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"SMAC"

SONIC MAPPING AND CALIPER
RESEARCH AND DEVELOPMENT

Larry E. Handy

November 1983

MASTER

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New Mexico Energy Research and Development Institute

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"SMAC" -- SONIC MAPPING AND CALIPER RESEARCH AND DEVELOPMENT

Final Report
Phase IA

Principal Investigator:

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MASTER

November 1983

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7. ABSTRACT (A 200-word or less factual summary of the most significant information. If report includes a significant bibliography or literature survey, mention here.) Phase IA of this project consisted of developing and testing the Sonic Mapping and Caliper (SMAC) Tool in both an oil and a geothermal well. The first field test of the SMAC was successfully run in an oil well located in Edmonton, Canada. The well had an inner diameter (I.D.) of seven inches and was cased to 3300 feet. An additional 120 feet of the well was open hole. The log from this test recorded each collar location, the casing conditions, and the fracture zone in the open hole. In the course of the test it was immediately possible to determine the DIP angle of the fractures during real time transmission of the data to the surface. The second and third field tests were conducted at the Geothermal Site, Fenton Hill, New Mexico. Test No. 2 was run in the cased portion of Well GT-2. The SMAC Tool went to a depth of 2,000 feet at a temperature of approximately 100°C. The performance of the SMAC Tool was excellent and yielded collar location and casing condition information. Test No. 3 was run in a 9 5/8 inch I.D. cased portion of Well EE-2. The test was run to a depth of 750 feet at a temperature of 75°C. One of the purposes of this test was to compare the SMAC Tool with the Sandia Simplec Tool. The SMAC Tool log provided a clearer and more detailed picture of the interior of the casing than did the log of the Sandia Simplec Tool. Based on the encouraging results of these tests, we are confident that the Phase II SMAC Tool can be further developed to include a 24-point caliper and a three-dimensional graphic display in order to provide more information about the conditions inside oil and geothermal wells. The SMAC Tool can also be developed to include a gyroscope system for orienting the log in relationship to North and a high temperature and pressure option.											
8. KEY WORDS (6 to 12 entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separate key words by semicolons.) <table style="width: 100%; border: none;"><tr><td style="width: 33%;">1. Cased hole;</td><td style="width: 33%;">3. Fracture zone;</td><td style="width: 33%;">5. Inner diameter;</td></tr><tr><td>2. Collar location;</td><td>4. Gyroscope system;</td><td>6. Open hole;</td></tr><tr><td></td><td></td><td>7. Well logging</td></tr></table>			1. Cased hole;	3. Fracture zone;	5. Inner diameter;	2. Collar location;	4. Gyroscope system;	6. Open hole;			7. Well logging
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on loan from TIC.*

FOREWORD

The two firms which have existing agreements with Hot Hole Instruments, Inc. (HHI) for the Sonic Mapping and Caliper (SMAC) Tool have both expressed enthusiasm over the future of a tool of this nature.

In a letter to Mr. Larry E. Handy, President of Hot Hole Instruments, Inc., dated February 25, 1983, E. W. (Ted) Anderson, President of Ted Anderson Services, Ltd, of Edmonton, Canada, said:

"We called upon all the major oil companies who have large Canadian operations. We showed them the laboratory presentation information that you gave us from the development SMAC Tool and they were all very interested in running a completely developed SMAC Tool as soon as possible."

"From our oil industries' interest, we believe that Hot Hole Instruments and Ted Anderson Services, Ltd, will not be able to keep up with the demand."

On March 4, 1983, David Lemke, Executive Vice President of AMF Scientific Drilling, Irvine, California, wrote:

"The ability to detect and see fractures, holes in casings, rust, and logging cable wear makes this a very important logging tool. I have taken a market survey of our customers and the interest is extremely high in Japan, the Philippines, Indonesia, and Thailand."

"We have mentioned the three-dimensional monitor display system that you plan on adding to the SMAC Tool to our customers and the response is tremendous."

INTRODUCTION

The inspection of well casings and the mapping of fractures are two of the primary concerns of the oil, gas, and geothermal industries. Casings in oil and gas wells deteriorate with time, and splits in the casing lead to lost circulation in the wells.

In wells that are cased in the production zone, the perforations in the casings tend to fill with chemical deposits. Accurate detection of these deposits indicates the best time to inject acid into the well in order to clean the perforations.

An instrument that can provide significant data from wells with hostile environments has an immediate market potential. The ability to detect problem areas within the well casings is economically advantageous to the well operator. In addition, the ability to map the fracture zones of the wellbore produces information concerning the status of the oil or gas field needed by the reservoir engineer. Fracture zone information is also valuable in the operation of geothermal wells. The mapping of the angle and direction of the fractures can help confirm that fractures extend between pairs of wells.

Hot Hole Instruments, Inc. (HHI) has developed a prototype Sonic Mapping and Caliper (SMAC) Tool which both inspects well casings and maps fracture zones in an economical manner. The tests on the SMAC Tool during the past few months have shown that it can provide significant data under adverse conditions. To date, the SMAC has successfully run over 20,000 feet of cable in field tests that were performed both in Edmonton, Canada, and Fenton Hill, New Mexico.

Further development work is planned for the SMAC Tool. When the tool is in production, it will be manufactured in Los Alamos, New Mexico, and will have a positive impact on the economy of Northern New Mexico.

ABSTRACT

Phase IA of this project consisted of developing and testing the Sonic Mapping and Caliper (SMAC) Tool in both an oil and a geothermal well.

The first field test of the SMAC was successfully run in an oil well located in Edmonton, Canada. The well had an inner diameter (I.D.) of seven inches and was cased to 3300 feet. An additional 120 feet of the well was open hole. The log from this test recorded each collar location, the casing conditions, and the fracture zone in the open hole. In the course of the test it was immediately possible to determine the DIP angle of the fractures during real time transmission of the data to the surface.

The second and third field tests were conducted at the Geothermal Site, Fenton Hill, New Mexico. Test No. 2 was run in the cased portion of Well GT-2. The SMAC Tool went to a depth of 2000 feet at a temperature of approximately 100°C. The performance of the SMAC Tool was excellent and yielded collar location and casing condition information.

Test No. 3 was run in a 9 5/8 inch I.D. cased portion of Well EE-2. The test was run to a depth of 750 feet at a temperature of 75°C. One of the purposes of this test was to compare the SMAC Tool with the Sandia Simplec Tool. The SMAC Tool log provided a clearer and more detailed

picture of the interior of the casing than did the log of the Sandia Simplec Tool.

Based on the encouraging results of these tests, we are confident that the Phase II SMAC Tool can be further developed to include a 24-point caliper and a three-dimensional graphic display in order to provide more information about the conditions inside oil and geothermal wells. The SMAC Tool can also be developed to include a gyroscope system for orienting the log in relationship to North and a high temperature and pressure option.

OBJECTIVES

The main objective of Phase IA was to develop and test a prototype acoustical transmitter receiver tool that would evaluate conditions in both cased and open wellbores. The results of these tests were to be compared with the data taken from the same well at Fenton Hill by the Sandia Simplec Tool. Tests were run in both types of wells and the SMAC Tool is now a working prototype.

The primary objective of Phase II is to overcome problems in design, and to fabricate and test the new features.

Additionally, Phase II will include the completion of the development of the 24-point caliper, three-dimensional graphic display, gyroscope system, and high temperature and pressure options. All of these items are expected to improve the quality of data provided by the SMAC Tool.

DESIGN CHARACTERISTICS

The SMAC Tool is a microprocessor controlled sonic imaging device which provides information on the casing and wall conditions of a borehole. One section of the downhole tool consists of a transducer which sends out an acoustical signal 500 times during every revolution of the device which rotates at a speed of 180 rpm. In the SMAC Tool the transducer is located at the tip of the instrument. This increases the tool's immunity to vibrations and possible roughness in the walls of a well. The stability adds to the effectiveness of the SMAC Tool.

The signal from the transducer bounces off the walls of the borehole and is then detected, amplified, and processed. The strength of the reflected signal provides information about the condition of the surface and is translated into light and dark areas on the log which is printed on a continuous chart recorder. A strong reflected signal (caused by a smooth surface) produces a dark area on the log and a weak one (caused by a rough surface), a light area. A change in the gain can differentiate between a hole in the surface of the borehole and a patch of rust.

Over 500 data points per 360 degree sweep are recorded on a graphic display.

The Phase I prototype SMAC is designed to resolve data from holes ranging between 2 inches (minimum) and 24 inches (maximum) in diameter without the need to change any internal electronic modules in the downhole portion of the tool. The SMAC Tool is capable of viewing both openhole and cased borehole wall fractures as small as 0.05 inches wide in an 8 inch I.D. casing and 0.10 inches wide in a 24 inch I.D. casing.

Laboratory testing of the SMAC Tool has been performed in up to ten pound mud with a 30 percent attenuation of signal strength. Currently the potential users of the SMAC have been operators of production, not exploration wells, and are less interested in the operation of the SMAC Tool in conjunction with mud.

The prototype of the SMAC Tool has already operated in temperatures up to 100°C. The development of the high temperature option will increase this range.

DESCRIPTION OF WELLS

Test Well No. 1 was located in Edmonton, Canada, and filled with oil and brine solution. The well has an I.D. of 7 inches and is cased to 3300 feet. An additional 120 feet of the well is open hole. The fracture zone extends for 50 feet below the casing. Below the fracture zone is 70 feet of production zone. In this particular well, the production zone is below the end of the casing so no perforations exist in the casing. The temperature encountered in this well was 30°C. The well is approximately 35 years old. Testing of the SMAC Tool in the Edmonton well was done during July of 1983.

Figure 1 shows the casing and open hole wellbore in the Edmonton well. The following is a brief description of the areas indicated in Figure 1.

- A. The level to which the concrete backed up during the cementing of the casing.
- B. The casing collar.
- C. The exact location of the float collar.

- D. The guide shoe and the end of the casing are cemented to the borehole.
- E. The fracture area is directly below the casing and extends for forty feet to the production zone.
- F. The production zone, which extends for 60 feet below the fracture zone.

Test Wells Nos. 2 and 3 were experimental geothermal wells located at the Fenton Hill Site west of Los Alamos, New Mexico, and filled with hot water. Test Well No. 2 (Well GT-2) has an I.D. of 7 inches. The SMAC logged to 100°C and a depth of 2000 feet. Tests were run in GT-2 in September of 1983.

Tests in Well No. 3 (Well EE-2) were run to a depth of 750 feet on October 19, 1983. Well EE-2 has an I.D. of 9 5/8 inches and a temperature of 75°C. Both Fenton Hill wells are cased.

PHASE ONE RESULTS

The attached logs are the results of the investigation of the wells. In each case the SMAC Tool provided an accurate picture of the inside of the boreholes.

Figures 2, 3, and 4 are the printouts of three separate surveys of the same portion of the Edmonton wellbore which corresponds to Figure 1. The similarities between Figures 2, 3, and 4 demonstrate the accuracy and repeatability of data generated by the SMAC Tool.

Figure 5 is the comparison of three SMAC Tool logs run in the cased wellbore of Well EE-2 at Fenton Hill, New Mexico. This diagram correlates with the actual log printouts, Figures 6, 7, and 8. The scars

in the well casing can be seen in the same locations as shown on all three logs. A comparison with Figure 9, the printout from the Sandia Simplec Tool, demonstrates the greater resolution that can be obtained by the SMAC Tool.

In the logs from the SMAC Tool, marks can be seen in the center of the scars between the 590 and the 630 foot level. These signals could well show that the scars are worn places produced by the logging cable which is used to lower the testing tools into the well. Wear produced by the cable would be rounded and the reflection of the signal from the back of the scar much stronger than the reflection from the sides. In addition, several of the marks end at casing joints. Since the casing in the well is slightly offset at the joints, the wear from the cables would be irregular from casing section to casing section as is shown on the logs.

It is also possible that the scars could be splits in the casing. Development of the 24-point caliper will enable HHI to differentiate between splits and surface scars since the caliper will be able to measure the depth of the irregularities.

PHASE TWO

The 24-point caliper and three-dimensional monitor display being proposed for the SMAC Tool will increase the amount of information that can be obtained from the inside of a borehole. Rather than simply showing the existence of defects on the inside of the casing, the caliper will give hard information on the depth of these defects, making it possible to differentiate between surface flaws and structural problems. Casings

deteriorate during the lifetime of a well and information of this nature will enable the operator to make an informed decision concerning well maintenance.

Several companies have expressed an interest in the capabilities of the SMAC Tool. Hot Hole Instruments, Inc. already has contracts to provide the tool to AMF Scientific Drilling and to Ted Anderson Services, Ltd, of Canada when the tool goes into production. The contracts include a provision for HHI to share in the revenues generated from leasing the SMAC.

Currently there is no way to orientate the logs inside the casing in relationship to the external world. The completion of the gyroscope system will rectify this situation by using North as a reference. This will also determine the direction of the DIP angle.

Deep oil and gas wells, as well as geothermal wells operate at high temperatures and pressures. The high temperature and pressure option being proposed in Phase II will extend the SMAC Tool's capabilities to operate in wells with temperatures up to 275°C and pressures up to 20,000 psi.

CONCLUSIONS

The work completed during Phase IA has demonstrated that the SMAC Tool is a reliable means of gathering information from the inside of well-bores. The continuation of R&D support by the New Mexico Energy Research and Development Institute will assist in solving the problems of orientation, caliper, hardening against temperature and pressure in a prototype SMAC Tool which could lead to a production model.

In addition to the existing contracts with AMF Scientific Drilling and Ted Anderson Services, Ltd, a number of others have expressed a strong interest in Hot Hole Instruments.

The Hot Dry Rock Project of the Los Alamos National Laboratory has previously purchased two high temperature Spinners from HHI and is presently negotiating for the future purchase of two high temperature SMAC Tools.

The Los Alamos County Council recently approved an application from the Los Alamos Economic Development Corporation (LAEDC) asking the state for a community development block grant to aid HHI. This project will involve using Community Development Block Grant (CDBG) funds to acquire a facility to accommodate HHI and its projected growth of approximately 200 people by 1985.

Hot Hole Instruments, Inc. plans to draw on the existing labor force in Northern New Mexico, rather than hiring employees from out-of-state. Heavy emphasis of on-the-job training will allow the employees of HHI to advance technically over a two to three year period, upgrading the Northern New Mexico technical labor force.

When the SMAC Tool becomes a production instrument, the economy of Northern New Mexico will also be enhanced by the fact that a major portion of users are out-of-state firms. The leasing and service agreement of the SMAC Tools will bring money into New Mexico; money that will be redistributed in the form of payroll and the purchase of raw materials.

ACKNOWLEDGEMENT

The staff of Hot Hole Instruments, Inc. would like to thank Dave Lemke of AMF Scientific Drilling, California; Ted Anderson of Ted Anderson Services, Ltd, Canada; along with Bert Dennis, his entire ESS-6 Group and the associated Fenton Hill personnel of the Los Alamos National Laboratory for their cooperation and assistance throughout Phase IA of this project.

Figure 1
EDMONTON WELLBORE

Figure 5

EE-2 COMPARISON OF LOGS

(A)
(B)
(C)
(D)
(E)
(F)

EDMONTON LOG 1

EDMONTON LOG 2

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Figure 3

980 M

EDMONTON LOG 3

Figure 4

570

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590

600

610

620

630

640

650

LOG 4

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Figure 6

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Figure 7

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710

720

730

740

750

FENTON HILL EE-2
10-19-83 RHI SMAC
750' TO 550' 6" FPM

Microfilm
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Figure 8

Sandia Borehole Televiwer Log
Los Alamos Well EE-2
1/15/82

Figure 9