

IPGT High Priority Topic Area 04: STIMULATION PROCEDURES

Issue/description: Reservoir volume and productivity of wells are two of the most critical issues impacting economic viability of EGS projects. Both of these are dependent on effective stimulation procedures.

There are two related issues: the ability to isolate zones to enable discrete fracture zones to be stimulated (zonal isolation) and the ability to monitor and interpret hydraulic and microseismic data obtained during stimulation treatment (reservoir characterization). Please refer to separate issue statements.

The key stimulation procedure questions to be addressed concern:

- a) what is the most effective stimulation procedure, to meet reservoir volume and productivity objectives? This includes maximizing fracture networks/pervasive permeability rather than discrete pathways and concerns such questions as rate of pressure build-up, cycling, cross-well stimulation, viscosity of injecting fluid, the minimization of risks of breakthrough/short-circuits etc.
- b) how can the effectiveness of a stimulation treatment be assessed during the treatment operation? This concerns assessments of area/volume and permeability while the stimulation spread is over a well.

Status/Gap Analysis: The oil and gas industry has considerable experience fracturing rock to enhance fluid flow, but largely in sedimentary rocks, granular in structure and with an inherent porosity. The petroleum industry's state-of-the-art equipment creates fracture half-lengths of 200 to 400 feet or more.

EGS reservoirs will include low porosity crystalline rocks, presenting a significantly different natural environment. For example, EGS reservoirs frequently have pre-existing natural fractures but with inadequate permeability. There are several examples of successful stimulations in crystalline geothermal reservoirs where stimulated areas exceeding several km² have been achieved, but all of these have been in proof-of concept projects. Experience is limited and there is not yet an established procedure.

Much work has been undertaken concerning the interpretation of microseismic data (e.g. More Than Cloud and post-MTC projects), but there is not yet an established method for interpreting the effectiveness of a treatment during stimulation operations.

Hydraulic fracturing has had mixed results in hydrothermal fields, in part due to inadequate characterization of the host rock (including the stress state and the location, direction, and permeability of pre-existing fractures). This shortcoming results in inadequate data and modeling for effective fracture treatment design.

Projects underway in France and Australia currently define the state-of-the-art in reservoir characterization technologies. The first phases of the project at Soultz, France, created a reservoir at 3,900 m in 165 °C rocks that produced 25 l/s of water at 140 °C. In 1998, the production well was extended to 5,000 m, where a predicted rock temperature of 200 °C was verified. Hydraulic fracturing in 2000 produced a 1.1 km³ reservoir that has been stimulated to create a circulation loop.

A second project at Landau, Germany, used well stimulation techniques to create a small operating system. This project produces at a rate of 100 l/s due to the connection of the stimulated fractures with a pre-existing fracture system. In Australia, projects in the Cooper Basin have achieved sub-horizontal stimulations extending up to 1.8km from the injecting well at depth of 4,200 m, with production exceeding 25 l/sec from one fracture zone. Treatments are planned in a well completed to 4,910m. Several proof-of concept projects are expected to be undertaken in Australia during 2009/10 and there are several stimulation projects underway in the U.S.

Objectives: The objectives are to develop:

- a) optimal procedures for stimulation treatment operations
- b) the capacity to assess the effectiveness of stimulation during the treatment operation

Potential Approach: It is likely that the objectives will require a mix of theoretical and laboratory work in conjunction with field trialling/testing. Given that field work is expensive, and likely to be part of commercial operations, it is expected that a co-operating team of researchers and companies will need to be established. Given the progress to date made by MTC and post MTC researchers, it is likely that these teams will include those research groups.

There are important current company projects in the U.S. (being carried out with DoE support), in Australia and in Europe: co-operation involving these companies is expected to be critical.

It is suggested that a forum be established involving the active companies, stimulation researchers and geophysics/rock physics (eg MTC) researchers, with the immediate objectives of:

- establishing the technical structure, i.e. project structure and focus field projects
- establishing the committed parties and co-operative arrangements

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Information Sources/references

The Future of Geothermal Energy (MIT Report) 2006

An Evaluation of Enhanced Geothermal Systems Technology, Geothermal Technologies Program, USDOE EERE, 2008