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Acoustic Borehole-Imaging Physical Modeling System, Almost D.I.Y.

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Abstract Summary

The information obtained from borehole imaging tools is increasingly utilized for the characterization of sedimentary strata and the features present within reservoirs. Access to the internal geometry of the drilled section of a well enables geoscientists to develop a more sophisticated interpretation of the local geology. In this study, we will present the development of two prototypes: an initial prototype and a final prototype, along with the proof of concept for an acoustic image profile acquisition system using laboratory models. Despite their simplicity, these systems allow for the examination of various aspects of the process's physics, including the impact of sensor standoff, resolution in relation to sensor frequency, spatial sampling, and the effects of dispersive fluids, among others.

Introduction

The use of acoustic borehole-imaging tools in the oil and gas industry is increasingly routine. Motivated by the quality of the information obtained, most Brazilian pre-salt wells used this tool by default. However, with the increase of the exclusive use of logging while drilling (LWD) campaigns in many development wells, some important issues related to the parameterization of these tools have become even more relevant. Repeat logs are not a rule in LWD and usually, they happen only motivated by the acquisition of bad quality images during drilling due to the lack of adequate rate of penetration (ROP) and rotation rate (RPM) drilling parameters. To assist in this characterization of the effect of acquisition parameters on the quality of the signal obtained, we built a physical modeling system for acoustic borehole-image.

Methods and Materials

We developed an initial prototype with movement control in two axes (x and y) and an acquisition area of 150mm x 150mm with a 500kHz frequency transducer (figure 1). The control of the acquisition and registration system was programmed in Python language. We obtained excellent results, consistent with the images obtained by the well log tools. With this prototype was possible to define the main and most important variables in the development of the final version. Unlike the field tool, the complete recording of the wave is carried out for each pair of positions in x and y, which soon showed us the infeasibility of working with files in ASCII format.

The final prototype has control over 3 axes (x, y and z), allowing the variation of the position of the source in front of the object under analysis (like the stand-off parameter). We use control drivers with precision of the order of 0.1mm for the 3 axes. The full acquisition area in the final model is 1000mm x 800mm, more than enough for a 12 ¼ stage of a typical well (figure 2). Different transducers can be used in the equipment, to simulate different frequencies and different source sizes (spot). The equipment responsible for emission of the electrical signal allows precise control of the source energy. The final record of the acquisition is made in binary format, which is later transformed into SEGY format, to facilitate data visualization and storage.

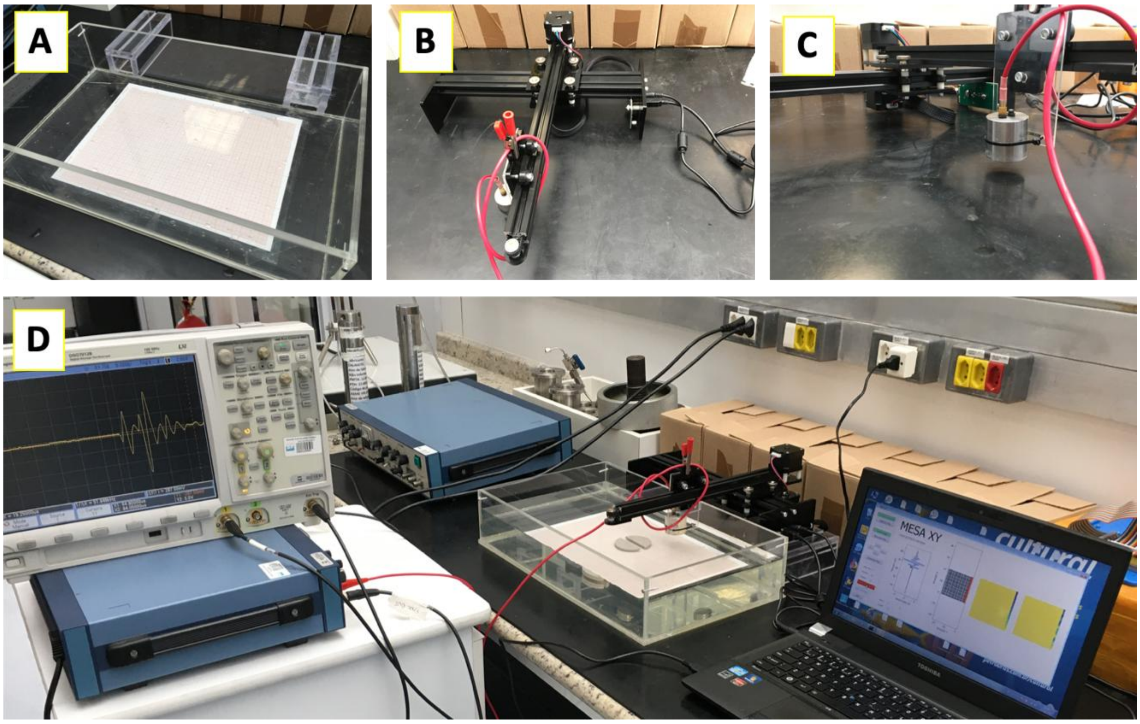

Figure 1: Initial prototype built in the rock physics laboratory. In A, we can identify the acrylic structure where the physical model will be assembled and subsequently submerged in water. In B, we have an overview of the XY mechanical movement system. In C, a detail of the measurement transducer used (Panametrics D7201). In panel D, a view of the system assembled and in operation, with the model already submerged in water, controlled by a standard notebook. In this same panel, we can identify the electronic components used (pulser-receiver and oscilloscope).

Figure 2: Final Prototype. This equipment is equipped with control over three axes (x, y, and z) and can analyze an area of 1000mm x 800mm. Furthermore, it allows the interchange of transducers with different frequencies.

Results

Several models were built, using rock blocks, metal template and models printed on a 3D printer, to help characterize the features observed on the borehole wall, such as bedding, fractures and vugs. Figure 3 shows the results obtained from a rock block model that simulates various fracture opening values, allowing us to identify the feature within the amplitude domain.

The use of transducers with different frequencies reproduced well the reduction in resolution observed in the field when using transducers with lower frequencies, as well as the increase in the signal-to-noise ratio with the decrease in stand-off (by varying the position of the z-axis). We designed a metal template featuring calibrated holes ranging from 20mm to 2mm, with the purpose of assessing the resolution achieved based on the frequency utilized (Figure 4). These and other results can be used in the future as annotated data for machine learning and pattern recognition studies, as we have a direct relationship between the real geometry and the acoustic signal.

In Li *et al*. (2019), a similar study is presented, in which the developed equipment was employed to validate the creation of an acoustic borehole-image tool. The authors discuss the initial laboratory tests conducted to evaluate the transducers' capability to detect typical features of the borehole wall.

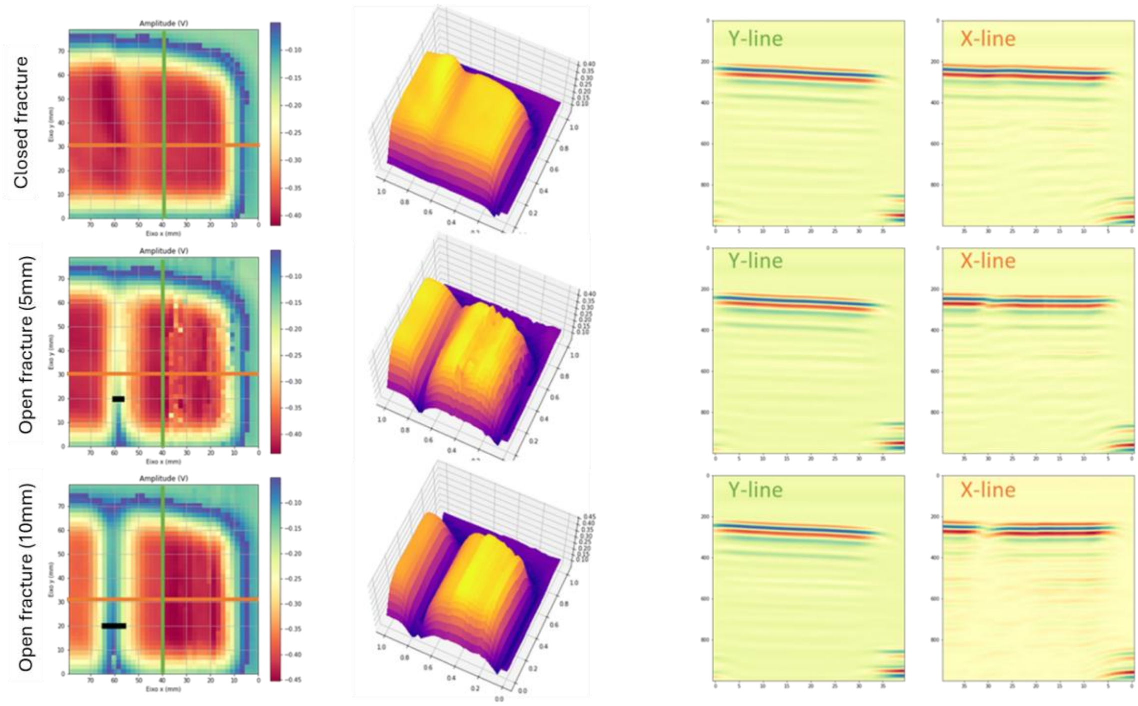

Figure 3: Fracture opening model: a rock block exhibiting various fracture openings, with results presented in the amplitude domain. The effect on the signal can be observed in the x-line.

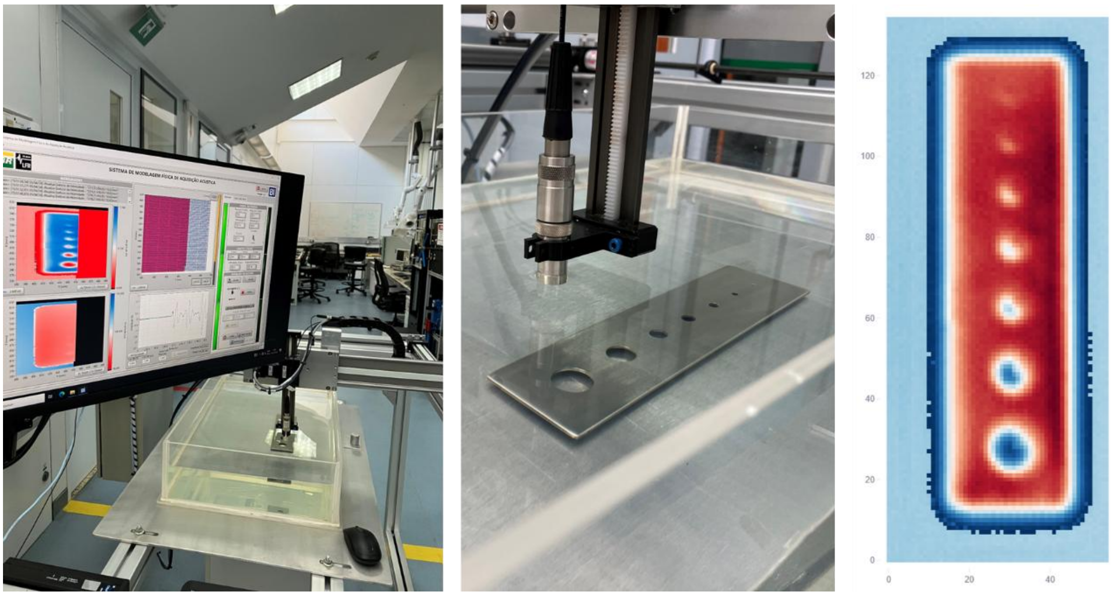

Figure 4: Metal plate simulating various hole diameters, illustrating a study on acquisition resolution. This example utilized a 1 MHz transducer.

Conclusions

The results of the tests conducted so far on the final prototype have shown great promise. We observed behavior similar to that of the acoustic imaging tool in terms of time-of-flight and amplitude images. The ability to test the effects of different frequencies on the imaging of controlled features in a laboratory setting will enhance the interpreter's understanding of the method's limitations. Additionally, there is potential for applying pattern recognition techniques to digital models created in the laboratory, such as fracture patterns, pore sizes, and the openings and fillings of fractures, to the data acquired during well logging.

Acknowledgments

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References

Li, P., J. Lee, R. Coates, Jin J. and S. M. Wong, 2019, New 4.75-in. Ultrasonic LWD Technology Provides High-Resolution Caliper and Imaging in Oil-Based and Water-Based Muds: Petrophysics, 60 (06), 712-732