**WATER RESOURCES RESEARCH GRANT PROPOSAL**

**Project ID**: CT741

**Title**: A Tracer Dilution Method for Deriving Fracture Properties in Crystalline Bedrock Wells

**Focus Categories**: Groundwater, Solute Transport

**Keywords**: well hydraulics, water quality, water levels, solute transport, hydrogeology, fracture hydrology, contaminant transport, bedrock fractures, aquifer characteristics

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**Federal Funds**: $19,430

**Non-Federal Matching Funds**: $44,625

**Congressional District**: 2nd

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**Abstract**

Most rural domestic wells in New England derive their water from fractured crystalline rocks. Unfortunately, our knowledge of the hydraulic characteristics of subsurface, water-bearing fractures is sparse. Such information is critical in evaluating ground water supplies, in conducting wellhead protection, and in preventing and remediating ground water contamination in crystalline rock. In recent years, the U.S. Geological Survey (USGS) has developed cutting edge techniques to perform downhole fracture testing. These techniques, however, may be cost prohibitive to be applied on a large scale. This research is aimed at developing more cost-effective methods for conducting downhole fracture characterization. As such, it should aid the rural community and state and local environmental regulators in assessing the availability of ground water and the source and transport of contamination in fractured crystalline rock.

The goal of this research is to develop a cost effective, technically sound method for conducting downhole fracture characterization using tracers. The research is focused on developing a unifying method that can identify water bearing fractures that intersect a well, that can provide information on the interconnectiveness of fractures in relation to a well (recharging and discharging fractures), that can be used to determine the transmissivity of fractures, used to determine the hydraulic head in fractures, and that can quantify fracture water quality (including contamination). Uniquely, we have an opportunity to compare our tracer results with those of the U.S. Geological Survey, derived using their integrated downhole geophysical and hydraulic packer test methods. If brought to fruition, the tracer test method may make downhole testing more practical. As such, it can help in assessing the availability of ground water in fractured crystalline rock and in protecting the ground water resource.

Most rural domestic wells in New England derive their water from fractured crystalline rocks. Unfortunately, our knowledge of the hydraulic characteristics of subsurface, water-bearing fractures is sparse. As such, drilling productive domestic wells in crystalline rock is a hit or miss proposition that could result in consumers laying out thousands of dollars for a "dry hole". This lack of information also prohibits performing, in any quantitative fashion, ground water resource estimates that can be used in guiding developers or land use planners. A lack of information also inhibits applying the concepts of wellhead

protection to municipal wells founded in rock. Importantly, when bedrock wells are impacted by contamination, the absence of fracture information complicates evaluating contaminant sources, and means to remediate these problems.

Over the last several years, the USGS has conducted geophysical and hydrologic research aimed at developing techniques to characterize fracture hydrology as part of their Toxic Substances Hydrology Program. This research has shown that that superficial investigations of ground water conditions in bedrock wells (that basically entail water level measurements and well sampling) can be highly misleading owing the nature of fracture flow. Their research has shown that fracture rock assessments requires detailed characterization. In that light, they have developed "tool boxes" of techniques that can be applied in characterizing fracture hydraulics and water quality. A detailed borehole investigation might entail the use of the following tools: a downhole television camera that provides a 360 degree digital image of the borehole wall for defining rock characteristics and location of fractures, an acoustic televiewer that provides magnetically oriented borehole wall images for determining fracture dip and strike, and a high resolution flowmeter for discerning water bearing fractures and identifying inflowing and outflowing fractures under both pumping and static conditions. These logging techniques would then be followed by packer testing to determine the hydraulic head in individual fracture zones, to conduct hydraulic testing for fracture transmissivity, and to collect water quality samples. Although the information derived by applying the USGS methods is comprehensive and definitive, it is also costly. The costs and the timeframe associated with the approach can inhibit its practicality.

The objective of this proposal is to develop a tracer technique to derive fracture information downhole, as a cost-effective compliment to the USGS "tool box" methods.