Mountain gas reservoirs: New Mexico Bureau of Mines and Mineral resources, p. 149.
- Broadhead, R.F., 1993, PB-8, Abo fluvial/deltaic sandstone, *in* Atlas of major Rocky Mountain gas reservoirs: New Mexico Bureau of Mines and Mineral Resources, p. 150-151.
- Broadhead, R.F., 1993, PB-9, Wolfcamp carbonate, *in* Atlas of major Rocky Mountain gas reservoirs: New Mexico Bureau of Mines and Mineral Resources, p. 152.
- Broadhead, R.F., and Speer, S.W., 1993, Oil and gas in the New Mexico part of the Permian Basin: New Mexico Geological Society, Guidebook to 44th field conference, pp. 293-300.
- Broadhead, R.F., 1984, Stratigraphically controlled gas production from Abo red beds (Permian), east-central New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 183, 36 pp.
- Broadhead, R.F., 1984, Geology of gas production from "tight" Abo redbeds, east-central New Mexico: Oil and Gas Journal, v. 82, no. 24, pp. 147-150, 154-158.
- Broadhead, R.F., Speer, S.W., Kottlowski, F.E., MacMillan, J.R., Cappa, J.A., Scott, G.L., Brannigan, J.P., and Mitchell, S., 1983, Guidebook for field trip to Abo red beds (Permian), central and south-central New Mexico: Roswell Geological Society and New Mexico Bureau of Mines and Mineral Resources, 73 pp.
- Broadhead, R.F., 1983, "Tight" Abo gas sands, east-central New Mexico (abstract): American Association of Petroleum Geologists, Bulletin, v. 67, pp. 430.

SAN JUAN BASIN PUBLICATIONS:

- Broadhead, R.F., 2018, The Upper Mancos Shale in the San Juan Basin: Three oil and gas plays, conventional and unconventional (update): American Association of Petroleum Geologists, Search and Discovery, Article no. 11096, 22 p.
- Broadhead, R.F., 2015, The Upper Mancos Shale in the San Juan Basin: Three plays, conventional and unconventional: American Association of Petroleum Geologists, Search and Discovery, Document No. 10791, 39 p.
- Broadhead, R., 2013, The Mancos Shale and “Gallup” zones in the San Juan Basin: geologic framework, historical production, future potential: Presented to San Juan Basin Energy Conference, Farmington, New Mexico, March 18, 2013.
- Broadhead, R.F., and Hoffman, G., 2002, Oil, natural gas and coal potential of McKinley County, New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open-file report 470, 1 CD- ROM.
- Broadhead, R.F., 1997, Oil, natural gas, and groundwater in the San Juan Basin, a summary, *in* Proceedings of the 41st annual New Mexico water conference: New Mexico Water Resources Research Institute, pp. 79-88.
- Broadhead, R.F., 1986, Petroleum resource potential of western Rio Arriba County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file report 233, pp.34-64.
- Broadhead, R.F., 1986, Petroleum resource potential of San Juan County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file report 232, pp. 43-87.
- Broadhead, R.F., 1986, Petroleum resource potential of McKinley County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file report 231, pp. 72-123.
- Broadhead, R.F., 1984, Petroleum resource potential of the Northern Rio Puerco Resource Area, in Sandoval and Bernalillo Counties and adjacent parts of McKinley, Cibola, and Santa Fe Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file report 211, pp. 243-291.

ELEVATOR BASINS PUBLICATIONS (also see publications on Tucumcari Basin)

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- Broadhead, R.F., 2001b, New Mexico Elevator Basins 2, Petroleum systems described in Estancia, Carrizozo, Vaughn Basins: Oil and Gas Journal, v. 99.3, p. 31-35.
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- Broadhead, R.F., 1999, Petroleum source rocks in Pennsylvanian elevator basins of New Mexico (abstract): Transactions and abstracts of 1999 Southwest Section AAPG Convention, p. 89.
- Broadhead, R.F., and Chapin, C.E., 1999, Petroleum systems in late Paleozoic elevator basins, southern ancestral Rocky Mountains (abstract): American Association of Petroleum Geologists, 1999 annual convention, program, p. A16 .
- Broadhead, R.F., 1998, Oil and gas activities in New Mexico in 1997: New Mexico Geology, v. 20, no. 4, p. 89-96.
- Broadhead, R., 1998, Petroleum source rocks in late Paleozoic elevator basins: the Tucumcari, Estancia, Vaughn, and Carrizozo Basins (abstract), *in* Proceedings volume for Frontier and underexplored basins of New Mexico: Petroleum Technology Transfer Council, pages not consecutively

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TUCUMCARI BASIN PUBLICATIONS (including Sin Nombre area)

- Broadhead, R.F., 2004, Petroleum geology of the Tucumcari Basin – overview and recent exploratory activity: New Mexico Geology, v. 26, no. 3, p. 90-94.
- Broadhead, R.F., 2003, Petroleum potential of Sin Nombre area, east-central New Mexico: Transactions Southwest Section AAPG Convention, Fort Worth, Texas, CD-ROM.
- Broadhead, R.F., 2003, Petroleum potential of Sin Nombre area, east-central New Mexico: West Texas Geological Society, Bulletin, v. 42, no. 8, p. 4-9.
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- Broadhead, R.F., 2002, Geologic structure and petroleum source rocks of the Tucumcari Basin, east-central New Mexico (abstract) , in Transactions Southwest Section AAPG Convention: Roswell Geological Society, p. 76.
- Broadhead, R.F., and Jones, G., 2002, Petroleum potential of the Sin Nombre area, DeBaca, Roosevelt, Curry, Lincoln, Guadalupe, and Chaves Counties, New Mexico: a reconnaissance report: New Mexico Bureau of Geology and Mineral Resources, Open-file report 467, 1 CD-ROM.
- Broadhead, R.F., Frisch, K., and Jones, G., 2002, geologic structure and petroleum source rocks of the Tucumcari basin, east-central New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open-file report 460, 1 CD-ROM.
- Broadhead, R.F., Frisch, K., and Jones, G., 2002, Geologic structure and petroleum source rocks of the Tucumcari basin, east-central New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open-file report 460, 1 CD-ROM.
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- Broadhead, R.F., 1985, Stratigraphy and petroleum geology of Dockum Group (Triassic), northeastern New Mexico: New Mexico Geological Society, Guidebook to 36th field conference, pp. 307-314.
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- Broadhead, R.F., 1984, Subsurface petroleum geology of Santa Rosa sandstone (Triassic), northeast New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 193, 22 pp.

RATON AND LAS VEGAS BASINS PUBLICATIONS:

- Broadhead, R.F., 2015, Petroleum geology of the Las Vegas Basin: an overview, *in* Lindline, J., Petronis, M., and Zebrowski, J., eds., *Geology of the Las Vegas region: New Mexico Geological Society, Guidebook 66*, p. 253-260.
- Broadhead, R.F., 2012, Hydrocarbon-water and CO₂-water systems in the pre-Cretaceous section in the New Mexico part of the Raton Basin: *The Mountain Geologist*, v. 49, no. 2, p. 55-74.
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- Broadhead, R.F., 2009, Oil, natural gas and helium potential of the Chupadera Mesa area, Lincoln and Socorro Counties, New Mexico: *New Mexico Geological Society, Guidebook to 60th field conference*, p. 359-374.
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- Broadhead, R.F., 2002, Petroleum geology of the McGregor Range, Otero County, New Mexico: *West Texas Geological Society, Bulletin*, v. 42, no. 4, pp. 4-11.
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Broadhead, R.F., 1994, Have you ever wondered why New Mexico is so rich in oil and gas?: Lite Geology, Winter 1993, pp. 2-4.

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Ron Broadhead, Curriculum Vitae (November 2019)

Appendix B - Invited Presentations

Helium; geology of accumulations and relation to other gases in the reservoir, presented to Albuquerque Geological Society, Albuquerque NM, February 6, 2019

Relationship of helium and CO₂ to other gases in New Mexico reservoirs, presented at American Association of Petroleum Geologists Annual Conference and Exhibition, Salt Lake City UT, May 2018.

Marine Mancos Shale core, San Juan Basin, New Mexico. This was a 3-day core display presented at the American Association of Petroleum Geologists Annual Conference and Exhibition, Salt Lake City UT, May 2018.

Petroleum geology of New Mexico: An overview and recent developments, presented at Society of Professional Independent Earth Scientists Annual meeting, Santa Fe NM, June 12, 2018.

Oil and gas at the southeastern end of the San Juan Basin: Recent resurgence due to horizontal drilling in the Upper Mancos Shale, presented to Roswell Geological Society dinner meeting, Roswell NM, October 9, 2018.

Geology of helium resources in New Mexico, presented to Roswell Geological Society, March 14, 2017.

Helium occurrences and resources of New Mexico, presented to New Mexico Landman's Association, Roswell NM, November 15, 2017.

Helium: Geology of accumulations and relationship to other natural gases in the reservoir. Presented to AAPG Geoscience Technology Workshop, Houston TX, October 2016.

Carbon dioxide and helium gases in New Mexico: Distribution and relation to other gases in the reservoir, presented to Geological Society of America Annual Meeting, Denver CO, September 2016.

Exploring the potential linkages between oil-field brine reinjection, crystalline basement permeability, and triggered seismicity for the Dagger Draw oil field, southeastern New Mexico, USA using hydrologic modeling: Geological Society of America, Annual meeting abstracts, Denver CO, September 2016.

Mark Person of NMT EES Dept. was the speaker.

Petroleum geology of Mora County. Presented to Mora County Commission, February 23, 2016.

The Upper Mancos Shale in the San Juan Basin: Three plays, conventional and unconventional. Presented at monthly dinner meeting of Roswell Geological Society, November 10, 2015.

Overview of selected shale plays in New Mexico. Presented at City Different Petroleum Club, Santa Fe NM, July 30, 2015.

What are hydraulic fracturing and directional drilling? Presentation made in conjunction with F. David Martin, New Mexico Secretary of Energy, Minerals and Natural Resources at Annual meeting of New Mexico Rural Water Association, April 13, 2015.

Broadhead, R.F., 2014, Induced seismicity in New Mexico, presented to NM Tech Workshop on Induced Seismicity, August 21, 2014, Socorro NM.

Broadhead, R.F., 2014, Overview of selected shale plays in New Mexico, presented at Rocky Mountain Association of Geologists Luncheon meeting, August 6, 2014.

R. Broadhead, Invited Presentations (continued)

Broadhead, R.F., 2014, Mississippian of southeast New Mexico Part I: Carbonate stratigraphy, reservoir characteristics and plays, presented as Rocky Mountain Association of Geologists pre-luncheon talk, August 6, 2014.

Broadhead, R.F., Mississippian of southeast New Mexico Part II: The Barnett Shale, presented as Rocky Mountain Association of Geologists pre-luncheon talk, August 6, 2014.

Broadhead, R.F., 2014, Mississippian of southeast New Mexico Part III: The lower Morrow or “false” Barnett shale, presented as Rocky Mountain Association of Geologists pre-luncheon talk, August 6, 2014.

Broadhead, R.F., 2014, Hydraulic fracturing in NM presented to NM Tech Workshop on Hydraulic Fracturing, March 27, 2014, Socorro NM.

Broadhead, R.F., 2013, Shale plays in New Mexico: Independent Petroleum Association of New Mexico annual meeting, Albuquerque NM, August 9, 2013.

Broadhead, R., 2012, Helium in New Mexico: Geologic distribution and exploration possibilities. Presented to Permian Basin Section SEPM luncheon meeting, October 24, 2012.

Broadhead, R.F., 2012, Mississippian carbonates of southeastern New Mexico: stratigraphy and reservoir characteristics, presented to:
Albuquerque Geological Society luncheon meeting, March 7, 2012.
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Broadhead, R.F., 2012, Shale gas possibilities in New Mexico, presented to Shale Gas Conference sponsored by New Mexico Tech Center for Energy Policy, Hobbs, NM, January 12-13, 2012.

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Broadhead, R., 2010, Petroleum geologic framework of the Tucumcari Basin, east-central New Mexico, with a synopsis of recent exploratory activity: Society of Independent Professional Earth Scientists, 47th annual meeting, Colorado Springs CO, June 2010.

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Broadhead, R.F., 2009, Geologic history of naturally occurring CO₂ deposits in New Mexico, presented to Research Experience in Carbon Sequestration (RECS) symposium, Albuquerque, New Mexico, July 20, 2009.

Broadhead, R.F., 2009, Petroleum geology of the Tucumcari Basin, presented to Albuquerque Geological Society, January 7, 2009.

Broadhead, R.F., 2008, The natural gas potential of the Raton and Las Vegas Basins, north-central New Mexico, presented to Roswell Geological Society, November 11, 2008.

Broadhead, R.F., 2008, Core workshop and field trip – examples and analogues for the Tucumcari Basin, given for Shell Oil Company Western U.S. Tight Sands Exploration Team, October 20-22, 2008, Socorro NM.

Broadhead, R.F., 2008, The geology and uses of helium, presented at Rio Rancho Public Library, October 18, 2008.

R. Broadhead, Invited Presentations (continued)

Broadhead, R.F., 2008, Remaining oil and gas resources of New Mexico, presented to:
Four Corners Geological Society, September 19, 2008.
Roswell Geological Society, January 15, 2008.

An introduction to petroleum geology, with applications to New Mexico. Presented to Socorro Rotary Club, February 21, 2007.

Helium in New Mexico: Geologic distribution and exploration possibilities. Presented at Albuquerque Geological Society luncheon, February 7, 2007.

Underdeveloped oil fields in Upper Pennsylvanian and Lower Permian carbonate reservoirs of southeastern New Mexico: Initial development missed major reserves. Presented to American Association of Petroleum Geologists, 2006 Annual Convention, Houston TX, April 12, 2006.

Oil, natural gas and helium potential of Chupadera Mesa area. Presented to Roswell Geological Society, September 12, 2006.

Helium in New Mexico: geologic distribution and exploration possibilities, presented to:
Tulsa Geological Society, October 10, 2006.
Roswell Geological Society, Roswell NM, November 8, 2005.

Exploration possibilities for helium in New Mexico with emphasis on Socorro County. Presented to Socorro Rotary Club, December 7, 2005

Evaluation of potential for oil & gas inside Secretary's potash area. Presented to U.S. Bureau of Land Management Resource Advisory Committee, Socorro NM, September 22, 2005.

Remaining oil and natural gas resources of New Mexico, presented to:
Albuquerque Geological Society, Albuquerque NM, June 1, 2005
City Different Petroleum Club, Santa Fe NM, February 23, 2005.

Petroleum source rocks and structure of the Tucumcari Basin, east-central New Mexico. Presented to Tulsa Geological Society, Tulsa OK, May 24, 2005.

Oil, natural gas, and helium potential of Chupadera Mesa, central New Mexico. Presented to Midland, TX Chapter of the Society of Professional Earth Scientists, Midland TX, May 18, 2005.

Underdeveloped oil fields in Upper Pennsylvanian and Lower Wolfcampian carbonates of southeast New Mexico, presented to:
Mid-Continent Section Meeting of American Association of Petroleum Geologists, Wichita, Kansas, August 29, 1999.
Southwest Section Meeting of American Association of Petroleum Geologists, Abilene, Texas, March 2, 1999.
Albuquerque Geological Society, September 1997.

Petroleum source rocks in late Paleozoic elevator basins: the Tucumcari, Estancia, Vaughn, and Carrizozo Basins, presented to:
Four Corners Geological Society, Farmington, New Mexico, January 22, 1999.
Roswell Geological Society, Roswell, New Mexico, January 12, 1999.
Permian Basin Section SEPM, Midland, Texas, December 1998.

Petroleum geology of Tucumcari Basin, east-central New Mexico presented to Albuquerque Geological Society, November 1998.

R. Broadhead, Invited Presentations (continued)

Petroleum geology of Estancia Basin presented to Santa Fe Geological Society, February 1998.

Underdeveloped oil fields in the Upper Pennsylvanian and Lower Wolfcampian of southeast New Mexico presented to Albuquerque Geological Society, September 1997.

Petroleum Geology of Estancia Basin, New Mexico presented to Roswell Geological Society, March 1996.

Geology of Bravo dome carbon dioxide gas field: presented to:

American Association of Petroleum Geologists, Annual Meeting, April 1991

Roswell Geological Society, Roswell, NM, October 1991

West Texas Geological Society, Midland, TX, July 1992.

Petroleum geology of Pennsylvanian and Lower Permian strata, Tucumcari Basin: presented to:

Rocky Mountain Association of Geologists, Denver, CO, September 1987

West Texas Geological Society, Midland, TX, March 1989

Roswell Geological Society, Roswell, NM, April 1989

Albuquerque Geological Society, Albuquerque, NM, June 1989.

Abo sands in subsurface, southeast New Mexico: presented to:

Permian Basin Section SEPM, Midland, TX, March 1985

Albuquerque Geological Society, Albuquerque, NM, June 1985.