

INTERIM REPORT

High Impact Systems (Rock Bits, Coring & More) Technical Review & Risk Reduction Study

for the

BEAM – “Borehole into Earth's Mantle” Project

Prepared For:

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IODP-MI



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Purpose:

Provide a review of Blade's progress to date.

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1 Executive Summary

The focus of Blade's work to date has been to meet with the key oilfield service providers of bits and coring systems, to explain the technical issues around the BEAM project, and to get information about their hard rock product offerings. The intent is to then compare the BEAM requirements with the current status of hard rock drilling and coring technology, evaluate the technical trends and to determine the company's ability and willingness to provide technical solutions to the BEAM project. The key project milestones thus far are as follows:

- April 11: Met with National Oilwell Varco (NOV)
- April 12: Met with Baker-Hughes
- April 13: Met with Halliburton
- April 30: Presented a paper on the Blade 2011 mantle drilling feasibility study at the Offshore Technology Conference in Houston. Gathered information from relevant exhibitors at the conference.
- May 2: Met with Yoshi Kawamura in Houston, and provided a review of the service company meeting results
- June 7: Met with CDEX engineers in Yokohama, and provided a review of the service company meeting results
- June 28: Follow-up meeting with NOV.
- June 29: Visit to the IODP-USIO office

A meeting with Ulterra, who at one time provided the C-7 and C-9 series of core bits that have been the mainstay of IODP's scientific drilling efforts to date, is scheduled for July 24. A third meeting with NOV is planned for early August. Schlumberger is the only major service provider that Blade has not been able to meet with as of yet.

It should be noted that of all the companies Blade has talked to thus far NOV has by far expressed the most interest and enthusiasm about being involved in the BEAM project. NOV has, for example, volunteered to run mechanical tests on a sample of basalt rock from the 1256D hole to help determine its drillability using NOV's in-house evaluation procedures, and has agreed to run tests on the synthetic diamonds developed by Dr. Irifune of Ehime University – at no cost to IODP.

It was clear that NOV is genuinely interested in the BEAM project and quite willing to provide their own time and resources to help identify solutions to the technical issues around the BEAM project - something that is not evident from the other two companies Blade has talked to - thus far at least.

2 Discussion

The focus of Blade's work for this project has been to evaluate the hard rock drilling and coring technology that currently exists within the oil and gas industry and to understand where and how the technology will be trending in the future. To this end, Blade developed a presentation (reference Appendix A) that summarized the BEAM project objectives and the technical issues around drilling and coring into the mantle and has thus far met with three of the four key oilfield service providers of bits and coring systems. The purpose of these initial meetings was to introduce the BEAM project, get information about their current product offerings and their technical development efforts, and to identify their ability and willingness to provide technical support to the BEAM project.

Initial meetings were held on April 11, 12, and 13 with National Oilwell Varco (NOV), Baker-Hughes and Halliburton respectively, at their offices in Houston. NOV provides Reed and Hycalog bits. Baker provides Hughes Christensen bits, and Halliburton provides Security and DBS bits. The meetings were quite informative and Blade was gratified to see that the meetings were attended by the relevant product line managers and technical representatives from all three companies. The key observations that came out of these meetings are as follows:

- All three companies are generally interested in the BEAM project, NOV in particular.
- Halliburton expressed concerns over "what's in it for me" - which each company expressed to some degree.
- All three companies believe that they have current products that would provide better performance compared to current scientific drilling practices and results.
- All three companies have active ongoing technology development programs that will result in new products on the market well before the nominal 2018 start date for the BEAM project.
- All three companies have extensive experience with hard rock, and high temperature drilling and coring applications within the oil and gas industry. They all have a sound technical understanding of drilling and coring mechanics as well as the bit design and bottom hole assembly performance software models that are used to develop optimized performance solutions.
- It is quite possible that a formal "R&D" program may not be required to address the BEAM technical issues around bit and coring performance because of the natural progression of technology improvement within the oil and gas industry.

The results of these meetings were reviewed with Yoshi Kawamura on May 1 during the Offshore Technology Conference in Houston. The results were also presented to CDEX engineers at a meeting in Yokohama on June 7. Note that the minutes of the three meetings can be found in the Appendices B, C and D.

BEAM is a complicated project from the standpoint of both the technical issues and the fact that it is managed and will be operated by a non-profit scientific organization, which is obviously atypical for the oil and gas industry. NOV stated that they were unclear on how best to move forward and requested that Blade prepare a list of possible steps that could be taken to address the BEAM project's technical and commercial issues with the support of a manufacturing service company. Blade subsequently prepared this list (reference Appendix E) and sent it to all three companies. The intent was that the list could serve as the basis of internal discussions within the companies to help them determine their level of interest, resource requirements, costs and to serve as the basis

for subsequent meetings with Blade. So far, NOV is the only company that has responded which led to a follow-up meeting on June 28.

2.1 NOV June 28 Follow-up Meeting

A second meeting with NOV was arranged for June 28 when Yoshi Kawamura would be able to attend. The meeting included a tour of NOV's bit performance testing lab, their bit manufacturing facility, and a presentation about their development of high-temperature bearing seals for a new series of roller cone bits designed for geothermal applications, and a presentation on their wireline retrievable rotary coring system.

The key observations from the meeting are as follows:

- NOV has an extensive drill bit research lab at their Conroe, Texas facility that can simulate a wide variety of actual drilling conditions.
- The lab has a side selection of different types of rocks that are used for drill bit testing including two types of basalt that come from Faroe Islands and the US Pacific Northwest.
- NOV is working on the bearing system design for 8-1/2" and 12-1/4" roller cone bits to be used in geothermal applications with temperatures up to 288°C. They have successfully run 3 prototype bits in New Zealand at up to 260°C and have plans to run several more. The goal is to add these bits to their product line in sizes ranging from 7-7/8" to 12-1/4".
- NOV also has a wireline retrievable rotary core system known as "Corion Express". The system can cut 3.0" and 3-1/2" cores and up to 90 ft of core can be cut at one time. The standard core bit diameter is 8-3/4" but 9-7/8" bits can be also be used. Core recovery is presently greater than 90%.
- NOV noted that no one uses roller cone core bits these days. All coring is doing with fixed cutter bits.
- Of all the companies Blade has talked to thus far NOV has by far expressed the most interest and enthusiasm about being involved in the BEAM project. They, for example, volunteered to run mechanical tests on a sample of basalt rock from the 1256D hole to help determine it drillability using NOV's in-house evaluation procedures, and they agreed to run tests on the synthetic diamonds developed by Dr Irifune of Ehime University – at no cost to IODP.

It was clear from this meeting that NOV is genuinely interested in the BEAM project and quite willing provide their own time and resources to help identify solutions to the technical issues around the BEAM project – something that is not evident from the other two companies Blade has talked to - thus far at least. The minutes of this meeting are provided in Appendix F.

It was agreed that the next meeting with NOV will be held in early August and include discussions on NOV's high-temperature drilling fluids and downhole tools.

2.2 IODP-USIO Visit

Y.Kawamura, N.Pilisi and B.Whitney made a visit to the IODP-USIO office at Texas A&M on June 29. The intent of the visit was to meet with the JOIDES Resolution operations people to see about getting more detailed bit run and operational data from 1256D that is needed to determine the bit design requirements for the BEAM project. Unfortunately the operations people were not available that day, however discussions were had with Phil Rumford, Chad Broyles, Kevin Grigar and Carlos Zarkian and we were able to examine core samples that were obtained from Expedition #335 which will be used for testing by NOV

2.3 Forward Plan

Blade's efforts over the next several months will be focused on the following:

- Contacting Baker Hughes and Halliburton to arrange follow-up meetings.
- Arranging an initial meeting with Schlumberger
- Arrange an initial meeting with Varel International
- Meeting with Ulterra on July 24.
- Working with Y.Kawamura to obtain core samples from IODP-USIO for NOV to test. Note that Y.Kawamura will also coordinate getting samples of Dr. Irifune's nano-polycrystalline diamonds for testing by NOV.
- Attempting to get the detailed 1256D bit run and operational data from IODP-USIO so that the data can be provided to NOV for review.
- Finalizing plans for a third meeting with NOV in early August.

3 Appendix A: Blade Presentations

The presentation that summarizes the BEAM project objectives and the technical issues around drilling and coring into the mantle which is used to introduce the project to the oilfield bit and coring system service providers is embedded below.



BEAM Overview
Presentation - April.ppt

The presentation that summarizes the results of the initial meetings with NOV, Baker Hughes and Halliburton is embedded below.



BEAM Project - Yoshi
Update OTC 2012, R2

4 Appendix B: NOV Initial Meeting Minutes

Meeting With: National Oilwell Varco (NOV)

Meeting Date: 11 April, 2012

Location: NOV Office* – Conroe, Texas

Attendees:

Hector Sanchez	NOV, Global Product Manager
Blake Mock	NOV, Account Manager
Piero D'Ambrosio	NOV, Director Advanced Drilling Solutions
Michael Coss	NOV, Product Line Mgr, Directional Drill Bits
Daryl Ramnarace	NOV, Director Strategic Integrated Solutions
Alexis Garcia	NOV, Product Line Mgr, Harsh Rock Drill Bits
Charles Luther	NOV, Business Development Manager
Nicolas Pilisi	Blade
Bob Pilko	Blade
Bill Whitney	Blade

Purpose

This was the kick-off meeting with NOV to explain the BEAM project, review the project objectives and the technical issues, and get their preliminary feedback on possible technical solutions and their interest in participating in the project in some capacity. This was the first of three initial meetings with oilfield service companies that provide bits and coring services which were intended to introduce BEAM and to get a feel for what the service company's reaction would be.

Synopsis

Somewhat overwhelmingly, seven of NOV's key managers attended the meeting which indicates that they took the meeting seriously. They offer a variety of different services and believe they have existing equipment that would provide improved performance over what is currently being used on the Chikyu/Resolution. They noted that a more holistic approach would be needed to resolve the technical issues around the BEAM project since focusing just on bits does not address all the interdependent issues. For example, the BHA, drill string, hydraulics, fluids and so on also need to be addressed in order for the bits to work effectively. They are also willing to continue discussions around the BEAM project.

Highlights

- Hector Sanchez will be the main point of contact
- They noted that the idea of developing any sort of R&D program would require further internal discussions.
- Because of the complexity of the BEAM project and to help them determine a way forward, they asked that Blade prepare a list of specific tasks that might need to be done to resolve the project's technical issues. They would use the list as the basis of their internal discussions, evaluate the resource requirements and provide a structured response to Blade about how they could support the project.

BEAM Bit/Coring Performance Study Interim Report

- They provide Reed and Hycalog roller cone and fixed cutter bits.
- They provide both wireline and conventional coring systems.

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5 Appendix C: Baker Hughes Initial Meeting Minutes

Meeting With: Baker Hughes

Meeting Date: 12 April, 2012

Location: Baker Hughes Office* – The Woodlands, Texas

Attendees:	Bob Welch	Baker Hughes, Product Liner Manager, Drill Bits
	Matt Meiners	Baker Hughes, Product Liner Manager, Diamonds
	Less Shale	Baker Hughes, Product Liner Manager, Coring
	Nicolas Pilisi	Blade
	Bob Pilko	Blade
	Bill Whitney	Blade

Purpose

This was the kick-off meeting with Baker Hughes to explain the BEAM project, review the project objectives and the technical issues, and get their preliminary feedback on possible technical solutions and their interest in participating in the project in some capacity. This was the second of three initial meetings with oilfield service companies that provide bits and coring services which were intended to introduce BEAM and to get a feel for what the service company's reaction would be.

Synopsis

Three of Baker Hughes' key product line managers attended the meeting. They also came prepared with their own presentations about their products and services which indicates that they took the meeting seriously. They were previously involved with the KTB project in Germany (tried to reach the Mantle onshore), so they are familiar with the technical issues that a mantle hole will need to address. They believe they have existing equipment that would provide improved performance over what is currently being used on the Chikyu/Resolution. They are also willing to continue discussions around the BEAM project.

Highlights

- Consideration should be given to incorporating rotary sidewall coring systems into the BEAM formation evaluation program.
- Their aluminum inner core barrels need to be changed out to steel after 200F in order to account for differential thermal expansion.
- Their longest ever core run was 620 feet.
- They regularly cut 300 to 400 ft of core in the Eagle Ford shale gas play.
- When coring fractured formations they use their Hydrolift core system that has a "clam shell" feature to capture the core intact and also has anti-core jamming features.

BEAM Bit/Coring Performance Study Interim Report

- Only 30% of the bits used today are roller cone bits because of advances in PDC bit technology. As such, roller cone bit development technology is now mostly focused on the more difficult and challenging applications.
- Their roller cone “performance” bit product line is called “Vanguard”.
- They have a full scale drilling simulator at their Woodlands facility. They can adjust all the variables needed to simulate drilling different rock strengths, but they cannot simulate high temperature environments.
- The question was raised about how drilling hard granite compares to drilling igneous rocks.
- They recommend open bearing bits vs. sealed bearing bits for applications greater than 550F.
- The mantle hole has the potential for being able to use hybrid bits which combine the features of both roller cone and PDC bits.
- They would want to use their “DART” team to determine the ideal systems approach to drilling and coring into the mantle.
- They were involved with KTB where hybrid bits were used to drill basalt. They have experience drilling basalt and gabbros.
- They would suggest an iterative development process for identifying and/or developing the optimum bit / core head solutions for BEAM. Ideally this would involve testing a bit on an actual IODP hole, taking it back and reviewing the bit condition and bit run results, making changes to the design and then running it again at a new IODP location.
- PDC braising is done at 1100F, but the bond strength tends to degrade at about half that temperature.
- They have an ongoing R&D program for cutters. They will have a new cutter design available later on this year.
- Diamond impregnated bits may be an option. Diamonds don’t like high temperatures but there are steps that can be taken to mitigate this (i.e. longer posts). Performance for these bit types is optimized by rotary speed (rpm’s) as opposed to WOB.
- Formation abrasiveness is a function of the silicone content of the rock.
- They are developing a geothermal drilling system that includes bits, BHA’s and fluids that will be commercial in 2015.
- They have several technical centers around the world that could be available support BEAM.
- They are averaging 98% core recovery right now.
- Bob Welch will continue to be the point of contact for issues around BEAM.
- They provide Hughes Chistensen roller cone and fixed cutter bits.
- They provide conventional core systems.
- They offer several tools for determining a formation’s drillability which aids in the selection of the optimum bit options. For example:
 - “Rocky” is a rock mechanics software package used for evaluating lithology and calculating formation strengths.

- "EROP" is an analytical tool used to predict rate of penetration based on lithology, formation strength and drilling parameters.
- "Drill Bit Advisor" is a rule-based expert system used to analyze raw drilling and well log data to develop optimum bit designs.

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6 Appendix D: Halliburton Initial Meeting Minutes

Meeting With: Halliburton

Meeting Date: 13 April, 2012

Location: Halliburton's Office* – Houston, Texas

Attendees:

Larry Hall	Halliburton, N. America Region Coring Manager
Brad Dunbar	Halliburton, Fixed Cutter Product Manager
Lorne Rutherford	Halliburton, Global Business Development Mgr
Nicolas Pilisi	Blade
Bob Pilko	Blade
Bill Whitney	Blade

Purpose

This was the kick-off meeting with Halliburton to explain the BEAM project, review the project objectives and the technical issues, and get their preliminary feedback on possible technical solutions and their interest in participating in the project in some capacity. This was the third of three initial meetings with oilfield service companies that provide bits and coring services which were intended to introduce BEAM and to get a feel for what the service company's reaction would be.

Synopsis

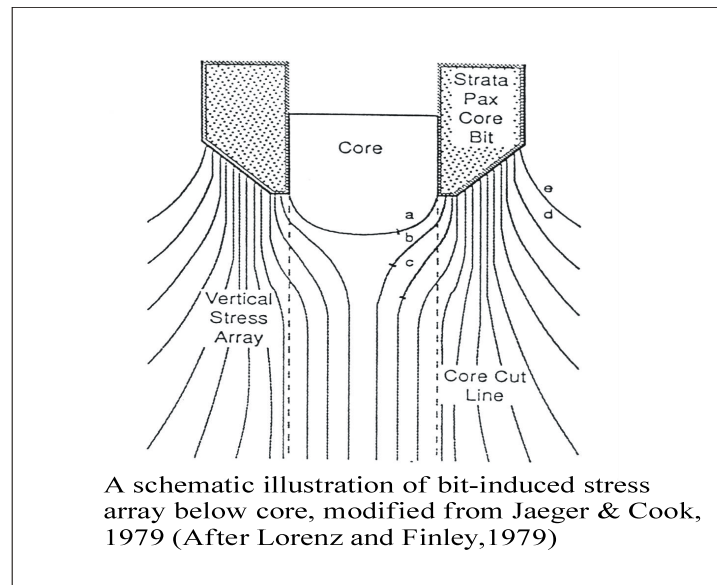
Three of Halliburton's key product line managers attended the meeting. They also came prepared with their own presentations about their products and services which indicates that they took the meeting seriously. They have also discussed coring services with JAMSTEC and CDEX in the past. They believe they have existing equipment that would provide improved performance over what is currently being used on the Chikyu/Resolution. They are also willing to continue discussions around the BEAM project, however they do not think that they could justify a large R&D project in support of the BEAM project.

Highlights

- Larry Hall mentioned that he doesn't think that they could embark on a large R&D project because there are not enough resources within Halliburton or enough potential benefit. His comment was based on previous discussions he had with JAMSTEC and CDEX.
- However, he also said that he believes that Halliburton has existing tools that are better than what is currently being used, and that the natural progression of technological development will most certainly provide a solution to coring into the mantle within 5 years. As such, a formal R&D program might not be required for BEAM.
- Later in the meeting they said that they can core the mantle with one of their existing core heads right now and that they can core anything up to the point that steel melts. So they are not concerned about 250-300C magnitude temperatures.

BEAM Bit/Coring Performance Study Interim Report

- Their “RockSwift” coring system is wireline retrievable developed for use in Coal Bed Methane applications. They have run this with 60 ft core barrels. The system needs drill pipe that had at least a 4.250” ID.
- As illustrated below, they noted that roller cone bits are the worst type one can use for coring. The WOB and the crushing effect of the bit teeth can damage the rock even before the core is cut which may adversely impact coring performance and recovery.



- They provided copies of the presentation material that they went through during the meeting.
- Larry Hall will be the point of contact.
- They provide Security and DBS roller cone and fixed cutter bits.
- They provide both wireline and conventional coring systems.
- They provide several tools that are used to analyze formation properties to optimize bit selection such as “DatCi”, “SPARTA”, and “IBitS”

<p style="text-align: right;">HALLIBURTON</p> <p>Brad D. Dunbar Fixed Cutter Product Manager Drill Bits & Services</p> <hr/> <p>16548 Donwick Drive • Conroe, TX 77385-3506 P. O. Box 60490 • Houston, TX 77205 Direct: 936.442.4984 Cell: 713.397.1541 e-mail: brad.dunbar@halliburton.com</p>	<p style="text-align: right;">HALLIBURTON</p> <p>Larry M. Hall North America Region Coring Manager Drill Bits & Services</p> <hr/> <p>3000 N Sam Houston Parkway E Bldg: Interwood - 108 Houston, TX 77032 Office: 281.986.4460 Fax: 281.871.6163 Cell: 281.630.8972 e-mail: larry.hall2@halliburton.com</p> <p style="text-align: right;">HALLIBURTON</p> <p>Lorne Rutherford Global Business Development Manager Coring - Downhole Tools Drill Bits and Services</p> <hr/> <p>3950 Interwood S. Pkwy Houston, TX 77032 Office: 281 871 6370 • Cell: 713 408 0660 e-mail: Lorne.Rutherford2@Halliburton.com</p>
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7 Appendix E: BEAM Followup Options (generic)

BEAM - Borehole into Earth's Mantle Bit and Coring Technology Development Questions

BEAM is a complicated project from the standpoint of the technical issues and the fact that it is managed and will be operated by a non-profit scientific organization. As such, it is presently unclear how best to move forward to resolve the technical issues. To facilitate a discussion about this, Blade has prepared a list of possible steps that could be taken to address the technical and commercial issues with the support of a manufacturing service company. The idea is that the list could serve as the basis of internal discussions within <company> to help determine your level of interest, resource requirements, costs and so on.

Blade would therefore appreciate it if <company> could review the steps provided below and indicate your level of interest. We would not expect a lengthy formal response but would be happy to meet with you to discuss this in more detail at your convenience.

Again, Blade has been asked by IODP to:

- Identify current hard rock drill bit equipment and services.
- Investigate potential technological gaps and improvements that will enable hard rock drill bits to stay on-bottom longer, decreasing drilling time and risk.
- Identify current hard rock coring systems and services.
- Investigate possible development of new hard rock coring systems to improve the quality and quantity of cores recovered in order to satisfy the scientific objectives.
- Provide a recommendation of the most efficient and most viable hard rock drill bits and coring systems for the BEAM drilling project spud date in 2017-2018.
- Provide an estimate of how the designers, manufacturers, and service companies of such equipment and services may accelerate their technological offerings, including an estimate of the technological improvement costs to IODP and the scientific drilling community.
- Identify additional high-impact drilling equipment and services for the BEAM project where technological improvements will also reduce project time and risks.

Possible Technical Issue Resolution Steps

1. Would you be willing to provide information / marketing material on your current hard rock bit product lines that might be suitable for the BEAM project?
2. Would you be willing to provide information / marketing material on your current hard rock coring system product lines that might be suitable for the BEAM project?
3. Would you be willing to provide information on hard rock bit designs and coring systems that are under development that might be suitable for the BEAM project?

4. Would you be willing to provide information on the key design features for high temperature, hard rock roller cone, fixed cutter, and impreg bits and core systems? For example, what do you think the main issues are, what are the ideal design features that one would look for, which ones have current solutions, which might need an R&D program to address the BEAM project needs?
5. What kind of modeling software do you have that, for example, considers lithology and rock strength for the selection of optimum bits? Will you provide an input list or form, so that we can begin gathering sufficient information?
6. What bit testing facilities do you have and what kind of drilling related variables can be adjusted?
7. Would you be willing to provide information on your previous experience drilling and coring in high temperature and hard rock areas that are similar to what is expected in the BEAM project. What information would you need from Blade/IODP to make this comparison?
8. Would you be willing to review previous IODP project bit and coring performance records and provide a cursory evaluation of the data, your general opinions of the results and general suggestions for alternative bits and core heads – at no cost?
9. Would you be able and willing to do a detailed examination of previous IODP project bit and coring performance records and well log data and do a comprehensive performance evaluation in order to come up with a optimized bit and core/head recommendation based on your current product line offerings? If so, how much would it cost and how long would it take, and how would it need to be structured?
10. Would you be willing to participate in an R&D program to address the bit and coring technical issues associated with the BEAM project? How would you think a program like this should be structured and roughly what would it cost?
11. Do you have any other opinions, suggestions or advice?

Blade Energy Partners
May 2012

8 Appendix F: NOV 28 June Meeting Minutes

Meeting With: National Oilwell Varco (NOV)

Meeting Date: 28 June, 2012

Location: NOV Office* – Conroe, Texas

Attendees:

Chuck Wright	NOV, Research Lab Manager, Drill Bits
David McGehee	NOV, Product Line Manager, Coring
Gordon Schutt	NOV, Engineering Manager, Manufacturing
Bruce Burr	NOV, Project Manager, Bearing Systems, Drill Bits
Daryl Ramnarace	NOV, Director Strategic Integrated Solutions
Alexis Garcia	NOV, Product Line Mgr, Harsh Rock Drill Bits
Mike Pridgeon	NOV, Engineering Mgr, Product Line Engineering
Yoshi Kawamura	IODP-MI
Nicolas Pilisi	Blade
Bill Whitney	Blade

Purpose

This was the second meeting with NOV – after they had time to review Blade’s list of suggested steps to move the BEAM project forward and to discuss the project internally. The purpose of the meeting was to focus more closely on the BEAM technical issues and the possible solution that NOV may be able to provide.

Synopsis

Again, somewhat overwhelmingly, NOV organized an all day meeting that included a tour of their bit performance testing lab, their bit manufacturing facility, and presentations about a new series of geothermal bits they are developing and their wireline retrievable rotary coring system.

Of all the companies Blade has talked to thus far NOV has by far expressed the most interest and enthusiasm about being involved in the BEAM project. They, for example, volunteered to run mechanical tests on a sample of basalt rock from the 1256D hole to help determine its drillability using NOV’s in-house evaluation procedures, and they agreed to run tests on the synthetic diamonds developed by Dr. Irifune of Ehime University – at no cost to IODP.

NOV is a major oilfield service company and has, over the past few years, bought numerous different companies which has allowed them to offer a wide variety of equipment and services to the oil and gas industry, from the mud pumps on the Chikyu, to downhole tools, drilling fluids and bits. NOV stated that they are a technology development company and feel that if they have the best technology, people will buy their products and services. As such, they have less of a short term “what’s in it for me” attitude than other service companies. They are genuinely interested in the BEAM project and quite willing to help find solutions to the technical issues. This isn’t to suggest that they will “always” be willing to do everything for “free”, but at least for now at a

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foundational level, they have shown a willingness to provide their own time and resources to help identify solutions to the technical issues around the BEAM project – something that is not evident thus far from the other two companies Blade has talked to.

A third meeting has been planned for early August which will include discussion on high-temperature drilling fluids and downhole tools.

Highlights

- The NOV drill bit research lab at their Conroe facility has the capabilities for:
 - Simulating actual drilling conditions
 - Simulating the overburden pressure for different types of rock in atmospheric and pressurized conditions
 - Installing a flow loop that simulates downhole pulses and shocks allowing the location and magnitude to be measured. They can use the exact same drilling fluid systems that are used in the field including oil based mud (although they prefer not to from an environmental standpoint since it is costly and complicated to dispose of)
 - Doing downhole electronics testing with vibration at hot and cold temperatures
 - Doing seal development and testing and develop the “k-rev” curves which represent the seal life at different temperature and load conditions. They are in the process of upgrading the equipment to handle 1000 rpms to simulate the higher rotational speeds found in downhole turbines.
 - Doing compressional and tensile materials testing
- The lab also has a complete prototype shop that is used for developing new products so that there is no impact on their regular manufacturing processes.
- NOV has samples (boulders) of “every rock that you can think of” that are used for bit development and performance testing. This includes examples of sandstone, limestone, dolomite, granite and two types of basalt – one from the Faroe Islands and one from the US Pacific Northwest. NOV purchases large boulders of different rock types from mining operations around the world and then uses them for bit testing.
- The lab can design tests and equipment for virtually any application which includes running tests for their competitors.
- Chuck Wright manages the lab and, somewhat amazingly, has an extensive knowledge about the drillability of basalt. He volunteered to run mechanical tests on a core sample of basalt recovered from the 1256D hole to determine the rock’s unconfined compressive strength (UCS) which is essentially a measure of how hard it is to drill. Once the UCS is known, the matching bit design requirements can be determined. He will also be able to compare the characteristics of the 1256D basalt to the other basalt samples he has. He is also interested in new technology and agreed to run some tests on the nano-polycrystalline diamonds developed by Dr. Irifune of Ehime University¹ and compare them to the properties of the sintered diamonds NOV currently uses in their bits. Both series of tests will be done at no cost to IODP.

¹ The potential application of Dr. Irifune’s work for the mantle project was discussed at a meeting between JAMSTEC, IODP-MI, Blade and Dr. Irifune at the JAMSTEC office in Tokyo on June 6th.







- NOV is working on the bearing system design for 8-1/2" and 12-1/4" roller cone bits to be used in geothermal applications. The bits have an IADC 517 classification and the bearings are designed for 288°C / 550°F. High temperature rubber and grease is used for the seal design and there are metal spring seal energizers that are used to offset the seal compression due to temperature. They have successfully run 3 of the prototype bits in New Zealand at up to 260C thus far and have plans to run several more. The goal is to add these bits to their product line in sizes ranging from 7-7/8" to 12-1/4".
- NOV also has a wireline retrievable rotary core system known as "Corion Express". The system can cut 3.0" and 3-1/2" cores and features a core jamming indicator that indicates whether the core has jammed or whether the rate of penetration has slowed. Jammed cores can be remediated via wireline. Up to 90 ft of core can be cut at one time. The standard core bit diameter is 8-3/4" but 9-7/8" bits can be also be used. Core recovery is presently greater than 90%.
- NOV noted that no one uses roller cone core bits these days. All coring is doing with fixed cutter bits. They also felt that the C-9 core bit was not a hard rock bit.
- It was agreed that the next meeting with NOV will be held in early August and include discussions on NOV's high-temperature drilling fluids and downhole tools.
- Daryl Ramnarace (Director, Strategic Integrated Solutions) will now be the main point of contact.

- **IODP-USIO Visit**

- After the NOV meeting Y.Kawamura, N.Pilisi and B.Whitney made a visit to the IODP-USIO office at Texas A&M on June 29. The intent of the visit was to meet with the JR operations people to see about getting more detailed bit run and operational data from 1256D that is needed to determine the bit design requirements for the BEAM project. Unfortunately the operations people were not available that day, however discussions were had with Phil Rumford, Chad Broyles, Kevin Grigar and Carlos Zarikian and we were able to examine core samples that were obtained from Expedition #335 which will be used for testing by NOV.

Action Items

- Blade will contact Chuck Wright to find about the core sample size that is needed for the UCS testing. Y.Kawamura will make arrangements for requesting an Expedition #355 basalt core sample from IODP-USIO. A suitably sized sample will then be sent to NOV for testing.
- Y.Kawamura will coordinate getting samples of Dr. Irifune's nano-polycrystalline diamonds for testing by NOV.
- Further attempts will be made to get the detailed 1256D bit run and operational data from IODP-USIO so that the data can be provided to NOV for review.

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