Nanotech Tagging for Cuttings Depth Identification

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Abstract

Direct petrophysical characterization of drill-cuttings has come a long way in recent years. When performed while drilling, integrated into standard mud logging practices, it has the potential to support or displace logging while drilling (LWD) for formation evaluation and geosteering. Mud logging is particularly promising in coiled tubing drilling, where LWD tools are not available to the industry due to the extremely reduced hole size. However, until now, mud logging deployment has suffered from subpar quality due to uncertainties in cuttings depth assignment, arising from wellbore mud hydraulics, poor hole cleaning, inaccurate knowledge of the return-trip lag time up the annulus due to wellbore caving and lagging of cuttings during their trip to the surface. This is even more challenging in long horizontal sections, where gravitational debris accumulation, hydraulics, and hole cleaning are more problematic. When the mud return trips lasts approximately thirty minutes, it is common to have depth uncertainties of ± 20 feet or more. Inaccurate labeling of the collected cuttings increases these errors. Here we propose to tag cuttings while they are generated at the drillbit with penetrating, impregnating nano-tags. The lag time of the tags is determined by the downward-trip time through the dimensionally-accurate drill pipe/coil ID, which takes significantly less time (around 1 - 3 minutes) than the upward-trip (about 30 minutes for a 5000 ft deep well); therefore the depth uncertainty is dramatically reduced at ± 1 ft or so. Most advantageously, the depth correlator nano-tags reside inside the cuttings to identify their depth of origin with a depth uncertainty of +/- 1 ft or so at the time of petrophysical analysis, even if cuttings get shifted or slightly scrambled in transport or storage.The nano-tags are polystyrenic nanoparticles (NPs) that undergo thermal degradation to generate unique mass spectra. The synthesis of the nanoparticles via emulsion polymerization in water is simple and low-cost, both in a small batch and in a large scale flow-reactor. The sizes of the as-made NPs are narrowly distributed in the range of 20-60 nm. The as-made, low-density NPs are compatible with water-based-mud and with oil-based-mud via a reverse emulsion. Pyrolysis GCMS (Py-GCMS) is used to detect each unique mass spectrum of the NPs at ppm levels on the limestone cuttings. This disruptive technology has the potential to significantly improve the depth accuracy of cuttings in mud logging, thus improving the quality and accuracy of the lithological and petrophysical analyses performed. The Py-GCMS detection of the NPs is especially beneficial for unconventional reservoirs that need to determine TOC, kerogen and bitumen content, and maturity at precise depths from cuttings. The detection of the nanoparticles could be automated and programmable using an auto-sampler and a library of mass spectra data.

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