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**NEOGENE BASIN-FILL AQUIFER SYSTEMS OF THE BI-NATIONAL PASO DEL NORTE REGION—ADVANCES IN CHARACTERIZATION OF THEIR DEPOSITIONAL HISTORY AND HYDROGEOLOGIC FRAMEWORK**

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**Abstract**

Major progress has been made during the past decade in characterizing the depositional history and hydrogeologic framework of the basin-fill aquifer systems that collectively form the only significant groundwater resource in the Paso del Norte region of south-central New Mexico, western Trans-Pecos Texas, and north-central Chihuahua, Mexico. The region includes the Mesilla and Hueco-Tularosa basins of the Rio Grande rift tectonic province, and the Mesilla and El Paso Valleys of the Rio Grande/Bravo fluvial system. Most importantly, the El Paso/Ciudad Juárez/Las Cruces metro-area (with a population of about 2 million) is centered in the river-valley corridor. Hydrogeologic/GIS research described here was coordinated by the New Mexico Water Resources Research Institute; however, it is only part of several ongoing multi-institutional/disciplinary studies of surface-water and groundwater resources. For example, a new phase of hydrogeologic/geohydrologic investigations has recently been initiated in collaboration with El Paso Water Utilities-Hydrogeology and GIS Sections, and the Universidad Autónoma de Ciudad Juárez-Centro de Información Geográfica.

The two major aquifer systems of the Paso del Norte region comprise 1) intermontane-basin fill of the Neogene Santa Fe Group that is as much as 750 m thick; and 2) fluvial channel deposits of the Late Quaternary Rio Grande, which are confined to the inner river valley and less than 30 m thick. To date, their depositional history and hydrogeologic framework have been digitally characterized with two surficial maps, 36 cross sections, and a structure-contour map of the base of the Santa Fe Group. The most productive lithofacies assemblages in the basin-fill aquifer system are 1) fluvial and fluvial-deltaic sands of the *Upper Santa Fe hydrostratigraphic unit (HSU)* deposited by the ancestral Rio Grande; and 2) thick eolian-sand deposits in the *Lower Santa Fe HSU*. The latter lithofacies is mainly restricted to a 200-500 m depth zone below the Mesilla Valley floor. Pluvial lake and associated fluvial systems in the Tularosa Basin (*Lake Otero-NM*) and the Bolson de los Muertos (*Rio Casas Grandes/Lake Palomas-Chihuahua*) were major contributors to aquifer recharge in the Late Quaternary (~6 to 100 ka).

## Selected References

- Anderholm, S.K. and C.E. Heywood. 2003. *Chemistry and age of ground water in the southwestern Hueco Bolson, New Mexico and Texas*. U.S. Geological Survey Water-Resources Investigations Report 02-4237. 16 p.
- Bedinger, M.S., K.A. Sargent, and W.H. Langer (editors). 1989c. *Studies of geology and hydrology in the Basin and Range province, southwestern United States, for isolation of high-level radioactive waste -- evaluation of regions*. U.S. Geological Survey Professional Paper 1370-H. 61 p. (B1)
- Bryan, K. 1938. Geology and ground-water conditions of the Rio Grande depression in Colorado and New Mexico. In *Regional Planning: Part VI—The Rio Grande joint investigations in the upper Rio Grande basin in Colorado, New Mexico, and Texas, 1936-1937*. National Resources Committee, Washington, D. C., U. S. Government Printing Office. I: 196-225.
- Castiglia, P.J. and P.J. Fawcett, P.J. 2006. Large Holocene lakes and climate change in the Chihuahuan Desert. *Geology*. 34.2:113-116.
- Cliett, T. 1969. Groundwater occurrence of the El Paso area and its related geology: *New Mexico Geological Society Guidebook*. 20:209-214.
- Collins, E.W. and J.A. Raney. 2000. *Geologic map of west Hueco Bolson, El Paso region, Texas*. The University of Texas at Austin, Bureau of Economic Geology, Miscellaneous Map No. 40, scale 1:100,000.
- Connell, S. D., J.W. Hawley, and D.W. Love. 2005. Late Cenozoic drainage development in the southeastern basin and range of New Mexico, southeasternmost Arizona, and western Texas. In *New Mexico's Ice Ages*. Edited by S.G. Lucas, G.S. Morgan, and K.E. Zeigler. New Mexico Museum of Natural History and Science, Bulletin 28. 125-150.
- Darton, N.H. 1916. *Geology and Underground Water of Luna County, New Mexico*. U.S. Geological Survey Bulletin 618. 188 p.
- Eakin, T.E., D. Price, and J.R. Harill. 1976. *Summary appraisals of the nation's groundwater resources - Great Basin region*. U.S. Geological Survey Professional Paper 813-G. 37 p.
- Frenzel, P.F. and C.A. Kaehler. 1992. *Geohydrology and simulation of ground-water flow in the Mesilla Basin, Doña Ana County, New Mexico and El Paso County, Texas; with a section on water quality and geochemistry by S. K. Anderholm*. U.S. Geological Survey Professional Paper 1407-C. 105 p.
- Gile, L.H., J.W. Hawley, and R.B. Grossman. 1981. *Soils and geomorphology in a Basin and Range area of southern New Mexico—Guidebook to the Desert Project*. New Mexico Bureau of Mines and Mineral Resources Memoir 39. 222 p.
- Hawley, J.W. 2005. Five million years of landscape evolution in New Mexico: An overview based on two centuries of geomorphic conceptual-model development. In *New Mexico's Ice Ages*. Edited by S.G. Lucas, G. Morgan, and K.E. Zeigler. New Mexico Museum of Natural History & Science Bulletin No. 28. 9-93.
- Hawley, J.W. and J.F. Kennedy. 2004. *Creation of a digital hydrogeologic framework model of the Mesilla Basin and southern Jornada del Muerto Basin*. New Mexico Water Resources Research Institute Technical Completion Report 332, 105 p., with CD ROM including 2005 Addendum extending model into Rincon Valley and adjacent areas.
- Hawley, J.W. and J.M. Kernodle. 2000. Overview of the hydrogeology and geohydrology of the northern Rio Grande basin – Colorado, New Mexico, and Texas. In *Proceedings of the 44th Annual New Mexico Water Conference: The Rio Grande Compact: It's the Law*. Edited by C.T. Ortega Klett. New Mexico Water Resources Research Institute Report No.310. 46-38.
- Hawley, J.W. and R.P. Lozinsky. 1992. *Hydrogeologic Framework of the Mesilla Basin in New Mexico and Western Texas*. New Mexico Bureau of Mines and Mineral Resources Open File Report 323. 55 p.
- Hawley, J.W., J.F. Kennedy and B.J. Creel. 2001. The Mesilla Basin aquifer system of New Mexico, West Texas and Chihuahua—an overview of its' hydrogeologic framework and related aspects of

- groundwater flow and chemistry. In *Aquifers of West Texas*. Edited by R.E. Mace, W.F. Mullican III and E.S. Angle. Austin, Texas Water Development Board Report 356. 76-99.
- Hawley, J.W., F.E. Kottowski, W.S. Strain, W.R. Seager, W.E. King, and D.V. LeMone. 1969. The Santa Fe Group in the south-central New Mexico border region. In *Border Stratigraphy Symposium*. New Mexico Bureau of Mines and Mineral Resources Circular 104. 52-76.
- Hawley, J.W., B.J. Hibbs, J.F. Kennedy, B.J. Creel, M.D. Remmenga, M. Johnson, M. Lee, and P. Dinterman. 2000. *Trans-International Boundary aquifers in southwestern New Mexico*. New Mexico Water Resources Research Institute, New Mexico State University, prepared for U.S. Environmental Protection Agency-Region 6 and International Boundary and Water Commission; Technical Completion Report-Interagency Contract X-996350-01-3.126 p.
- Heywood, C. E. 1995. Investigation of aquifer-system compaction in the Hueco basin, Texas, USA. In *5<sup>th</sup> International symposium on land subsidence*. Delft, Netherlands. International Association of Hydrological Sciences Publication 234: 35-45.
- Heywood, C. E. and R.M. Yager. 2003. Simulated ground-water flow in the Hueco Bolson, an alluvial-basin aquifer system near El Paso, Texas. U.S. Geological Survey, Water Resources Investigations Report 02-4108. 27 p.
- Hibbs, B. 1999. *Hydrogeologic and water quality issues along the El Paso/Juarez corridor: An international case study*. Environmental & Engineering Geoscience. V:1:27-39.
- Hibbs, B. J. and B.K. Darling. 2005. Revisiting a classification scheme for U.S.-Mexico alluvial basin-fill aquifers. *Ground Water*. 43.5:750-763.
- Hibbs, B. J. and M. Merino. 2006. A geologic source of salinity in the Rio Grande aquifer near El Paso, Texas. *New Mexico Journal of Science*. 46 (in press).
- Hogan, J.E., F.M. Phillips, and B.R. Scanlon. 2004b. Introduction and overview. In *Groundwater recharge in a desert environment: the southwestern United States*. Edited by Hogan, J.E., F.M. Phillips, and B.R. Scanlon. Washington, D.C., American Geophysical Union, Water Science and Application 9. 1-14.
- Hutchison, W.R. 2006. *Groundwater management in El Paso, Texas*. Boca Raton, FL, Dissertation.com. 329 p.
- Kernodle, J.M. 1992b. *Summary of U.S. Geological Survey ground-water-flow models of basin-fill aquifers in the Southwestern Alluvial Basins region, Colorado, New Mexico, and Texas*. U.S. Geological Survey Open File Report 90-361. 81 p.
- Kernodle, J.M. 1996. *Simulation of Ground-water Flow in the Albuquerque Basin, Central New Mexico, 1901-95, with Projections to 2020*. U.S. Geological Survey Water Resources Investigations Report. 59 p.
- King, W.E., J.W. Hawley, A.M. Taylor, and R.P. Wilson. 1971. *Geology and Ground-water Resources of Central and Western Doña Ana County, New Mexico*. New Mexico Bureau of Mines and Mineral Resources Hydrologic Report 1. 64 p.
- Knowles, D. B. and R.A. Kennedy. 1958. *Ground-water resources of the Hueco Bolson northeast of El Paso, Texas*. U.S. Geological Survey Water-Supply Paper 1426. 186 p. (E3)
- Lee, W. T. 1907. *Water Resources of the Rio Grande Valley in New Mexico*. U.S. Geological Survey Water-Supply Paper 188. 59 p.
- Leggat, E. R. 1962. *Development of ground-water of the El Paso district, Texas*. Texas Water Commission, Bulletin 6204. 56 p.
- Leggat, E. R. and M.E. Davis. 1962. *Analog model study of the Hueco Bolson near El Paso, Texas*. Texas Water Development Board. 26 p.
- Leggat, E.R., M.E. Lowry, and J.W. Hood. 1962. *Ground-water resources of the lower Mesilla Valley, Texas and New Mexico*. Texas Water Commission Bulletin 6203. 191p.
- Mack, G.H. and W.R. Seager. 1990. Tectonic controls on facies distribution of the Camp Rice and Palomas Formations (Pliocene-Pleistocene) in the southern Rio Grande rift. *Geological Society of America Bulletin*. 102: 45-53.
- Mack, G.H., D.W. Love, and W.R. Seager. 1997. Spillover models for axial rivers in regions of continental extension: The Rio Mimbres and Rio Grande in the southern Rio Grande rift, USA. *Sedimentology*. 44:637-652.
- Mattick, R. E. 1967. *A seismic and gravity profile across the Hueco bolson, Texas*. U.S. Geological Survey, Professional Paper 575-D. D85-D91.

- Meinzer, O.E. and R.E. Hare. 1915. *Geology and Water Resources of Tularosa Basin, New Mexico*. U.S. Geological Survey Water-Supply Paper 343. 317 p.
- Meyer, W.R. 1976. *Digital model for simulated effects of ground water pumping in the Hueco Bolson, El Paso area, Texas, New Mexico, and Mexico*. U.S. Geological Survey Water-Resources Investigations 58-75. 31 p.
- Mifflin, M.D. 1988. Region 5, Great Basin. In *Hydrogeology—The Geology of North America*. Edited by W. Back, J.S. Rosenshein, and P.R. Seaber. Boulder, CO, Geological Society of America DNAG. O-2. 69-78.
- Myers, R. G. and B.R. Orr. 1986. *Geohydrology of the aquifer in the Santa Fe Group, northern West Mesa of the Mesilla Basin near Las Cruces, New Mexico*. U.S. Geological Survey Water-Resources Investigations Report 84-4190. 37 p.
- Naus, C.A. 2002. Conceptual model of the bolson-fill aquifer, Soledad Canyon area, Doña Ana County, New Mexico. *New Mexico Geological Society Guidebook*. 53:309-318.
- Nickerson, E. L. 2006. *Description of piezometers and ground-water-quality characteristics at three new sites in the Lower Mesilla Valley, Texas, and New Mexico*. U.S. Geological Survey Scientific Investigations Report 2005-5248. 27 p. Persistent URL: <http://pubs.water.usgs.gov/sir20055248>
- Nickerson, E. L., and R.G. Myers. 1993. *Geohydrology of the Mesilla ground-water basin, Doña Ana county, New Mexico, and El Paso County, Texas*. U.S. Geological Survey Water-Resources Investigations Report 92-4156. 89 p.
- Orr, B.R. and D.W. Risser, D.W. 1992. *Geohydrology and potential effects of development of freshwater resources in the northern part of the Hueco Bolson, Doña and Otero Counties, New Mexico, and El Paso County, Texas*. U.S. Geological Survey Water-Resources Investigations Report 91-4082. 92 p.
- Peterson, D.M., R. Khaleel, and J.W. Hawley. 1984. *Quasi Three-dimensional Modeling of Groundwater Flow in the Mesilla Bolson, New Mexico*. New Mexico Water Resources Research Institute Technical Completion Report No. 178. 185 p.
- Phillips, F. M., M.A. Walvoord, and E.E. Small. 2004. Effects of environmental change on groundwater recharge in the American Southwest. In *Groundwater recharge in a desert environment: the southwestern United States*. Edited by Hogan, J.E., F.M. Phillips, and B.R. Scanlon. Washington, D.C., American Geophysical Union, Water Science and Application 9. 273-294.
- Phillips, F.M., J.F. Hogan, S.K. Mills, and J.M.H. Hendrickx. 2002. Environmental tracers applied to quantifying causes of salinity in arid-region rivers: Preliminary results from the Rio Grande, southwestern USA. In *Water resources perspectives: Evaluation, management and policy*. Edited by A.S. Alsharhan and W.W. Wood. Amsterdam, Elsevier. 327-334.
- Reeves, C.C., Jr. 1969. Pluvial Lake Palomas, northwestern Chihuahua, Mexico. *New Mexico Geological Society Guidebook* 20. 143-154.
- Reiter, M. 2001. Using precision temperature logs to estimate horizontal and vertical groundwater flow components. *Water Resources Research*. 37: 3: 663-674.
- Sayre, A. N. and P. Livingston. 1945. *Ground-water resources of the El Paso area, Texas*. U.S. Geological Survey Water-Supply Paper 919. 190 p.
- Sayre, A.N. and E.L. Stephenson. 1937. The use of resistivity methods in the location of salt-water bodies in the El Paso, Texas, area. *American Geophysical Union Transactions*. 18<sup>th</sup> Annual Meeting. 393-398.
- Scanlon, B.R., B.K. Darling, and W.F. Mullican III, 2001, Evaluation of Groundwater recharge in basins of Trans-Pecos Texas. In *Aquifers of West Texas*. Edited by R.E. Mace, W.F. Mullican III and E.S. Angle. Austin, Texas Water Development Board Report 356. 26-40.
- Seager, W.R. and P. Morgan. 1979. Rio Grande rift in southern New Mexico, west Texas, and northern Chihuahua. In *Rio Grande Rift: Tectonics and Magnetism*. Edited by R.E. Riecker. Washington, D.C., American Geophysical Union. 87-106.
- Seager, W.R., J.W. Hawley, F.E. Kottowski, and S.A. Kelley. 1987. *Geology of the east half of Las Cruces and northeast El Paso*. 1x2 degree sheets, New Mexico, New Mexico Bureau of Mines and Mineral Resources Geologic Map GM-57, scale 1:125,000.
- Sharp, J.M., Jr., 2001, Regional groundwater flow systems in basins in Trans-Pecos Texas. In *Aquifers of West Texas*. Edited by R.E. Mace, W.F. Mullican III and E.S. Angle. Austin, Texas Water Development Board Report 356. 66-75.

- Slichter, C.S. 1905a. *Field measurements of the rate of movement of underground waters*. U.S. Geological Survey Water-Supply and Irrigation Paper 140. 122 p.
- Slichter, C.S. 1905b. *Observations on ground waters of the Rio Grande valley*. U.S. Geological Survey Water-Supply Paper 141. 83 p.
- Theis, C.V., 1938, Ground water in the middle Rio Grande valley. In *Regional Planning: Part VI—The Rio Grande joint investigations in the upper Rio Grande basin in Colorado, New Mexico, and Texas, 1936-1937*. National Resources Committee, Washington, D. C., U. S. Government Printing Office. I: 268-291.
- Wade, S.C. and M. Reiter. 1994. Hydrothermal estimation of vertical ground-water flow, Cañutillo, Texas. *Ground Water*. 32. 5: 735-742.
- Walvoord, M.A., and Scanlon, B.R., 2004, Hydrologic processes in deep vadose zones in interdrainage arid environments. In *Groundwater recharge in a desert environment: the southwestern United States*. Edited by Hogan, J.E., F.M. Phillips, and B.R. Scanlon. Washington, D.C., American Geophysical Union, Water Science and Application 9. 15-28.
- Wilson, C. A. and R.R. White. 1984. *Geohydrology of the central Mesilla Valley, Doña Ana County, New Mexico*. U. S. Geological Survey, Water-resources Investigations Report 82-444. 144 p.
- Wilson, C.A., R.R. White, R.B. Orr, and R.G. Roybal. 1981. *Water Resources of the Rincon and Mesilla Valleys and Adjacent Areas*. New Mexico State Engineer Technical Report 43. 514 p.
- Witcher, J.C., J.P. King, J.W. Hawley, J.F. Kennedy, J. Williams, M. Cleary and L. Bothern. 2003. *Sources of Salinity in the Rio Grande and Mesilla Basin Groundwater*. New Mexico Water Resources Research Institute, Technical Completion Report No. 325. 168 p, with appendices and plates on CD ROM.
- Woodward, D.G. and R.G. Myers. 1997. *Seismic investigation of the buried horst between the Jornada del Muerto and Mesilla ground-water basins near Las Cruces, Doña Ana County, New Mexico*. U.S. Geological Survey Water-Resources Investigations Report 97-4147. 45 p.
- Zohdy, A. A. R. 1969. The use of Schlumberger and equatorial soundings in groundwater investigations near El Paso, Texas. *Geophysics*. 4: 713-728.