Geochemistry, radiocarbon ages, and paleorecharge conditions along a transect in the central High Plains aquifer, southwestern Kansas, USA

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Water samples from short-screen monitoring wells installed along a 90-km transect in southwestern Kansas were analyzed for major ions, trace elements, isotopes (H, B, C, N, O, S, Sr), and dissolved gases (He, Ne, N_2, Ar, O_2, CH_4) to evaluate the geochemistry, radiocarbon ages, and paleorecharge conditions in the unconfined central High Plains aquifer. The primary reactions controlling water chemistry were dedolomitization, cation exchange, feldspar weathering, and O_2 reduction and denitrification. Radiocarbon ages adjusted for C mass transfers ranged from <2,600 (^{14}C) yr B.P. near the water table to 12,800±900 (^{14}C) yr B.P. at the base of the aquifer, indicating the unconfined central High Plains aquifer contained a stratified sequence of ground water spanning Holocene time. A cross-sectional model of steady-state ground-water flow, calibrated using radiocarbon ages, is consistent with recharge rates ranging from 0.8 mm/yr in areas overlain by loess to 8 mm/yr in areas overlain by dune sand. Paleorecharge temperatures ranged from an average of 15.2±0.7°C for the most recently recharged waters to 11.6±0.4°C for the oldest waters. The temperature difference between Early and Late Holocene recharge was estimated to be 2.4±0.7°C, after taking into account variable recharge elevations. Nitrogen isotope data indicate NO_3 in paleorecharge (average concentration = 193 µM) was derived from a relatively uniform source such as soil N, whereas NO_3 in recent recharge (average concentration = 885 µM) contained N from varying proportions of fertilizer, manure, and soil N. Deep water samples contained components of N_2 derived from atmospheric, denitrification, and deep natural gas sources. Denitrification rates in the aquifer were slow ($5\pm2\times10^{-3}$ µmol N L^{-1} yr^{-1}), indicating this process would require >10,000 years to reduce the average NO_3 concentration in recent recharge to the Holocene background concentration.