SAGA Report No. 7

Report on the IDDP "Kick-off Meeting" of 3-4 March 2009, Reykjavík, Iceland

Executive summary

The "kickoff meeting" at the Orkugarður auditorium in Reykjavik was held two weeks before a rig is to be activated at the Krafla geothermal field in NE Iceland to resume drilling the IDDP-1 exploratory/research well. Drilling and casing to 800 m occurred in December 2008. Drilling to 4500m depth should take a further 115 days. The workshop reviewed the planning for drilling and testing this well, and integration of the drilling and activities on site, including downhole logging and experiments, and sampling of rocks and fluids, including coring. The more than 40 attendees were mostly members of the three advisory panels, Drilling Technology, Geosciences, and Fluid Handling and Evaluation, together with the downhole logging group (ISOR and HITI), Deep Vision (the steering committee), and SAGA (the advisory committee). The program and a list of attendees of the workshop are attached to this report. After a day of presentations by representatives of these groups, and a half day of discussions, a number of items were discussed that could require further review or action, that are listed in this report. Overall, however, the review of the comprehensive plans presented was very positive: there were no "show-stoppers" identified.

Brief Synopsis of the Presentations

Bjarni Pálsson, the IDDP-1 Project Manager for Landsvirkjun, began by reviewing the timetable for the IDDP-1 and the facilities and accommodation available at Krafla for the project at this remote site. With a March 16 start, the target depth should be reached in early July, and after the well heats, the first flow test should occur about August 10-15. One sensitive issue is that, as the well is in an area frequented by tourists in the summer months, it will be necessary to limit public access to the site. Press inquiries should be directed to the official spokesmen, Bjarni Pálsson and Guðmundur Ó Friðleifsson. The well will be drilled by Jardboranir, using the hydraulic rig TYR, a Drillmec HH300, with automated pipe handling. Unnur Björnsdóttir, on behalf of Jardboranir, gave a review of safety procedures, rules and briefings. Everyone entering the site must report to the tool pusher and be aware of safety procedures.

Sverrir Þórhallson on behalf of the drilling technology team then presented an overview of the comprehensive drilling program document, developed during the last two years. The well design anticipates bottom hole temperatures of 500 ^{o}C and pressures of 240 bars. Below 800 m depth superheated steam is likely to be encountered that entails high wellhead pressures, so it is essential to keep a positive pressure of water while drilling. An abundant water supply with back-up supply systems is therefore necessary. In addition to the surface casing, and two intermediate casings already set to 800 m depth, there will be a 13 5/8" anchor casing from 300 to 2400 m, a 9 5/8" production casing to 3500 m, and a 7" diameter slotted liner from 3500 to the 4500 m target depth. These long casing strings each require cementing in two (or more) stages. Special high temperature cements have been developed based on experience from 400°C wells in Larderello, Italy and a consultant will advise on the staged cementing. In order to reach the planned depth, to ensure good cementing of the casing, and to prevent the possibility of subsurface blowouts by uncontrolled flow between fractures, special attention will be paid to loss of circulation. Shallower than 3000 m, attempts will be made to seal any loss zone of > 5 l/s with Loss Circulation Material (LCM), or if necessary the leakage will be sealed by cementing. Deeper than 3000 m similar attempts will be made to seal any loss zone of > 10 l/s. The current time estimate is 90 days for drilling, 7.5 days for logging and 30 days for coring. The estimated cost of the drilling operation (excluding spot coring) is approximately 20.5 million USD at the present rate of exchange (115 ISK/1 USD) and the budget for coring for the geoscience program is approximately 4.5 million USD.

Alister Skinner, of ACS Coring Services, reported on the coring barrel and bits developed specially for this project designed to operate at 250-300°C. Enlarged waterways on the bits permit a flow of 40 l/s to assist cooling and a temperature probe inside a memory tool in the core barrel records the temperature history while tripping and coring. Thus the core barrel can hold a 9.5 m long core of 4'' diameter. A highly successful test of this equipment was performed in the RN-17B well at the Reykjanes geothermal field at a depth of ~2800 m in a well inclined at 35° where the formation temperature was 340°C. The full 9.3 m of core drilled was recovered, while the temperature of the core barrel remained at about 100°C. After core runs at Krafla the core barrel will be transported intact from the well to a work room near the power plant for unloading and curation of the core.

Wilfred Elders, the Co-Principal Investigator for science, then discussed the purpose and strategy for the coring program. If circulation is lost and the well conditions preclude the use of high-temperature logging tools, drill cores are the only record of what was drilled. Cores are necessary for petrophysical characterization of the formation, and are much preferable to drill cuttings to determine mineral alteration, the nature of permeability and the sequence of fracturing and vein filling in response to fluid-rock interaction. Mineral assemblages and fluid inclusions in the cores are also indicators of geothermometry and fluid composition. The proposed strategy for coring is: (1) between 2400-2800 m when a major feed point reached, (2) between 2700-2800 m at a bit changing point (saving 1 round trip), (3) between 3100-3200 m at a bit changing point, (4) at the 3500 m casing point (if well condition allows), (5) ~ 3800 m at bit changing point, (6) ~ 4200 m at a bit changing point, (7-10) 3 or 4 cores at discretion of PI's, specifically at interesting lithology, or when a major feed point is reached (subject to the condition of the well).

Kristin Ingason, of Mannvit, then discussed the wellhead, designed for superheated steam flowing at 470^{o}C and 180 bars, and the valves and blow-out preventers necessary at each stage of drilling, and for the flow test before the pilot plant stage. These conditions are stringent design criteria. Another issue of concern is acid corrosion of the casings, expansion spool, and wellhead valves which will be ANSI 2500 class and cladded with 309 stainless steel for corrosion resistance.

Guðmundur Ó Friðleifsson, Co-Principal Investigator for Geoscience, briefly reviewed the geosciences aspect of the site, which lies about two km east of the fissures that fed the last eruption of the Krafla volcano from 1975-1984, but only about 300 m to the west of a fissure that fed the magma-phreatic eruption of the Viti crater in 1724. That fissure system dips about 2-3^{o} to the west and may be possibly be intersected at 4-5 km depth in the IDDP-1 well. Seismic and MT studies suggest that the magma chamber that underlies the Krafla caldera is at 4-5 km depth near the well site, but there is a finite chance that small magmatic intrusions occur at shallower depth. The geology of the geothermal field is well known to a depth of 2 km from the ~ 40 wells already drilled, but only one of them, KJ-39, the most recent, encountered magma, when molten rock flowed into the drill pipe. Even at these extreme conditions in KJ-39, the temperature measured in the drill head assembly while circulating was only 386^{o}C. Sigurveig Árnadóttir of ISOR discussed the strategy for recording the lithology of the cores and cuttings using a core scanner. It is intended to set up a core handling facility and basic petrographic laboratory at the Krafla power plant with thin section and fluid inclusion capabilities and to operate a Data Information System to put daily records on to the IDDP website < www.iddp.is>. Wilfred Elders, Co-Principal Investigator, then covered other aspects of the geosciences program. The Central Science Team of the IDDP (CST-IDDP) consists of some 41 different science projects from eight different countries (Iceland- 19, USA - 13, France - 8, Germany -3, Italy- 2, New Zealand - 2, Russia - 2, Japan -1, and UK – 1.) One deficiency is that unfortunately there are no high-temperature downhole fluid samplers available in Iceland, although there is a plan to attempt to create and recover synthetic fluid inclusions once the well has flowed sufficiently to discharge the fluids introduced by drilling. After the drilling and the initial description of the cuttings and core are complete, at a date to be announced, the CST-IDDP will be invited to select subsamples of the rocks and cuttings for laboratory study. The rocks will be archived by ISOR in northern Iceland and will be made available to other investigators one year after the sampling event. Members of the CST will be asked to acknowledge the funding sources that made the samples and data available and to contribute reports to a conference in 2010, with a subsequent joint IDDP publication.

Kristin Ingason then discussed the first phase of the flow testing program which will be carried out only after the well is completed and has thermally equilibrated with the formation. Flow through a 4" choke into a separator and a condenser will be used to obtain fluid samples and to measure enthalpy. If the produced fluid has an enthalpy greater than 2850 kj/kg and decompresses to dry superheated steam, and is prevented from mixing with colder water, then HCl gas present will not form hydrochloric acid in a liquid water phase. Thus corrosion can be treated at the surface rather than being a downhole problem. It is therefore necessary to allow the well to bleed during heat up to limit condensation in the wellhead. Halldór Ármannson, of ISOR, discussed the probable origin of the HCl that has been a long standing problem at Krafla. Earlier it was thought that CO_2 and HCl were both exsolved magmatic gases, based on their mass ratios. However certain wells, such as KJ-12 have relatively low CO_2/HCl ratios, so it is possible that a concentrated brine exists at depth that is the source of the chlorine. Jónas Matthíasson of the FHE group pointed out that the produced fluids are likely to contain 100-600 mg/kg of SiO_2, whereas only 1 mg/kg would be acceptable in a heat exchanger. Passing the superheated steam through a wet scrubber to remove silica reduces the available enthalpy. For example, if the power output of a flow of 50 Kg/s was 47MWe, a wet scrubber would reduce it to 35 MWe.

Ragnar Ásmundsson, of ISOR, reported on the HITI program in which the development of various high temperature logging tools and devices for geothermal applications is being made, lasting beyond any existing downhole instruments. A 300°C tolerant televiewer with a natural gamma detector has already been assembled and an instrument measuring temperature, pressure and fluid flow at 400°C is in development, now on fast-track to try to make deadlines in the IDDP drilling schedule. Both ISOR's 'standard package' instruments and HITI tools, when available, will be used as required and dictated by the borehole's temperature and pressure conditions. An ISOR logging truck will be stationed at Krafla for use by the project.

Grímur Björnsson, of Reykjavik Geothermal Company suggested that the minimum horizontal stress of the Krafla reservoir could be measured by a mini-hydrofrac test followed by a televiewer survey just below the 2.4 km deep casing shoe. Steve Hickmann of the USGS could provide a televiewer with a heat shield rated to 260^{o}C for this test of the stress field. On the other hand, members of the drilling group commented that creating fractures so close to the casing shoe would be potentially deleterious to the integrity of the casing and to prevention of internal blowouts. Further discussion revolved around the desirability of carrying out standard leak tests that involve much lower stresses and potential for fracturing the formation or damaging the casing/cement. However scanning the whole open section by televiewer is desirable. Robert Fournier of SAGA briefly discussed the advantages of using CO_2 as a working fluid in producing power from geothermal systems, referring to work going on that is investigating this concept.

Additional Issues and Contingencies raised in discussion

(1) Using drillable fiber glass (or plastic?) pipe as a cementing string when healing loss circulation zones would obviate cementing in drill pipe.

(2) Below the 3.5 km casing how would we decide that the target has been reached short of downhole PT logging or a flow test. The aim is to reach an enthalpy exceeding that of the critical point of water by a sufficient amount so that the dew point is not reached as fluid flows up the well bore during flow testing. Deep in the well mineral assemblages and fluid inclusion in cores and cuttings may be the best indicators available of bottom hole temperatures and fluid compositions before the well is flowed.

(3) If shallow magma is encountered, have we a fallback position? Drilling into magma at too shallow a depth in the IDDP-1 would mean abandoning the supercritical target, but at least we should attempt to sample quenched molten rock as best we can. We should then seal off the lower section and complete the well as a producer from a shallower reservoir.

(4) Is the proposed 7 inch slotted liner necessary? Probably yes, but it depends on the injectivity and the pressure drop when the well flows.

(5) How do you induce flow if the water level in the well is low? It will be allowed to heat up slowly and it probably will be self flowing, but stimulation via coiled tubing may be necessary.

(6) Are the logging tools to be deployed, including the 6 m long televiewer, compatible with the stuffing box and lubricator as designed for the high pressure rating of the well head. They should be, but extra care will be necessary.

(7) Additional cooling water inlets are necessary to cool the blowout preventers and for the kill line to the casing annulus with provision to unload air entrained in the cooling water. This modification is being made.

(8) What is the policy if we have stuck drill pipe? Shaped charges will be available if necessary to shear the pipe. If this occurs at a temperature too high to use mud motors to side track, then we will need a whipstock to divert the well past the obstruction, without being able to determine or control the direction. There would be a delay as whipstocks are not in the inventory in Iceland.

(9) Why are we not using PDC bits which have a higher temperature rating than tricone bits.? Successful use of PDC bits requires experience that is lacking in Iceland. With care the tricone bits should suffice. It is important to circulate while tripping in to keep the bearings of the bit within their temperature tolerance.

Conclusions

After these panel discussions, members of the SAGA committee and Deep Vision met to review progress and make recommendations. After ten years of discussions, planning and seeking funding, drilling of what we hope will be the world's first supercritical geothermal well is about to proceed towards its target. We are grateful to those involved for their efforts. Review of the comprehensive plans did not reveal any critical issues remaining to be resolved as these plans begin implementation on 16th March 2009.

The IDDP-1 well "Kick-off Meeting" – 3 to 4 March 2009

Agenda

Tuesday – Plenary Session (Reports of current status) 9:00

Opening – and a short discussion of what we expect to achieve at this meeting

Landsvirkjun	Bjarni Pálsson	20 min + 10 discussion

The Krafla Drillsite – Organization chart – Accommodation – Facilities at drill site (water supply –electricity - web access etc) – Safety issues at drill site (during and post drilling) – Public Relation issues – other items of importance

Jardboranir	Unnur Björnsdóttir	30 min

Description of the drill rig, organization, safety etc.

Drilling Program	Sverrir Thorhallsson	30 min + 15 discussion

1) Drilling Program / drill logs/ daily reports/ web access personnel requirem
2) Drilling – phases - 2400, 3500, 4500 – down hole motors /bits / CORING
3) Mud program AVA
4) Cementing of the casing PEAK/Schlumberger
5) Organization/safety issues
6) Contingency Planning
   - (i) Excessive loss circulation
   - (ii) High pressure kicks
   - (iii) Internal flow /blow out
   - (iv) Stuck drillstring
   - (v) Magmatic temperatures
   - (vi) Acidity and corrosion
   - (vii) Fishing policy / side tracking?
   - (viii) Other problems/decisions ?

Coffee break 10:45 20 min

Spot Corning		Alister Skinner	20 min
	Equipment		
	RN-17 B Experience		
	Organization at Krafla (core drillers?)		
	Coring contingency	Wilfred Elders	10 min
	Discussion		10 min

Fluid Handling and Evaluation	Kristin Ingason	10 min + 10 min

Well Head - Equipments – Time Schedule

The IDDP-1 well "Kick-off Meeting" – 3 to 4 March 2009

LUNCH 13-14

Geosciences Program:

	Guðundur Ó. Fridleifsson & Sigurveig Árnadóttir	30 min

1) General strategy/ geological logging/ daily reports – (LVP-DIS- ISOR web access
2) Geological personnel requirements and their assignments and schedules
3) Geophysical onsite personnel requirements and their assignments
4) Well Report – Initial Description of drill cuttings and cores – PI's role

	Wilfred A. Elders	30 min

5) Down hole fluid sampling
6) Sampling Party after drilling and the initial flow test
7) Scientific research and publications
8) Obligations from IDDP Deep Vision, ICDP and NSF
9) Future planning IDDP 2 and IDDP 3

Fluid Handling and Evaluation

	Kristinn Ingason and Halldór Ármannsson	30 min

1) First Flow Test – plan
2) 2nd flow test - full scale test

Pilot Plant	Jónas Matthíasson	15 min

1) Initial Ideas

Coffee break 15:45 pm

Other Items		60 min

1)	Hiti tools – and other T-indicator tools	Ragnar Ásmundsson
2)	Other tools – televiewer/fracture tests?	Grímur Björnsson
3)	EGS + CO_2 - modelling?	Robert O. Fournier
4)	General discussion and panel assignment	Wilfred Elders

Wednesday Morning 9:00 am

Panel Sessions	9 – 10
Plenary session – reports from panels – Summary	10-11
Deep Vision meeting	11-13

LUNCH 13-14	->	SAGA Meeting (+ BP, STh, KI)	14-16

The IDDP-1 well "Kick-off Meeting" – 3 to 4 March 2009

IDDP-Kick-off meeting	Affilication	IDDP role
SAGA		
Alister Skinner	ACS Coring Services, Scotland	SAGA
Dennis Nielson	DOSECC USA	SAGA
Guðmundur Ó. Friðleifsson	IDDP-PI/ -Ofiice/ HS Orka hf	SAGA,DV, PI, GS,CST
Hagen Hole	GCNZ Ltd. - New Zealand	SAGA
Jón Örn Bjarnason	ISOR	SAGA, FHE
Robert O. Fournier	USGS USA	SAGA
Runólfur Maack	Mannvit	SAGA
Stefán Arnórsson	University of Iceland	SAGA,CST
Sveinbjörn Björnsson	Orkustofnun	SAGA
Wilfred A. Elders	UCR - USA	SAGA, PI, CST
Project leaders		
Bjarni Pálsson	Landsvirkjun Power	IDDP-PM and -DT
Sverrir Þórhallsson	ISOR	DT leader,CST
Kristinn Ingason	Mannvit	FHE leader
Deep Vision		
Albert Albertsson	HS Orka hf	DV,FHE
Björn Stefánsson	Landsvirkjun	DV
Einar Gunnlaugsson	Orkuveita Reykjavíkur	DV
Pal E. Andersen	StatoilHydro ASA	DV
DT-group		
Hinrik Árni Bóasson	Mannvit	(Engineer - in Krafla)
Sveinbjörn Hólmgeirsson	LVP	DT, LVP-PM
Helgi Leifsson	OR	DT
Jón Búi Guðlaugsson	OR	DT
FHE group		
Teitur Gunnarsson	Mannvit	FHE
Claus Ballzus	Mannvit	FHE
Jónas Matthiasson	Verkís	FHE
Hannes Sverrisson	Mannvit	FHE
Kristján Einarsson	LVP	FHE
GS- group		
Gestur Gíslason	Reykjavik Geothermal	GS
Jardboranir hf		
Ari Stefánsson	Jardboranir	CEO
Bjarni Guðmundsson	Jardboranir	PM on site
Steinar Már Þórisson	Jardboranir	PM on site
Unnur Björnsdóttir	Jardboranir	
Vignir Demusson	Jardboranir	
Consultants		
Anette K. Mortensen	ISOR	(geology in Krafla)
Ásgrímur Guðmundsson	LVP	LVP-PM
Benedikt Steingrímsson	ISOR	ISOR PM
Bjarni Gautason	ÍSOR	geology
Grímur Björnsson	Reykjavik Geothermal	CST
Hermann Guðmundsson	ÍSOR	Coring
Hörður Halldórsson	ÍSOR	Borehole logging
Ivar Spilling	StatoilHydro	DT-support
Magnús Ólafsson	ÍSOR	PM for LV at ISOR
Ragnar Ásmundsson	ISOR	CST, HITI
Sigurveig Árnadóttir	ÍSOR	DIS-geologist
Auður Ingimarsdóttir	ÍSOR	DIS-geologist
Þorsteinn Egilsson	ÍSOR	borehole logging
Ari Ingimundarson	ÍSOR	Engineering