Environmental Management Science Program

Project ID Number 54857

Surface Nuclear Magnetic Resonance Imaging of Water Content Distribution in the Subsurface

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June 1, 1998

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Research Objective

The objective of the project is to evaluate Surface Nuclear Magnetic Resonance Imaging (NMRI) for determining water content distribution in the subsurface. In NMRI the interaction of the magnetic moment of hydrogen (protons) nuclei with external applied electromagnetic (EM) fields is measured. In surface NMRI the Earth's magnetic field causes alignment of the spinning protons. An alternating EM field is generated by a loop of wire laid on the Earth surface. The alternating current driven through the loop at the Lamor frequency of protons in liquid water. The component of the EM field perpendicular to the Earth's field causes a precession of protons from their equilibrium position. Water content distribution in the subsurface is derived from measurements on the EM field caused by the return of the precessing protons to equilibrium after the current in the transmitter loop is terminated.

The scientific goals of the R & D are:

- to verify and validate the theoretical concepts and experimental results of Russian scientists , who first introduced this method.
- to evaluate the range of applications and limitations of this technology for practical field measurements.

NMRI has the potential of providing a remote, direct, unique method for subsurface water measurements. All present methods are either intrusive or indirect (e.g. electrical resistivity measurements).

Research Progress and Implications

In the past year progress has been made along two separate paths. These are:

- 1) Field Measurements. Surface NMRI equipment manufactured by IRIS Instruments of France was tested over a number of sites with good hydrogeologic control. The results of these measurements can be summarized as follows:
 - The NMRI measurement directly and uniquely determines water distribution in coarse grained aquifers; geologic formation from which water can be readily withdrawn.
 - Water content can not be determined by this technique in fine grained sediments.
 - The signal to be measured is very small and EM interference's from power lines makes NMRI a difficult measurement in an urban setting.
 - The presence of minerals with a high magnetic susceptibility interfere with reliable measurements.
- 2) Theoretical Computations. The inversion of the experimental measurements requires the computation of the EM field within the Earth. We have extended these computations with the design of fast algorithms for computing the EM field for Earth stratified in electrical resistivity.

Planned Activities

We will continue to expand our field measurements over controlled hydrogeologic settings, so that the range of applications and limitations can be clearly understood.