Determination of formation density through RC rods in iron ore environments

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SUMMARY

Logging through drill rods and casing is a well–known challenge in the coal, oil and gas industries, and several techniques have been developed to obtain open–hole values using open-hole tools in cased–hole (C-thru). Due to the differences between conventional open-hole and iron ore environments and practices, simply applying the same methods can result in spurious data and unreliable findings.

A revised tool design together with an improvement upon the standard oil and gas technique through single wall rods was required to ensure accurate results. Development of an appropriate compensation algorithm and response through Reverse Circulation (RC) rods was determined where multiple walls of steel and gaps of fluid and air separate the tool from the target formation.

Key words: Iron ore, density, drill rods, c-thru

INTRODUCTION

Slimline logging is widely used in mining exploration campaigns worldwide. In the specific case of iron ores, slimline logs provide key information for the characterization of lithological units, and for the estimation of grade (quality) and reserves (tonnage). The main geophysical measurements for iron exploration are formation density, magnetic susceptibility, structural logs (acoustic and optical televiewers, four arm dipmeter), and compensated sonic travel times (for geomechanical characterization of rock masses). One of the major difficulties for comprehensive logging in these materials is associated with the friable nature and low mechanical strength of some formations, which cause frequent borehole collapses. This condition limits the acquisition of complete open–hole logs and can increase the risk of entrapment of tools in some circumstances.

Logging through casing is a well–known challenge in the oil and gas industry, and several techniques have been developed to obtain open–hole values using open-hole tools in cased–hole (C-thru. In the case of iron ore exploration is somewhat different in that the casing is not cemented in, nor is it uniform from hole to hole. Add to this the wide variety of drill rods employed throughout the industry and even on a single site.

Initial plans were to design and improve a standard oil and gas technique through single wall rods where the rods are close to the diameter of the borehole wall. While possible, appropriate variations of hole conditions and timing on the well proved hard to obtain and an attempt was made to develop a compensation algorithm and response through RC rods where multiple walls of steel and gaps of fluid and air separate the tool from the target formation.

METHOD AND RESULTS

In the determination of a compensated density log both the long and the short spaced density measurements penetrate through the material being compensated for and the measurement is affected to a different degree by the formation and the perturbing material. The difference in penetration depth allows a determination of the effect of the material, or materials, for which we would like to compensate. For example, with the shorter spaced sense the material being compensated for occupies a much larger area of the zone of investigation compared to that of the longer spaced sense which penetrates further into the formation. Subsequently we have been able to identify and compensate for the interference between the tool and the borehole wall.

Two prototype tools were developed with upgraded gamma radiation sensors and different spacings between the short and long spaced sensors. After trials of different tools, an optimum pair of spacings have been determined that gives the best repeatability, large enough count rate, and provides enough difference in penetration depth to compensate for the materials encountered between the tool and the borehole wall. This design has shown open-hole and through rods logs are comparable and repeatable (see Figure 1). This example also shows that compensation is achieved for different positions of the RC rods with respect to the bore-hole wall and/or caving of the well-bore.

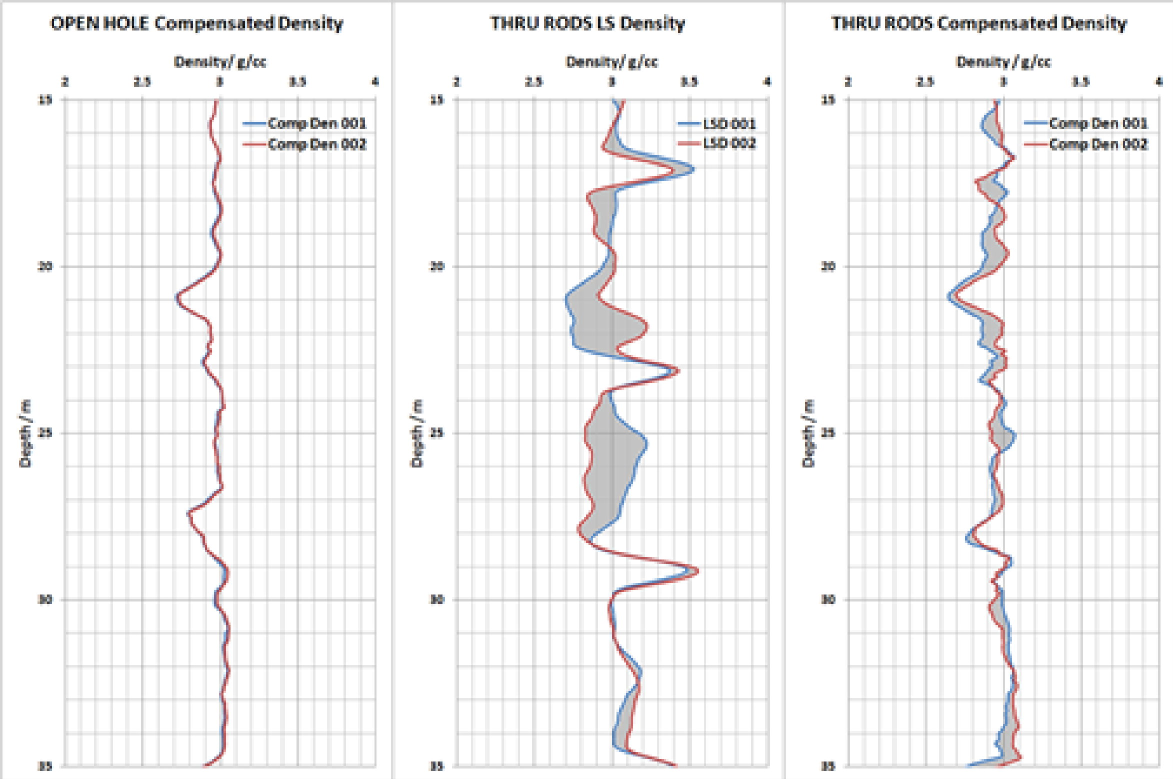

Figure 1: Repeatability of Open Hole, Through Rods and Compensated logs

CONCLUSIONS

The tool design and the now-patented compensation algorithm determined has proven to remove the interference from the non-uniform drill rods as exemplified by the removal of the casing joints and has reflected accurate formation densities. This method improves upon the previous work done by Wordsworth et al. (2015) where the rods were uniform and caving outside the rods was not compensated for. This technique shows that using optimum spacings of density detectors one can determine an accurate formation density in iron ore environments through RC rods.

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