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Estimating Rock Strength From Non-Destructive Strength Testing (EQUOTIP) and Related Benefits

W.H. Hujer* (OMV E&P), T. Finkbeiner (OMV E&P) & M. Persaud (OMV E&P)

SUMMARY

The results indicate that a strong correlation exists between Equotip Leeb hardness and UCS derived from scratch-test data for different lithologies. Tests on full cores also fit into the correlation. Larger variations in data range were encountered in coarse-grained sandstones, sandstones characterized by high amounts of clay minerals and fines as well as in lithologies that exhibit high rock strengths. Further in-house research is planned to find individual correlations or other testing devices for those lithologies. The results show that the Equotip can be used for estimating UCS from lithologies where representative plugging is not possible. The method is fast and equipment costs and logistics are low. Scratch tests derived UCS can be used for calibration. Estimating UCS from hardness testing cannot replace triaxial, hollow cylinder or scratch tests but can complement those tests, especially if data is needed urgently or other testing is not possible.

Introduction

Non-destructive strength tests are increasingly used for measuring/estimating unconfined compressive strength (UCS) of rocks. These types of tests are particularly attractive because they do not destroy the core interval tested. Impact testing using an Equotip hardness tester is one of these tests. The Equotip originates from metal testing and measures Leeb hardness. The Proceq Equotip Hardness tester is a hand-held, electronic, battery operated, spring loaded device that plunges a tungsten carbide ball with a diameter of 3 mm towards the surface of the tested material, in this case a rock.

Method and/or Theory

The theory behind this method is that the height of the rebound of a small steel ball after its collision with a rock surface depends on the elasticity of the surface, which in turn reflects to a certain extent the mechanical strength of a rock (Aoki and Matsukura, 2008). Verwaal and Mulder (1993) published an equation that for estimating unconfined compressive strength (UCS) from between Leeb hardness.
SENERGY published a work on the application of UCS estimated from Equotip hardness for sand failure evaluation recently (Daniels et al., 2012) using the original Verwaal and Mulder equation.
The Equotip hardness tester can be used especially in cases where rock mechanic data is needed and compressive testing on representative rock samples (mostly cylindrical samples ”plugs”) is not possible.
OMV E&P initiated a research project to test the use of the Equotip hardness tester for estimating UCS for different types of rocks. The single impact method (12 impacts in sample area; Daniels et al., 2012) was used on slabbed surfaces and full cores. The maximum and minimum reading were excluded and the remaining 10 readings were used for averaging. The averaged Leeb hardness readings were correlated with scratch-test derived UCS (instead of UCS derived from compression tests) from the same core depths (Fig. 1).

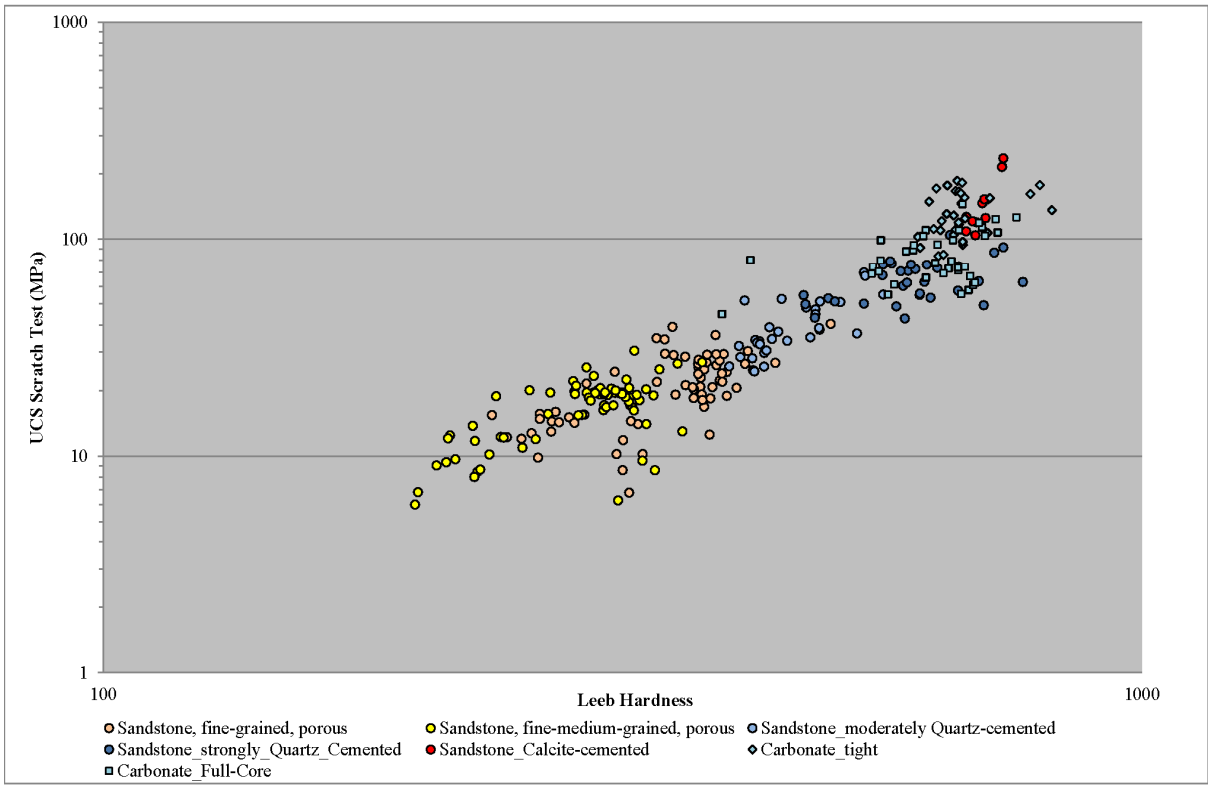

Figure 1 *The figure shows the results of the averaged Equotip Leeb hardness measurements plotted against the UCS results obtained from scratch tests at the same core depth. A clear correlation exists between Leeb hardness and scratch test derived UCS.*

Conclusions

The results indicate that a strong correlation exists between Leeb hardness and UCS derived from scratch-test data for different lithologies (figure 1). Tests on full cores also fit into the correlation. Larger variations in data range were encountered in coarse-grained sandstones, sandstones characterized by high amounts of clay minerals and fines (Daniels et al., 2012) as well as in lithologies that exhibit high rock strengths. Further in-house research is planned to find individual correlations or other testing devices for those lithologies.

The results show that the Equotip can be used for estimating UCS from lithologies where representative plugging is not possible. The method is fast and equipment costs and logistics are low. Scratch tests derived UCS can be used for calibration. The hardness testing cannot replace triaxial, hollow cylinder or scratch tests but can complement those tests, especially if data is needed urgently or other testing is not possible.

References

Aoki, H. and Matsukura, Y. [2008]. Estimating the Unconfined Compressive Strength of Intact Rocks from Equotip hardness. Bull. Engl. Geol. Environ., v. 67, pages 23-29.

Daniels, G., McPhee, C., McCurdy, P. and Sorrentino, Y.. Non-Destructive Strength Index Testing Applications for Sand Failure Evaluation. SPE 158326.

Verwaal, W. and Mulder, A. [1993]. Estimating Rock Strength with the Equotip Hardness Tester. Int. J. Rock. Mech. Min. Sci. Geomech. Abstr. 30, pages 659-662.