

Davis, S.N., L.D. Cecil, M. Zreda and S. Moysey, 2001, Chlorine-36, bromide, and the origin of spring water, *Chemical Geology* 179 (1-4), 3-16.

Natural ratios of chlorine-36 (^{36}Cl) to stable chlorine (i.e., $^{36}\text{Cl}/\text{Cl} \times 10^{-15}$) vary in shallow groundwater of the United States from about 50 in coastal areas to about 1400 in the northern Rocky Mountains. Ratios lower than these indicate the presence of chloride (Cl^-) that has been isolated from the atmosphere for hundreds of thousands of years, if not longer. Higher ratios, which can exceed 5000, usually originate from fallout from testing thermonuclear devices in the western Pacific in the 1950s.

Natural mass ratios of chloride to bromide (Cl^-/Br^-) in precipitation vary in the United States from about 250 in coastal areas to about 50 in the north-central states. Lower ratios may suggest contamination from human sources. Higher ratios, which may exceed 2000, commonly reflect the dissolution of halite. Seawater has a Cl^-/Br^- ratio of 290.

Both ^{36}Cl and Cl^-/Br^- ratios have been measured in 21 samples of spring water collected from springs in 10 different states. Brackish water from Saratoga Springs area in New York has low values for both ^{36}Cl and Cl^-/Br^- ratios. This indicates that a large component of the water has a very deep origin. Brackish water from Alexander Springs in Florida has a low ^{36}Cl ratio but a high Cl^-/Br^- ratio similar to seawater. This suggests the addition of ancient seawater that may be trapped in the aquifer. Big Spring in Iowa discharges water with a very high Cl^-/Br^- ratio but a moderate ^{36}Cl ratio. The high ratio of Cl^-/Br^- may be produced by dissolution of road salt or agricultural chemicals. Of the 21 springs sampled, only 10 appeared to have potable water not significantly affected by human activity.

Chlorine-36 from testing of nuclear devices is still being flushed out of four of the spring systems that were sampled. Thus, more than 45 years have passed since ^{36}Cl was introduced into the aquifers feeding the springs and the systems, as yet, have not been purged.