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T_1-T_2 NMR on Shale Cuttings

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Summary (All headings should be Arial 12pt bold)

In recent years, nuclear magnetic resonance (NMR) core applications have expanded rapidly due to the prolific increase in horizontal drilling. One new application is NMR porosity measurement on cuttings. Green Imaging Technologies (GIT) developed a NMR porosity measurement on PDC and non-PDC cuttings that measures within 5% of the porosities obtained from rock core plugs and logging data. The objective here is to extend this measurement with other techniques commonly found in NMR rock core analysis and NMR well logging. T_1-T_2 NMR in traditional measurements has been used for fluid typing and organic content characterization and in this work we have extended that methodology to cuttings. In general, measurements in horizontal wells are limited to only a gamma ray and cuttings. Few wireline logs or cores are taken during the development phase. Using cuttings NMR measurements allows for more frequent measurements for minimal cost to resolve such issues as well spacing or heterogeneous changes in unconventional resources in laterals. Using NMR measurements on cuttings to replace or supplement NMR core analysis and horizontal wireline logging would be extremely beneficial, technically and financially.

Theory / Method / Workflow

Inversion recovery-CPMG (IR-CPMG) NMR pulse sequence is used to simultaneously measure T_1 and T_2 relaxation times on rock core plugs, crushed core plugs to PDC bit size and PDC cuttings from similar depths. Data acquisition is done on a 20 MHz NMR spectrometer. The data is then displayed on a 2D map, with T_2 on x-axis and T_1 on y-axis. The T_1-T_2 map can be divided into regions and based on how much NMR signal is present in each region, the distinct hydrocarbon species can be deduced. In samples from unconventional oil and gas wells the regions correspond to bitumen, clay bound water, free water and free hydrocarbon content. Samples were studied in as received, dry, 100 % Sw, 100% So and mixed saturated sample states in order to test the robustness of the T_1-T_2 map method. Cuttings sample preparation closely followed the steps from our previous URTEC and SCA publications on NMR based porosity measurement on cuttings. Comparison of NMR data was done on datasets from rock core plugs, crushed plugs, NMR well log and original well cuttings.

Results, Observations, Conclusions

Utica, Marcellus, Madison and Woodford samples were measured. The results from cuttings were within 5% of routine helium porosities on corresponding plugs. In some cases wettability and rock type played a factor in determination of porosity and permeability. Limitations from the acquisition can largely be removed by some a-priori information on the cuttings to help with sample preparation and more accurate cuttings' depth information. In summary, the developed methodology on PDC bit cuttings works not only on a singular rock type but is transferable among

different rock types and maturities. It appears to be a cheap and accurate method to determine key volumetric components for operators in unconventional resources. Lastly the ability to take multiple samples along the lateral could help future determination of heterogeneity which is a possible culprit for varied EUR response in specific plays.

Novel/Additive Information

The results of this study are very encouraging and imply the measurement could become routine in labs and well sites especially when logging or coring is impractical.

Acknowledgements

References

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