Uncertainty, Effectiveness and Improvements in Core and Well Data Integration for Geomechanics in Tight Carbonate Reservoirs

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ABSTRACT

We review some shortcomings of conventional core and well data integration loops and their impact on the value of geomechanical studies. We introduce new evidences suggesting that conventional workflows for geomechanics often fail to address important challenges in the characterization of tight carbonate formations in several middle-eastern fields. In particular we focus on cases where poor data results in models that are poorly conditioned and thus inappropriate to assist engineers for necessary decisions about well designs and field management options. The following aspects are discussed:

i) Quality checking of rock mechanical test results;

a. Sample requirements: Conventional strength testing methods requires dedicated samples which must be prepared according to stringent specifications in terms of shape and size;
b. Natural dispersion: the test interpretation for inter-particular strength rely on the occurrence of a specific type of failure along shear planes inclined with respect to the cylindrical sample axis, yet only a fraction of samples fail this way. Natural defects and heterogeneity in tested samples often lead to different failure behaviors, thereby invalidating the test interpretation;
c. Testing conditions and core preservation standards: Rock mechanical tests should be performed on samples extracted as early as possible from the fresh core and preserved until testing takes place.

ii) Integration of RMT and well logs for mechanical properties;

a. Discrete measurements: strength tests run on plug samples are concerned with a limited fraction of the core volume and sometimes leave representative features out of the testing program;
b. Size of data sets: Large volumes of samples are required to constitute statistically representative data sets, to minimize the impact of outliers and to identify co-existing rock facies.
c. Resolution scales: Plug samples must be representative of average values inferred from wireline logs at a lower resolution. However, length scales associated with rock heterogeneity are smaller than the average size of plug samples;
d. Upscaling: Several rock facies may coexist in the same well, each of them characterized by unique relationships between mechanical rock properties and other properties (including geological/mineralogical facies) derived from well logs.

e. Data compatibility: Differences must be accounted for between in-situ (i.e. borehole and reservoir conditions) and laboratory conditions.

iii) Benefits of continuous measurements on whole cores

a. Logistics: Core testing technologies described in this talk are integrated in one compact and portable test bench, which requires light logistical support and minimum sample preparation for fast and efficient testing campaigns that can be run at an early phase of the laboratory analysis program.
b. Continuity and Resolution: High resolution continuous profiles of these rock properties are used to estimate geomechanical and petrophysical properties and their correlation with the mineralogical composition, and map geomechanical facies for further calibration of well and reservoir models at different scales;
c. Repeatability: Non-destructive tests are run on whole cores; robustness is demonstrated via repeatability;
d. Redundancy: New laboratory testing technologies to provide direct measurements of mechanical, acoustic, and mineralogical rock properties on whole core samples..
e. Size of data sets: Large sets of high quality data are obtained from fresh cores, improving the statistical representation of core data for the reservoir under study.

A review of several case studies reveal the necessity of additional steps for the quality checking of standard rock mechanical tests results and the benefits of using continuous high-resolution core data. These enhanced data acquisition and integration workflows enable the generation of more realistic geomechanical models and in turn better well and reservoir management decisions. Tight calibration of rock mechanical properties using continuous measurements on the core often exhibited property variation at high resolution leading to identification of new reservoir opportunities.