Apr 16th, 11:00 AM - 2:00 PM

Photomicrograph Analysis of Marcellus Well-Cuttings from Northeast Pennsylvania

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2014 Cedarville University Research Symposium

Abstract:

Often times when an oil or gas well is drilled in an area with limited geophysical and mud logs, the geologist or mudlogger describing the drill cuttings may wonder about the veracity of their work. Such an uncertainty may decrease the rate and accuracy of the mudlogging procedure, or inhibit personnel from determining how far drilling has advanced in relation to the target zone. If a descriptive guide containing photomicrographs was available early in the development of a new gas field, mudloggers would be more definitive in their analysis of drill cuttings. In order to test this idea, a descriptive guide was created to help with the identification of drill cuttings from a natural gas well drilled in Sullivan Co., PA, located in the Marcellus Shale play of northeast Pennsylvania. The well was sampled every 30' starting at a depth of 600' and ranging to 8,500' below the surface. Basic lithology types encountered during drilling and mudlogging included sandstone, siltstone, limestone and shale. Representative samples of each significant lithology were analyzed for this study. The created guide utilizes photomicrographs taken with a Motic 2300 camera mounted on a Motic polarizing microscope. Helicon Focus software was used for focus stacking. The photomicrographs have been matched with data and descriptions from the on-site mudlogs which list both formation tops and the lithological sequences. Printed color hardcopies and DVD versions of the guide will be distributed to the operator who provided the cuttings for the study. A request will be made that the operator provides feedback regarding the usefulness of the guide.

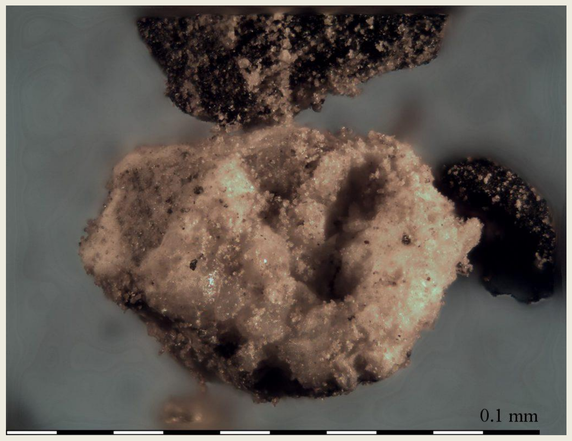
Procedure:

Varying lithologies were initially determined through the use of a mudlog, provided by Chief Oil & Gas, produced by Horizon Well Logging, LLC. Comparisons were made between the given descriptions, lithologies, and Rate of Penetration (ROP) log. Individual well cutting samples were then analyzed using the Motic polarizing microscope in order to better identify the rock type. Once the mean cutting size and lithology was determined for each sample, individual grains were photographed under both 4x and 10x magnification in order for proper identification. Each image produced was comprised of ≥ 25 photographs taken using a Motic 2300 camera and compressed and focused using Helicon Focus software. Descriptions were then produced for each sample in order for comparison with the provided mudlog lithologies.

Findings:

It was determined that certain lithologies were accurately portrayed by the mudlog, but incongruities occurred within sandstone-siltstone sequences. All portions of the log that identified formation tops and bottoms, Tully Ls, Hamilton Sh, Marcellus Sh, Purcell Ls, and Onondaga Ls, were accurately described. The upper most formation listed on the log was the Tully Ls, located at a vertical depth of 6100 ft. Above the Tully Ls is a series of alternating sandstone-siltstone sequences, ranging 5500 ft. in length, whose compositions are relatively similar. Varying quartz, mica, pyrite, and calcite granules comprised the lithologies whose colors ranged from reddish brown to dark gray. Samples whose contents were largely sub-angularly rounded quartz grains were deemed sandstones. Particle sizes were slightly larger than those found in the accompanying siltstones. Siltstones samples commonly appeared light gray to gray, sub-rounded, and were commonly well sorted. The mudlog record varied in accurately identifying these lithologies due their similar natures. Such conclusions are somewhat expected due to the nature of the mudlogging process and the many uncertainties encountered during drilling. During the drilling process, mudloggers must hurriedly determine the depth of drilling and lithological characteristics by taking into account "lag time," the amount of time necessary for the cuttings to travel from the drill bit to the surface. Drilling mud as well as previously ground cuttings may also be incorporated in the samples due to the rapid progression of the drill bit (rate of penetration logs, ROP).

Tully Limestone

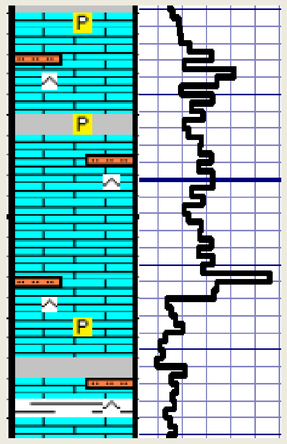


Description

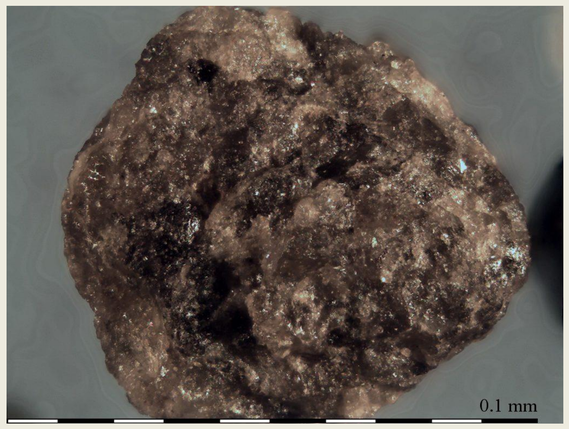
Tully Ls: 6150 ft., 70 % CaCO3, lt to clr carb ls, dk gry lmy Sltst/Sh, sub ang, calc cmt, cl incl, pyr nod.

(Tully Limestone, depth of 6150 ft., 70% Calcium Carbonate, light to clear carbonaceous limestone, dark gray limy siltstone/shale, sub-angularly rounded, calcareous cement, possible clay inclusions, pyrite nodules)

Lithology/ROP (min/ft.)



Sandstone

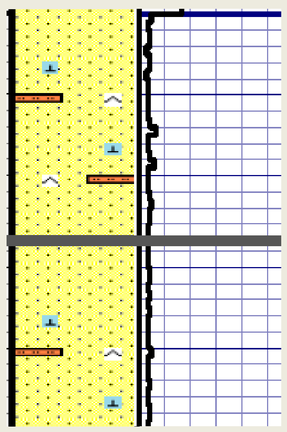


Description

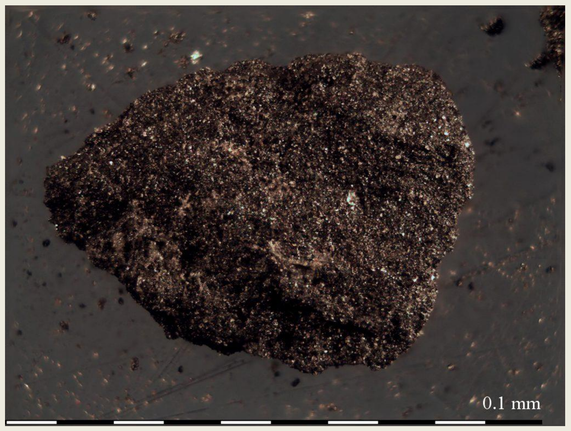
SS: 2130 ft., 80% SS, gry to lt gry, mgr, sub ang to sub rnd, hi qtz cont, med sort, brit, cal nod, sltst grans.

(Sandstone, depth of 2130 ft., Formation N/A, 80% sandstone, gray to light gray, medium grained, sub-angularly rounded, high quartz content, medium sorting, brittle, calcareous nodules, siltstone granules)

Lithology/ROP (min/ft.)



Marcellus Shale

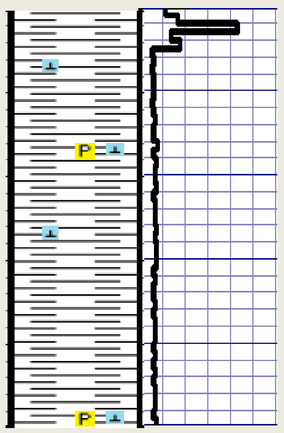


Description

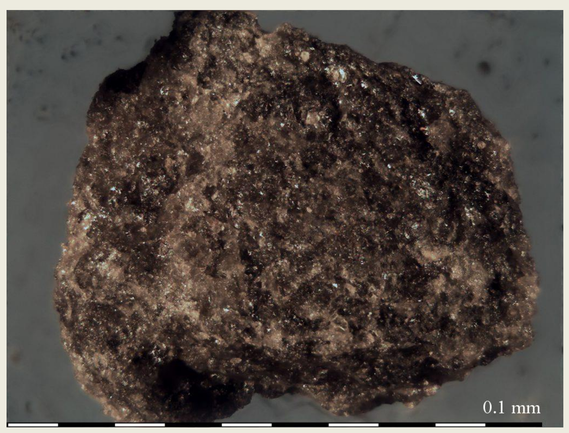
Marcellus Sh: 7700 ft., dk gry to gry, sub rnd, med sort, arg, mic and pyr par, mnr calc, blky to plty.

(Marcellus Shale, depth of 7700 ft., dark gray to gray, sub-rounded to, medium sorting, argillaceous, mica and pyrite particles, mnr calcite, blocky to platy)

Lithology/ROP (min/ft.)



Siltstone

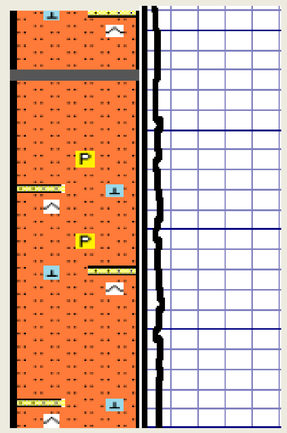


Description

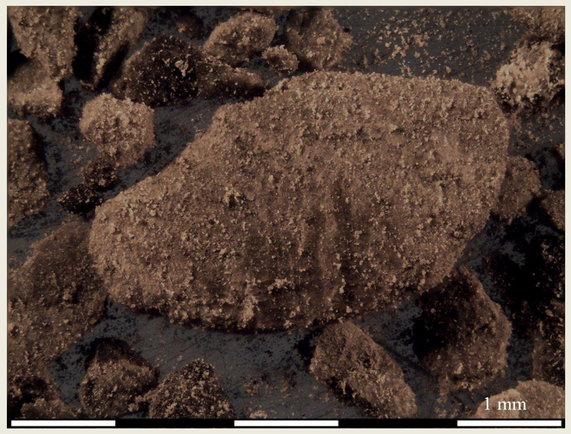
Siltst: 4140 ft., 80% Siltst, gry to dk gry, sub ang to sub rnd, hi mica and qtz cont, w sort, ss grans, pyr nod.

(Siltstone, depth of 4140 ft., Formation N/A, 80 % Siltstone, gray to dark gray, sub angular to sub rounded, high mica and quartz content, well sorted, sandstone granules and pyrite throughout)

Lithology/ROP (min/ft.)



Limy Shale

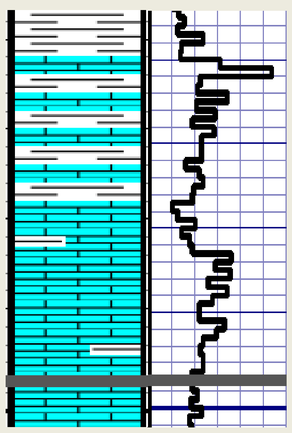


Description

Purcell Ls: 7830 ft., 45% Lm, 40% Sh, gry to lt gry, sub rnd, med to fr sort, calc cmt, cl part, calc cov sh.

(Purcell Limestone, depth of 7830 ft., 45% Limestone, 40% Shale, gray to light gray, sub rounded, medium to fair sorting, calcite cement, clay particles, calcite covered shale which reacts strongly to HCl.)

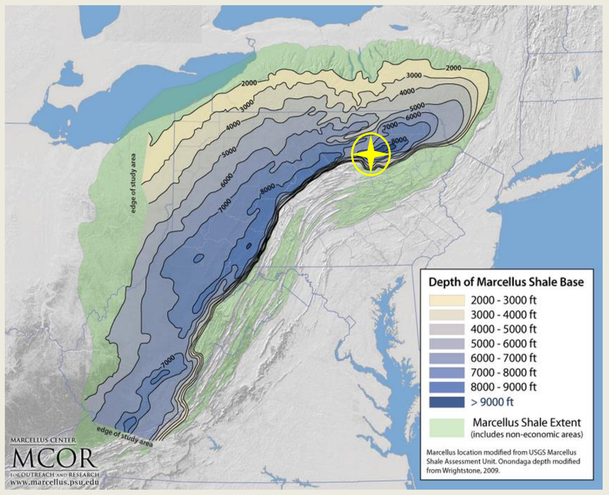
Lithology/ROP (min/ft.)



The Marcellus Shale Play:

The Marcellus Shale is currently one of the most productive shale gas resources in the United States. Technological advances in horizontal and directional drilling have increased the accuracy and productivity of operations. Pennsylvania has seen the majority of production over the past decade, which has been focused in two main "hot zones" located in the Southwest and Northeastern portions of the state. The U.S. Energy and Information Administration reported that between 2011 and 2012, Pennsylvania's total marketed natural gas grew by 72%. Currently, the Marcellus play is averaging a mean production value > 26 Bcf/day, second only to the Eagle Ford Shale located in Texas (Marcellus Drilling Productivity Report, 2014). Generally, the Devonian aged Marcellus is found within the Appalachian Basin at depths between 4,000 and 8,000 ft. and ranges in thickness from 20 to 250 ft. Such depths increase the need for precision and overall interpretation of the structure and lithology of the underlying sediments; the intended goal of this study.

*Star Denotes location of the studied well in Sullivan Co., PA.



Acknowledgements:

Much thanks to Mr. Ray Strom for providing assistance and direction, throughout the study. His invaluable experience with microphotography and imaging software was crucial in the completion of this project.

References:

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Dacheux Unit 1H Mudlog, Horizon Well Logging, 2012, Chief Oil & Gas, LLC.

Lithologic Guide

Limestone

Shale

Siltstone

Sandstone