REPORT OF WORKSHOP No 1 OF THE ICELAND DEEP DRILLING PROJECT, NESJAVELLIR, ICELAND, MARCH 17-19, 2002

EXECUTIVE SUMMARY

The Iceland Deep Drilling Project (IDDP) is an investigation of supercritical phenomena in hydrothermal systems within the mid-ocean rift system in Iceland. Workshop No 1 of the IDDP was concerned primarily with developing the optimum strategy of meeting the difficult technical challenges of drilling and sampling wells to depths of 3.5 to 5 km and temperatures of >450°C. The workshop led to a clearer definition of the conditions likely to be encountered and developed the guidelines for planning drilling and coring. The outcome was an enthusiastic endorsement of the project by both industrial and scientific partners in the IDDP. We anticipate that the site of the first well will be chosen in the near future, allowing the specific well design to be finalized and cost estimates to be made. The next step is to make, and begin implementing, a detailed science plan with broad international participation.

INTRODUCTION

The IDDP plans to drill a series of deep boreholes to penetrate into supercritical zones thought to exist beneath three currently exploited geothermal fields in oceanic ridge-type spreading centres in Iceland. The main aim is to produce fluids for power production that have significantly higher enthalpies than are currently being utilized. Deep Vision, a consortium of Icelandic energy companies, is funding the IDDP. A feasibility study, with a budget of more than US $ 300,000, is currently under-way, examining the three candidate sites and the economic and engineering issues of drilling to greater depths and higher temperatures than are currently drilled (See the IDDP web page at www.os.is/iddp/). Deep Vision has invited the participation of the scientific community to use these wells for scientific studies that are consistent with the project, to the mutual advantage of both industrial and scientific participants. Accordingly a start-up meeting was held in Reykjavik in June of 2001, with funding from the International Scientific Continental Drilling Program (ICDP), to begin planning a scientific program. A ***Science Applications Group of Advisors*** (SAGA), with both Icelandic and international membership was formed (see Appendix 1) to develop the guidelines for a scientific program within the IDDP.

A workshop, funded by the ICDP, was held at Nesjavellir, Iceland, March 17-19th 2002, to assess the progress of the feasibility study, and to discuss the options for meeting the challenges of drilling at these high temperatures while maximizing the sampling and measurements essential to the scientific program being planned. Appendix 2 shows the Agenda of the Workshop and the List of Attendees The SAGA committee met on March 19-20th to review the input from the workshop and its significance for the scientific program. A second workshop to develop the specifics of this scientific program is planned for October 2002.

BACKGROUND

Why Study Supercritical Conditions?

The physics and chemistry of supercritical fluids in the Earth's crust are of considerable interest in understanding problems as diverse as the cooling of igneous intrusions, contact metamorphism, the formation of hydrothermal ores, and the submarine hot springs known as black smokers on mid-ocean ridges. Superheated steam produced from a fluid initially in the supercritical state can have a higher enthalpy than steam produced from an initially two-phase system. Large changes in physical properties at, and near, the critical point in dilute fluid systems can lead to extremely effective rates of mass and energy transport. Similarly, because of major changes in the solubility of minerals above and below the critical state, supercritical phenomena can play a major role in high temperature water/rock reaction and the formation of ore bodies. Hitherto, study of the supercritical phenomena has been restricted to either small-scale laboratory experiments or to investigations of "fossil" supercritical systems exposed in mines and outcrops. Furthermore mathematical modeling of the chemistry of supercritical fluids is hampered by a lack of a reliable thermodynamic database over the range of temperatures and pressures of the supercritical state.

Why Drill in Iceland?

Iceland is the largest landmass straddling a mid-ocean ridge. The tectonic setting of this diverging plate boundary results in active rifting and volcanism that provides the heat source for the well-established Icelandic geothermal industry. Very high heat flows within this active tensional regime indicate supercritical temperatures should exist at drillable depths in several places in Iceland. Temperatures greater than 300°C are commonly encountered in wells drilled to only 2 km. The likely existence of permeable regions in brittle basaltic rock at supercritical temperatures at still greater depths beneath some of these geothermal fields is inferred from the distribution of hypocentral depths of seismic activity that continues to below 5 km.

Each of the three sites selected for consideration by the IDDP displays a different stage in the tectonic development of the mid-ocean ridge. The Reykjanes site represents an immature stage of rifting with a heat source that probably is a sheeted dike swarm. Fluids produced by 2 km deep geothermal wells in this system are evolved seawater. At Nesjavellir, the Hengill central volcano is the high temperature heat source for a geothermal reservoir in a graben that has temperatures of up to 400^{o}C at 2.2 km, and is recharged by meteoric water. The Krafla high-temperature geothermal field is developed above a magma chamber in a mature, active, volcanic caldera. It produces evolved meteoric water with some addition of volcanic gases.

It is clear that the objectives of the IDDP overlap with those of drilling being considered on submarine ocean ridges by the international ocean-drilling program. Indeed Iceland might be considered as a *"Mission Specific Platform"* for drilling at a divergent plate margin.

GOALS AND ORGANIZATION OF IDDP WORKSHOP 1

Drilling to temperatures of 450°C or greater at depths of 3.5 to 5 km presents severe technical challenges compared to those faced by most other scientific drilling projects (see Table 1, Some Deep Wireline Coring Projects). Given this background it was decided that the focus of the first IDDP workshop should be on the drilling strategy required to meet the scientific objectives of the IDDP (see Appendix 2, Workshop Agenda).

Table 1: Some Deep Wireline Coring Projects (Modified from data compiled by Bernd Wundes)

Project		**Depth**		**Thermal Regime**
Iceland Deep Drilling Project (planned)	IDDP	4000-5000 m	Vertical	400-600°C
Chinese Continental Scientific Drilling	CCSD	5000 m	Vertical	Medium
French Geological Exploration for Tunnelling	ALPET.	3000 m	Deviated	Cold
Hawaii Scientific Drilling Project	HSDP	4400 m	Vertical	Cold
Japanese Unzen Drilling Project (planned)	USDP	2200 m	Deviated	Hot
Kontinental Tiefbohrung (Vorbohrung)	KTB	4001 m	Vertical	Cold
Ukraine Krivoy Rog Superdeep Borehole		5400 m	Vertical	Cold
Long Valley Scientific Drilling Program	LVEW	3000 m	Vertical	Cold
San Andreas Scientific Drilling Project	SAFOD	4200 m	Deviated	Medium

The workshop began with a review of the ultimate scientific goals of the IDDP, "*to investigate supercritical phenomena in an ocean rift setting*". This was followed by a discussion of supercritical phenomena, with dilute and saline fluids, and of the geology of the environments in which they are likely to occur at drillable depths in Iceland. Discussion followed on computer modeling of the chemistry of supercritical fluids in equilibrium with basaltic rocks.

The purpose of these discussions was to define more exactly the drilling targets we are seeking to explore from both industrial and scientific viewpoints. A discussion of the requirements of the scientific program for cores, fluids and downhole measurements followed, as input to a broad review of possible well design and coring techniques. This, in turn, provided the background for the discussion of the optimization of drilling strategies. Similarly consideration of the engineering requirements of sampling and measuring the flow characteristics of supercritical fluids led to discussion of the optimization of fluid sampling and testing systems.

The workshop then split into three panels, "Geosciences", "Fluid Handling and Evaluation" and "Drilling". These panels reported back to the Plenary Session of the Workshop and made recommendations to guide the progress of the feasibility study. By the time of the Science Planning Workshop in October 2002, we anticipate that site selection will have been made, and that plans for well design and sampling, and their associated costs, will be near completion.

Finally, fruitful discussions between SAGA and representatives of Deep Vision were held that emphasized their serious commitment to the IDDP.

REPORT OF THE GEOSCIENCE PANEL

The charge to the panel was to discuss geoscience issues in support of the various technical topics assigned to both the Fluid Handling and Evaluation Panel and the Drilling Panel. Development of a comprehensive detailed science program will be the purpose of the next workshop of the IDDP to be held in October 2002. One of the principal objectives of the IDDP is to establish if high-temperature (400-500^{o}C) and high-pressure crustal fluids can be extracted economically from roots of high-temperature geothermal systems. The first aim of the Geoscience Panel was therefore to help define the drilling target by specifying the likely range of conditions of fluid temperature, pressure and composition, and of lithology and permeability that might be encountered at depth in the three sites being investigated by the feasibility study. Depending on the initial salinity of the recharge water, minimum supercritical temperatures will be in the range 375 to 425^{o}C, and minimum fluid pressures in the range 225 to 350 bars. Depending on the temperature gradient this will require drilling to 3.5 to 5 km depths.

Preliminary well simulator models being carried out as part of the feasibility study indicate that temperatures of 450^{o}C or greater, at initial fluid pressures of 350 bars or less, are necessary in order prevent the fluid from entering the two-phase field liquid water plus "wet" steam, during ascent and decompression. It is possible that the steam produced in the resulting 2-phase mixture might have an enthalpy no higher than steam produced from a "conventional" geothermal well that taps a liquid water reservoir. However, the mass fraction of that steam in the 2-phase mixture that results from adiabatic decompression of supercritical fluid should be much greater than that generally produced by flashing steam from a liquid water reservoir.

The chemical composition of supercritical fluids in the Earth´s crust is different in different geological environments. In different localities in Iceland, and at different times in a given locality, supercritical fluids may have originated as meteoric water or seawater, and may contain volcanic gases evolved from magmas intruded along rifts. In addition to the extraction of heat from these fluids, another societal benefit could be extraction of metals and other valuable chemical constituents from solution.

Two major topics of fluid characterisation were discussed at the meeting: (1) likely initial compositions of the aquifer fluids and their temperatures and pressures, and (2) the corrosion and scaling potentials as the fluids depressurize and cool during ascent to the surface. Considerable attention was given to thermodynamic modeling of fluid-mineral interactions at supercritical conditions. At this time there are uncertainties regarding the actual temperature, pressure, salinity and gas content of supercritical fluids occurring in basaltic rocks. Resolving that uncertainty is one of the major goals of the

IDDP. Assuming a certain initial fluid composition, temperature, and pressure, it is possible to model with a high degree of certainty the scaling potential for some silicates, such as quartz, but with little certainty for many other minerals, such as the sulfides. The general consensus was that scaling problems would be greater in a system involving seawater, as expected at Reykjanes, as compared to more dilute water systems as at Nesjavellir and Krafla. In particular, it is expected that sulfide deposition will be more extensive from seawater as compared to dilute water systems. Also acidity due to transfer of gases from the magma heat source is known to enhance rock dissolution and in this way intensify sulfide deposition during decompression and cooling.

The Geoscience Panel recommended that reaction progress modeling should be continued to evaluate the composition of dilute and seawater fluids in basalt over the range of temperature and pressure of interest. The Panel also recommended that assessments of the composition of fluids in equilibrium with hydrothermal mineral assemblages found in basaltic rocks altered by aqueous fluids, at 300-500^{o}C and 200-1000 bars, should also be made for comparison with the fluids actually observed. This would help to determine the reliability of predictions of behavior at higher temperatures, and make more certain estimates of scaling potentials of sulfides and other minerals. At a later stage another priority should be modeling of heat and mass transfer in the supercritical state at the candidate sites for drilling.

Attention was also given to issues such as the amount of rock and fluid sampling, necessary to characterize the supercritical environment. The panel pointed out that, as the deepest geothermal wells in Iceland reach only 2.3 km, some coring should be planned between 2.5 and 3.5 km, depths where temperatures would be subcritical. This would also be a good test of the coring system employed before the higher target temperatures are reached.

Another drilling-related issue considered by the Geoscience Panel was how to recognize when supercritical conditions had been penetrated while drilling. Several approaches were suggested. The first would be to augment the “mud-logging” system normally used in geothermal drilling, looking for “kicks” in parameters such as circulation losses/gains, differences in inlet/outlet temperatures, and gas, chloride, and other chemical components of the “mud” returns. The second approach would be to use applied geothermometry during drilling by making on-site studies of core and cuttings, studying mineral assemblages and fluid inclusions. Other valuable information would be gained by deployment of high-temperature, downhole pressure, temperature, and possibly flowmeter tools.

The panel made the following general recommendations with respect to selection of the site for the first deep well:-

i) Drill where the supercritical zone is likely to be at the lowest pressure and shallowest depth. Not only does this reduce the drilling costs but should also lead to higher enthalpy of the discharged fluid at the wellhead. It should also lead to lower concentrations of dissolved solids in the fluid, and possibly better permeability. However it could lead to higher HCl than would be the case for production at higher pressure.

ii) Select a geothermal system of low salinity to minimize problems of scaling, corrosion and acidity.

iii) Avoid lithologies with rocks of silicic and intermediate composition as they behave plastically at lower temperatures than do basalts, and are likely either to have poorer permeability or to contain fluids and gases at, or near, lithostatic pressures.
iv) Drill where indications in the shallower reservoir and geophysical studies suggest the existence of permeabilty at the depth of the supercritical zone.
v) Play safe by siting the first deep well of the series where the available data are adequate to meet the above criteria so that the possibilty of failure is least.

REPORT OF THE FLUID HANDLING AND EVALUATION PANEL

The charge to the panel was to discuss the approach being used by the feasibilty study to design a fluid handling system, and the implications of that design for the science program and for the drilling strategy. Given the uncertainties of investigating a fluid from a hitherto unexplored deep geothermal aquifer, with unknown pressure, temperature, chemistry and permeability, it is premature to begin designing a pilot plant. The immediate need after drilling into supercritical conditions is to produce the fluid to the surface for sampling and analysis while protecting the well from scaling or corrosion that might prevent its future use. It is possible that downhole samplers could be deployed, however sufficient production is necessary to remove contaminants introduced by drilling. Another issue is how to isolate production from different zones in a long open interval, and, if necessary, prevent downhole inter-formational blow-outs.

The concept proposed by the feasibility study is to use a removable inner liner reaching to the producing aquifer. This "pipe" is intended both to protect the well casing and to allow inspection of the effects of corrosion and scaling at different depths after removal. Flow would be measured at the well head and attempts would be made to measure pressure/temperature profiles downhole. Samples for chemical analysis would be collected over a range of flow conditions, giving vital information on the reservoir conditions.

The Panel met jointly with the Geoscience Panel to discuss how the chemistry of the supercritical fluids could be predicted, in terms of non-condensable gases and dissolved solids, either by modeling or by analogy with known geological situations. The possible extraction of hydrogen and/or other salable materials from the fluid was discussed. At present, 200 tonnes of hydrogen are vented annually from the Nesjavellir geothermal field and 100 tonnes from the Namafjall field near Krafla. Methods of splitting hydrogen sulfide to yield hydrogen and sulfur exist.

Another issue discussed was the possibility of *in situ* extraction of metals from fluids similar to those that occur in black smokers on ocean ridges. Of the three sites being investigated by Deep Vision, the Reykjanes Peninsula would be the most likely to have suitable chemistry for this approach to be considered. A downhole process of metal extraction from supercritical fluid that would require a wide diameter hole was briefly discussed.

The recommendations of the panel were:
i) The concept of producing through a solid liner (the "pipe") seems prudent,although there are a number of technical issues to discuss, such as metallurgy and diameter of the liner, and the specifications of downhole valves, liner hangers, and expansion collars, etc, and the disposal of the produced fluids.
ii) Heating of the pipe, for example by induction, may be necessary.

iii) Downhole valve assembly is preferable to enable replacement of the pipe.
iv) Calculations were presented to the panel, which indicate that the temperature of the fluid in the formation should exceed 450°C at an initial fluid pressure less than 350 bars for the steam to offer enthalpy advantages over steam from wells of conventional depth.
v) It appears that up to an order of magnitude more electricity might be generated by the fluid from a well producing from a supercritical zone than is produced from a conventional steam-water well.

REPORT OF THE DRILLING PANEL

The charge to the panel was:-
1) to review the difficulties of drilling in basalts at >450°C at depths of 3.5 to 5 km,
2) to discuss experiences of drilling in other high-temperature regimes,
3) to examine different coring systems that could be used,
4) to make recommendations to Deep Vision on optimising the design and drilling of a "dual purpose" well that meets both scientific and industrial objectives safely and economically.

Fruitful discussions were held among panel participants with a diversity of experience in drilling in different environments, and with representatives of organizations that have developed different approaches to drilling and coring. The Panel continued from its June 2001 meeting by considering four options for adding science coring in two different sizes of production wells (Figure 1, Well Profiles A & B). Well Profile A has a 9 5/8 inch production casing to 3500 m, whereas Well Profile B has a 9 5/8 inch casing to 2400 m with a 7 inch production casing to 3500 m. The upper part of Profile B (to 2400 m) is the design currently used in standard production wells used in the geothermal fields of the Reykjanes Peninsula. It is estimated that drilling, coring and reaming to a nominal depth of 5000 m would take about 250 days.

Based on presentations from representatives of DOSECC, AQUATIC (CCS), and BOHRGESELLSCHAFT RHEIN-RUHR (BRR), three different coring systems were considered for evaluation to core in the interval 2400 m to 3500m, and for continuous coring below 3500 m (Table 2, Four Options for Coring). These use two modes of coring; (a) "Large Diameter" diameter coring, with large diameter core, large kerf, and (b) "Small Diameter" coring with smaller core, small kerf, and low mud volumes (Table 3, Technical Data for Deep Wireline Coring). It was shown that either system produces insignificant well cooling as coring produces less than a tenth of the mudflow used in conventional rotary drilling.

Each of the technologies available provides distinct advantages and drawbacks (Table 4, Tradeoffs between Small Diameter- and Large Diameter Hole). The choice will be dictated primarily by the required well diameter for flow testing and logging and also by such parameters as maximum hookload availability and well-safety considerations, and costs. The specific details of the well design like casing depths, cementing plans, and coring method(s) are dependent on completion of the pre-feasibility study. If funds allowed, it would be desirable to evaluate at least two of the available technologies by coring parts of the interval between the currently exploited hydrothermal reservoir (2,400 m) and the bottom of the cased part of the well (3,400 m, Figure 1). The technique that performs best in that interval would then be the preferred choice for coring into the supercritical zone. In the likely event that the latter approach proves economically unfeasible, a coring sub-contractor will be chosen on the basis of cost and technical merit.

The above approach to designing the first IDDP well combines tried and tested geothermal rotary drilling technology, used in Iceland for many years, with a wireline coring approach that has been deployed successfully in geothermal exploration and development in Indonesia and elsewhere. The conservative design is illustrated by well profile A (Figure 1), with a string of 13 3/8 inch casing cemented in to a depth somewhat greater than the typical (2,000 m) Iceland geothermal reservoir, nominally 2,400 m. Well profile B represents the current standard geothermal well completion with a 9 5/8 inch casing string cemented in at the top of the production zone. The decision on which approach to use will be dictated by the commercial and engineering requirements and cost considerations of Deep Vision.

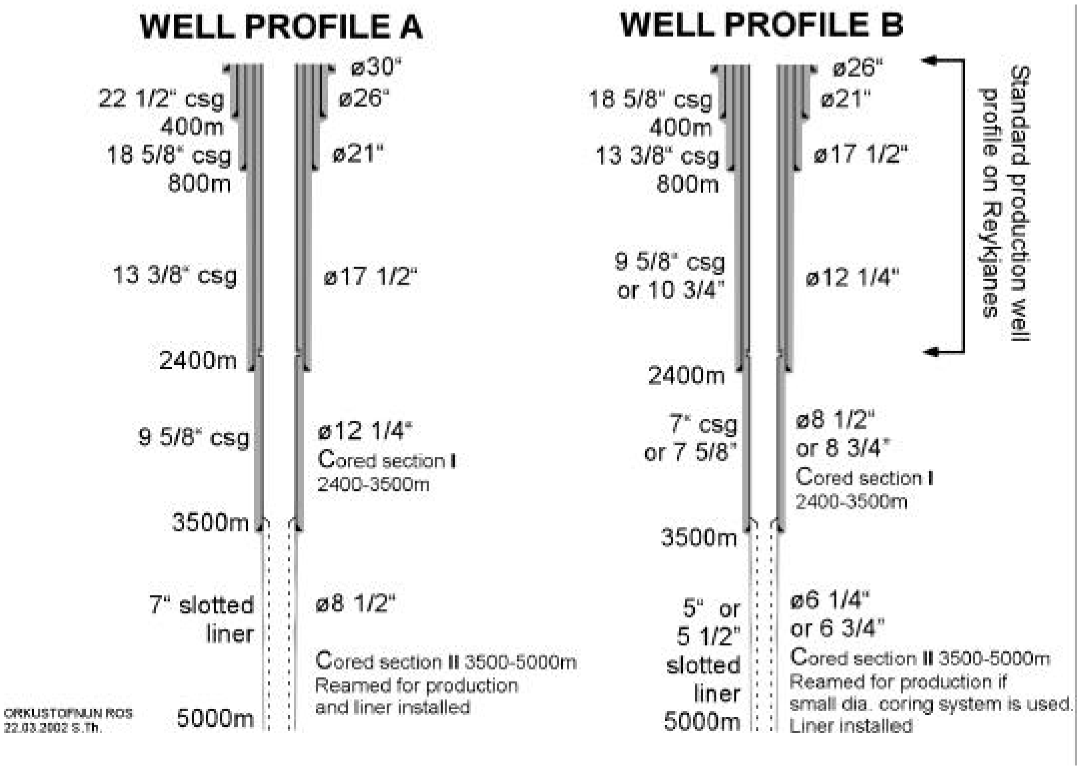

Figure 1. Well profile A and Well Profile B

The idea is that science drilling would begin from the nominal 2,400 meter depth (actual depth will be determined by local conditions at whichever site is chosen). In the case of both Well Profile A or B, a "bushing string" of technical casing will be tied back to the surface, and a wireline corehole will be drilled through the conventional reservoir interval (Figures 2A & 2B) to near the top of the supercritical zone, nominally 3,500 m in Figure 1. This hole will be, in turn, reamed to an appropriate diameter, necessary logging and testing will be performed, and then coring resumes until the desired temperature (in the range of 400 to 500° C) is reached (hopefully at less than the nominal value of 5,000 m shown in Figure 1). Another string of casing will be tied back to the surface and cemented in (Figure 2). A slotted liner will have to be run in the open hole section and a “pipe” run to surface to meet the requirements of the fluid handling and evaluation panel. Fluid sampling and testing will be conducted, and the supercritical regime evaluated. This stage concludes the scientific well testing and sampling. Then, depending on the results of the evaluation of the supercritical regime, the lower part of the well will either be plugged and abandoned, or reamed and fitted with a production liner to facilitate large scale production of fluid both for commercial purposes and more comprehensive scientific and technical studies of fluid properties.

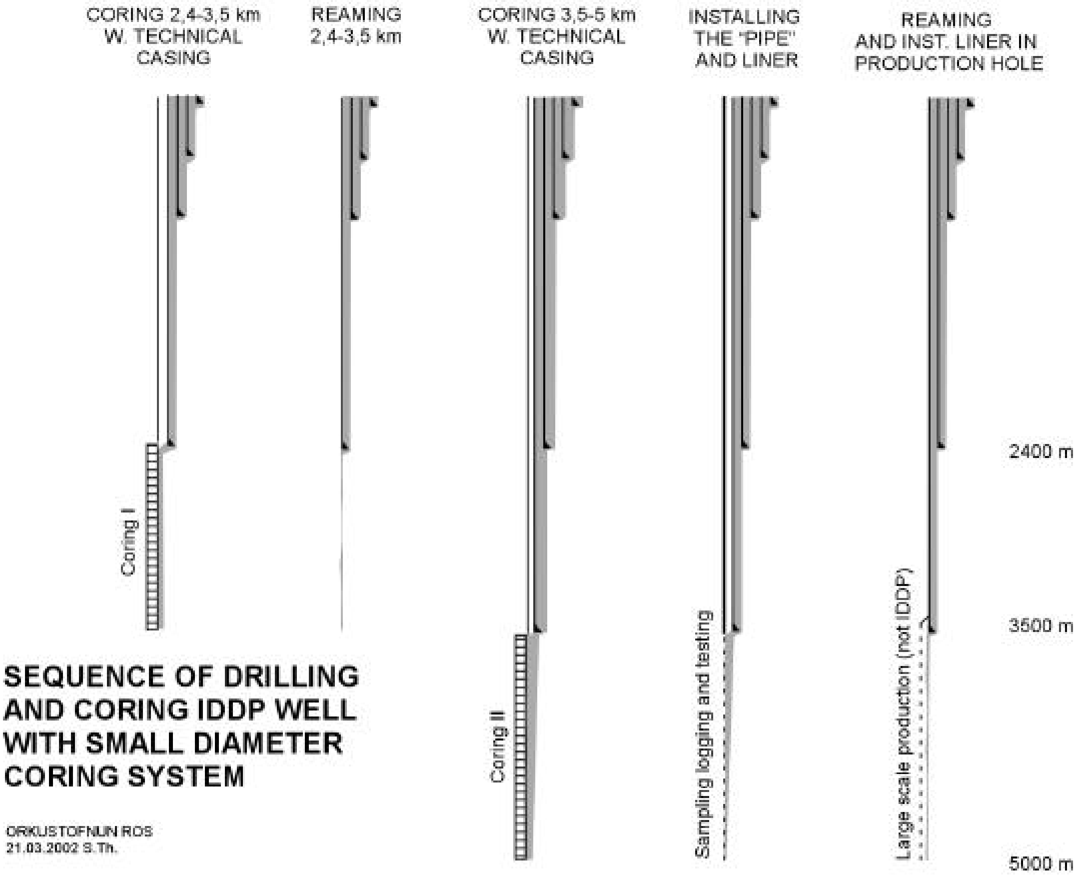

Figure 2 A. Sequence of drilling and coring with small diameter coring

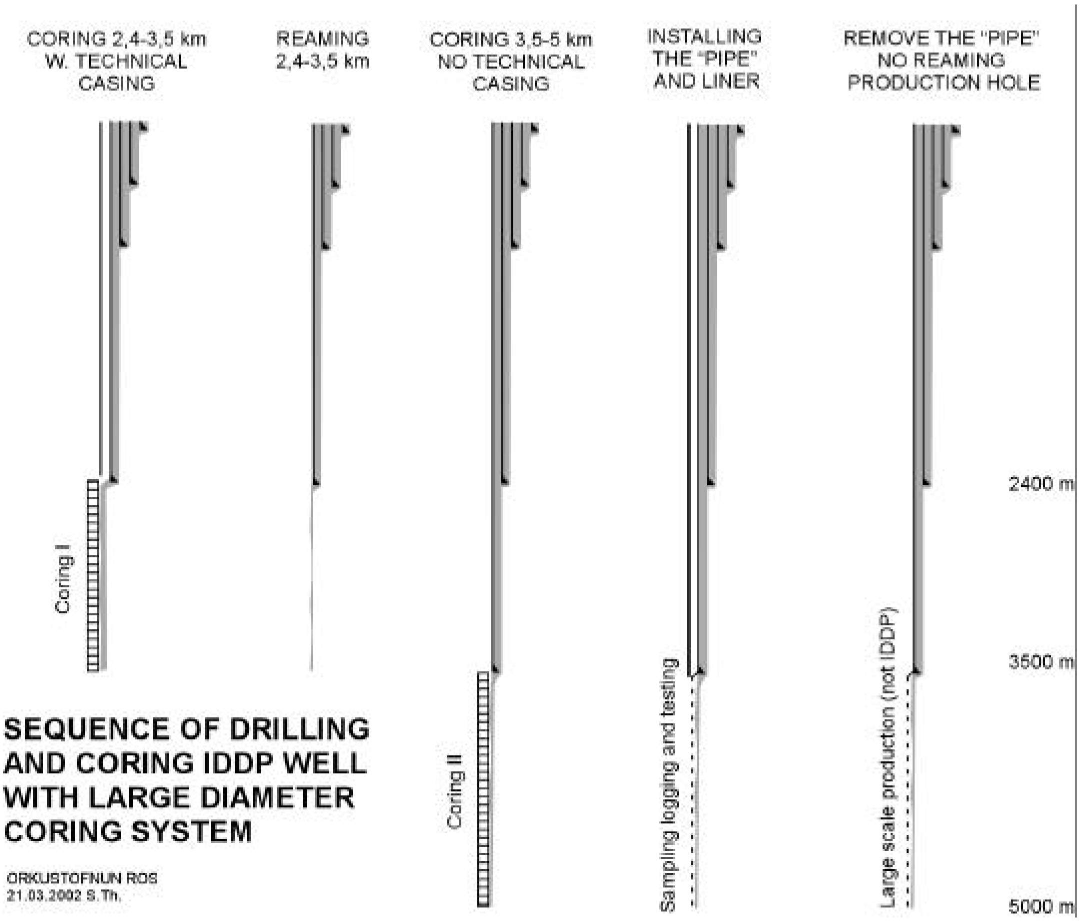

Figure 2B. Sequence of drilling and coring with large diameter coring

Table 2. Four options for coring in wells A and B

Four Options	Rig Capacity	Production Casing	Last Hole Dia	Core Size	Hole Size		Cored Sec km	**Option**
Small Diameter Hole	180 ton	7"	6 1/4"	2.4"	3 7/9"	DOSECC	2.3-3.4 3.4-5.0	**op-1**
		7 5/8"	6 3/4"	4.0"	6 3/4"	BRR	2.3-3.4 3.4-5.0	**op-2**
Large Diameter Hole	250 ton	9 5/8"	8 1/2"	2.6-3.1"	8 1/2"	CCS	2.3-5.0	**op-3**
				2.4"	3 7/9"	DOSECC	2.3-5.0	
				4.0"	6 3/4"	BRR	2.3-5.0	
				2.6-3.1"	8 1/2"	CCS	3.4-5.0	**op-4**
				2.4"	3 7/9"	DOSECC	3.4-5.0	
				4.0"	6 3/4"	BRR	3.4-5.0	

Table 3. Technical data for deep wireline coring systems (ref. Bernd Wundes)

Technical Data for Deep Wireline coring Systems

ITEM	**CCS Aquatic**	**ICDP-WL (Micon)**	**SK5 BRR**	**DOSECC**	
				Top Str as WLDP	**Cr Brl** and WLDP
Last Casing or	9 5/8"	7"	7 5/8"	5"x7.53 mm	
temporary working string					
Hole Diameter	222 mm	155.6 mm	171.5 mm	96 mm	
Core Diameter	80 mm	94 mm	101.6 mm	63.5 mm	
Drillpipe Type	ADP	Special	Special	Hydril	HMCQ
Pipe OD, mm	164-168	139,7	139,7	88,9	88,9
Tooljoint OD, mm	197	146	162	99,06	88,9
Pipe ID, mm	146	123,5	123,7	74,73	77,8
Tooljoint ID,mm	144	110	123,5	76	77,8
Traction Tensile,MN	>3.3	>3.0	>3.1	0,93	0,42
Makeup Torque, Nm	30.000	21.000	25.000	4.339	2.000
Mudflow rate, l/min	700-1500	175	250	100	100
Mud Velocity, Pipe OD,m/s	0.75-1.5	0,79	0,54	0.44	0.79
Mud Velocity, t-joint OD, m/s	1.9-3.1	1,29	1,68	0.72	1,62
Weight in air, kg/m	23,5	29	30	13.73	9,81
Depth rating, m for SF=2	9000	6358	6358	6560	2634
Material Grade pipe	Aluminum	G105	P110	S125	C1541
		30CrNiMo8V	SAE4145 Hmod	Thread cut in wall	

Table 4 : Tradeoffs between small diameter- and large diameter hole coring systems

Hole type :	Cooling Effect	Money	Casing/cementing	Core Diameter	Diameter of the "pipe"
Small Diameter	Minus (low flow rate)	Plus	Minus (Narrow annulus)	64 mm	Minus
Large Diameter	Plus (for CCS)	Minus (Large hookload)	Plus	80-102 mm	Plus
Qualitative judgment. Numbers need to be developed. Issues include %core recovery,high temp capability, and degree of cooling.					

GENERAL CONSIDERATIONS AND FUTURE PLANS

If Deep Vision's long term goals of economic energy production and mineral extraction from supercritical geothermal resources are realized, the approach could improve the economics of high-temperature geothermal resources world-wide. This will require a great deal of technology development over the coming decades. However the first step is to drill in search of the supercritical fluids. The wide-ranging discussions at the workshop allayed doubts that the IDDP wells can be drilled and sampled, using available technology and at reasonable costs. The feasibility study being carried out by the National Energy Authority of Iceland and its subcontractors appears to be well on track.

Discussions with representatives of Deep Vision were very productive. They reaffirmed the commitment of the consortium to the IDDP and their willingness to facilitate scientific studies. Meetings with the power companies will take place shortly to present ideas on the preferred well design and on site selection. Choice of the site for the first deep well will depend partly on business decisions on financing and partly on environmental permitting. However, the long term expectation is that deep wells will be drilled at all three sites by the power companies, and that these wells will be made available for deepening and coring for scientific studies. From a scientific viewpoint all three sites are appealing.

This prospect opens up the opportunity for a very comprehensive scientific program investigating the anatomy of a mid-ocean rift zone, by tying together land–based and ocean-based deep borehole studies with complementary geological and geophysical studies. The next step is to organize a workshop on the science to be done in connection with the first deep hole, while developing plans for a much more comprehensive and long-term program.

APPENDIX 1 IDDP - Membership of SAGA :

Stefán **Arnorsson**		University of Iceland
Jón Örn **Bjarnason**		Orkustofnun, Geoscience, Iceland
Guido **Cappetti**		Erga Gruppo Enel, Italy
Wilfred A. **Elders**	PI	University of California, USA
Gudmundur Ó. **Fridleifsson**	PI	Orkustofnun, Geoscience, Iceland
Robert O. **Fournier**		USGS, USA
Valdemar K. **Jónsson**		University of Iceland
Runólfur **Maack**		VGK Engineering, Iceland
Dennis **Nielson**		DOSECC, USA
Gudmundur **Palmason**		Orkustofnun, Geoscience, Iceland
Seiji **Saito**	PI	Tohoku University, Japan
John **Sass**		USGS, USA
Alister **Skinner**		BGS, Scotland U.K.
Valgardur **Stefansson**		National Energy Authority, Iceland

Appendix 2 IDDP / ICDP Workshop 1 Agenda

OVERVIEW

	17 March 2002	18 March	19 March	20 March	21 March
	Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
	Workshop begins			*Departure to*	*Departure to Europe*
				Europe	*and Japan*
09:00	Welcome / IDDP introduction	High-T logging and sampling	Panels continue	**SAGA -**	**PI-meeting**
09:15	Workshop goals	(Cancelled for unforseen reason)		**meeting**	**complete**
09:30	Supercritical phenomena	Producing through the "pipe"		Review of	**SAGA report**
10:00	Supercritical phenomena continued	Casing Design		reports	
10:40	***Coffee 20 min***	***10:10 Coffee 20 min***	***Coffee 20 min***	***Coffee 20 min***	
11:00	Feasibility Report - 3 presentations	10:30 Ocean Hydrothermal Res.	**Prelim. Report within Panels**	topic groups	
12:00	ICDP - Introduction	10:50 Interface Science-Drilling	Discussion		**PI-meeting ends**
		11:10 Organization of panels			
12:30	***Lunch***	***Lunch***	***Lunch***	***Lunch***	***Lunch***
13:30	Supercritical phenomena cont.	**Split into Panels**	**Plenary session**	SAGA report	
14:10	Case studies from active high-T	1 Drilling Technology	Final panel reports,	writing	
14:30	fields > 340°C 4-5 presentations	2 Fluid Handling	discussions and		
15:00	Improving borehole stability	3 GeoSciences	recommendations		
15:30	***Coffee 20 min***	***Coffee 20 min***	Earliest departure	*Departure*	*Departure to USA*
16:10	Rig selection / the Jotun rig	Panels continue	*to USA & Europe*	*to USA & Europe*	
16:30	The DOSECC hybrid coring system				
16:50	Coring technology (BRR)				
17:10	Improved Drill Bits			**SAGA -**	
17:30	Complete Coring System (CCS)				
18:00	**end**		**Workshop ends**	**meeting ends**	
18:30	Reception hosted by Orkuveita Reykjavikur				
19:30	Dinner			**PI-meeting**	

	Sunday 17 March 2002		**Chairman**	**DETAILS**
09:00	Welcome / IDDP introduction	Gudmundur Omar Fridleifsson	**Seiji Saito**	15 min
09:15	Workshop goals	Wilfred A. Elders		15 min
09:30	Supercritical phenomena-geochem.	Robert O. Fournier		30 min
10:00	Supercritical phenomena-geochem.	H. Armannson & G. Gislason		20 min
10:20	Supercritical phenomena-geochem.	Mark Reed		20 min
10:40	***Coffee 20 min***			
11:00	Feasibility report - Drilling Technique	Sverrir Thorhallsson	**Gudmundur Pálmason**	20 min
11:20	Feasibility report -Fluid handling	Runólfur Maack		20 min
11:40	Feasibility report - Geosciences	Gudmundur Omar Fridleifsson		20 min
12:00	ICDP - What is ICDP ?	Ulrich Harms		20 min
12:30	***Lunch***			
13:30	Supercritical phenomena at < 3,5 km	Gudmundur Omar Fridleifsson	**Valgardur Stefánsson**	20 min
13:50	Supercritical phenomena at > 3,5 km	Dennis Bird		20 min
14:10	Kakonda hostile fluid/rock T>340°C	Seiji Saito		20 min
14:30	Geysers hostile fluid/rock T>340°C	Dennis Nielson		20 min
14:50	NJ-11/KG-4 hostile fluid/rock T>340°C	Benedikt Steingrimsson		20 min
15:10	Salton Sea hostile fluid/rock T>340°C	W.A.Elders		20 min
15:30	Improving borehole integrity and stability	Vincent Maury		20 min
15:50	***Coffee 20 min***			
16:10	Rig selection / the Jötunn rig	Thór Gíslason	**John Rowley**	30 min
16:40	The DOSECC hybrid coring system	Marshall Pardey		30 min
17:10	Coring technology (BRR)	Bernd Wundes		30 min
17:40	Discussion			
18:00	**Break - Reception 18:30 - Dinner 19:30**			
	Monday 18 March 2002			
09:00	Improved Drill Bits	Mike Thigpen		20 min
09:20	Complete Coring System (CCS)	Mikhail Gelfgat		30 min
09:50	Producing through the "pipe"	Jón Örn Bjarnason	**Stefán Arnórsson**	20 min
10:10	Casing Design	Matthias Matthiasson		20 min
10:30	***Coffee 30 min***			
11:00	Ocean Hydrothermal Resources	Daniel Fraser	**Robert Fournier**	20 min
11:20	Interface Science-Drilling	John Sass		20 min
11:40	Organization of panels - open discussion	Wilfred Elders		20 min
12:00	***Lunch***			
13:30	**Split into Panels**			

Appendix 3 List of Attendees

No.	Participants	Affiliation	Location
1	Wilfred A. Elders	University of California	Riverside, USA
2	Seiji Saito	Tohoku University	Sendai, Japan
3	John Sass	USGS	Flagstaff, USA
4	Robert O. Fournier	USGS	Menlo Park, USA
5	Dennis Nielson	DOSECC	Salt Lake City, USA
6	Mark Reed	University of Oregon	Eugene, USA
7	Dennis Bird	Stanford University	Stanford, USA
8	John Rowley	Pajarito Enterprises.	Los Alamos, USA
9	Mary Rowley	Pajarito Enterprises.	Los Alamos, USA
10	Daniel Fraser	University of Manitoba	Winnipeg, Canada
11	Mikhail Gelfgat	Aquatic Company	Moscow, Russia
12	Vincent Maury	GEOMEC, Scientific Adviser	Idron, France
13	Marshall Pardey	QD Tech, Inc	Salt Lake City, USA
14	Bernd Wundes	Bohrgesellschaft Rhein-Ruhr	Dortmund-Kurl, Germany
15	Mike Thigpen	Varel P.D.Products	Houston, USA
16	Ulrich Harms	ICDP	Potsdam, Germany
17	Gord Klimenko	University of Manitoba	Canada
18	Nic Nicols	Baker Hughes International	USA
19	Tor Tan Eriksen	Baker Hughes International	Stavanger, Norge
20	Gudmundur Pálmason	Orkustofnun GeoScience	Reykjavik, Iceland
21	Stefán Arnórsson	University of Iceland	Reykjavik, Iceland
22	Valgardur Stefánsson	*National Energy Authority*	Reykjavik, Iceland
23	Jón Örn Bjarnason	Orkustofnun GeoScience	Reykjavik, Iceland
24	Runólfur Maack	VGK-engineering	Reykjavik, Iceland
25	Gudmundur Ómar Fridleifsson	Orkustofnun GeoScience	Reykjavik, Iceland
26	Einar Gunnlaugsson	Orkuveita Reykjavikur	Reykjavik, Iceland
27	Albert Albertsson	Hitaveita Sudurnesja	Reykjavik, Iceland
28	Björn Stefansson	Landsvirkjun	Reykjavik, Iceland
29	Sverrir Thórhallson	Orkustofnun GeoScience	Reykjavik, Iceland
30	Ólafur G. Flóvenz	Orkustofnun GeoScience	Reykjavik, Iceland
31	Benedikt Steingrímsson	Orkustofnun GeoScience	Reykjavik, Iceland
32	Ásgrímur Gudmundsson	Orkustofnun GeoScience	Reykjavik, Iceland
33	Grímur Björnsson	Orkustofnun GeoScience	Reykjavik, Iceland
34	Halldór Ármansson	Orkustofnun GeoScience	Reykjavik, Iceland
35	Knútur Árnason	Orkustofnun GeoScience	Reykjavik, Iceland
36	Ingi Th. Bjarnason	Science Institute, Univ.of Iceland	Reykjavik, Iceland
37	Gestur Gíslason	Orkuveita Reykjavikur	Reykjavik, Iceland
38	Claus Ballzus	VGK Engineering	Reykjavik, Iceland
39	Matthías Matthíasson	VGK Engineering	Reykjavik, Iceland
40	Teitur Gunnarsson	VGK Engineering	Reykjavik, Iceland
41	Kristinn Ingason	VGK Engineering	Reykjavik, Iceland
42	Thór Gíslason	Iceland Drilling Ltd.	Reykjavik, Iceland
43	Sturla Fanndal	Iceland Drilling Ltd.	Reykjavik, Iceland
44	Bjarni Gudmundsson	Iceland Drilling Ltd.	Reykjavik, Iceland
45	Árni Gunnarsson	Landsvirkjun	Reykjavik, Iceland
46	Bjarni M. Júlíusson	Landsvirkjun	Reykjavik, Iceland
47	Bjarni Pálsson	Landsvirkjun	Reykjavik, Iceland
48	Geir Þórólfsson	Hitaveita Sudurnesja	Reykjavik, Iceland
49	Thorbjörn Karlsson	University of Iceland	Reykjavik, Iceland

	Invited guests	Affiliation	Location
50	Friðrik Sophusson	Landsvirkjun	Reykjavik, Iceland
51	Agnar Olsen	Landsvirkjun	Reykjavik, Iceland
52	Bjarni Bjarnason	Landsvirkjun	Reykjavik, Iceland
53	Gudmundur Þóroddsson	Orkuveita Reykjavíkur	Reykjavik, Iceland
54	Ásgeir Margeirsson	Orkuveita Reykjavíkur	Reykjavik, Iceland
55	Ingólfur Hrólfsson	Orkuveita Reykjavikur	Reykjavik, Iceland
56	Júlíus Jónsson	Hitaveita Sudurnesja	Reykjavik, Iceland
57	Bent Einarsson	Iceland Drilling Ltd.	Reykjavik, Iceland
58	Þorkell Helgason	National Energy Authority	Reykjavik, Iceland
59	Valgerður Sverrisdóttir	Minister of Industry and Commerce	Reykjavik, Iceland
60	Þorgeir Örlygsson	Permanent Secretary, IVR (MIC)	Reykjavik, Iceland
61	Vilhjálmur Lúdvíksson	The Icelandic Research Council	Reykjavik, Iceland
61	Sveinbjörn Björnsson	National Energy Authority	Reykjavik, Iceland
62	Ingvar B. Friðleifsson	UNU-Geothermal Training Program	Reykjavik, Iceland
63	Magnús Ólafsson	Orkustofnun GeoScience	Reykjavik, Iceland
64	Kristján Saemundsson	Orkustofnun GeoScience	Reykjavik, Iceland