work has been performed. This publication should be in the libraries of all facilities where basic or applied actinide chemistry is studied or used as well as on the bookshelves of those working in various aspects of the field of actinide solution chemistry. It should also be a useful addition to the libraries of other institutions where the kinetics of oxidation-reduction reactions in solution are studied.

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Isotope Techniques in Groundwater Hydrology 1974, Volumes I and II
(Proceedings of an International Atomic Energy Agency Symposium)

Publishers	Unipub, Inc. (1974)
Price	$24.00 each volume
Pages	Vol. I, 504; Vol. II, 499
Reviewer	Donald G. Jacobs

The use of isotopes in groundwater hydrology began with the use by Willard Libby of ^{14}C, and later ^{3}H, for dating. Isotope techniques in groundwater hydrology have become more refined over the past few decades and have been extended to nonradioactive isotopes.

This two-volume book represents the proceedings of the fourth symposium on the subject of isotope hydrology organized by the International Atomic Energy Agency (IAEA) and held in Vienna on March 11-15, 1974, and includes papers devoted to the development and application of isotope techniques. Unlike the preceding symposia in this series, this symposium and proceedings were limited to groundwater hydrology.

The symposium was attended by 196 participants from 38 countries and 5 international organizations. The proceedings consists of 51 papers presented at the symposium and organized into 7 subject areas. As typical of the proceedings of IAEA meetings, formal discussion of the papers that took place at the meeting is included.

The 27 papers in Vol. I discuss the results of studies in which measured concentrations of environmental isotopes were used in conjunction with classical hydrologic measurements in interpretation of local and regional hydrology. Tritium and ^{14}C are useful in studies of the dynamics of hydrologic systems. Measurements of these radioisotopes provide an estimate of the apparent age of the water and, in conjunction with other hydrologic measurements, can be used to estimate rates of recharge. Further refinement on the rate of recharge and the direction and velocity of flow is possible by considering spatial distribution of concentrations and relating these to the concentration history of recharge waters. Measurement of ^{13}C provides a means for adjustment of ages determined by ^{14}C.

Stable environmental isotopes (^{2}H and ^{18}O) are useful in determining the origin of recharge waters. The variation of ^{18}O concentration with altitude allows the hydrologist to determine the altitude of the recharge zone. Deuterium and ^{18}O measurements, in conjunction with determination of the age of water in various formations, can be used to infer climatic changes in the region of study.

Measurement of isotopic compositions in geothermal waters is useful in determining the origin and mixing of groundwater sources. Panichi et al. used variations in ^{18}O and ^{3}H with time in geothermal fields to determine progressive modifications in the field during exploitation. They also suggest that time variations could be useful in checking the effects of reinjection of waste water into the field.

Although the measurement of environmental isotopes provides useful information in groundwater studies, there are some problems in their use and interpretation, and these are addressed in a number of papers and in the recorded discussions. In fractured formations where rates of movement are fast relative to the rates of mixing, both temporal and spatial variations in concentrations are likely to be greater than in well-mixed systems. Sauzay sampled rainwater falling into and water percolating from lysimeters to establish a relationship between the two. The temporal concentrations in the percolate, as one would anticipate, always show less variation than in the rainwater.

Winograd and Farlekas discuss limitations of assumptions commonly used in interpretation of information on ^{14}C in groundwater systems. They point out that a major source of CO_2, in addition to that generated in the soil zone, can affect the dissolved carbonate content of water. Also, in thick aquifers, there may be significant variations of water chemistry and isotope chemistry with depth; in studies of such systems, water should be sampled at different depths. They state that regular variations in ^{14}C and $\delta^{13}C$ down the hydraulic gradient do not guarantee a meaningful interpretation of either absolute or relative groundwater velocities.

Argon-39 techniques are useful for dating water as the $t_{1/2}$ of 269 yr fills the gap between $^{3}H(t_{1/2} = 12.3$ yr) and $^{14}C(t_{1/2} = 5730$ yr). Argon is a noble gas and thus exhibits simple geochemical and hydrologic behavior. Isotopic ratios of $^{234}U/^{238}U$, $^{34}S/^{32}S$, and $^{15}N/^{14}N$ also can be used to provide useful information in hydrologic studies.

Most of the papers deal with studies of particular groundwater systems and are generally of more interest to hydrologists than to the typical member of the American Nuclear Society (ANS). The papers by Isaacson et al. and by Robertson are of interest to ANS members since they represent work undertaken to describe the movement of radionuclides discharged into the ground. Studies at the Hanford reservation indicate that meteoric water does not percolate to the water table, but rather moves downward only a few meters during autumn and winter and is removed by evaporation and evapotranspiration during the summer. There are also several papers devoted to further development and application of mathematical

models for predicting the movement and dispersing of groundwater. Those concerned with the potential movement of radionuclides in groundwater systems should be interested in these developments.

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Californium-252 in Teaching and Research

Authors	E. J. Hall and H. H. Rossi
Publisher	International Atomic Energy Agency, Vienna (1974) (Distributed by UNIPUB)
Pages	141
Price	$7.00
Reviewer	Arthur F. Scott

The authors of this small volume state that it was prepared "to promote the safe introduction of the man-made nuclide californium-252 into the teaching programs of universities and research institutes in Member States of the International Atomic Energy Agency." Californium-252 decays both by spontaneous fission and alpha emission and is a source of mixed gamma rays and neutrons. The use and handling of the nuclide, therefore, present special problems for the experimenter. The first part of the book (11 chapters) deals with radiation physics and methods of measuring the quantity and quality of different types of radiation; it also reviews the phenomena generally treated as "biological effects of radiation." The discussion of radiological physics and radiation protection focuses on first principles and on material not easily accessible in published form.

The second half of the book (nine chapters) is a laboratory manual describing a range of experiments in physics and radiobiology. It is stated that "the aim of the manual is to guide postgraduate university students in the safe conduct of instructive experiments involving this mixed gamma-ray and neutron emitter." The introductory experiments illustrate the characteristics of detection instruments and the principles of radiation physics. Five major experiments involving plant and animal material are designed to demonstrate radiation effects. The experimental part of the book contains very interesting material which is well presented. It must be noted, however, that some of the experiments call for special equipment; one experiment, indeed, "can only be performed if a number of californium-252 sources of relatively large radioactive content are available." On the other hand, three experiments are presented as low dose-rate experiments with "californium-252 and/or radium" as sources.

The volume contains two appendices as follows:

Appendix I: Physical Characteristics of Californium-252

Appendix II: Description of Californium-252 Sources and the Prototype Use and Storage Facility (by I. A. Lerch and J. Haider).

The book concludes with a valuable list of references and an excellent bibliography. There is a small special section with "Additional Safety References for Appendix II." The last item in the book is a "Conversion Table: Factors for Converting Units to SI System Equivalents."

Altogether, this small volume merits high praise and, as quoted in the opening paragraph of this review, should serve the goal of the authors admirably. The book can also serve as a useful reference text for courses in radiochemistry and radiobiology. This book, so rich in content, would certainly benefit by the inclusion of an index.

Arthur F. Scott, following the completion of doctoral work at Harvard, spent a year with the late Kasimir Fajans in Munich. In 1923 he joined the chemistry staff at Reed College, and for the next 50 years he served on the College's faculty, except for an interlude of 11 years during which he taught at The Rice Institute in Houston. A year's leave-of-absence (1958-1959) was invested in study and work at the reactor at MIT and at the Hot Laboratory at Brookhaven. In 1948 Scott introduced a course in radiochemistry into the curriculum at Reed College; in 1968 he was given the responsibility of installing a TRIGA reactor (250 kW) on the Reed campus. This reactor now serves a consortium of ten colleges in the Portland area for educational and research purposes. In 1948 Reed established a six months' training program in radiobiology, first under the sponsorship of the Division of Biology and Medicine of the U.S. Atomic Energy Commission and subsequently under the sponsorship of the Medical Branch of the Armed Services Special Weapons Project. Scott was Coordinator of this special program, which was continued on an annual basis for a period of ten years. In 1950, Scott became chairman of the first Radiation Advisory Committee of the Oregon State Board of Health, and in 1968 he was appointed chairman of the Oregon State Nuclear Development Coordinating Committee, serving in this capacity for two years.