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ACNWC-0027

Darrell L Leap, Ph.D.

Registered Professional Hydrogeologist (AIH)
Certified Professional Geologist (IN)

5932 Lookout Drive, West Lafayette, IN 47906
Phone: (317) 494-3699–office; (317) 567-2578–home
Fax: (317) 496-1210

rec'd 12/19/94

December 20, 1994

Ms. Lynn Deering
ACNW Staff Scientist
Advisory Committee on Nuclear Waste
United States Regulatory Commission
Washington, DC 20555

Dear Ms. Deering:

This is an answer to your fax to me of December 7, 1994, in which you asked two questions about isotopic dating of ground water and ground-water travel time:

(1) From what I can determine, it is likely that three isotopic methods can be useful for dating ground water and estimating travel time, provided that the caveats discussed below are fully addressed.

A. Tritium, is an old standby, but contamination between horizons is a problem. If one takes a sample at depth and it gets contaminated with more recent tritium while being taken out of the ground, it will certainly cause errors in the interpretation of analytical results. Additional contamination from already-contaminated labs is also a problem. If the tritium counter is not properly shielded from cosmic rays, it can also cause erroneous countings of disintegration's. Contamination from certain wristwatch dials can be a problem also. But, tritium still remains one of the best, if not the best environmental tracers for a time span of perhaps 25 to 30 years.

B. Carbon-14, accurate back to perhaps 40,00 years BP, is also reasonably good as a tracer, but numerous adjustments have to be made, as was brought out in the meeting in October in Las Vegas. One problem is estimating the amount of C-14 in the atmosphere thousands of years ago, but the error in the interpretations of analyses with this uncertainty should not rule out the useful of the method, keeping in mind the envelope of error that may result in age determination by the method.

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C. For more recent recharge, the CFC's seem to be quite useful as tracers what from I have been reading. It would be most useful if a comparison between tritium and CFC's could be made at Yucca Mountain for very recent recharge.

It seems that there are significant problems with Chlorine-36. We have tried it at Purdue on water from glacial-outwash aquifers, but have more questions than answers. The presence of rather high background levels is a problem, and it may be due in part to production at depth. The same problem may plague efforts at NTS. So many questions still persist about the efficacy of Chlorine-36 that it may be a few years before the methodology is developed to the point of sufficient accuracy to warrant its use.

(2) If isotopic methods are not going be available, the only alternative method I can think of is predicting travel time by modeling. With the present density of subsurface data, this method is likely to be even less reliable than tracing with isotopic tracers. In using either tracer methods or modeling, enough subsurface data is needed to show the actual path (within reasonable limits of accuracy) of travel. This information seems to be lacking.

From the simple equation, $V = (1/n)K(dH/dL)$, where n = effective porosity, V = velocity, L = travel distance, and dH/dL = hydraulic gradient; it is apparent that L is of greatest importance. With modeling for travel time, the added burdens of accurately estimating hydraulic conductivity and effective porosity of the flow pathways are onerous and perhaps impossible to accurately ascertain with any degree of certainty over any significant distance.

Thus, the advantage of estimating travel time with tracers is that it is a direct method. From the arrival times of the tracer breakthrough curves or certain concentration values, one can obtain a much more realistic estimate of travel time and velocity (provided path length and source concentration are known) than one can obtain with modeling, simply because

$V = L/T$, where L is travel path length, and T = travel time.

Finally, in either case, and isotopic tracer methods seem the best, enough subsurface data is required to accurately determine the most permeable and most productive flow pathways in order to determine where the water is coming from and to where it is going before an estimate of travel time can make sense. It is highly recommended that more exploration be done to determine these pathways.

Darrell I. Leap