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A Comparison of Different Laboratory Treatment (Cleaning) Procedures for Cuttings Samples Drilled with Oil-Based Muds: Examples from the Montney and Duvernay Formations

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Summary

Over the past decade, a variety of advanced laboratory techniques and workflows have been developed for evaluating geochemical, petrophysical and geomechanical characterization properties of drill cuttings samples (Egermann et al., 2006; Solano, 2010; Ortega and Aguilera 2014a,b; Haghshenas et al., 2016; Ghanizadeh et al., 2018, 2020). Despite some inevitable challenges [e.g. insufficient sample amount (vials), improper sample size, etc.], the use of drill cuttings samples is generally advantageous for evaluating reservoir quality and rock mechanical properties due to their common availability, inexpensive collection cost and the possibility of high-resolution sampling in heterogeneous reservoirs. In addition, drill cuttings samples are routinely the only reservoir samples that are available from multi-fractured horizontal wells (MFHWs).

Proper sample preparation and treatment (i.e. cleaning/drying) is a critical step prior to any laboratory-based analysis performed on drill cuttings samples, particularly for those cuttings obtained using oil-based muds, which is a common mud system used in the drilling of Montney and Duvernay horizontal wells. However, there is currently no standard procedure established for cleaning/drying drill cutting samples contaminated with oil-based mud, resulting in uncertainty in derived cuttings properties and inconsistency in laboratory evaluations conducted by different vendors.

This work presents results from an ongoing laboratory study comparing the effectiveness of three cleaning/drying methods including 1) organic solvent cleaning (dichloromethane), 2) a customized thermal process (180 °C) based on the modified extended slow-heating (ESH) programmed pyrolysis (Sanei et al., 2015) and 3) short-term rinsing with a trademark surfactant. The primary objective is to determine the method that is capable of removing the highest amount of oil contamination while imposing the least (or preferably none) alteration to the rock matrix properties, e.g. composition, fabric, and pore structure. Two suites of drill cuttings samples were collected from two horizontal wells penetrating the productive intervals of the Montney and Duvernay formations in Alberta (Canada). These drill cuttings samples were selected from different locations along the lateral sections to account for possible facies variations. Importantly, following an identical experimental workflow, drill cuttings sub-samples with different particle sizes were separated (after sieving) and analyzed independently to examine the impact of sample heterogeneity and particle size on the outcomes. Core and cuttings samples (drilled with water-based mud) obtained from the adjacent vertical sections of the analzed horizontal wells were further analyzed as reference samples to establish base-lines for comparing properties of interest.

To track the variations in rock matrix properties before and after cleaning/drying, a comprehensive set of experimental analyses were conducted including: standard and ESH programmed pyrolysis (organic matter type and content), optical organic petrography, X-ray fluorescence (XRF, elemental composition), X-ray Diffraction (XRD, mineralogical composition), helium pycnometry (grain density, porosity); low-pressure gas (N_2, CO_2) adsorption (surface area, pore size distribution, pore volume); gas rate-of- adsorption (ROA; permeability/diffusivity), and scanning electron microscopy (SEM; rock fabric).

Experimental observations indicate that, as opposed to the surfactant-aided rinsing process, the solvent and thermal treatments are capable of removing the majority of the oil-based mud contamination from the analyzed drill cuttings samples. SEM observations further reveal that the solvent treatment can remove mud-fine particles that coat the external surface of drill cutting grains more effectively than the thermal method. In addition, comparing identical sub-samples pre- and post-treatment, the solvent method results in higher surface area, pore volume, and permeability than thermal cleaning. Organic petrography observations indicate that no visual alteration is induced in the organic matter of the analyzed sub-sample pre- and post-treatment with organic solvent and thermal pyrolysis. Based on mineralogical composition evaluation pre- and post-treatment, no alteration in the mineral structure/composition is observed after solvent and thermal cleaning; however, the removal of barite (an additive in oil-based mud) contamination was feasible using the organic solvent only.

Through the application of an integrated laboratory workflow on two diverse drill cuttings sample suites differing in geological properties (Montney, Duvernay), the variation in rock fabric, composition and pore structure is identified before and after three different treatment procedures. The quantification of the observed variations may have important implications for evaluating matrix storage, transport and geomechanical properties from drill cuttings samples, which are commonly treated by some form of cleaning/drying procedure prior to laboratory experiments.

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