ANNEX I
Project Plan

High pressure and high temperature geothermal grouts

Project ID:	09-01-013
Coordinator:	Dr. Gísli Guðmundsson, Mannvit hf
Start date:	October 2009
Duration:	11 months
Partners:	Reykjavík University, Innovation Center Iceland Icelandic GeoSurvey

1 Project description

General description of the project, clarify what the intended work involves and specify the need or importance for this work in connection with geothermal energy.

Iceland's geographical location on the Mid-Atlantic Ridge, accounts for its constant geologic activity and access to geothermal heat. Nowadays Iceland has become one of the front-running countries when it comes to utilizing geothermal energy for domestic and industrial purposes. One of the major structures and investments in geothermal plants are the geothermal wells where the steel casings are secured with cement based grout. This project deals with grouts for cementing steel casings in geothermal wells where high temperature and high pressure are prevailing (geothermal grout). The current status is such that there is negligible knowledge in Iceland about the properties of geothermal grouts, and such knowledge is also very limited globally.

Geothermal grout is an essential part in the preparation of geothermal wells. It is placed in the annulus between the steel casing and the rock walls of the drilled well in order to secure the casing and prohibit contamination and/or mixing of aquifers. A carefully prepared grouting job is therefore a critical factor in the well preparation and any fragility in the grout can lead to lost production zones, cold water leaking into production zones or geothermal water leaking into freshwater zones. Other factors that can take place are inter-zonal migration and possible fresh water aquifer contamination which reduces the lifetime and the capacity of the well. Both factors can be very expensive in a comprehensive project like drilling and preparation of geothermal wells. Delays due to occasional premature stiffening of the grout during cementing and uncertain and long hardening time of the grout with consequential production losses are also problems that drilling teams and owners are facing.

The currently used grout in geothermal wells in Iceland has been used almost unchanged for decades and has been proven mainly adequate at geothermal drilling sites. It is however a very basic design compared to today's technology which means there is a significant area which can be improved. Here in Iceland there is a great experience with currently used geothermal grout, but when it comes to grout intended deep geothermal wells, the experience is relatively little. Abroad there is a wealth of experience from the oil and gas industry dealing with well grouts, but at limited temperatures. There is some experience in Italy from the geothermal fields there, but the wells are all at relatively shallow depths.

ICI Rheocenter, Mannvit and Reykjavik University recently received a grant from Rannis´s Fund for Research Equipment (Tækjasjóður) to purchase a highly sophisticated device called RheoMicroScope. This device can measure material properties of grout at up to 400 bar pressure which corresponds to 4000 m high hydrostatic pressure or about 2400 m deep geothermal well (by using density 1700 kg/m^3 of the suspension in the well). The temperature of the grout sample can simultaneously be increased up to 180 °C to simulate the environmental condition in the well. The RheoMicroScope is therefore a great opportunity for Icelanders to take a leading role in the research and development of high temperature and high pressure grouts for geothermal wells and could be one of the presumptions of success in the deep drilling project attempted in Iceland. If this deep drilling project will be successful, there will be a great need for this type of grout everywhere on the earth where geothermal deep drilling will be attempted.

1.1 Objectives and GEORG WP relevance

Specify the main objectives of the project and explain the relevance it has to GEORG WP. Please also explain how the project will help GEORG achieving its main objectives

The main goal of this project is to improve the properties of the currently used geothermal grout in the fresh and hardened state and also to develop new grouts for high temperature and high pressure conditions in deep geothermal wells. The key to this seems to be a considerable decrease in the w/c-ratio of the currently used grout which must be without loss of or even improved workability in the fresh state. This will be achieved by utilizing different or new admixtures and other ingredients.

By decreasing the water content of the cement grout it will be aimed for important characteristics such as increment in final strength of the hardened material as well as reduced shrinkage and cracking. The negative effects on the grout which will occur when water content will be decreased will be compensated by testing various cement types with various additives. Another crucial issue is to design superior grout with improved; rheological properties, stability (homogeneous grout with minimum segregation but preferably without one) as well as improved properties of hardened grout. It is also considered feasible to be able to control the strength development in the grout with regard to temperature and pressure e.g. so that the strength will always be similar after certain time.

The consortium group, which consists of the leading scientists of Mannvit, ICI Rheocenter, Reykjavik University and Icelandic GeoSurvey have been very active in this field of research in previous years and have a very good knowledge of materials properties of the currently used mix design. Their previous work have made it clear that the currently used mix-design has a rather high yield value but at the same time a very low plastic viscosity. Both these factors are because of an excessive amount of water in the mix. The innovation of the project is based on the utilization of new equipment and usage of new admixtures, which have not been applied to these kind of grouts.

2 Work plan and time schedule:

Provide a short work plan broken down into subtasks which should follow the logical phases of the implementation of the project. A timeline should be presented as well as list of deliverables and milestones. Please keep in mind the submission of progress- and annual reports to GEORG, while planning the deliverables and milestones.

Subtask	Start, months	Finish, months	Deliverable/ Milestone
1. Improved mix-design, material selection and testing of grout Effect of temperature on general properties of grout Testing of selected mix proportions and constituent materials	0	4	Progress report
2. Assessment of temperature and pressure conditions in boreholes Effect of pre cooling Modelling of temperature and pressure conditions in boreholes Assessment of reliability of CBL measurements Recommendation for evaluation of strength development in grout in boreholes	3	5	Progress report
3. Testing of behavior selected mixes at high pressure Testing of general properties Behaviour at high pressure and temperature Recommendations for selecting of constituents and mix-design og grout	6	9	Progress report
4. Full-scale testing of selected mixes	9	10	
5. Final report		11	Final report

3 Project Management

Make a short description of the applicants involved in the project, inform about the resources that will be assigned to the project. Also specify in clear and simple manner who is resposible for what and how that will be managed.

Several individuals both at Mannvit and ICI Rheocenter have considerable experience in being project leaders of both Icelandic and international research projects.
Mannvit operates a management system according to the ISO 9001:2008 standard; certified by the British Standard Institution (BSI). The key factor of the system, setting the baseline for quality assurance in Mannvits services, is the project management process, operating from the input of service requirements to the output of delivered products and services. Marketing, Procurement, Human Resource and Information Technology (IT) are the main support processes for project management, and are responsible for delivering services as the project demands.

The project management process incorporates standard practices to ensure that customer quality requirements are met. The standard process is divided into three categories.

Project preparation and planning
All projects are prepared, planned and registered in a systematic way. This is to make sure that customer requirements are completely understood and that Mannvit has the competence and available resources to meet them.

Project management and control
Projects are managed and controlled as planned. This is done through regular project meetings with the customer and with project personnel. Projects are also constantly monitored and assessed regularly to make sure that project quality and tolerances are on the right track. The customer always gets feedback from project assessment.

Review and issue of project´s production
All working documents are reviewed for quality and approved by skilled specialists before they are issued and delivered to customers. The quality review process is pre-defined in project planning and approved by the customer. All issued drawings and documents are registered in an electronic database.

4 Budget overview

Insert the "Costs" spreadsheet from the application documents. Explain the basic cost structure of the project. If it's assumed informative an additional budget summary can be included here, that, however, should not exclude the standard forms. Please justify, in simple terms, how the criterias of chapter 6, Section I in the „Proposal & Award Policies & Procedures Guide" are fulfilled.

Consortium: **Mannvit, ICI_RhC, ICI_Elo**
Name of Project: **Geothermal Borehole concrete**

ISK '000	Year	Unit cost	Year 1 2009/2010 Man-months	Year 1 2009/2010 Total	Year 2 2010/2011 Man-months	Year 2 2010/2011 Total	Year 3 2011/2012 Man-months	Year 3 2011/2012 Total	Grand Total
Salaries including overhead									
Senior researcher NMI	SW	1.378	3,2	4.410		0		0	4.410
Senior researcher NMI	SK	1.378	1,3	1.791		0		0	1.791
Próféssor HR	OHW	1.565	0,4	626		0		0	626
Senior Technical Expert	SS	1.760	0,7	1.232		0		0	1.232
Project Manager	GG	1.760	0,8	1.408		0		0	1.408
Senior Technical Expert	KIv	1.760	0,8	1.408		0		0	1.408
Scientific Coordinator	THH	1.485	0,1	149					
International Advisor	BJW	1.760	0,2	352					
Technician	SA	1.147	1,8	2.065					
Expert advisor	STH	1.560	0,2	312		0		0	312
Total			9,5	13.752	0	0	0	0	11.187
Operational exp. (Efniskostn)									
a SEM Microscope operational expenses				1.000					1.000
b RheoMicroScope operational expenses				450					450
c Laboratory operational expenses, Mannvit				750					750
Total				2.200		0		0	2.200
Travel expenses									
a Mannvit				300					300
b ICI Rheocenter				300					300
c									0
Total				600		0		0	600
Total cost				16.552		0		0	13.987
Financing									
a In kind own fin ICI, confirmed				1.500					1.500
b Landsvirkjun grant, confirmed				1.000					1.000
c Reykjavik university, confirmed				600					600
d Golden Bay Geothermal silica, confirmed				1.400					1.400
e Icelandic Cement Ltd. , to be confirmed				700					700
f SIKA Denmark, to be confirmed				1.800					1.800
g In kind own fin. Mannvit, confirmed				2.000					2.000
h In kind own fin. Iceland GeoSurvey				100					100
Total other financing				9.100	55%	0	N/A	0	N/A 9.100
Requested funding from GEORG				7.452	45%		N/A		N/A 7.452
Total financing				16.552		0		0	16.552

The total cost of the project is 16.552 million ISK, included in this figure is financing from GEORG 7.452 million ISK or about 45 % of the total cost. The salaries are independent for each partner and are based on their salary cost, but certain discount is given and in addition each partner has its own financing. Operational cost is about 2.2 million ISK or about 13 % of the total cost, this figure is based on cost of running the involved laboratories and performing tests, etc. Travel expenses are about 0.6 million ISK or about 3.6 % of the total cost, this cost amounts to two trips to conferences abroad.