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A Study of the Relationship between Well Cuttings, Geophysical Logs, and Production Data for Select Wells from the Utica Shale, Eastern Ohio

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Abstract
The Utica Shale has been classified as an “unconventional” shale play. In eastern Ohio the Utica Shale play encompasses both the Utica Shale and Point Pleasant Formations. Significant oil and gas reserves have been identified as being present in the Utica Shale play, leading to an increase in exploration and production activity. As of late 2013, numerous horizontal wells have been drilled in eastern Ohio. Drilling, completion, and production records for these wells are required to be submitted to the Ohio DNR, and within a specified period of time are released to the public. To conduct this current study, ODNR information was acquired for seven Utica Shale wells in eastern Ohio, and the relationship between well cuttings, geophysical logs, and production data was examined. A multi-step procedure was taken in selecting and studying the materials and data available through the ODNR. The selection of the specific wells for this project occurred after close examination of the entire body of available Utica Shale data. Next, well cuttings for the selected wells were petrographically examined and described. The well cuttings were also subjected to a TCE solvent test to help verify the presence of hydrocarbons. X-ray diffraction was conducted on the cuttings by a third party lab for the purpose of determining the presence of clay type within the well’s production interval. Geophysical logs for each of the seven wells were obtained for corroboration with the well cuttings analysis. The wells’ production data and completion records were also pulled from the ODNR’s database. After compiling all the data from these various tests, records, and examinations, a comparative table was produced which allowed for the determination of relationships between the geologic conditions and the completion and production information of all the wells. The findings indicate that in certain cases clear-cut relationships can be found between geologic and man-induced characteristics and in other cases no relationship is found.

Methods
Well Cuttings Analysis
Specific intervals of well cuttings within the Utica Shale and Point Pleasant Formation (Fig. 1) were requested from the Ohio Geological Survey, H.R. Collins Lab and Core Repository and examined on site. Cuttings were analyzed with a Bausch & Lomb StereoZoom 7 binocular microscope (Fig. 2) and photographed for further analysis (Fig. 3). In several cases photomicrograph investigation was also implemented to more closely examine individual well cuttings (Fig. 4). In addition, fifteen 1-gram well cuttings samples corresponding to five of the seven selected wells were released from the Ohio Geological Survey, H.R. Collins Lab and Core Repository for additional study (Fig. 5). All fifteen samples were retrieved from the horizontal components of their respective wells. These samples were then analyzed and given detailed descriptions. Portions of these samples were also sent away to a third party lab for X-ray diffraction analysis.

TCE Solvent Test
Trichloroethylene solvent was used to aid in the extraction and detection of hydrocarbons within well cuttings (Fig. 6). Two samples, ranging from 0.05g-0.1g, were selected from each of the fifteen “horizontal” well cuttings samples for testing. One sample was left in its original state, while the other was crushed into fine particles. Approximately 0.5mL of TCE solvent was then applied to each sample, and extraction of any hydrocarbons from the samples was observed as UV fluorescence under a black-light.

Geophysical Log Interpretation
Seven geophysical logs corresponding to the selected wells were requested from the Geologic Records Service of the ODNR. Specifically, Gamma Ray and Rate of Penetration (ROP) logs were used to identify formation tops and perforation zones related to completion procedures for each well (Fig. 7).

Completion Records - Production Data
Completion records containing perforation and stimulation intervals, fracture treatments, and injection rates were obtained from the ODNR database; in addition to initial and annual production data for the seven selected wells. This data was then compiled and assessed alongside all other diagnostic results, in an effort to highlight certain trends.

Utica Shale Map: Selected Well Sites

Figure 1. Well cuttings sample boxes.
Figure 2. Analysis under binocular microscope.
Figure 3. Photograph of well cuttings Well 5, Interval: 8,490-8,460 (ft).
Figure 4. Left: Photograph of well cuttings Well 6, Interval: 7,526-7,550 (ft). Right: Photomicrograph image, individual well cutting.
Figure 5. Photograph of well cuttings Well 7, Interval: 12,280-12,340 (ft).
Figure 6. Photograph of well cuttings Well 8, Interval: 11,450-11,540.
Figure 7. Geophysical log Well 3.

Results
All data and analysis resulting from the various tests, records, and examinations were compiled within a comparative table. The table contains a comprehensive well description for each of the seven wells, well cuttings analysis for specified horizontal intervals, and well completion records detailing items of interest. In addition, TCE test results are included along with initial and annual production values for oil, gas, and brine quantities. From the comparative table relationships between the geologic conditions and the completion and production information relating to all wells can be determined.

Comparative Table

Conclusions
Upon analysis of all compiled data and results, several relationships or trends can be inferred.

- Correlation of the lithology of samples demonstrated by descriptions of well cuttings within the horizontal components of all wells, with the exception of Well 1 and Well 5 where no data was available. Shale is the dominant lithology within all wells’ horizontal sample intervals; medium to dark gray in color with varying amounts of calcareous constituent.
- TCE Solvent Test reveals the following trend. Samples that have an initial high UV fluorescence intensity continue to fluoresce longer (after re-immersion in TCE Solvent) than samples that display an initial lower intensity. Therefore, the abundance of hydrocarbons within high UV fluorescing samples is most likely greater than samples that demonstrate lower UV fluorescing intensities. Consequently, samples that contain a greater abundance of hydrocarbons are described as “dark gray and carbonaceous” within the well cuttings analysis. Ultimately this portrays a relationship between lithological characteristics and the presence/abundance of hydrocarbons.
- Correlation of completion processes and corresponding production data. There appears to be a relationship between the fracture treatments (specifically the amount of frac fluid and propping agent), number of perforation shots, and injection rates; with initial and annual production of oil (bbls) and gas (mcf). Well 2 within the comparative table demonstrates this trend.
- An overarching relationship exists between the lithological characteristics of samples (specifically noted in well cuttings descriptions and TCE test results) and the completion and production information previously outlined. Particular completion processes corresponding with increased initial and annual production of oil (bbls) and gas (mcf) correlate with a relative abundance of hydrocarbons (TCE test results) and lithology characteristics such as, “gray to dark gray shale” (well cuttings analysis).

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