From 1995 to 2001, the U.S. Geological Survey, together with other federal, state, and local governments, agencies and tribes, conducted an investigation of the Middle Rio Grande Basin (MRGB). The investigation was designed to improve the understanding of the hydrology, geology, and land surface characteristics of the MRGB and to provide the scientific information needed for water-resources management. One component of this investigation was a study using chemical and isotopic data from groundwater to characterize groundwater flow throughout the basin.

The MRGB, as defined for the study of groundwater chemistry, covers approximately 3,060 square miles in central New Mexico’s Rio Grande Valley. It extends from Cochiti Lake, about 40 miles north of Albuquerque, downstream to near San Acacia about 55 miles south of Albuquerque.

**Sampling and Analyses**

As part of this study, 280 wells — including 116 monitoring wells, 34 domestic wells, 82 production wells, and 45 windmills — and eight springs were sampled throughout the MRGB during the summers of 1996 through 1998.

Concentrations of environmental tracers and other chemical and isotopic substances were measured in the groundwater samples. The analyses included major- and minor-element chemistry, tritium (³H), tritiogenic helium-3 (³He), chlorofluorocarbons (CFCs: CFC-11, CFC-12, CFC-113), sulfur hexafluoride (SF₆), oxygen-18 (¹⁸O) and deuterium (²H) in water; carbon-13 (¹³C) and carbon-14 (¹⁴C) of dissolved inorganic carbon (DIC); sulfur-34 (³⁴S) of dissolved sulfate; and dissolved gases, including oxygen, nitrogen, argon, methane, helium, neon, and carbon dioxide.

Most of the wells sampled intercept water in the upper 500 feet of the Upper Santa Fe aquifer. However, geochemical data from a series of piezometer nests in the vicinity of Albuquerque provided additional data on variations of the chemical parameters, to depths as much as 1500 feet below the water table.

To gain information about potential sources of recharge to the aquifer system, water from the Rio Grande and adjacent drains and laterals, Tijeras Arroyo, Bear Canyon, the Rio Puerco and the Jemez River also was sampled and analyzed variously for CFCs, stable isotopes, tritium, and major- and minor-element chemistry on a monthly basis. Samples of air and unsaturated zone gas were analyzed for CFCs, SF₆, and ¹³C of CO₂ gas.

In addition, groundwater samples were collected at all 91 operational City of Albuquerque production wells in the summer of 1997 for analysis of stable isotopes. Archived groundwater samples from City of Albuquerque production wells, water from the Rio Grande, and precipitation from the 1980s also were analyzed for stable isotopes.

The geochemical data were used to:
- Identify recharge areas.
- Date the young (0 to 50 years) and old (greater than 1000 years) water in the aquifer.
- Trace the movement of groundwater throughout the basin.
- Estimate recharge rates.
- Trace seepage from the Rio Grande and from the drains and lateral that has entered the Santa Fe Group aquifer in the Albuquerque area.
- Provide geochemical data to help refine the USGS groundwater flow model developed for the MRGB.

**Results Reveal Patterns**

The results of the analyses show significant regional patterns that can be mapped throughout the basin, many with a strong north-south component. These patterns appear to reflect recharge from the basin margins and from the Rio Grande. Other more local patterns appear to delineate recharge from the Rio Puerco, the Ladron Peak area to the southwest, Abo Arroyo, and Tijeras Arroyo.

Groundwater of the MRGB shows large variations in the isotopic compositions of hydrogen and oxygen. In the general area of Albuquerque, variations of approximately 10 to 15 per mil in δD appear to separate groundwater derived from the eastern mountain front from groundwater derived from the Rio Grande. Some stable-isotope values in a north-south striking zone extending from the Jemez River along the western half of the basin to areas southwest of Albuquerque are depleted relative to water from the Rio Grande. The isotopically depleted waters are also some of the oldest waters in the basin and probably represent water recharged in the area of the Jemez Mountains during the last glacial period.

Compiled from U.S. Geological Survey sources listed at the end of this article

Niel Plummer (USGS, Reston) collecting CFC sample in the Middle Rio Grande Basin (photo by F.E. Gebhardt, USGS, Albuquerque).
some 20,000 radiocarbon years ago. Carbon-14 (\(^{14}\text{C}\), a radioactive isotope with a half-life of 5730 years) was used to date groundwater recharged in the MRGB during about the past 30,000 years. Because the chemical and isotopic data indicate little effect of geochemical reactions on radiocarbon activity along flow paths in the primarily siliciclastic basin-fill sediment, unadjusted radiocarbon ages appear to provide reasonable age estimates for most groundwater in the basin. Preliminary unadjusted radiocarbon ages suggest a bimodal distribution of groundwater ages throughout the basin. The \(^{14}\text{C}\) data indicate relatively young waters, about seven thousand years old, along most of the basin margins, and in approximately the upper 200 feet of the inner valley sediment. Very old water, 18 to 20 thousand years old, occurs through most of the western half of the basin and at depths greater than 500 feet below the water table.

Chlorofluorocarbon, tritium, and helium data are being used to recognize areas that received recharge within the past 30 to 50 years. These tracers of modern recharge are found in some groundwater and springs near the basin margins and arroyos and in groundwater from the upper 200 feet of the inner valley. CFCs and/or tritium data are also being used to recognize water samples with potential for contamination of old \(^{14}\text{C}\) with modern sources.

This study has demonstrated that chemical and isotopic data can be used to improve the understanding of regional groundwater flow systems such as that of the Middle Rio Grande Basin. Sources of water to the basin-fill aquifer were recognized and were shown to delineate groundwater flow paths. Radiocarbon ages were used to determine travel times along flow paths, and to estimate modern and paleorecharge rates to the aquifer. Modern recharge rates estimated from the spatial- and depth-related radiocarbon ages were less than 20 percent of the previously-used recharge rate for the groundwater flow model (Kernodle et al., 1995) for the basin. Recharge rates during the last glacial period were estimated to be at least 6-fold greater than the modern radiocarbon-based recharge rates. This improved understanding of groundwater sources and ages is being used to further refine the U.S. Geological Survey groundwater flow model for the MRGB (Sanford et al., 2000).

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References


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