PROJECT SUMMARY

Project Title: Evaluating Permeability Enhancement Using Electrical Techniques

Applicant: Science Applications International Corporation (SAIC)

Collaborating with: The Geological Survey of Japan (GSJ/AIST)

Principal Investigator: John W. Pritchett, SAIC

Methods: An investigation of the potential utility of monitoring hydrofracturing operations in EGS development projects using downhole self-potential ("SP") measurements in nearby shut-in observation wells is proposed. Prior theoretical investigations have demonstrated the feasibility of the approach, in the sense that SP signals far in excess of detection thresholds will propagate hundreds of meters from pressurized fractures within a few weeks under reasonable conditions. Field experiments have demonstrated that injecting fluid underground produces detectable SP signals even if injection pressures are much lower than will usually be required to fracture rock and create synthetic permeability.

Importance: To create "artificial" geothermal reservoirs, most proposed EGS techniques seek to increase the flow capacity by hydrofracturing hot but impermeable rock, pumping high-pressure fluid into one or more injection wells and enhancing permeability by opening pre-existing sealed fractures and/or creating new ones. Although there is little question that fracturing rock and creating permeability in this way will often be feasible, the real difficulty is appraising, in detail, the permeability structure of the fracture network thereby induced. It is important that the hydraulic connections between production and injection wells be neither too poor (resulting in no fluid flow) nor too good (resulting in "short-circuiting" and rapid cooling). Unless the permeable fractures can be accurately mapped, the cost of subsequent trial-and-error drilling to try to establish a suitable fluid circulation system is likely to dominate project economics and render EGS noncompetitive in the energy market for the indefinite future.

Objectives: The current state-of-the-art in hydrofracture evaluation and characterization is microearthquake monitoring, but this technique, by itself, does not provide sufficient precision concerning fracture locations and cannot distinguish permeable fractures (connected to the fracture network) from impermeable (isolated) ones. But combining microearthquake monitoring with downhole SP monitoring has the potential to provide more information than either technique alone. The specific objectives of the proposed project are:

1. To gain fundamental understanding of the mechanisms by which hydrofracturing operations can cause electrical signals to propagate outward into an EGS geothermal reservoir and be detected by instrumentation located in nearby shut-in observation wells,

2. To establish the quantitative relationships among *(a)* reservoir rock and fluid properties, *(b)* fracture characteristics, *(c)* well characteristics, and *(d)* the amplitudes, propagation rates, and spatial distributions of the resulting electrical signals,

3. To estimate the important reservoir mechanical, hydraulic and electrical properties that affect electrical signal characteristics in the laboratory, using rock samples gathered from candidate EGS field sites,

4. To identify and recommend preferred techniques for carrying out monitoring operations in the field to *(a)* detect and characterize the electrical signals caused by hydrofracturing and *(b)* gather other supporting information needed to interpret these signals, and

5. To devise procedures for subsequently analyzing the electrical signals obtained in combination with additional supporting information that will provide the best possible estimates of the spatial distribution of reservoir permeability created by the hydrofracturing operation.