



ANNEX I

Project Plan

Development of coupled reactive fluid flow models

Project ID: **09-01-003**

Coordinator: Hannes Jónsson, University of Iceland

Start date: April 1. 2009

Duration: 3 years

Partners: Reykjavik Energy and Lawrence Berkeley Labs

1 Project description

1.1 Objectives and GEORG WP relevance

The objective of this project is to develop coupled reactive fluid flow models for geothermal areas in Iceland, in order to be able to assess the impact of exploitation and help predict evolution of the systems. In particular, the Hengill area will be modelled with particular focus on the CarbFix experiment where CO₂ is pumped into the ground, and the low temperature Laugarnes area, where large amount of data on the effect of utilization is available. The goal is to be able to reproduce known and predict future scaling problems due to reservoir exploitation. Effort will also be put into determining how precipitation of amorphous phases is best simulated with reactive fluid flow models as these tend to be the first phases to precipitate. The model will include chemical kinetics as well as thermodynamics as well as transport of water and vapor phase through the porous rocks. Simulations will be carried out using the TOUGH2, iTOUGH and TOUGHREACT codes, which are all developed at Lawrence Berkeley Laboratory (LBNL). An important aspect of the work is to introduce the chemical rate and equilibrium parameters for basaltic geothermal systems into the TOUGHREACT code

2 Work plan and time schedule:

| Subtask | Start | Finish | Deliverable/Milestone |
|---|----------|----------|---|
| Calibration of physical reservoir parameters with inverse iTOUGH simulations | 01/06/09 | 01/12/09 | Gain confidence in parameters describing flow before adding chemistry to model |
| Development of a TOUGHREACT dissolution model for basaltic glass that simulates long and short term dissolution | 01/08/09 | 01/02/10 | Comparison between measured and calculated dissolution rates |
| Simulation of plug flow experiment with TOUGHREACT | 01/02/10 | 01/03/10 | Determine conditions at which CarbFix experiment is likely to be successful |
| Field scale reservoir simulations with TOUGHREACT | 01/03/10 | 01/05/10 | Determination of secondary phases forming in CarbFix at various depth and temperature intervals |
| Papers on reactive fluid flow modeling | 01/12/09 | 01/06/10 | 3-4 papers, each on one of the subtasks above |

| | | | |
|---|----------|----------|---|
| Definition of physical properties of a low-temperature geothermal reservoir | 01/01/10 | 01/09/11 | Use measurements to calibrate hydrological properties of a new model for a low-temperature geothermal reservoir |
| Add reactive transport to low temperature geothermal reservoir model. | 01/09/11 | 01/03/12 | Definition of chemical system. Determination of secondary phases forming during reservoir exploitation. Comparison to measurements. |
| Modeling precipitation of amorphous phases with reactive fluid flow models | 01/01/12 | 01/06/12 | Determine how amorphous phases are best simulated with reactive fluid flow models |
| Papers on reactive fluid flow modeling | 01/06/11 | 01/06/12 | 3 papers, each on one of the subtasks above |

3 Project Management

The project manager is Hannes Jónsson. Edda Sif Aradóttir (Ph.D. student, expected to graduate in June) will carry out the calculations related to carbon sequestration. Manuel Plasencia (Ph.D. student, expected to graduate in September 2012) will carry out the modelling of the low temperature zone at Laugarnes and then other geothermal areas. Eric Sonnenthal at LBNL will help with the use and modifications of the ToughReact code. Reykjavik Energy will provide information about the geothermal areas that will be modelled.

4 Budget overview

See attached Excel spread sheet called `georg_budget-prep-form_nov-2009.xls`

In 2009/2010, the requested funding will mainly cover part of Edda's (Ph.D. student) salaries and part of traveling costs due to collaboration with Eric Sonnenthal at LBNL as well as participation in the 2009 TOUGH Symposium.

In 2010/2011 and 2011/2012, the requested funding will cover salaries for a new Ph.D. student, Manuel Plasencia, hardware and software update and travel expenses, mainly due to the annual AGU Fall meeting.