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A Novel Use of Electrical Resistivity Sensing Equipment in Geology Research

(Outside Display Weather Permitting)

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Porosity is a fundamental property of rocks that contributes to fluid flow and bedrock coherency. Primary porosity is the void space formed between fused mineral grains, such as the small spaces that exist between grains of sand in a sandstone. Secondary porosity can develop by dissolution of the primary grains, or through the process of fracture development (Figure 1). In many cases, the secondary porosity in bedrock is the main contributor to groundwater flow, hence the serves as the migration path for any fluid that enters the groundwater system. During this project, we set out to refine a non-invasive geophysical technique (Azimuthal Electrical Resistivity: AER), to rapidly characterize the geometry of the fracture porosity in concealed bedrock using field examples from the local geology of the Lake Ontario region (Figure 2). Additionally, an AER simulator was developed to characterize the frequency of fractures in a controlled laboratory setting.

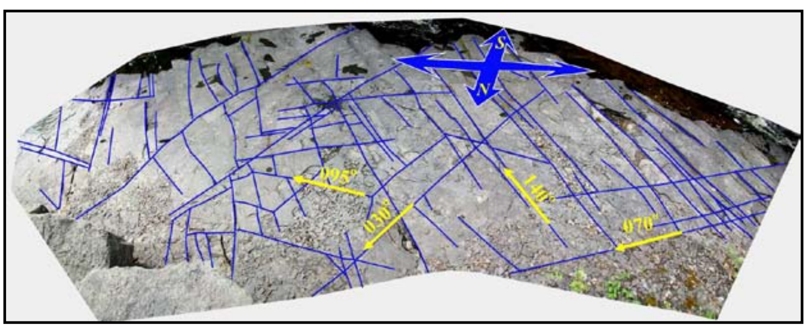

Figure 1. Photograph of fractures in Utica Shale (Whetstone Gulf State Park, NY) with the trace of fractures shown in blue. The yellow arrows show the geographic trend of the trace of four fracture sets.

Electrical resistivity is a technique where a controlled electrical current is induced into the ground at a fixed distance, and the response is monitored with electrodes that read the voltage drop at known points. With a controlled geometry, the apparent electrical resistivity is calculated (ohm-m) for a specific depth. In the case of AER, we utilize a standard Wenner four electrode array to arrive at ER values at a depth that is about 50% of the electrode spacing. Sequential azimuthal ER readings will identify small anisotropy in the rocks that is associated with fluid in fractures. In effect, ER readings parallel to fluid filled fractures will be lower than those that cross orthogonal to the fractures. By collecting ER data azimuthally (around the compass dial at a fixed interval), the plots of ER variation reveal the strike of fractures in the rock. Theoretically, an increase in fracture density (more breaks per rock volume) should result in lower ER values due to the presence of more fluid. Therefore, the AER simulator is being used to model this effect with the goal of finding a means to apply the variation in real world projects. A field experiment and the AER simulator will be demonstrated during the showcase.

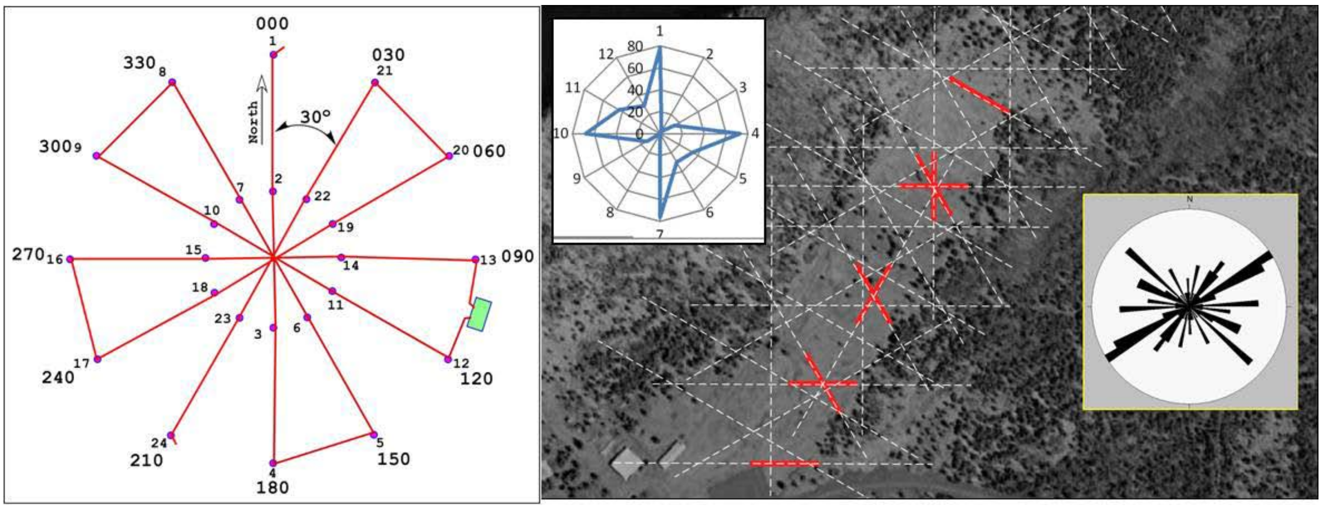

Figure 2. Azimuthal electrical resistivity surveys that were collected at Stony Point, Henderson, NY. The ER scale is in ohm-meters and shows one detailed result in blue. The diagram to the left is the AER schematic using a 24 node automated ER meter with switching capabilities. The red lines represent inferred fracture traces from five surveys and the azimuthal histogram shows the strike direction for bedrock fractures that were observed within a few hundred meters of the AER survey sites.