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Integrating Quantitative and Qualitative Rock Strength Data in Sanding Prediction

Abstract

Despite continued advances in sand production prediction software, numerical modelling does not always agree with observed sandface behaviour once a well is flowing. Where core is available, computer models should be calibrated to laboratory determined rock strengths, measured on plugs cut from the core. The number of core plugs is often restricted due to time limitations and availability of good quality core. These may not be fully representative of the entire reservoir section due to complex variations in rock composition. Sandstone failure and the onset of sand production can be more accurately predicted by integrating log derived rock strength, calibrated to rock mechanics laboratory test data, with petrographic observations made on the core; i.e. combining quantitative and qualitative methodologies. Such observations typically include mineralogy, rock texture, structure and reservoir quality. Laboratory numerical data are discrete, whereas log and observational data are continuous, and these do not always readily relate. This can make the integration of laboratory-to-field data a difficult process.

In an attempt to more closely relate quantitative and qualitative core data, a Schmidt impact testing hammer has been used to make hardness measurements along an entire core. The Schmidt hammer was originally designed for the non-destructive testing of concrete hardness in the civil engineering industry and was later adopted to estimate rock strength in mining, quarrying and tunnelling applications. The Schmidt hammer allows very rapid (and inexpensive) core testing, and has the added advantage of being non-destructive. Rock mechanics parameters can be determined in dense arrays that reflect the real inherent heterogeneity of the core.

Use of the Schmidt hammer has enabled extrapolation of laboratory determined rock strength across the entire core and has facilitated direct correlation of mineralogy and grain texture to sandstone failure and yield. Characterisation of overlying claystones has also provided essential data for the determination of stress shadowing effects. Further development and refinement of this technique should provide an additional useful tool in reservoir and overburden characterisation and predicting sand production. The technique does not require specialist rock mechanics knowledge and can be applied at the well site or core viewing room. Useful data can be obtained from core material ranging from fresh state to old archived material. The speed and practicality of the Schmidt hammer as a rock strength characterisation tool is seen to have great potential.

Introduction

Sanding prediction work often relies on numerical analysis (quantitative) without regard to reservoir quality, rock texture and micro-structure from core observations and petrology studies (qualitative). The two methods of approach compliment each other, and when combined, greatly enhance strength characterisation of sedimentary rocks. In practice however, the integration of numerical and observational data is often fraught with difficulties and pitfalls.

The unconfined (or uniaxial) compressive strength (UCS) is the most often quoted rock strength parameter. It is also the most readily understood sanding indicator by non-specialists in the field of rock mechanics. The UCS test has many disadvantages, but nevertheless has widespread and valuable application to wellbore stability and sand prediction. If UCS data are not available, many process steps are required to calculate an approximated UCS (Fig. 1). Laboratory UCS data can be plotted on a core log for the correlation of rock strength to petrological features. However, in heterogeneous reservoirs of complex sedimentology and mineralogy, the often-infrequent sample interval of UCS data makes accurate correlation and extrapolation difficult.