Hydrogeochemistry: The Past 25 and the Next 25 Years

Geochemical processes occur in every segment of the hydrological cycle. Hydrogeochemistry is the scientific discipline that characterizes the chemical and isotopic compositions of surface and groundwaters and that deciphers the chemical processes and mechanisms that determine these characteristics. The objective of hydrogeochemistry is to interpret, quantitatively and mechanistically, the chemical and isotopic compositions of groundwater and these compositions’ spatial and temporal evolution that is due to both natural processes and human perturbation.

The past twenty-five years saw transformation of this scientific discipline from “witch’s brew” into a credible science, and it has become an indispensable tool. In particular, tremendous progress has been seen in four areas of research and practice: (1) the use of isotopic and chemical tracers to quantify groundwater recharge and submarine groundwater discharge; (2) the kinetics of chemical reactions and geochemical modeling; (3) the mineral-water interfaces and control of contaminant fate and transport; and (4) the microbial process control of groundwater chemistry.

For the next twenty-five years, the warming climate, siting of geological repository for nuclear wastes in many countries, geological carbon sequestration, intensified agriculture, and rapid deterioration of water quality in the less developed world will all put the sustainability of water resources in peril. Hydrogeochemistry leads efforts to address these important issues. We will likely see watershed scale models that closely link hydrogeochemistry to atmospheric processes and biogeochemical cycles. Technological breakthrough in mass spectrometers, synchrotron-based techniques, remote logger of geochemical sensors, and big data technology will all make hydrogeochemical data abundant and accessible.