# Appendix L

## Carter (2017): Shale gas case study report, Starvaggi No. 1 (API# 3712522278), Washington County, Pennsylvania

# Shale Gas Case Study Report

# Starvaggi No. 1 (API# 3712522278)
# Washington County, Pennsylvania

Prepared for:

Midwest Regional Carbon Sequestration Partnership
(MRCSP) Phase III

Compiled by:

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Pennsylvania Geological Survey


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# 1.0 Introduction

This report presents bulk mineralogy, organic carbon and thermal maturity data from a natural gas well studied by the Utica Shale Research Consortium (the Consortium) for the Utica Shale Play Book Study (Patchen and Carter, 2015). As part of that Study, the Pennsylvania Geological Survey (PAGS) and Kentucky Geological Survey (KGS) conducted major mineralogy, total organic carbon (TOC) and bitumen reflectance analyses of selected samples from the Starvaggi No. 1 well. The mineralogy and TOC analyses were used to assess the lithology and source rock properties of the Utica Shale/Point Pleasant interval, and bitumen reflectance analyses were used to evaluate its thermal maturity (i.e., ability of the interval to produce petroleum hydrocarbons).

This purpose of this case study report is to compare shale rock composition and thermal maturity data for the Utica Shale/Point Pleasant interval in southwestern Pennsylvania, documenting any trends between the two. This report is one of the project deliverables for the tri-state study being led by PAGS for Subtask 1.2 of the Midwest Regional Carbon Sequestration Partnership (MRCSP)'s Phase III Regional Characterization work, and in concert with our Marcellus shale case study reports (Opsitnick, 2015; and Cooney, 2016), provide insight into the basic reservoir characteristics of these very prolific shale gas plays in the Appalachian basin.

## 1.1 Location

The Starvaggi No. 1 (API# 3712522278) is situated in Washington County, Pennsylvania in the heart of the MRCSP tri-state study area. This well was directionally drilled through thousands of feet of Ordovician strata before completion in the Cambro-Ordovician "Beekmantown" interval (Appendix A; Figure 1). Thus, all the subsurface geologic information and geophysical logs reported for this well include data regarding the overlying Utica and Point Pleasant formations, the focus of this report.

Like the Hill Unit 3H well (included in the Marcellus shale case study) PAGS has included the Starvaggi No. 1 well in the north-to-south geologic cross section prepared for the tri-state area (A-A' in Figure 2). Figure 3 illustrates a portion of the geophysical log available for the well.

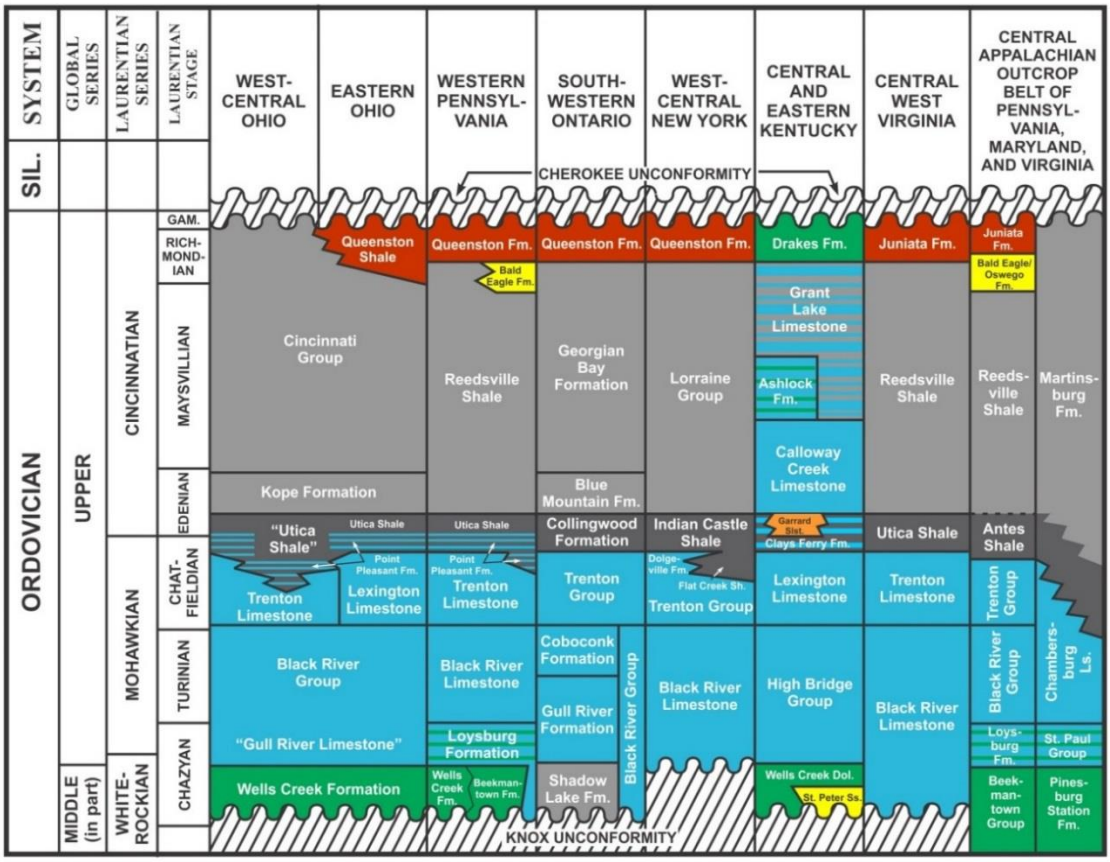



**Figure 1. Regional correlation chart of Ordovician strata (Patchen and Carter, 2015).**

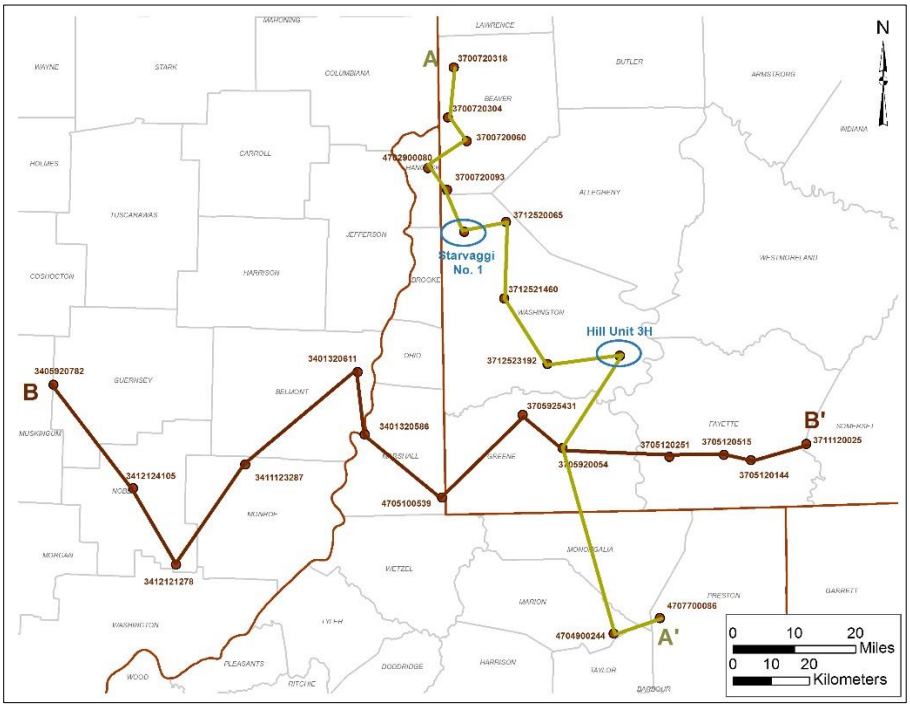



**Figure 2. North-south (A-A') and west-east (B-B') geologic cross section locations for the MRCSP tri-state study area.**

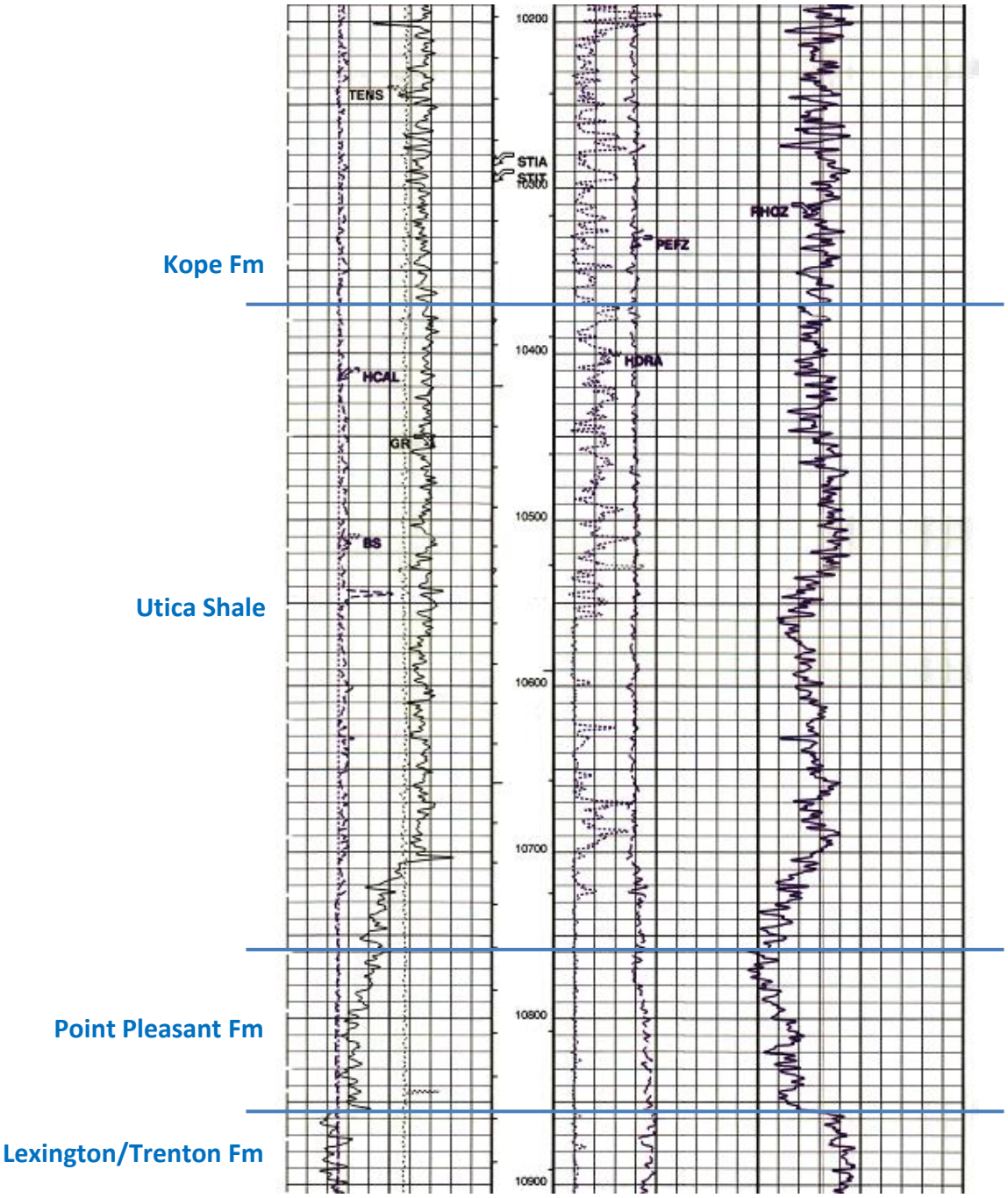



**Figure 3. Geophysical log for the Utica/Point Pleasant interval in the Starvaggi No. 1 well, annotated with Consortium formation top picks.**

## 2.0 Materials and Methods

Rock cuttings samples were collected from the Starvaggi No. 1 at 10-foot (ft) increments in the Kope (Reedsville equivalent) through Lexington/Trenton (Trenton equivalent) formations (see Figure 4 for nomenclature usage). Samples were taken from measured depths of 10,010 to 11,010 ft in the deviated portion of the borehole and were analyzed for bulk inorganic mineralogy, TOC and bitumen reflectance as summarized in Table 1. The reader is referred to Patchen and Carter (2015) for detailed discussions of the laboratory methods and techniques used to analyze these rock cuttings samples.

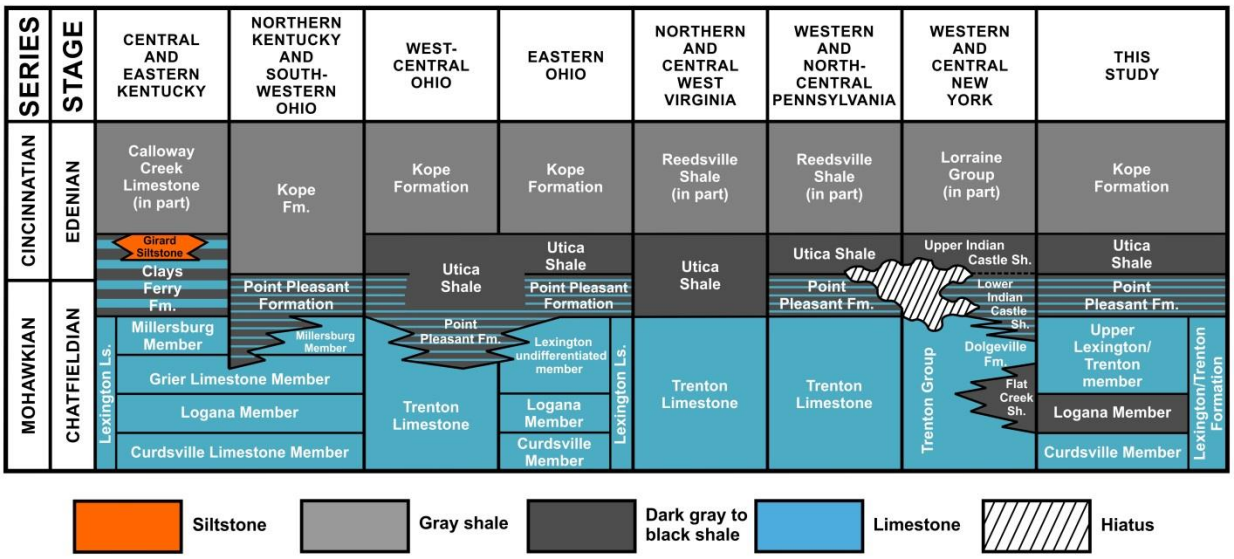



**Figure 4. Correlation chart for early Late Ordovician units, including nomenclature adopted by the Utica Shale Play Book Study (Patchen and Carter, 2015).**

*Table 1. Mineralogy, TOC and bitumen reflectance samples for the Starvaggi No. 1 well.*

| Depth (ft) | Formation | Bulk Mineralogy | TOC | PAGS Reflectance | KGS Reflectance |
|---|---|---|---|---|---|
| 10,010 | Kope | | X | | |
| 10,020 | Kope | | X | | |
| 10,030 | Kope | X | X | X | |
| 10,040 | Kope | X | X | | |
| 10,050 | Kope | X | X | | |
| 10,060 | Kope | X | X | X | |
| 10,070 | Kope | X | X | | |
| 10,080 | Kope | X | X | | |
| 10,090 | Kope | X | X | | |
| 10,100 | Kope | X | X | X | |
| 10,110 | Kope | X | X | | |
| 10,120 | Kope | X | X | | |
| 10,130 | Kope | X | X | | |
| 10,140 | Kope | X | X | | |
| 10,150 | Kope | X | X | | |
| 10,160 | Kope | X | X | | |
| 10,170 | Kope | X | X | | |
| 10,180 | Kope | X | X | | |
| 10,190 | Kope | X | X | | |
| 10,200 | Kope | X | X | X | |
| 10,210 | Kope | X | X | X | |
| 10,220 | Kope | X | X | | |
| 10,230 | Kope | X | X | X | |
| 10,240 | Kope | X | X | X | |
| 10,250 | Kope | X | X | | |
| 10,260 | Kope | X | X | X | |
| 10,270 | Kope | X | X | X | |
| 10,280 | Kope | X | X | | |
| 10,290 | Kope | X | X | | |
| 10,300 | Kope | X | X | X | |
| 10,310 | Kope | X | X | X | |
| 10,320 | Kope | X | X | X | |
| 10,330 | Kope | X | X | X | |
| 10,340 | Kope | X | X | X | |
| 10,350 | Kope | X | X | X | |
| 10,360 | Kope | X | X | X | |
| 10,370 | Utica | X | X | X | |
| 10,380 | Utica | X | X | X | |
| 10,390 | Utica | X | X | X | |
| 10,400 | Utica | X | X | X | |
| 10,410 | Utica | X | X | X | |
| 10,420 | Utica | X | X | X | |
| 10,430 | Utica | X | X | X | |
| 10,440 | Utica | X | X | X | |
| 10,450 | Utica | X | X | X | |
| 10,460 | Utica | X | X | X | |
| 10,470 | Utica | X | X | X | |
| 10,480 | Utica | X | X | X | |
| 10,490 | Utica | X | X | | |
| 10,500 | Utica | X | X | X | |
| 10,510 | Utica | X | X | X | |
| 10,520 | Utica | X | X | X | |
| 10,530 | Utica | X | X | X | |

| Depth (ft) | Formation | Bulk Mineralogy | TOC | PAGS Reflectance | KGS Reflectance |
|---|---|---|---|---|---|
| 10,540 | Utica | X | X | X | |
| 10,550 | Utica | X | X | X | |
| 10,560 | Utica | X | X | X | |
| 10,570 | Utica | X | X | X | |
| 10,580 | Utica | X | X | X | |
| 10,590 | Utica | X | X | X | |
| 10,600 | Utica | X | X | X | |
| 10,610 | Utica | X | X | X | X |
| 10,620 | Utica | X | X | X | |
| 10,630 | Utica | X | X | X | |
| 10,640 | Utica | X | X | X | |
| 10,650 | Utica | X | X | X | |
| 10,660 | Utica | X | X | X | |
| 10,670 | Utica | X | X | | |
| 10,680 | Utica | X | X | X | |
| 10,690 | Utica | X | X | X | |
| 10,700 | Utica | X | X | X | |
| 10,710 | Utica | X | X | X | |
| 10,720 | Utica | X | X | X | |
| 10,730 | Utica | X | X | X | X |
| 10,740 | Utica | X | X | X | X |
| 10,750 | Utica | X | X | X | |
| 10,760 | Point Pleasant | X | X | X | |
| 10,770 | Point Pleasant | X | X | X | |
| 10,780 | Point Pleasant | X | X | X | |
| 10,790 | Point Pleasant | X | X | X | |
| 10,800 | Point Pleasant | X | X | X | |
| 10,810 | Point Pleasant | X | X | X | X |
| 10,820 | Point Pleasant | X | X | X | |
| 10,830 | Point Pleasant | X | X | X | X |
| 10,840 | Point Pleasant | X | X | X | X |
| 10,850 | Point Pleasant | X | X | X | |
| 10,860 | Lexington/Trenton | X | X | X | |
| 10,870 | Lexington/Trenton | X | X | | |
| 10,880 | Lexington/Trenton | X | X | | |
| 10,890 | Lexington/Trenton | X | X | | |
| 10,900 | Lexington/Trenton | X | X | X | |
| 10,910 | Lexington/Trenton | X | X | | |
| 10,920 | Lexington/Trenton | X | X | X | |
| 10,930 | Lexington/Trenton | X | X | | |
| 10,940 | Lexington/Trenton | X | X | | |
| 10,950 | Lexington/Trenton | X | X | X | |
| 10,960 | Lexington/Trenton | X | X | X | |
| 10,970 | Lexington/Trenton | X | X | X | |
| 10,980 | Lexington/Trenton | X | X | X | |
| 10,990 | Lexington/Trenton | X | X | X | |
| 11,000 | Lexington/Trenton | X | X | X | |
| 11,010 | Lexington/Trenton | X | | | |
| | ***Sample count*** | ***99*** | ***100*** | ***72*** | ***6*** |

## 3.0 Results and Discussion

Table 2 presents the complete set of bulk mineralogy, TOC and bitumen reflectance analytical results for samples obtained from the Starvaggi No. 1 well. The following sections discuss these data and present graphics to illustrate data trends.

### 3.1 Bulk Mineralogy

As XRD analyses were interpreted, the Consortium assigned data to three categories – quartz+ (quartz, feldspars and pyrite), carbonate+ (calcite, dolomite and gypsum) and clay (muscovite and chlorite group minerals). PAGS plotted the data for these three categories to reflect changes in mineralogy with depth. Displaying the mineralogy results in this manner facilitates the interpretation of Utica and other formation tops (see Figure 5).

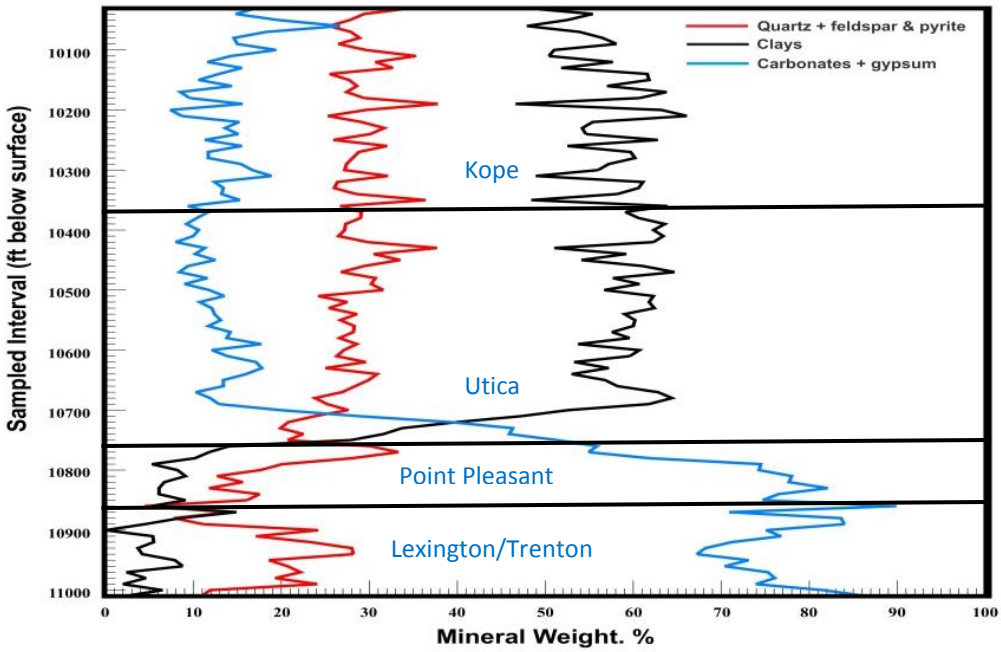



**Figure 5. Mineral fraction (weight %) versus sample depth (ft) for the Starvaggi No. 1. Deflections in clay and carbonate mineral percentages mark the boundaries between the Utica Shale and Point Pleasant Formation (10,760 ft), as well as identify the top of the underlying Trenton/Lexington Formation (10,860 ft) (modified from Patchen and Carter, 2015).**

*Table 2. Mineralogy, TOC and Bitumen Reflectance Results for the Starvaggi No. 1.*

| Depth (ft) | Formation | Quartz+ | | | | Clay | | Carbonate+ | | | Percent of Total Mineralogy | | | TOTAL PERCENTAGE | TOC (%) | PAGS Bitumen Reflectance | | KGS Bitumen Reflectance | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Quartz | Plagioclase | K feldspar | Pyrite | Muscovite | Chlorite Gp. | Calcite | Dolomite | Gypsum | Total Quartz+ | Total Clay | Total Carbonate+ | | | Mean Random BRo (%) | No. of Observations (N) | Mean Random BRo (%) | No. of Observations (N) |
| 10,010 | Kope | | | | | | | | | | | | | | 0.49 | | | | |
| 10,020 | Kope | | | | | | | | | | | | | | 0.54 | | | | |
| 10,030 | Kope | 24 | 11 | ND | 1 | 26 | 22 | 17 | ND | ND | 35 | 48 | 17 | 100 | 0.48 | 0.7 | 1 | | |
| 10,040 | Kope | 19 | 10 | ND | ND | 35 | 20 | 15 | ND | ND | 29 | 55 | 15 | 100 | 0.40 | | | | |
| 10,050 | Kope | 21 | 7 | ND | ND | 38 | 14 | 20 | ND | ND | 28 | 53 | 20 | 100 | 0.45 | | | | |
| 10,060 | Kope | 20 | 5 | ND | ND | 32 | 16 | 26 | 1 | ND | 25 | 48 | 27 | 100 | 0.41 | 0.6 | 2 | | |
| 10,070 | Kope | 18 | 10 | ND | ND | 36 | 18 | 18 | 1 | ND | 28 | 54 | 18 | 100 | 0.42 | | | | |
| 10,080 | Kope | 20 | 9 | ND | ND | 40 | 17 | 15 | ND | ND | 29 | 57 | 15 | 100 | 0.42 | | | | |
| 10,090 | Kope | 18 | 9 | ND | ND | 40 | 18 | 15 | ND | ND | 27 | 58 | 15 | 100 | 0.43 | | | | |
| 10,100 | Kope | 20 | 9 | ND | 1 | 32 | 19 | 19 | ND | ND | 30 | 51 | 19 | 100 | 0.39 | 0.9 | 3 | | |
| 10,110 | Kope | 25 | 11 | ND | ND | 24 | 27 | 14 | ND | ND | 35 | 50 | 14 | 100 | 0.39 | | | | |
| 10,120 | Kope | 20 | 10 | ND | ND | 41 | 17 | 12 | ND | ND | 31 | 58 | 12 | 100 | 0.38 | | | | |
| 10,130 | Kope | 25 | 8 | ND | ND | 28 | 24 | 13 | 2 | ND | 33 | 52 | 16 | 100 | 0.39 | | | | |
| 10,140 | Kope | 19 | 7 | ND | ND | 42 | 20 | 13 | ND | ND | 26 | 62 | 13 | 100 | 0.36 | | | | |
| 10,150 | Kope | 19 | 9 | ND | ND | 42 | 20 | 11 | ND | ND | 28 | 62 | 11 | 100 | 0.39 | | | | |
| 10,160 | Kope | 19 | 9 | ND | 1 | 41 | 16 | 13 | 2 | ND | 29 | 57 | 14 | 100 | 0.36 | | | | |
| 10,170 | Kope | 18 | 9 | ND | 1 | 45 | 19 | 9 | ND | ND | 27 | 64 | 9 | 100 | 0.35 | | | | |
| 10,180 | Kope | 21 | 8 | ND | ND | 41 | 20 | 10 | ND | ND | 29 | 61 | 10 | 100 | 0.44 | | | | |
| 10,190 | Kope | 27 | 11 | ND | ND | 23 | 24 | 16 | ND | ND | 38 | 47 | 16 | 100 | 0.36 | | | | |
| 10,200 | Kope | 21 | 8 | ND | ND | 44 | 19 | 7 | ND | ND | 30 | 63 | 7 | 100 | 0.31 | 1.1 | 1 | | |
| 10,210 | Kope | 17 | 8 | ND | 1 | 46 | 20 | 9 | ND | ND | 25 | 66 | 9 | 100 | 0.36 | 0.9 | 7 | | |
| 10,220 | Kope | 19 | 10 | ND | ND | 39 | 16 | 13 | 2 | ND | 29 | 55 | 15 | 100 | 0.29 | | | | |
| 10,230 | Kope | 22 | 10 | ND | ND | 37 | 18 | 12 | 2 | ND | 32 | 54 | 14 | 100 | 0.38 | 1.1 | 3 | | |
| 10,240 | Kope | 22 | 8 | ND | 1 | 35 | 20 | 15 | ND | ND | 30 | 55 | 15 | 100 | 0.41 | 1.0 | 3 | | |
| 10,250 | Kope | 18 | 8 | ND | 1 | 45 | 18 | 11 | 1 | ND | 26 | 63 | 11 | 100 | 0.37 | | | | |
| 10,260 | Kope | 21 | 11 | ND | ND | 37 | 16 | 14 | 1 | ND | 32 | 53 | 16 | 100 | 0.37 | 1.4 | 1 | | |
| 10,270 | Kope | 24 | 5 | ND | ND | 34 | 26 | 10 | 2 | ND | 29 | 60 | 12 | 100 | 0.38 | 1.1 | 20 | | |
| 10,280 | Kope | 19 | 9 | ND | 1 | 41 | 20 | 12 | ND | ND | 28 | 60 | 12 | 100 | 0.41 | | | | |
| 10,290 | Kope | 19 | 8 | ND | 1 | 41 | 17 | 15 | 1 | ND | 27 | 57 | 15 | 100 | 0.38 | | | | |
| 10,300 | Kope | 20 | 7 | ND | 1 | 37 | 19 | 17 | ND | ND | 27 | 56 | 17 | 100 | 0.39 | 1.1 | 2 | | |
| 10,310 | Kope | 23 | 7 | ND | 2 | 34 | 15 | 17 | 2 | ND | 32 | 49 | 19 | 100 | 0.47 | 1.0 | 4 | | |
| 10,320 | Kope | 18 | 8 | ND | ND | 43 | 18 | 12 | ND | ND | 26 | 61 | 12 | 100 | 0.41 | 0.9 | 2 | | |
| 10,330 | Kope | 18 | 8 | ND | 1 | 42 | 19 | 13 | ND | ND | 26 | 61 | 13 | 100 | 0.45 | 0.7 | 1 | | |
| 10,340 | Kope | 19 | 9 | ND | 1 | 40 | 18 | 13 | ND | ND | 29 | 58 | 13 | 100 | 0.46 | 0.8 | 2 | | |
| 10,350 | Kope | 26 | 10 | ND | 1 | 31 | 18 | 13 | 3 | ND | 36 | 48 | 15 | 100 | 0.47 | 0.9 | 2 | | |
| 10,360 | Kope | 18 | 8 | ND | 1 | 45 | 19 | 9 | ND | ND | 27 | 64 | 9 | 100 | 0.50 | 0.7 | 1 | | |
| 10,370 | Utica | 20 | 9 | ND | 1 | 41 | 19 | 10 | 1 | ND | 29 | 59 | 12 | 100 | 0.48 | 0.9 | 7 | | |
| 10,380 | Utica | 21 | 8 | ND | 1 | 42 | 19 | 10 | ND | ND | 29 | 61 | 10 | 100 | 0.55 | 1.0 | 6 | | |
| 10,390 | Utica | 18 | 8 | ND | 1 | 47 | 17 | 9 | ND | ND | 27 | 64 | 9 | 100 | 0.62 | 1.0 | 10 | | |
| 10,400 | Utica | 19 | 7 | ND | 1 | 45 | 18 | 10 | 1 | ND | 27 | 62 | 11 | 100 | 0.53 | 1.1 | 3 | | |

| Depth (ft) | Formation | Quartz+ | | | | Clay | | Carbonate+ | | | Percent of Total Mineralogy | | | TOTAL PERCENTAGE | TOC (%) | PAGS Bitumen Reflectance | | KGS Bitumen Reflectance | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Quartz | Plagioclase | K feldspar | Pyrite | Muscovite | Chlorite Gp. | Calcite | Dolomite | Gypsum | Total Quartz+ | Total Clay | Total Carbonate+ | | | Mean Random BRo (%) | No. of Observations (N) | Mean Random BRo (%) | No. of Observations (N) |
| 10,410 | Utica | 19 | 7 | ND | 1 | 46 | 18 | 10 | ND | ND | 27 | 63 | 10 | 100 | 0.61 | 1.0 | 4 | | |
| 10,420 | Utica | 21 | 8 | ND | 1 | 45 | 17 | 8 | 1 | ND | 30 | 62 | 8 | 100 | 0.53 | 1.2 | 5 | | |
| 10,430 | Utica | 28 | 8 | ND | 2 | 32 | 19 | 10 | 1 | ND | 38 | 51 | 11 | 100 | 0.47 | 1.1 | 3 | | |
| 10,440 | Utica | 22 | 9 | ND | ND | 42 | 18 | 10 | ND | ND | 31 | 59 | 10 | 100 | 0.61 | 1.0 | 5 | | |
| 10,450 | Utica | 20 | 12 | ND | 1 | 36 | 18 | 10 | 2 | ND | 34 | 54 | 13 | 100 | 0.67 | 1.1 | 10 | | |
| 10,460 | Utica | 21 | 8 | ND | 1 | 45 | 16 | 9 | ND | ND | 29 | 61 | 9 | 100 | 0.62 | 1.2 | 13 | | |
| 10,470 | Utica | 18 | 8 | ND | 1 | 47 | 17 | 8 | ND | ND | 27 | 65 | 8 | 100 | 0.50 | 0.9 | 7 | | |
| 10,480 | Utica | 18 | 12 | ND | 1 | 42 | 16 | 10 | 2 | ND | 31 | 58 | 12 | 100 | 0.55 | 0.8 | 1 | | |
| 10,490 | Utica | 19 | 11 | ND | 1 | 48 | 12 | 8 | 1 | ND | 30 | 61 | 9 | 100 | 0.55 | | | | |
| 10,500 | Utica | 17 | 13 | ND | 1 | 40 | 17 | 8 | 4 | ND | 32 | 57 | 12 | 100 | 0.55 | 1.0 | 3 | | |
| 10,510 | Utica | 17 | 7 | ND | 1 | 47 | 16 | 11 | 3 | ND | 24 | 62 | 14 | 100 | 0.85 | 0.9 | 3 | | |
| 10,520 | Utica | 17 | 9 | ND | 1 | 48 | 14 | 9 | 1 | ND | 28 | 62 | 11 | 100 | 0.64 | 1.0 | 11 | | |
| 10,530 | Utica | 19 | 6 | ND | 1 | 47 | 15 | 11 | 1 | ND | 25 | 62 | 12 | 100 | 0.94 | 1.1 | 1 | | |
| 10,540 | Utica | 16 | 11 | ND | 1 | 49 | 10 | 12 | 1 | ND | 29 | 59 | 12 | 100 | 1.49 | 1.0 | 24 | | |
| 10,550 | Utica | 17 | 8 | ND | 1 | 46 | 14 | 12 | 1 | ND | 27 | 60 | 13 | 100 | 1.65 | 1.0 | 25 | | |
| 10,560 | Utica | 19 | 8 | ND | 2 | 47 | 13 | 11 | 1 | ND | 28 | 60 | 12 | 100 | 1.98 | 1.0 | 14 | | |
| 10,570 | Utica | 20 | 6 | ND | 2 | 45 | 12 | 13 | 1 | ND | 28 | 58 | 14 | 100 | 1.96 | 1.1 | 11 | | |
| 10,580 | Utica | 20 | 6 | ND | 2 | 46 | 14 | 14 | ND | ND | 27 | 60 | 14 | 100 | 2.18 | 1.1 | 16 | | |
| 10,590 | Utica | 20 | 7 | ND | 2 | 41 | 12 | 15 | 3 | ND | 29 | 54 | 18 | 100 | 1.32 | 1.1 | 21 | | |
| 10,600 | Utica | 19 | 8 | ND | 1 | 47 | 14 | 11 | 1 | ND | 27 | 61 | 12 | 100 | 1.32 | 1.0 | 10 | | |
| 10,610 | Utica | 18 | 7 | ND | 1 | 47 | 12 | 13 | 1 | ND | 26 | 60 | 14 | 100 | 1.57 | 1.0 | 3 | 1.78 | 45 |
| 10,620 | Utica | 18 | 10 | ND | 2 | 40 | 14 | 16 | 1 | ND | 30 | 53 | 17 | 100 | 1.43 | 1.2 | 1 | | |
| 10,630 | Utica | 18 | 6 | ND | 1 | 42 | 15 | 17 | 1 | ND | 25 | 57 | 18 | 100 | 1.61 | 1.1 | 6 | | |
| 10,640 | Utica | 20 | 9 | ND | 2 | 41 | 12 | 15 | 1 | ND | 31 | 53 | 16 | 100 | 0.99 | 1.1 | 6 | | |
| 10,650 | Utica | 18 | 11 | ND | 1 | 42 | 15 | 13 | 1 | ND | 30 | 57 | 13 | 100 | 1.25 | 1.3 | 4 | | |
| 10,660 | Utica | 18 | 10 | ND | 1 | 42 | 17 | 11 | 3 | ND | 28 | 58 | 13 | 100 | 1.21 | 1.2 | 3 | | |
| 10,670 | Utica | 18 | 8 | ND | 1 | 48 | 14 | 10 | 1 | ND | 27 | 63 | 10 | 100 | 1.18 | | | | |
| 10,680 | Utica | 16 | 7 | ND | 1 | 52 | 13 | 11 | 1 | ND | 24 | 64 | 12 | 100 | 1.11 | 0.9 | 5 | | |
| 10,690 | Utica | 17 | 8 | ND | 1 | 48 | 14 | 12 | 1 | ND | 25 | 62 | 13 | 100 | 1.77 | 1.1 | 26 | | |
| 10,700 | Utica | 16 | 11 | ND | 1 | 44 | 9 | 15 | 5 | ND | 28 | 53 | 20 | 100 | 2.31 | 1.1 | 8 | | |
| 10,710 | Utica | 15 | 7 | ND | 1 | 36 | 11 | 23 | 6 | ND | 24 | 47 | 29 | 100 | 2.20 | 1.0 | 12 | | |
| 10,720 | Utica | 15 | 5 | ND | 1 | 31 | 9 | 34 | 5 | ND | 21 | 40 | 39 | 100 | 2.93 | 1.1 | 14 | | |
| 10,730 | Utica | 15 | 4 | ND | 1 | 26 | 8 | 42 | 4 | ND | 20 | 34 | 46 | 100 | 3.71 | 1.0 | 30 | 1.81 | 42 |
| 10,740 | Utica | 15 | 7 | ND | 1 | 32 | ND | 43 | 3 | ND | 23 | 32 | 46 | 100 | 3.46 | 1.0 | 13 | 1.76 | 37 |
| 10,750 | Utica | 14 | 5 | ND | 1 | 28 | ND | 48 | 4 | ND | 21 | 28 | 51 | 100 | 4.11 | 1.0 | 20 | | |
| 10,760 | Point Pleasant | 24 | 6 | ND | 1 | 11 | 3 | 51 | 4 | 1 | 30 | 14 | 56 | 100 | 3.95 | 1.1 | 24 | | |
| 10,770 | Point Pleasant | 28 | 5 | ND | 1 | 12 | ND | 52 | 3 | ND | 33 | 12 | 55 | 100 | 4.19 | 0.9 | 38 | | |
| 10,780 | Point Pleasant | 22 | 4 | ND | 1 | 8 | 2 | 54 | 8 | ND | 28 | 10 | 62 | 100 | 3.67 | 1.0 | 39 | | |
| 10,790 | Point Pleasant | 15 | 4 | ND | 1 | 5 | ND | 67 | 4 | 4 | 20 | 5 | 75 | 100 | 3.34 | 1.0 | 35 | | |
| 10,800 | Point Pleasant | 13 | 4 | ND | 1 | 8 | ND | 70 | 4 | ND | 18 | 8 | 74 | 100 | 2.70 | 1.0 | 8 | | |
| 10,810 | Point Pleasant | 12 | ND | ND | 1 | 9 | ND | 74 | 4 | ND | 13 | 9 | 78 | 100 | 3.04 | 1.1 | 12 | 1.81 | 32 |

| Depth (ft) | Formation | Quartz+ | | | | Clay | | Carbonate+ | | | Percent of Total Mineralogy | | | TOTAL PERCENTAGE | TOC (%) | PAGS Bitumen Reflectance | | KGS Bitumen Reflectance | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Quartz | Plagioclase | K feldspar | Pyrite | Muscovite | Chlorite Gp. | Calcite | Dolomite | Gypsum | Total Quartz+ | Total Clay | Total Carbonate+ | | | Mean Random BRo (%) | No. of Observations (N) | Mean Random BRo (%) | No. of Observations (N) |
| 10,820 | Point Pleasant | 14 | 1 | ND | ND | 7 | ND | 74 | 4 | ND | 16 | 7 | 78 | 100 | 2.88 | 1.0 | 5 | | |
| 10,830 | Point Pleasant | 12 | ND | ND | ND | 6 | ND | 80 | 3 | ND | 12 | 6 | 82 | 100 | 3.52 | 1.0 | 23 | 1.80 | 35 |
| 10,840 | Point Pleasant | 10 | 7 | ND | 1 | 6 | ND | 74 | 2 | ND | 18 | 6 | 77 | 100 | 3.39 | 1.0 | 8 | 1.79 | 45 |
| 10,850 | Point Pleasant | 11 | 4 | ND | 1 | 9 | ND | 72 | 3 | ND | 16 | 9 | 75 | 100 | 1.51 | 1.0 | 13 | | |
| 10,860 | Lexington/Trenton | 5 | ND | ND | ND | 5 | ND | 71 | 3 | 17 | 5 | 5 | 90 | 100 | 0.94 | 0.9 | 4 | | |
| 10,870 | Lexington/Trenton | 14 | ND | ND | 1 | 13 | 2 | 68 | 3 | ND | 14 | 15 | 71 | 100 | 0.65 | | | | |
| 10,880 | Lexington/Trenton | 8 | ND | ND | ND | 9 | ND | 81 | 3 | ND | 8 | 9 | 84 | 100 | 0.64 | | | | |
| 10,890 | Lexington/Trenton | 11 | ND | ND | 1 | 2 | 2 | 81 | 3 | ND | 11 | 5 | 84 | 100 | 0.45 | | | | |
| 10,900 | Lexington/Trenton | 16 | 8 | ND | ND | ND | ND | 71 | 4 | ND | 24 | 0 | 75 | 99 | 1.02 | 0.9 | 16 | | |
| 10,910 | Lexington/Trenton | 17 | ND | ND | ND | 5 | ND | 69 | 3 | 6 | 17 | 5 | 77 | 99 | 0.40 | | | | |
| 10,920 | Lexington/Trenton | 20 | 1 | ND | 3 | 6 | ND | 69 | 2 | ND | 23 | 6 | 71 | 100 | 1.61 | 1.0 | 32 | | |
| 10,930 | Lexington/Trenton | 26 | 1 | ND | 1 | 4 | ND | 63 | 5 | ND | 28 | 4 | 68 | 100 | 0.58 | | | | |
| 10,940 | Lexington/Trenton | 23 | 5 | ND | ND | 4 | ND | 62 | 5 | ND | 28 | 4 | 67 | 100 | 0.81 | | | | |
| 10,950 | Lexington/Trenton | 15 | 4 | ND | ND | 8 | ND | 71 | 2 | ND | 19 | 8 | 73 | 100 | 0.65 | 1.0 | 6 | | |
| 10,960 | Lexington/Trenton | 15 | 6 | ND | ND | 8 | 1 | 66 | 3 | 1 | 21 | 9 | 70 | 100 | 0.95 | 0.9 | 25 | | |
| 10,970 | Lexington/Trenton | 17 | 6 | ND | ND | 2 | ND | 70 | 5 | ND | 22 | 2 | 75 | 100 | 0.79 | 1.0 | 27 | | |
| 10,980 | Lexington/Trenton | 17 | 3 | ND | ND | 5 | ND | 74 | 3 | ND | 19 | 5 | 76 | 100 | 0.85 | 1.1 | 29 | | |
| 10,990 | Lexington/Trenton | 15 | 9 | ND | ND | 2 | ND | 71 | 2 | 2 | 24 | 2 | 74 | 100 | 0.88 | 1.0 | 27 | | |
| 11,000 | Lexington/Trenton | 9 | 3 | ND | ND | 7 | ND | 80 | 2 | ND | 12 | 7 | 82 | 100 | 1.20 | 1.1 | 41 | | |
| 11,010 | Lexington/Trenton | 11 | ND | ND | ND | 2 | ND | 84 | 3 | ND | 11 | 2 | 87 | 100 | | | | | |

ND - Not Detected

Blank indicates not analyzed

## 3.2 Total Organic Carbon

Table 3 presents a statistical summary of TOC results specific to the Utica Shale and Point Pleasant Formation in the Starvaggi No. 1 well. In this portion of the Appalachian basin, the Point Pleasant is considered part of the "Utica play" and often has higher %TOC values than the Utica itself.

***Table 3. Starvaggi No. 1 TOC results by formation.***

| | **Total Organic Content (%)** | | | |
|---|---|---|---|---|
| **Formation** | **Minimum** | **Maximum** | **Average** | **No. Samples** |
| Utica Shale | 0.47 | 4.11 | 1.36 | 39 |
| Point Pleasant Formation | 1.51 | 4.19 | 3.22 | 10 |

To display the geographic distribution and variability of TOC throughout the Appalachian basin for the Utica Shale Play Book Study, the Consortium overlaid isopach grids for each geologic interval (darker = thicker) with color-coded circles representing the highest %TOC encountered in each well for that interval. Wells with maximum %TOC values for each stratigraphic unit less than 1% are displayed in white, 1-2% (source rock threshold) are in yellow, 2-4% are light orange and values greater than 4% are in dark orange. To account for vertical variations in organic carbon, wells with more than 25 ft of greater than 1% TOC values were displayed using a smaller red circle outlined in white. Using this approach, the Starvaggi No. 1 plots as a red circle outlined in white for both the Utica and Point Pleasant TOC maps, and is well within the organic region identified by the Consortium (Figures 6 and 7, respectively).

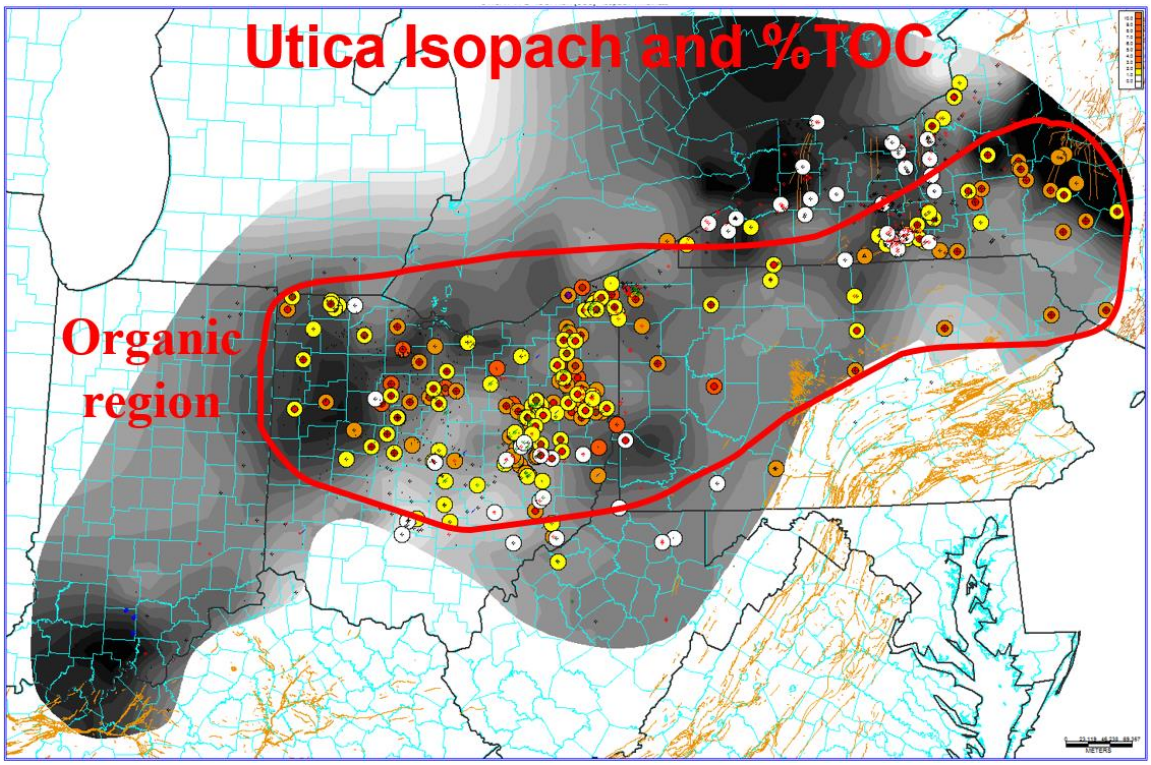



**Figure 6. Map of maximum TOC (%) measured in the Utica Shale (Patchen and Carter, 2015).**

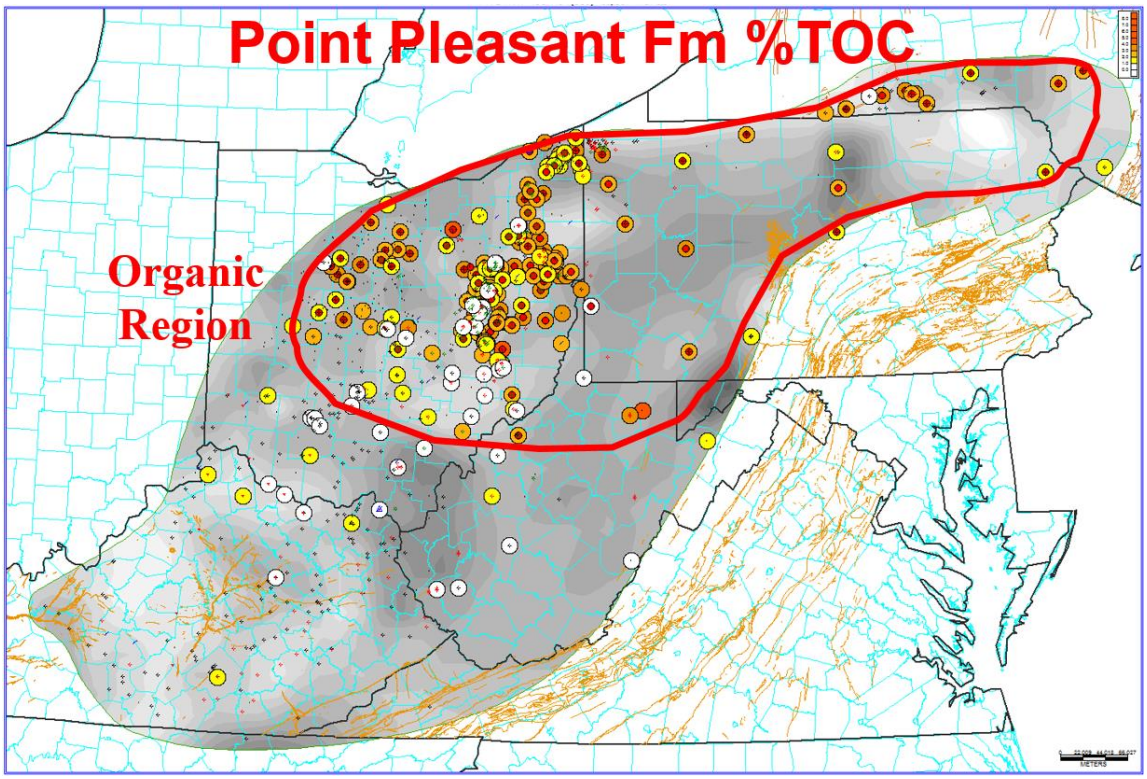



**Figure 7. Map of maximum TOC (%) measured in the Point Pleasant Formation (Patchen and Carter, 2015).**

## 3.3 Bitumen Reflectance

The organic petrography and thermal maturity of the Utica Shale and Point Pleasant intervals in the Starvaggi No. 1 were assessed by workers in both Pennsylvania and Kentucky. As shown in Table 1, PAGS measured the bitumen reflectance of rock cuttings samples from various depths (10,030 to 11,000 ft) and multiple formations: the Kope, Utica, Point Pleasant and Lexington/Trenton. KGS performed a more focused analysis, evaluating six samples from the Utica and Point Pleasant formations at depths of 10,610 to 10,840 ft.

***Pennsylvania***

Pennsylvania's bitumen reflectance (BRo%) measurements ranged from 0.6 to 1.4% over a 970-ft sampling interval (Table 2). The funnel-like shape plotted by these data (Figure 7) show that the Kope Formation had the largest range in BRo data, followed by the Utica and then the Point Pleasant and Lexington/Trenton intervals.

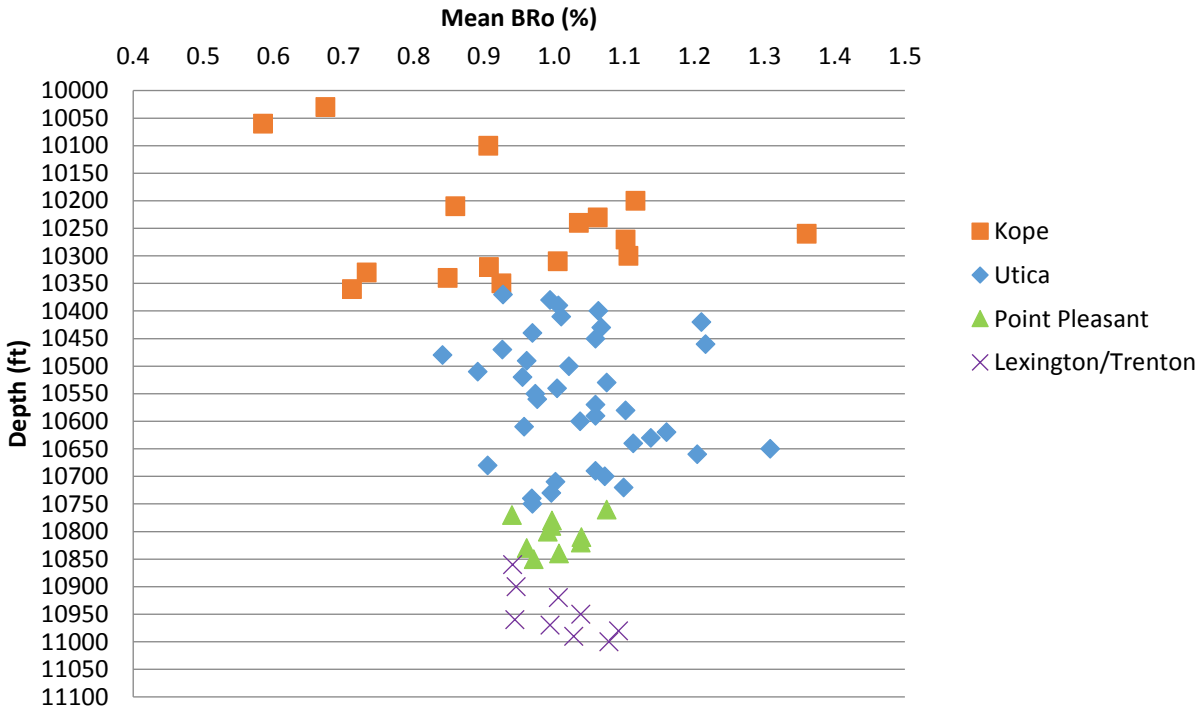



**Figure 7. Crossplot of mean bitumen reflectance measurements (BRo%) versus measured depth (ft) in the Starvaggi No. 1 well.**

A statistical summary of PAGS bitumen reflectance data by geologic interval is given in Table 4. The average BRo value in the Starvaggi No. 1 hovers around 1.0%, regardless of formation or number of

bitumen macerals (samples) observed. The number of maceral observations varied widely (depending on sample depth) and ranged from 1 to 41 observations per sample. Workers noted that the lower portion of the Utica Shale and upper portion of the Point Pleasant Formation in this well had a relatively large number of measurable macerals (i.e., 30-39), and that elevated TOC values (i.e., 3.34-4.19) were reported for these same sample depths (Table 2).

***Table 4. PAGS Starvaggi No. 1 bitumen reflectance measurements by formation.***

| Formation | Bitumen Reflectance (BRo%) | | | | |
|---|---|---|---|---|---|
| | Minimum | Maximum | Average | No. Observations Per Sample | No. Samples |
| Kope Formation | 0.6 | 1.4 | 0.9 | 1-20 | 16 |
| Utica Shale | 0.8 | 1.3 | 1.1 | 1-30 | 38 |
| Point Pleasant Formation | 0.9 | 1.1 | 1.0 | 5-39 | 10 |
| Lexington/Trenton Formation | 0.9 | 1.1 | 1.0 | 4-41 | 9 |

***Kentucky***

Kentucky's bitumen reflectance (BRo%) measurements ranged from 1.76 to 1.81% and averaged 1.79% over a 230-ft sampling interval specific to the Utica and Point Pleasant formations (Table 2). A statistical summary of KGS bitumen reflectance data for these intervals is provided in Table 5. The Utica Shale reported an average BRo of 1.78%, and the underlying Point Pleasant Formation reported an average BRo of 1.80%. The number of maceral observations made by Kentucky on a per-sample basis was notably larger than the Pennsylvania dataset, ranging from 32 to 45 observations per sample (Table 5).

***Table 5. KGS Starvaggi No. 1 bitumen reflectance measurements by formation.***

| Formation | Bitumen Reflectance (BRo%) | | | | |
|---|---|---|---|---|---|
| | Minimum | Maximum | Average | No. Observations Per Sample | No. Samples |
| Utica Shale | 1.76 | 1.81 | 1.78 | 37-45 | 3 |
| Point Pleasant Formation | 1.79 | 1.81 | 1.80 | 32-45 | 3 |

KGS also analyzed a sample of the geologically younger Marcellus Formation (6450 ft depth) from Washington County for comparison purposes. This sample reported a random vitrinite reflectance (Ro) value of 1.39%. In addition, the Pittsburgh coal bed, which occurs within about 500 ft of ground surface across Washington County, has a random Ro of 0.8 to 0.85% (Ruppert and others, 2010). Collectively,

these data indicate a random reflectance increase of about 1.0% over a depth range of roughly 10,000 ft in southwestern Pennsylvania (Figure 8).

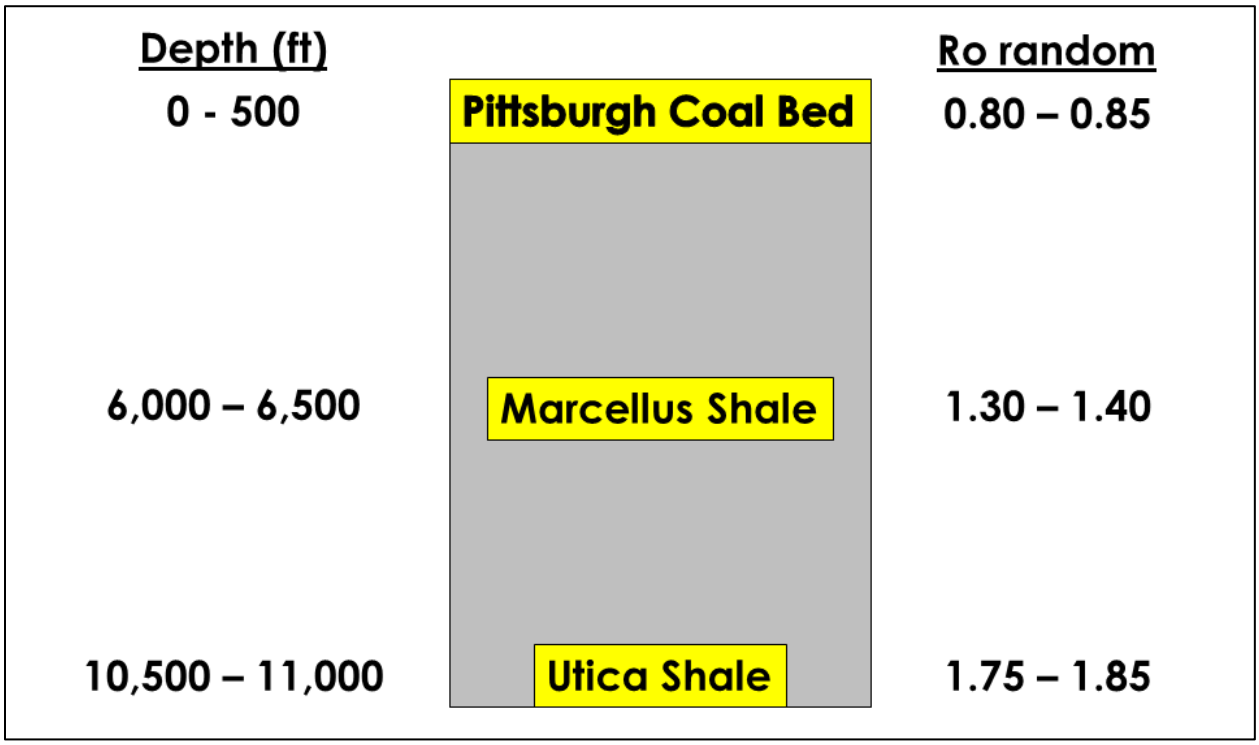



**Figure 8. Reflectance measurements for discrete depth intervals in Washington County, Pennsylvania (Patchen and Carter, 2015).**

These data support existing evidence of increasing thermal maturity of organic-rick source rocks with depth in this area of the Appalachian basin, as well as the production of dry gas from the Utica/Point Pleasant interval in southwestern Pennsylvania.

## 4.0 References Cited

Cooney, M.L., 2016, Antero Hill Unit 2H and Antero Hill Unit 3H wells, Washington County, Pennsylvania, 15 p.

Opsitnick, Alexandra, 2015, Reservoir Quality of the Marcellus Shale Play in the Hill Unit 2H and 3H Wells: Determining Mineralogical and Lithological Properties, Allegheny College Undergraduate Thesis, 99 p.

Patchen, D.G. and Carter, K.M., eds., 2015, A geologic play book for Utica Shale Appalachian basin exploration, Final report of the Utica Shale Appalachian basin exploration consortium, 187 p. Available from: http://www.wvgs.wvnet.edu/utica.

Ruppert, L.F., Hower, J.C., Ryder, R.T., Levine, J.R., Trippi, M.H., and W.C. Grady, 2010, Geologic controls on thermal maturity patterns in Pennsylvanian coal-bearing rocks in the Appalachian basin: International Journal of Coal Geology, v. 81, pp. 69-181.

# APPENDIX A. Starvaggi No. 1 Completion Report

5500-FM-OG0004 Rev. 1/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

# WELL RECORD AND COMPLETION REPORT

| DEP USE ONLY | |
|---|---|
| Site Id | Primary Facility Id |
| Client Id | Sub-facility Id |

| Well Operator | DEP ID# | Well API # (Permit / Reg) | Project Number | Acres |
|---|---|---|---|---|
| Fortuna Energy Inc. | | 37-125-222-78-00 | | |

| Address | Well Farm Name | Well # | Serial # |
|---|---|---|---|
| 203 Colonial Drive STE 101 | Starvaggi #1 | 1 | |

| City | State | Zip Code | County | Municipality |
|---|---|---|---|---|
| HorseHeads | NY | 14845 | Hanover WASH | Washington HANOVER |

| Phone | Fax | USGS 7.5 min. quadrangle map |
|---|---|---|
| 607-795-2700 | | Burgettstown |

**Check all that apply:** ☒ Original Well Record ☒ Original Completion Report ☐ Amended Well Record ☐ Amended Completion Report

## WELL RECORD

Also complete Log of Formations on back (page 2)

**Well Type** ☒ Gas ☐ Oil ☐ Combination Oil & Gas ☐ Injection ☐ Storage ☐ Disposal

**Drilling Method** ☐ Rotary – Air ☒ Rotary – Mud ☐ Cable Tool

| Date Drilling Started | Date Drilling Completed | Surface Elevation | Total Depth – Driller | Total Depth - Logger |
|---|---|---|---|---|
| 7-24-2006 | 9-11-2006 | 1150 ft. | 12191 ft. | 12191 ft. |

### Casing and Tubing

Cement returned on surface casing? ☒ Yes ☐ No
Cement returned on coal protective casing? ☐ Yes ☐ No ☒ N/A

| Hole Size | Pipe Size | Wt. | Thread / Weld | Amount in Well (ft) | Material Behind Pipe Type and Amount | Packer / Hardware / Centralizers Type | Size | Depth | Date Run |
|---|---|---|---|---|---|---|---|---|---|
| 22 | 20 | 94 | H-40 | 35 | | Packer | 7 inch | 11341 | |
| 17 1/2 | 13 3/8 | 54.5 | J-55 | 830.0 | Class A/850 Sacks | Bridge Plug | 7 Inch | 11870 | |
| 12 1/4 | 9 5/8 | 40 | P-110 | 7259.0 | Class A/550 Sacks | | | | |
| 8 1/2 | 7 | 29 | L-80 | 12191.0 | Class A/902 Sacks | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

## COMPLETION REPORT

### Perforation Record

| Date | Interval Perforated From | To |
|---|---|---|
| 12/11/2006 | 11940 | 11950 |
| 12/17/2006 | 11396 | 11522.0 |
| 12/17/2006 | 11396 | 11522.0 |
| | | |
| | | |
| | | |

### Stimulation Record

| Date | Interval Treated | Fluid Type | Fluid Amount | Propping Agent Type | Propping Agent Amount | Average Injection |
|---|---|---|---|---|---|---|
| 12/12/2006 | Beekmantown | Acid | 23 bbl | | | |
| 02-09-2007 | Black River | Acid | 24.1 bbl | | | |
| 02-09-2007 | Black River | Acid | 88 bbl | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

MAY 17 2007
DEP, SOUTHWEST REGION
OIL & GAS

| Natural Open Flow | Natural Rock Pressure | Hours | Days |
|---|---|---|---|
| After Treatment Open Flow | After Treatment Rock Pressure | Hours | Days |

**Well Service Companies** -- Provide the name, address, and phone number of all well service companies involved.

| Name | Name | Name |
|---|---|---|
| Stonewell Services | Halliburton Energy Services | EASTERN RESERVOIR SERVICES |
| Address | Address 101 LUCERNE RO AD | Address |
| City - State – Zip | City - State – Zip HOMER CITY PA | City - State – Zip UNIION CITY PA |
| Phone 989 -233-1238 | Phone 724-479-4031 | Phone 814 -438-2006 |

5500-FM-OG0004 Rev. 1/2007

# LOG OF FORMATIONS

Well API#: **37-125-2227800**

| Formation Name or Type | Top (feet) | Bottom (feet) | Gas at (feet) | Oil at (feet) | Water at (fresh / brine; ft.) | Source of Data |
|---|---|---|---|---|---|---|
| See attached sheet | | | | | | |

MAY 17 2007

DEP, SOUTHWEST REGION
OIL & GAS

*Please delete empty rows if necessary to make all of page 2 fit on one page.*

**Well Operator's Signature:**

RUSS ERLANDSON, FIELD FOREMAN APPALACHIA

Title:

Date: 4/23/07

**DEP USE ONLY**

Reviewed by:

Date:

Comments:

# Wellcore Daily Geology Operations Report

**Country:** USA **Well:** Fortuna Starvaggi#1 **Main Hole:** **Date:** 9/8/2006
**Area:** Appalachia **Surface:** **AFE #:** 56010 **Report #:** 50
**Objective:** Trenton, Black River Gas **AFE $:** $0 **Day Cost:** $0
**Spud Date:** **DFS:** 0 **Cost To Date:** $0

**MD:** 0.00 **TVD:** 0.00 **PD MD:** 0.00 **24 Hr. Progress:** 0
**Current FM:** **ROP:** 0.00 **Sliding:** 0.00 **Rotating:** 0

**AM Operations:** Running into hole with pipe to do clean out trip.

**24 Hr Summary:** Run in hole with sidewall coring tool. Cut 40 sidewall cores and recovered 38 cores. Pick up and run in hole with FMI tool. Complete logging program. Run in hole with drill pipe to do clean out trip.

**24 Hr Forecast:** Clean out trip and prepare to run liner.

**Contractor:** UNION DRILLING **Rig:** #48 **Mud:** Haliburton **Directional Co.:** Weatherford **MWD:** Weatherford

## Mechanical Hole Conditions

**Comments:**

| | Today Min. | Today Max. | Yesterday Min. | Yesterday Max. Comment | | Today Min. | Today Max. | Yesterday Min. | Yesterday Max. Comment |
|---|---|---|---|---|---|---|---|---|---|
| **Drag Rot Up:** | 0.0 | 0.0 | 0.0 | 0.0 | **Drag Rot Down:** | 0.0 | 0.0 | 0.0 | 0.0 |
| **Drag Slide Up:** | 0.0 | 0.0 | 0.0 | 0.0 | **Drag Slide Down:** | 0.0 | 0.0 | 0.0 | 0.0 |
| **Max. Allow Ten:** | 0.0 | 0.0 | 0.0 | 0.0 | **Torque:** | 0.0 | 0.0 | 0.0 | 0.0 |
| **String Weight:** | 0.0 | 0.0 | 0.0 | 0.0 | **Max. Allow Torque(90%):** | 0.0 | 0.0 | 0.0 | 0.0 |

## Bit Run Data

| | | | | | | Daily | | | | | Drilled | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bit #** | **Size** | **MFG** | **Model** | **Depth In** | **Progress** | **Hours** | **ROP** | **RPM** | **WOB** | **Depth Out** | **Depths** | **Hours** | **ROP** | **Condition** |
| 5 | 9 | SECURITY | XS42S | 7270.0 | 0.0 | 0.00 | 0.0 | 0 | 0 | 7700.0 | 430 | 15.00 | 28.7 | ------ |
| 6 | 9 | SECURITY | FM3745 | 7700.0 | 0.0 | 0.00 | 0.0 | 0 | 0 | 8240.0 | 402 | 56.50 | 7.1 | ------ |
| 7 | 9 | SECURITY | EBXS30S | 8350.0 | 0.0 | 0.00 | 0.0 | 0 | 0 | 8470.0 | 350 | 55.50 | 6.3 | ------ |
| 8 | 9 | HUGHES | HC506ZX | 9087.0 | 0.0 | 0.00 | 0.0 | 0 | 0 | 9642.0 | 1172 | 60.25 | 19.5 | ------ |
| 9 | 9 | REED | DSX111H9W | 10470.0 | 0.0 | 0.00 | 0.0 | 0 | 0 | 10690.0 | 1048 | 83.25 | 12.6 | ------ |
| 10 | 9 | HUGHES | HG506ZX | 10690.0 | 0.0 | 0.00 | 0.0 | 0 | 0 | 12191.0 | 1501 | 76.00 | 19.8 | ------ |

## Hole & Casing

| Section | Hole Depth | Hole Size | Casing Size | Casing Set At |
|---|---|---|---|---|
| surface | 152.0 | 20.00 | 19.000 | 52.00 |
| Surface#2 | 830.0 | 17.50 | 13.600 | 815.00 |
| Intermediate#1 | 7270.0 | 12.25 | 9.600 | 0.00 |
| Intermediate #1 | 7270.0 | 12.25 | 9.675 | 7258.40 |

## Mud

**Type:**
**Density:** 0
**Viscosity:** 0
**WL:** 0.00
**pH:** 0.00
**Chlorides:** 0.00
**Additives:**
**Comments:**



## Formation Tops

**Prog. KB:** 1168.00 **Actual. KB:** 1166.00 **GL:** 1150.00

| | ===== | Prog | ===== | ===== | Sample | ===== | | ===== | Log | ===== | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Formation** | **MD** | **TVD** | **SS** | **MD** | **TVD** | **SS** | **SS +/-** | **MD** | **TVD** | **SS** | **SS -/+** |
| Devonian Shale | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Tully | 5462.00 | 0.00 | -4296.00 | 5490.00 | 0.00 | -4324.00 | 0.00 | 5495.00 | 0.00 | -4329.00 | 0.00 |
| Moscow | 5534.00 | 0.00 | -4368.00 | 5570.00 | 0.00 | -4404.00 | 0.00 | 5567.00 | 0.00 | -4401.00 | 0.00 |
| Marcellus | 5618.00 | 0.00 | -4452.00 | 5640.00 | 0.00 | -4474.00 | 0.00 | 5654.00 | 0.00 | -4488.00 | 0.00 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Onondaga | 5684.00 | 0.00 | -4518.00 | 5720.00 | 0.00 | -4554.00 | 0.00 | 5718.00 | 0.00 | -4552.00 | 0.00 |
| Oriskany | 5876.00 | 0.00 | -4710.00 | 5920.00 | 0.00 | -4754.00 | 0.00 | 5918.00 | 0.00 | -4752.00 | 0.00 |
| Helderberg | 5935.00 | 0.00 | -4769.00 | 5980.00 | 0.00 | -4814.00 | 0.00 | 5985.00 | 0.00 | -4819.00 | 0.00 |
| Akron | 6209.00 | 0.00 | -5043.00 | 6270.00 | 0.00 | -5104.00 | 0.00 | 6259.00 | 0.00 | -5093.00 | 0.00 |
| Bertie | 6255.00 | 0.00 | -5089.00 | 6320.00 | 0.00 | -5154.00 | 0.00 | 6337.00 | 0.00 | -5171.00 | 0.00 |
| Salina-G unit | 6299.00 | 0.00 | -5133.00 | 6360.00 | 0.00 | -5194.00 | 0.00 | 6449.00 | 0.00 | -5283.00 | 0.00 |
| Camillus | 6406.00 | 0.00 | -5240.00 | 6465.00 | 0.00 | -5299.00 | 0.00 | 6485.00 | 0.00 | -5319.00 | 0.00 |
| Salina E | 6483.00 | 0.00 | -5317.00 | 6536.00 | 0.00 | -5370.00 | 0.00 | 6534.00 | 0.00 | -5368.00 | 0.00 |
| Salina Salt | 6997.00 | 0.00 | -5831.00 | 7027.00 | 0.00 | -5861.00 | 0.00 | 7024.00 | 0.00 | -5858.00 | 0.00 |
| Upper Vernon | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Lower Vernon | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Lockport | 7167.00 | 0.00 | -6001.00 | 7180.00 | 0.00 | -6014.00 | 0.00 | 7190.00 | 0.00 | -6024.00 | 0.00 |
| Rochester | 7795.00 | 0.00 | -6629.00 | 7812.00 | 7811.00 | -6645.00 | 0.00 | 7822.00 | 0.00 | -6656.00 | 0.00 |
| Dayton/Irondequoit | 8010.00 | 8007.00 | -6841.00 | 8028.00 | 8022.64 | -6856.64 | 0.00 | 8036.00 | 0.00 | -6870.00 | 0.00 |
| Sodus | 8026.00 | 8023.00 | -6857.00 | 8044.00 | 8038.11 | -6872.11 | 0.00 | 8052.00 | 0.00 | -6886.00 | 0.00 |
| Reynales | 8065.00 | 8060.00 | -6894.00 | 8084.00 | 8076.73 | -6910.73 | 0.00 | 8092.00 | 0.00 | -6926.00 | 0.00 |
| Grimsby | 8089.00 | 8083.00 | -6917.00 | 8108.00 | 8099.82 | -6933.82 | 0.00 | 8114.00 | 0.00 | -6948.00 | 0.00 |
| Whirlpool | 8211.00 | 8197.00 | -7031.00 | 8234.00 | 8218.63 | -7052.63 | 0.00 | 8230.00 | 0.00 | -7064.00 | 0.00 |
| Queenston | 8278.00 | 8258.00 | -7092.00 | 8296.00 | 8275.04 | -7109.04 | 0.00 | 8296.00 | 0.00 | -7130.00 | 0.00 |
| Lorraine | 9377.00 | 9210.00 | -8044.00 | 9400.00 | 9229.16 | -8063.16 | 0.00 | 9398.00 | 0.00 | -8232.00 | 0.00 |
| Utica | 10542.00 | 10219.00 | -9053.00 | 10545.00 | 10211.68 | -9045.68 | 0.00 | 10542.00 | 0.00 | -9376.00 | 0.00 |
| Trenton | 10719.00 | 10372.00 | -9206.00 | 10705.00 | 10350.18 | -9184.18 | 0.00 | 10704.00 | 0.00 | -9538.00 | 0.00 |
| Black River | 11093.00 | 10696.00 | -9530.00 | 11088.00 | 10684.40 | -9518.40 | 0.00 | 11042.00 | 0.00 | -9876.00 | 0.00 |
| Gull River | 11730.00 | 11249.00 | -10083.00 | 11740.00 | 11255.00 | -10089.00 | 0.00 | 11734.00 | 0.00 | -10568.00 | 0.00 |
| Chazey | 11810.00 | 11321.00 | -10155.00 | 11820.00 | 11325.75 | -10159.75 | 0.00 | 11816.00 | 0.00 | -10650.00 | 0.00 |
| Beekmantown | 11935.00 | 11427.57 | -10261.57 | 11930.00 | 11422.97 | -10256.97 | 0.00 | 11943.00 | 12191.00 | -11025.00 | 0.00 |

## Sample Description

| Formation | Top | Bottom | ROP Min. | ROP Max. | Gas | Lithology |
|---|---|---|---|---|---|---|

## Last Fracture/ Fault Indications

| Formation | Top | Bottom | Gas Min. | Gas Max. | Basis |
|---|---|---|---|---|---|



## Mud Logging Summary (Total Gas)

| | Depth | | | Gas Peak | | |
|---|---|---|---|---|---|---|
| Formation | Min. | Max. | Background | Min. | Max. | Comments |

## Remarks

Run in hole with sidewall coring tool. Cut 40 sidewall cores and recovered 38 cores. Pick up and run in hole with FMI tool. Complete logging program. Run in hole with drill pipe to do clean out trip.

## Contacts

**Geologist:** William Nelson & Sean Cadorette **Drilling Foreman:** TERRY CARPENTER
**Geologist Phone:** 607-857-5154 **Drilling Foreman Phone:** 607-742-7436

**Report By Wellcore HTML file created on: 9/7/2006 8:12:09 PM**

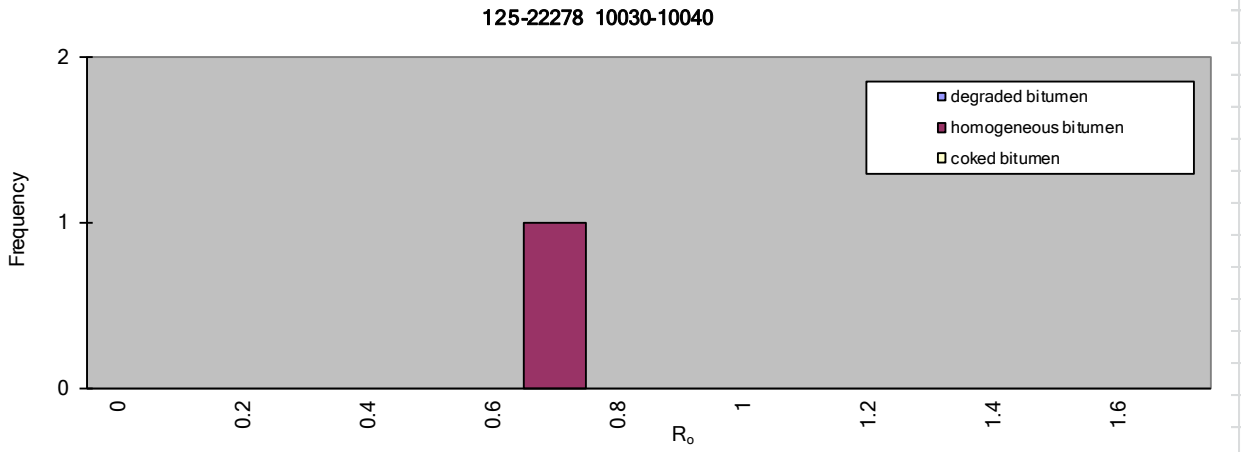
# APPENDIX B. Starvaggi No. 1 Bitumen Reflectance Reports Prepared by PAGS

## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/3/2013 |
| Project: | Utica Shale Consortium |
| Sample ID: | 125-22278_10030 |
| Lab ID: | |
| Sample Type: | shale |
| Date Analyzed: | 10/3/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 2 |
| maceral type: | bit |
| $R_o$: | 0.67 |
| s.d.: | 0.00 |
| Example Photograph: | |




## DATA

| |
|---|
| 0.674 |

| | | | | | |
|---|---|---|---|---|---|
| **All Data:** | **min:** | 0.674 | **max:** | 0.674 | |
| **Vitrinite Only:** | **min:** | 0.674 | **max:** | 0.674 | **V-types:** 1 |

## COMMENT

Standard: YAG [0.901]; Only one maceral.

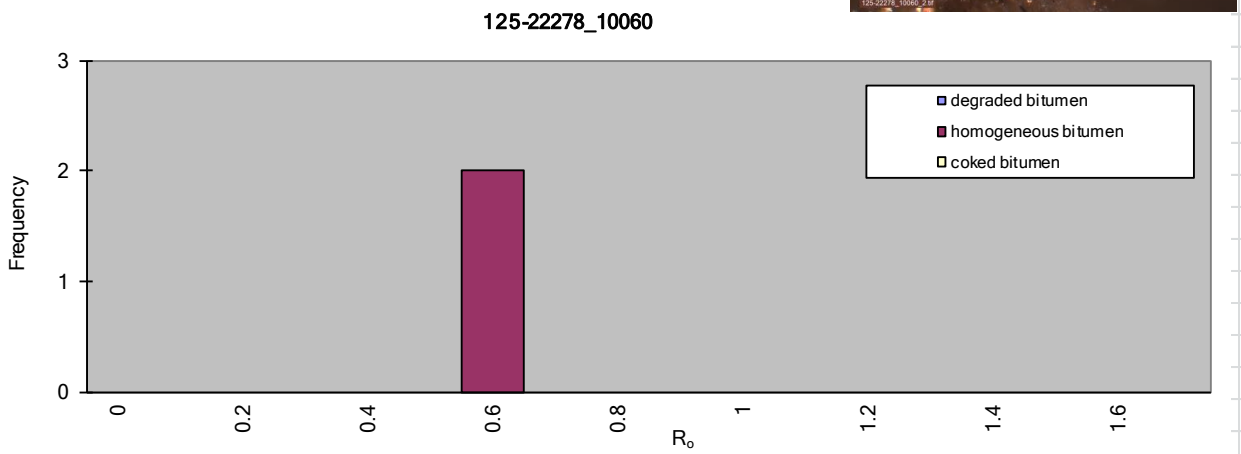
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/4/2013 |
| Project: | Utica Shale Consortium |
| Sample ID: | 125-22278_10060 |
| Lab ID: | |
| Sample Type: | shale |
| Date Analyzed: | 10/4/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 2 |
| maceral type: | Bit |
| $R_o$: | 0.59 |
| s.d.: | 0.01 |

Example Photograph:




## DATA

| |
|---|
| 0.571 |
| 0.599 |

**All Data:** min: 0.571 max: 0.599

**Vitrinite Only:** min: 0.571 max: 0.599 V-types: 1

## COMMENT

Standard: YAG [0.901]; Very lean; Some pyrite framboids

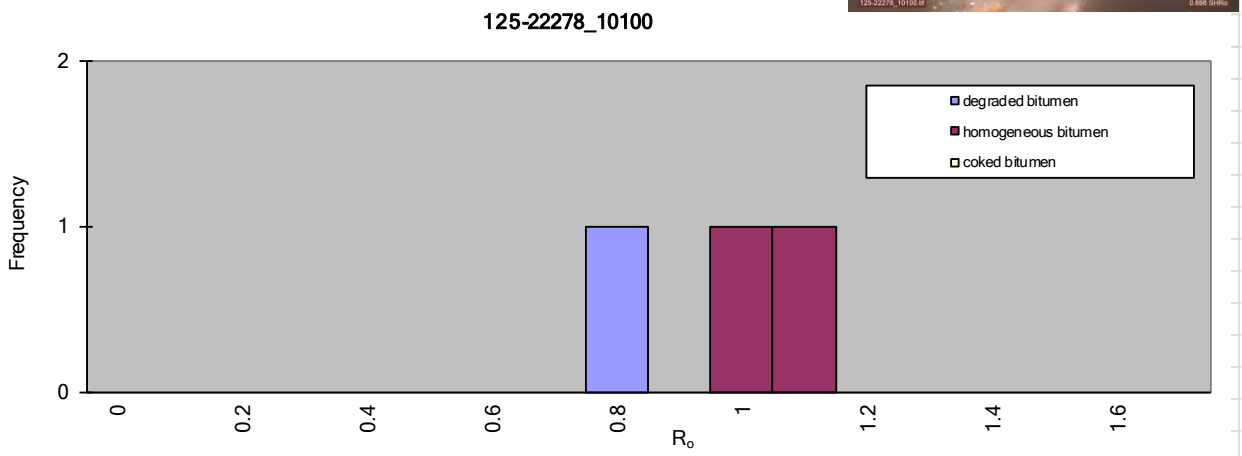
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/3/2013 |
| Project: | Utica Shale Consortium |
| Sample ID: | 125-22278_10100 |
| Lab ID: | 0 |
| Sample Type: | shale |
| Date Analyzed: | 10/3/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 3 |
| maceral type: | bitumen |
| $R_o$: | 0.91 |
| s.d.: | 0.14 |

Example Photograph:




## DATA

| |
|---|
| 0.711 |
| 0.971 |
| 1.037 |

**All Data:** min: 0.711 max: 1.037

**Vitrinite Only:** min: 0.711 max: 1.037 V-types: 4

## COMMENT

Standard: YAG [0.901]; Lean sample; large "unknowns" - very reflective and rust colored around edges; some small bitumen macerals

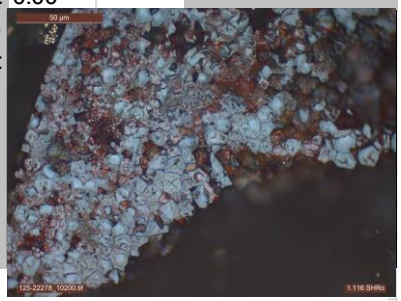
## SAMPLE INFORMATION

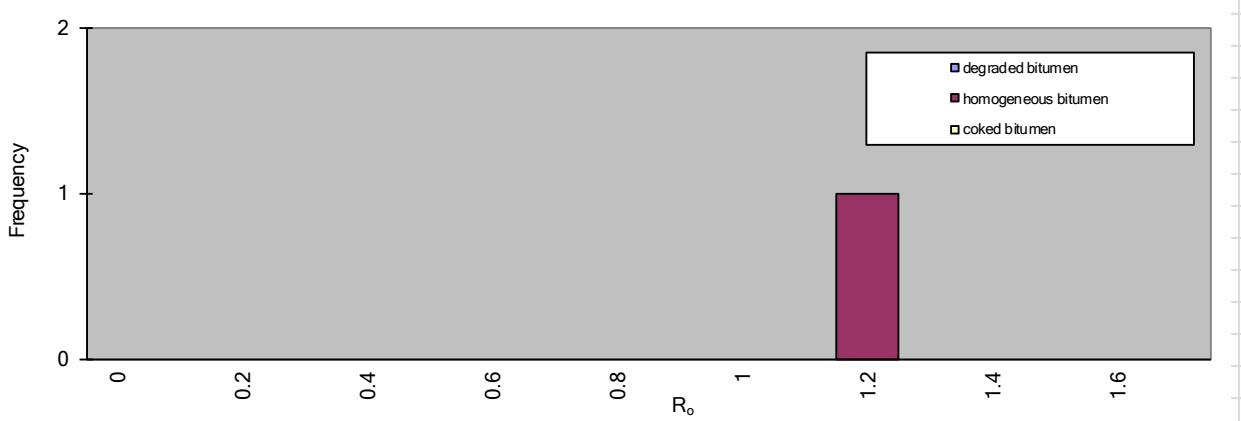
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/11/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10200 |
| Lab ID: | 0 |
| Sample Type: | shale |
| Date Analyzed: | 10/11/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 1 |
| maceral type: | bitumen |
| $R_o$: | 1.12 |
| s.d.: | 0.00 |

Example Photograph:






## DATA

| |
|---|
| 1.116 |

**All Data:** min: 1.116 max: 1.116

**Vitrinite Only:** min: 1.116 max: 1.116 V-types: 1

## COMMENT

Standard: YAG [0.901]; very lean sample.

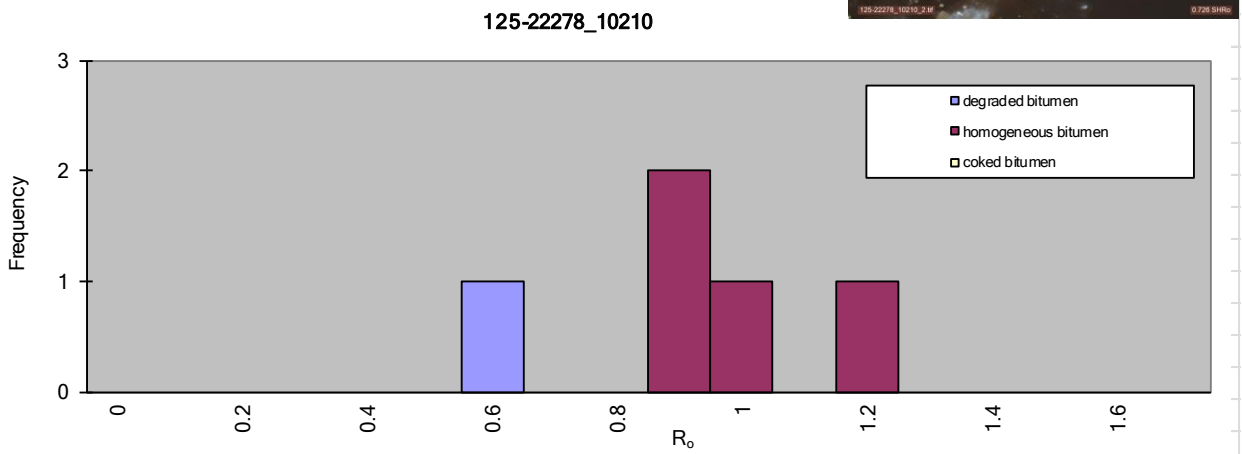
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/15/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10210 |
| Lab ID: | 0 |
| Sample Type: | shale |
| Date Analyzed: | 10/15/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 7 |
| maceral type: | bitumen |
| $R_o$: | 0.86 |
| s.d.: | 0.17 |

Example Photograph:




## DATA

| | |
|---|---|
| 0.560 | 0.814 |
| 0.726 | 0.883 |
| | 0.912 |
| | 0.980 |
| | 1.138 |

**All Data:** **min:** 0.560 **max:** 1.138

**Vitrinite Only:** **min:** 0.560 **max:** 1.138 **V-types:** 7

## COMMENT

Standard: YAG [0.901]; Noticed more bitumne but macerals are very small; looks like bitumen may have replaced some pyrite framboids - this has been observed in other samples as well, perhaps as some kind of secondary fluid movement of HC?

Starvaggi – API# 3712522278 – Washington County, PA

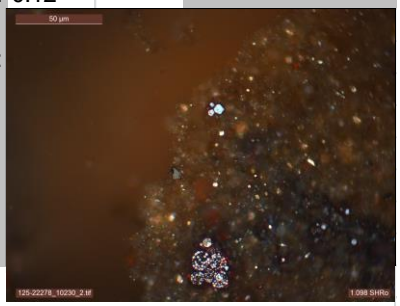
## SAMPLE INFORMATION

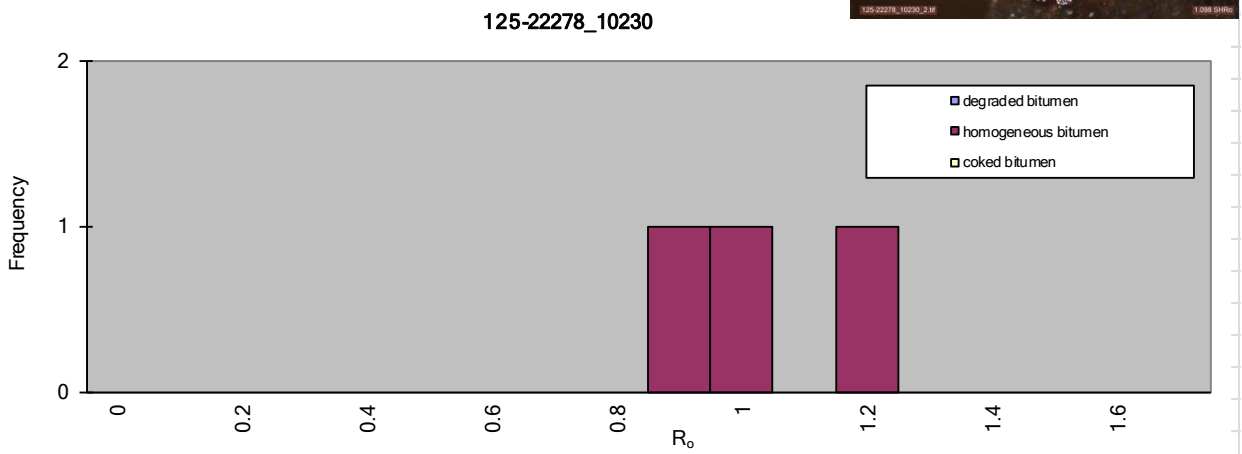
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/15/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10230 |
| Lab ID: | 0 |
| Sample Type: | shale |
| Date Analyzed: | 10/15/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 3 |
| maceral type: | bitumen |
| $R_o$: | 1.06 |
| s.d.: | 0.12 |

Example Photograph:






## DATA

| |
|---|
| 0.899 |
| 1.098 |
| 1.188 |

**All Data:** **min:** 0.899 **max:** 1.188

**Vitrinite Only:** **min:** 0.899 **max:** 1.188 **V-types:** 4

## COMMENT

Standard: YAG [0.901]; lean with some very small macerals

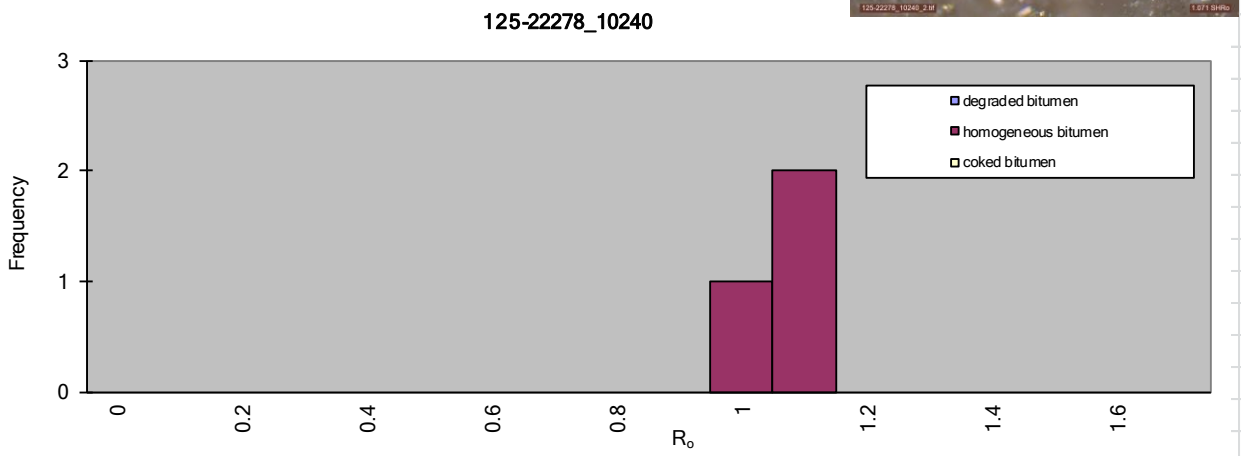
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/15/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10240 |
| Lab ID: | 0 |
| Sample Type: | shale |
| Date Analyzed: | 10/15/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 3 |
| maceral type: | bitumen |
| $R_o$: | 1.03 |
| s.d.: | 0.03 |

Example Photograph:




## DATA

| |
|---|
| 0.993 |
| 1.040 |
| 1.071 |

**All Data:** min: 0.993 max: 1.071

**Vitrinite Only:** min: 0.993 max: 1.071 V-types: 2

## COMMENT

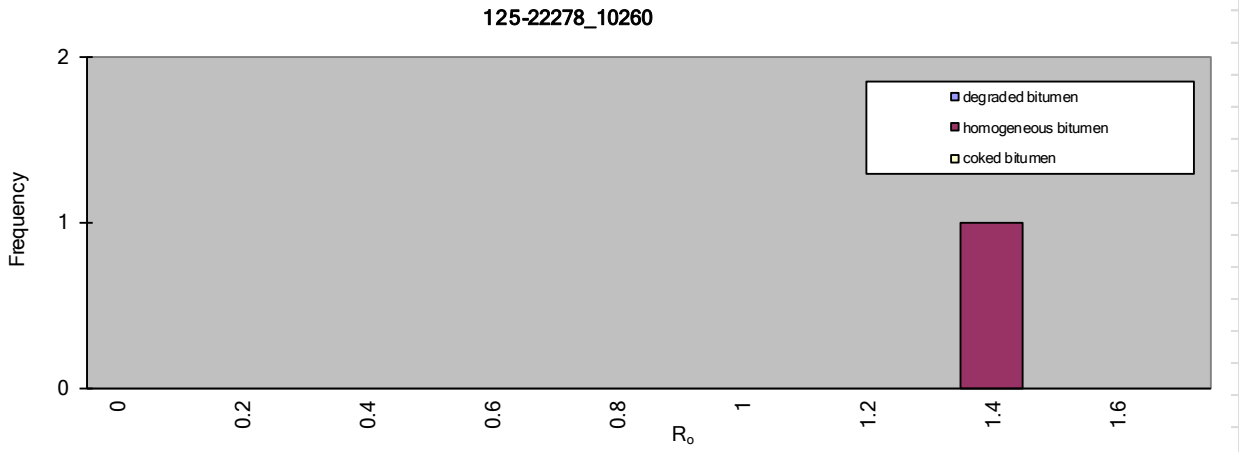
Standard: YAG [0.901]; hardly any bitumen; abundant "unknowns"

## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10260 |
| Lab ID: | 0 |
| Sample Type: | shale |
| Date Analyzed: | 10/16/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 1 |
| maceral type: | bitumen |
| $R_o$: | 1.36 |
| s.d.: | 0.00 |
| Example Photograph: | |




## DATA

| |
|---|
| 1.360 |

**All Data:** min: 1.360 max: 1.360

**Vitrinite Only:** min: 1.360 max: 1.360 V-types: 1

## COMMENT

Standard: YAG [0.901]; abundant pyrite framboids (indicative of shallow water deposition?) but very lean; Some fossil fragments.

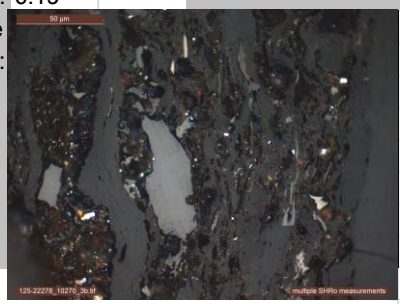
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10270 |
| Lab ID: | 0 |
| Sample Type: | shale |
| Date Analyzed: | 10/16/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

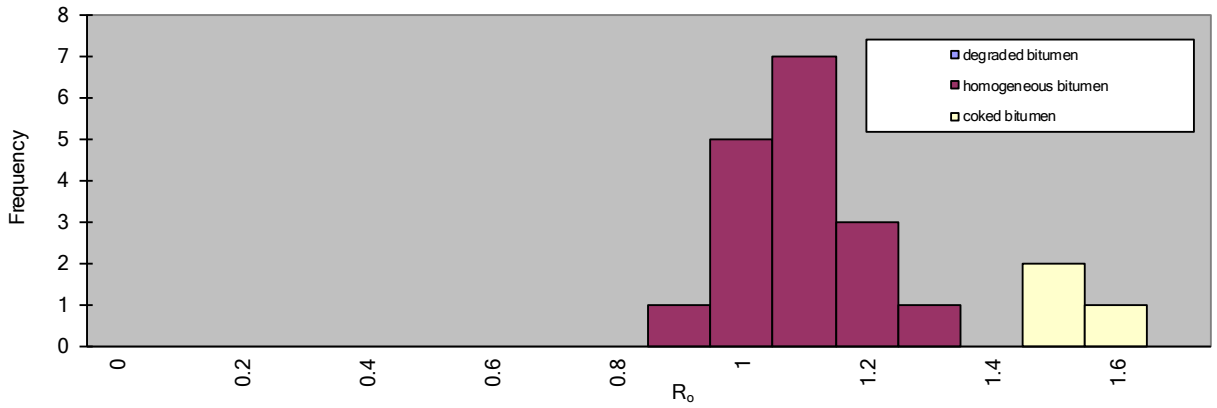
## RESULTS

| | |
|---|---|
| No. measurements: | 20 |
| maceral type: | bitumen |
| $R_o$: | 1.10 |
| s.d.: | 0.19 |

Example Photograph:



125-22278_10270




## DATA

| | |
|---|---|
| 0.886 | 1.056 |
| 0.906 | 1.056 |
| 0.909 | 1.060 |
| 0.941 | 1.123 |
| 0.956 | 1.150 |
| 0.966 | 1.169 |
| 1.008 | 1.282 |
| 1.039 | 1.405 |
| 1.042 | 1.472 |
| 1.049 | 1.571 |

**All Data:** **min:** 0.886 **max:** 1.571

**Vitrinite Only:** **min:** 0.886 **max:** 1.571 **V-types:** 8

## COMMENT

Standard: YAG [0.901]; Larger macerals but still relatively lean; one very large inhomogenous bitumen maceral (see photo 10270_3a or b) - appears to have multiple stages of HC movement?

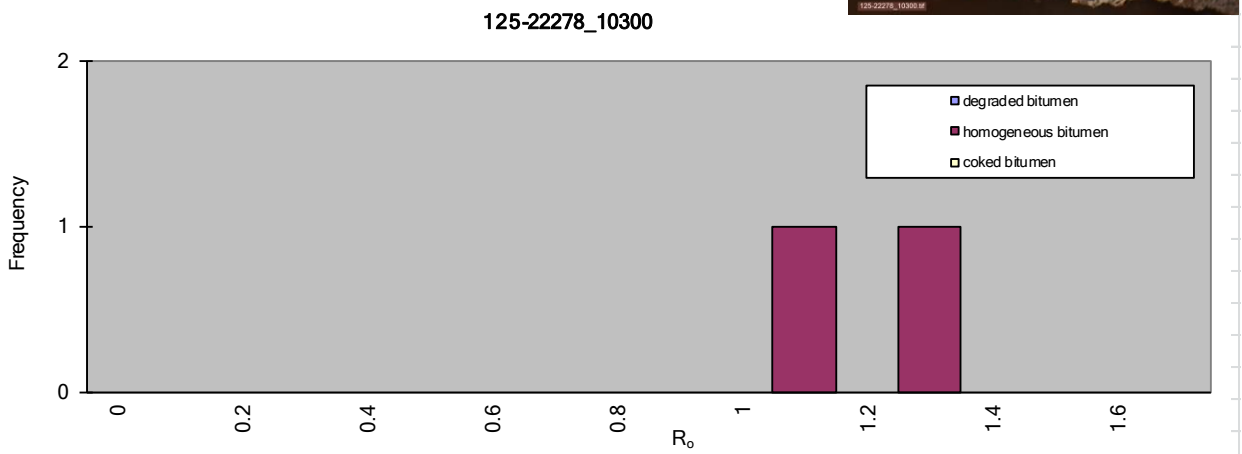
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Uica Shale Playbook |
| Sample ID: | 125-22278_10300 |
| Lab ID: | 0 |
| Sample Type: | shale |
| Date Analyzed: | 10/16/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 2 |
| maceral type: | bitumen |
| $R_o$: | 1.11 |
| s.d.: | 0.10 |

Example Photograph:




## DATA

| |
|---|
| 1.002 |
| 1.210 |

**All Data:** min: 1.002 max: 1.210

**Vitrinite Only:** min: 1.002 max: 1.210 V-types: 3

## COMMENT

Standard: YAG [0.901]; abundant pyrite, but not in framboid form; some very small macerals, otherwise extremely lean

Starvaggi – API# 3712522278 – Washington County, PA

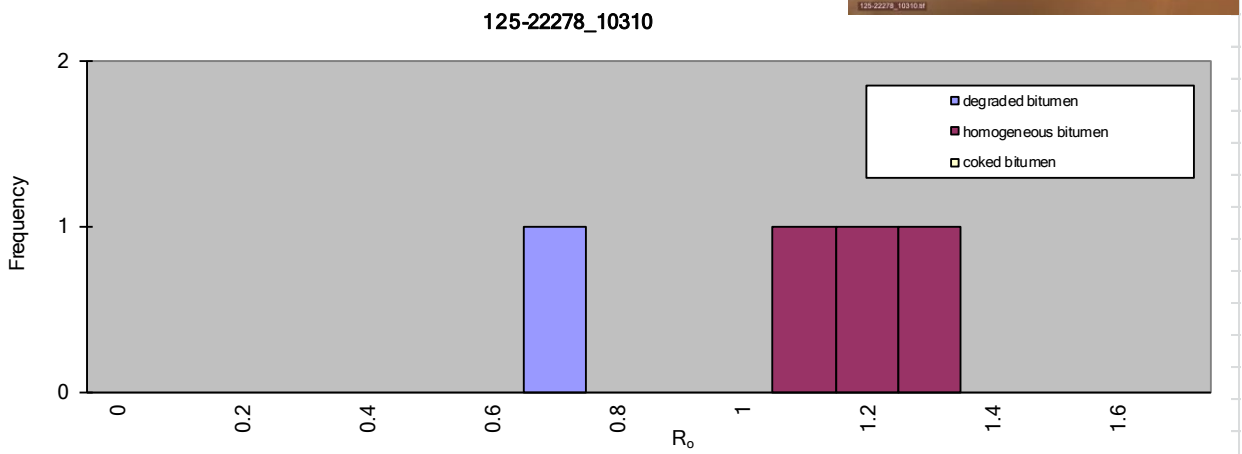
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10310 |
| Lab ID: | 0 |
| Sample Type: | shale |
| Date Analyzed: | 10/16/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 4 |
| maceral type: | bitumen |
| $R_o$: | 1.00 |
| s.d.: | 0.21 |

Example Photograph:




## DATA

| |
|---|
| 0.675 |
| 1.007 |
| 1.110 |
| 1.227 |

**All Data:** **min:** 0.675 **max:** 1.227

**Vitrinite Only:** **min:** 0.675 **max:** 1.227 **V-types:** 7

## COMMENT

Standard: YAG [0.901]; very lean; some very small bitumen macerals

Starvaggi – API# 3712522278 – Washington County, PA

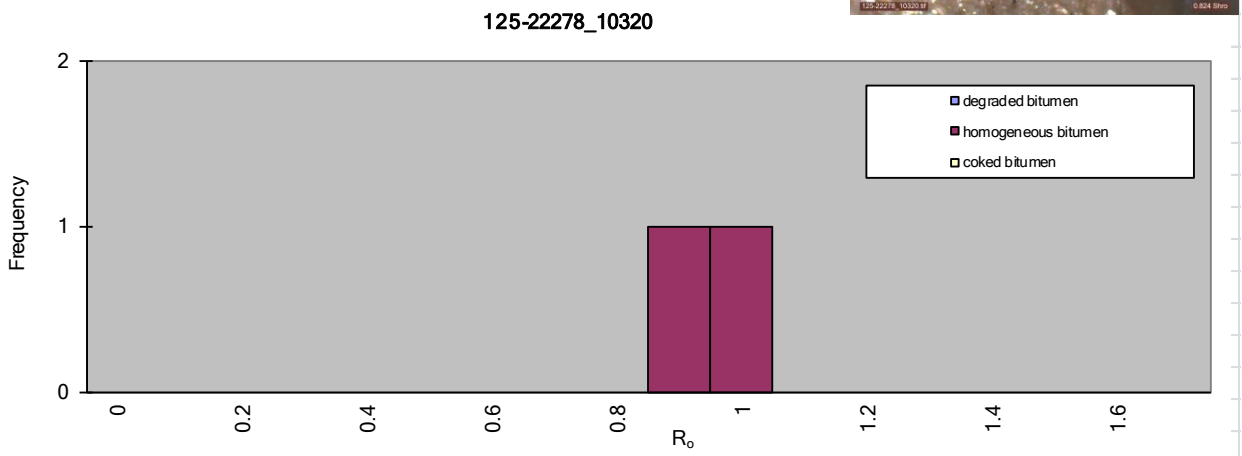
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10320 |
| Lab ID: | 0 |
| Sample Type: | shale |
| Date Analyzed: | 10/16/2013 |
| Operator: | M. cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 2 |
| maceral type: | bitumen |
| $R_o$: | 0.91 |
| s.d.: | 0.08 |

Example Photograph:




## DATA

| |
|---|
| 0.824 |
| 0.991 |

**All Data:** min: 0.824 max: 0.991

**Vitrinite Only:** min: 0.824 max: 0.991 V-types: 2

## COMMENT

Standard: YAG [0.901]; first observed chlorite

Starvaggi – API# 3712522278 – Washington County, PA

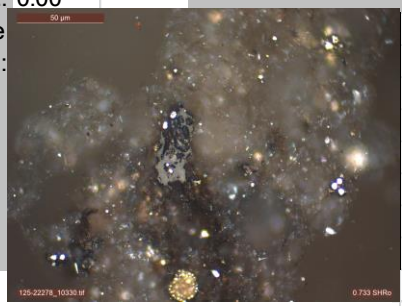
## SAMPLE INFORMATION

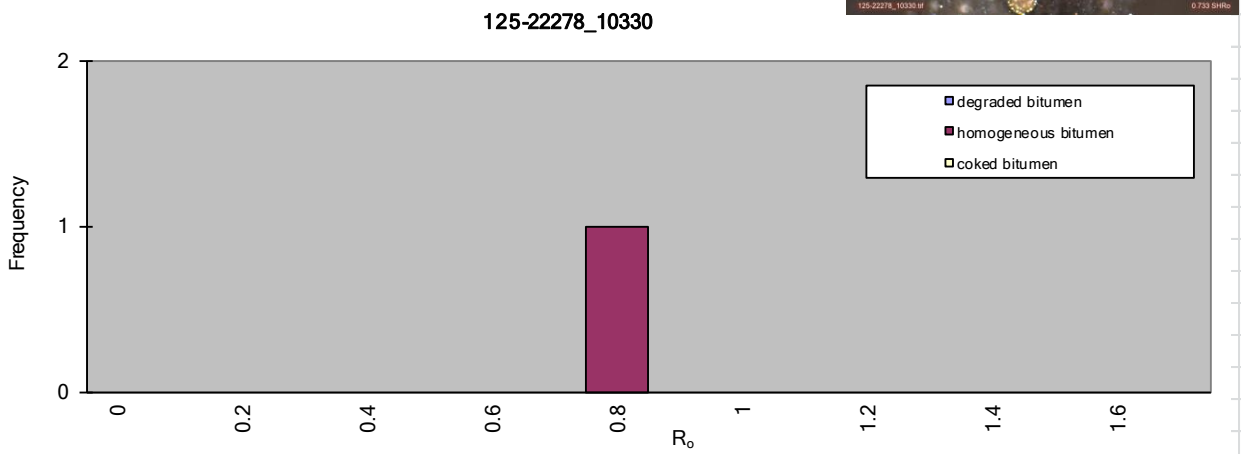
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10330 |
| Lab ID: | 125-22278_103 |
| Sample Type: | shale |
| Date Analyzed: | 10/16/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 1 |
| maceral type: | bitumen |
| $R_o$: | 0.73 |
| s.d.: | 0.00 |

Example Photograph:




## DATA

| |
|---|
| 0.733 |

**All Data:** min: 0.733 max: 0.733

**Vitrinite Only:** min: 0.733 max: 0.733 V-types: 1

## COMMENT

Standard: YAG [0.901]: Bitmen appears to be replacing pyrite, again.

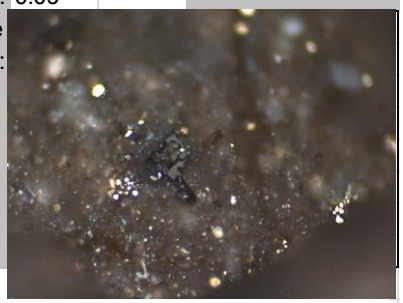
## SAMPLE INFORMATION

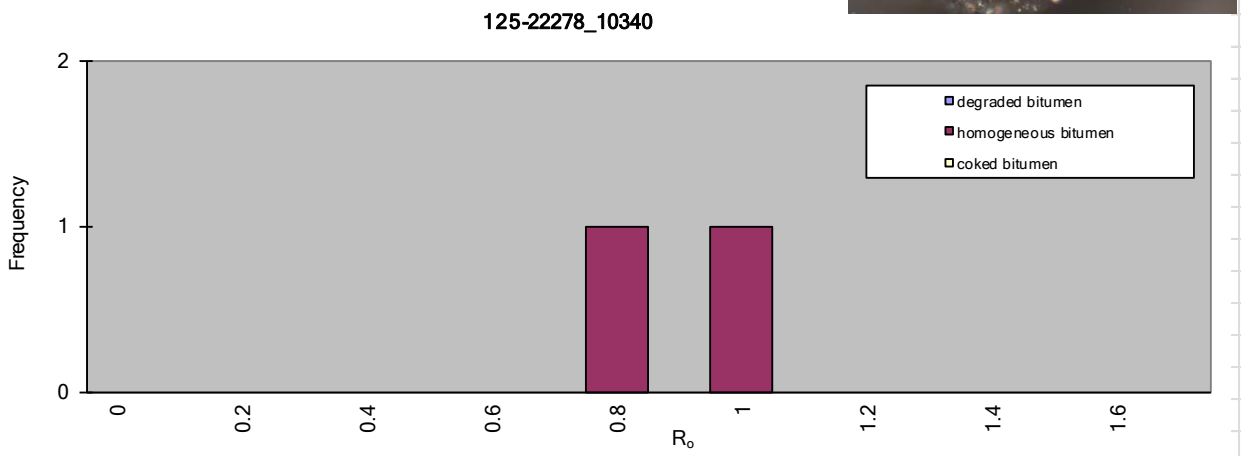
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10340 |
| Lab ID: | 125-22278_103 |
| Sample Type: | shale |
| Date Analyzed: | 10/16/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 2 |
| maceral type: | bitumen |
| $R_o$: | 0.85 |
| s.d.: | 0.09 |

Example Photograph:






## DATA

| |
|---|
| 0.757 |
| 0.939 |

**All Data:** min: 0.757 max: 0.939

**Vitrinite Only:** min: 0.757 max: 0.939 V-types: 3

## COMMENT

Standard: YAG [0.901]: Some shell fragments

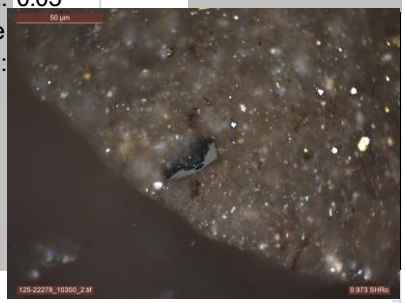
## SAMPLE INFORMATION

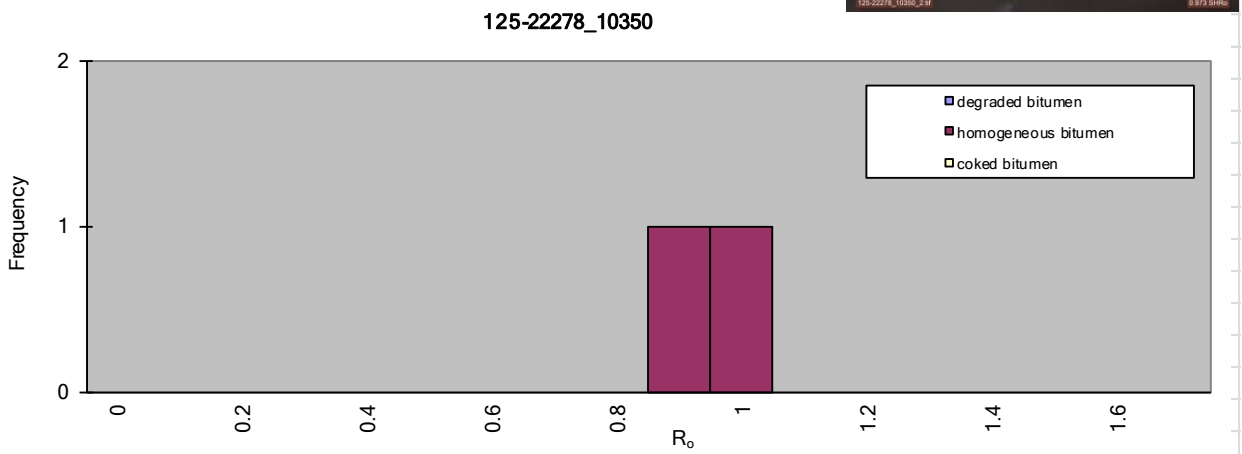
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-2278_10350 |
| Lab ID: | 125-2278_1035( |
| Sample Type: | shale |
| Date Analyzed: | 10/16/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 2 |
| maceral type: | bitumen |
| $R_o$: | 0.92 |
| s.d.: | 0.05 |

Example Photograph:






## DATA

| |
|---|
| 0.876 |
| 0.973 |

**All Data:** min: 0.876 max: 0.973

**Vitrinite Only:** min: 0.876 max: 0.973 V-types: 2

## COMMENT

Standard: YAG [0.901]; Though there is not a lot of pyrite, pyrite growths appear to have replaced some fossil fragments; more large "unknowns" with red, rusty coloring.

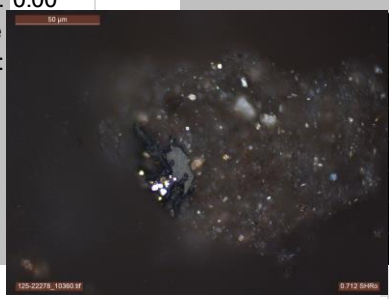
## SAMPLE INFORMATION

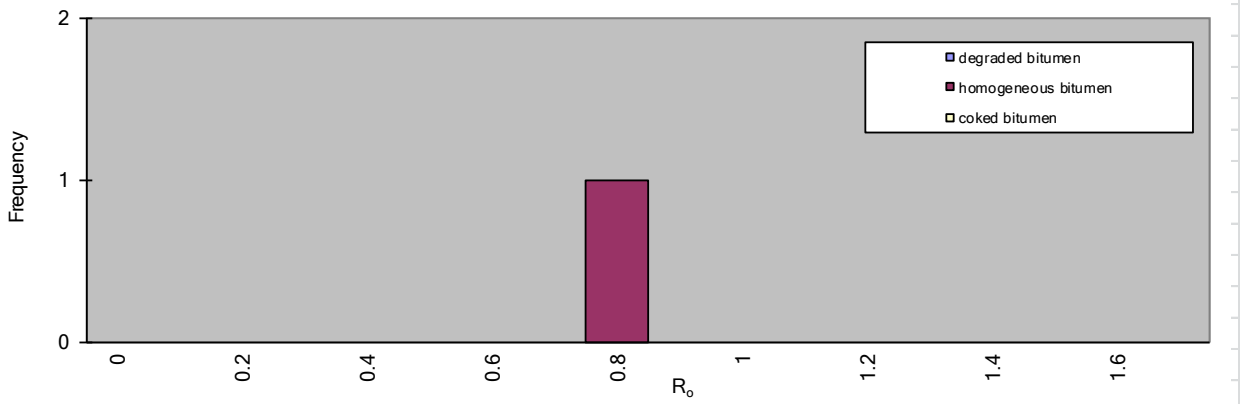
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10360 |
| Lab ID: | 125-22278_10360 |
| Sample Type: | shale |
| Date Analyzed: | 10/16/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 1 |
| maceral type: | bitumen |
| $R_o$: | 0.71 |
| s.d.: | 0.00 |

Example Photograph:






## DATA

| |
|---|
| 0.712 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **All Data:** | **min:** | 0.712 | **max:** | 0.712 | | |
| **Vitrinite Only:** | **min:** | 0.712 | **max:** | 0.712 | **V-types:** | 1 |

## COMMENT

Standard: YAG [0.901]; Abundant shell fragments; most bitumen appears as small fill structures, too small to make measurements on.

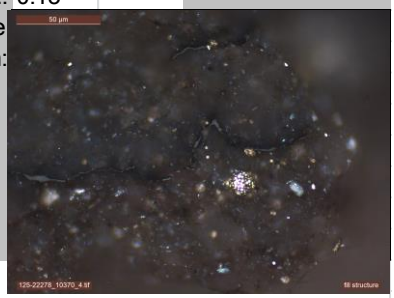
## SAMPLE INFORMATION

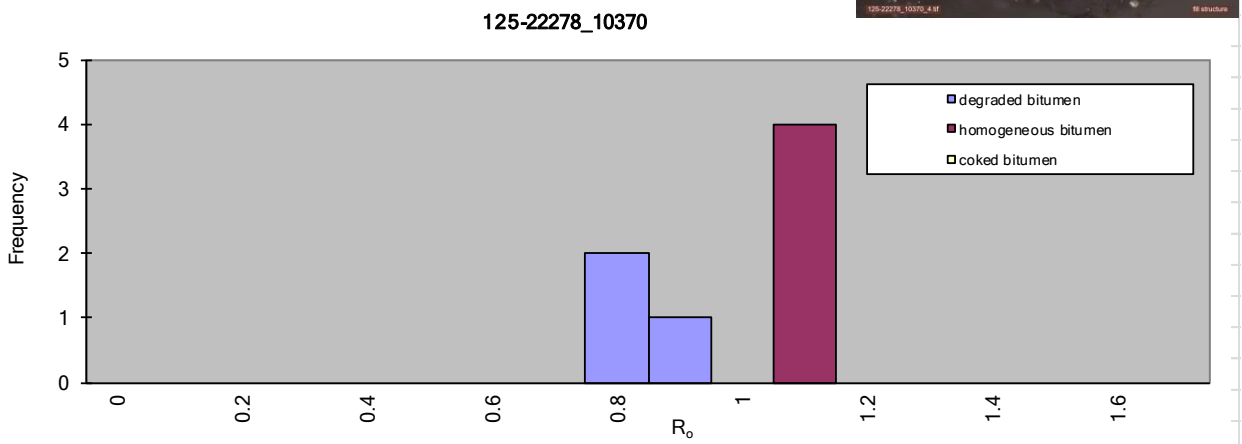
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10370 |
| Lab ID: | 125-22278_10370 |
| Sample Type: | Shale |
| Date Analyzed: | 10/17/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 7 |
| maceral type: | Bitumen |
| $R_o$: | 0.93 |
| s.d.: | 0.15 |

Example Photograph:






## DATA

| | |
|---|---|
| 0.712 | 1.029 |
| 0.720 | 1.041 |
| 0.861 | 1.053 |
| | 1.070 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **All Data:** | **min:** | 0.712 | **max:** | 1.070 | | |
| **Vitrinite Only:** | **min:** | 0.712 | **max:** | 1.070 | **V-types:** | 4 |

## COMMENT

Standard: YAG [0.901];S sample was too lean to have adequate sample volume; Bitumen more abundant in this sample than others; lower SHRo values reflect bitumen surrounded by darker minerals (possibly oxides?); Some pyrite was also present in this sample as very small pyrite framboids (indicative of shallow water deposition).

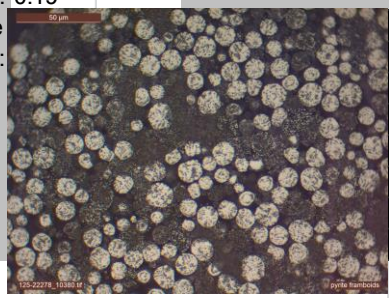
## SAMPLE INFORMATION

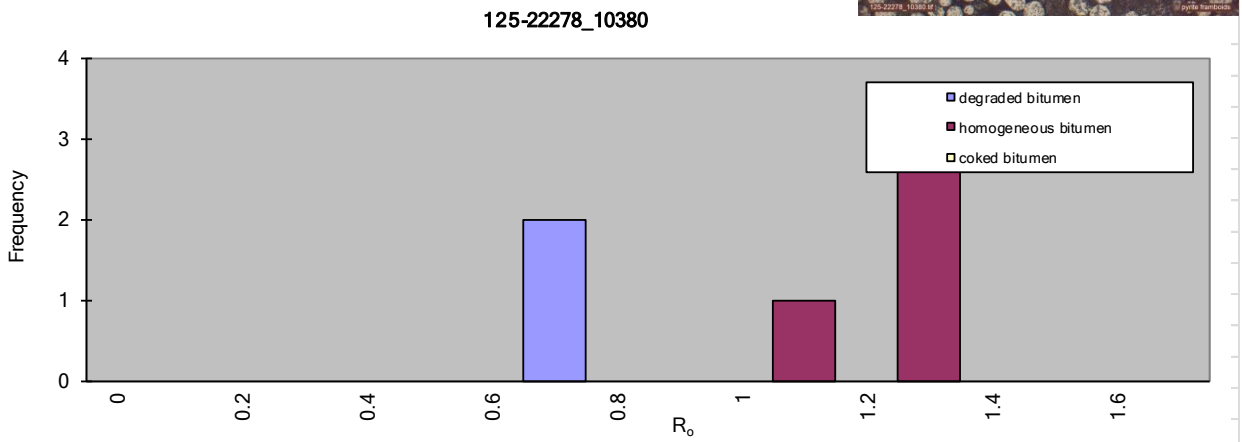
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10380 |
| Lab ID: | 125-22278_10380 |
| Sample Type: | shale |
| Date Analyzed: | 10/17/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 6 |
| maceral type: | bitumen |
| $R_o$: | 0.99 |
| s.d.: | 0.19 |

Example Photograph:






## DATA

| | |
|---|---|
| 0.724 | 1.092 |
| 0.741 | 1.108 |
| | 1.114 |
| | 1.185 |

**All Data:** min: 0.724 max: 1.185

**Vitrinite Only:** min: 0.724 max: 1.185 V-types: 5

## COMMENT

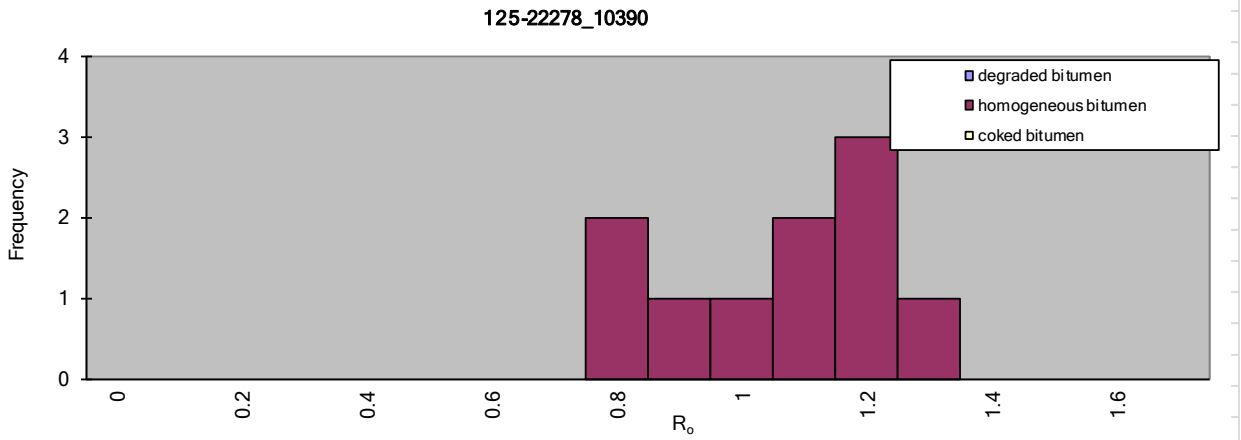
Standard: YAG [0.901]; very small macerals, many not large enough for measurment; abundant pyrite framboids

## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10390 |
| Lab ID: | 125-22278_10390 |
| Sample Type: | Shale |
| Date Analyzed: | 10/17/213 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 10 |
| maceral type: | 10/17/2013 |
| $R_o$: | 1.01 |
| s.d.: | 0.17 |
| Example Photograph: | |




## DATA

| | |
|---|---|
| 0.724 | 0.980 |
| 0.741 | 1.027 |
| 0.842 | 1.092 |
| | 1.108 |
| | 1.114 |
| | 1.185 |
| | 1.244 |

**All Data:** **min:** 0.724 **max:** 1.244

**Vitrinite Only:** **min:** 0.724 **max:** 1.244 **V-types:** 6

## COMMENT

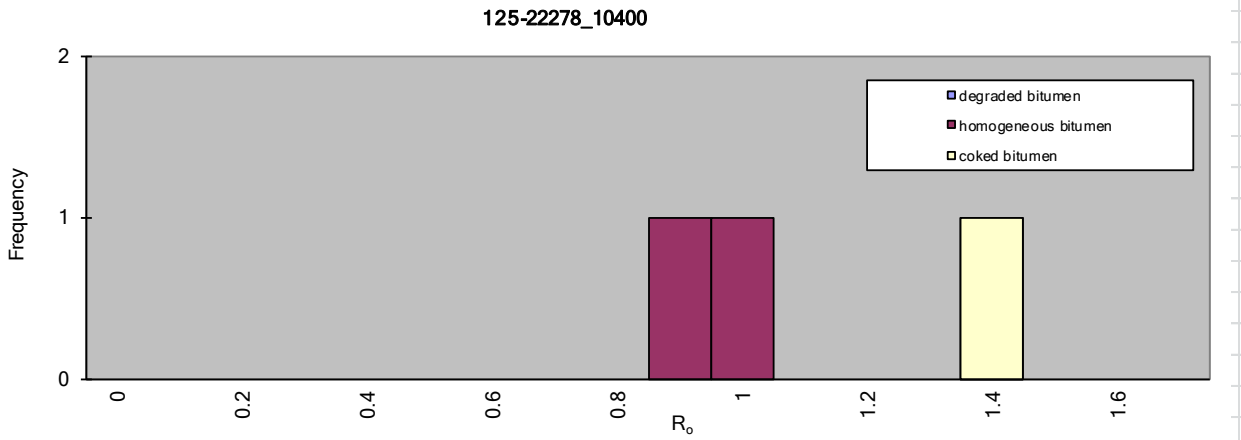
Standard: YAG [0.901]; most of the macerals consisted of fill structures. There appeared to be some fossil fragments in the matrix.

## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10400 |
| Lab ID: | 125-22278_10400 |
| Sample Type: | shale |
| Date Analyzed: | 10/17/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 3 |
| maceral type: | bitumen |
| $R_o$: | 1.06 |
| s.d.: | 0.19 |
| Example Photograph: | |




## DATA

| |
|---|
| 0.872 |
| 1.000 |
| 1.317 |

| | | | | | |
|---|---|---|---|---|---|
| **All Data:** | **min:** | 0.872 | **max:** | 1.317 | |
| **Vitrinite Only:** | **min:** | 0.872 | **max:** | 1.317 | **V-types:** 6 |

## COMMENT

Standard: YAG [0.901]; abundant pyrite framboids but very lean.

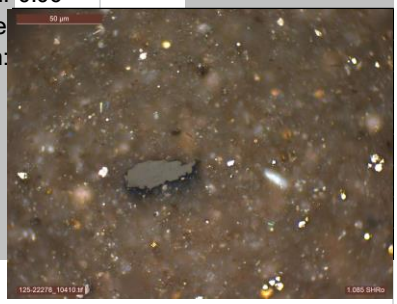
## SAMPLE INFORMATION

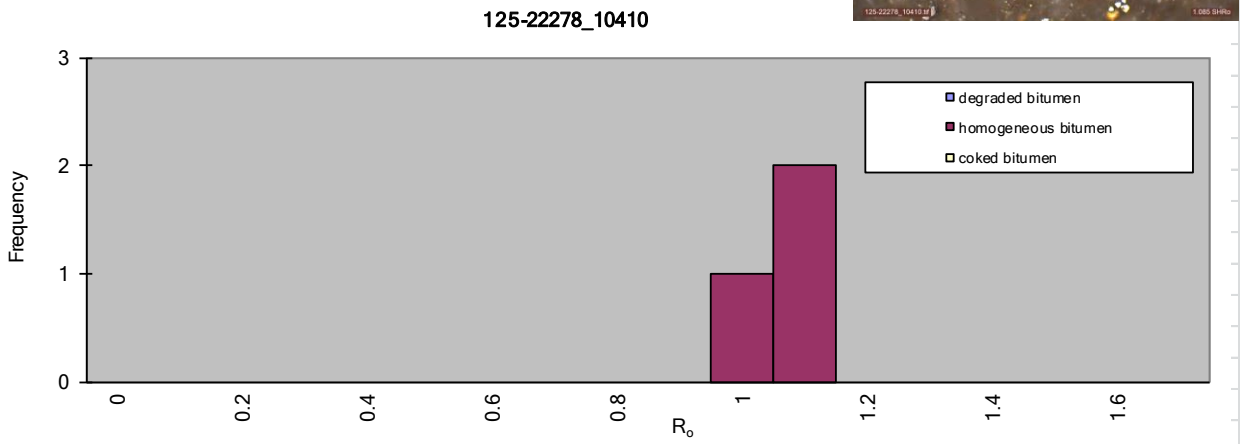
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10410 |
| Lab ID: | 125-22278_10410 |
| Sample Type: | shale |
| Date Analyzed: | 10/21/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 4 |
| maceral type: | bitumen |
| $R_o$: | 1.01 |
| s.d.: | 0.06 |

Example Photograph:






## DATA

| |
|---|
| 0.924 |
| 1.000 |
| 1.032 |
| 1.085 |

| | | | | | |
|---|---|---|---|---|---|
| **All Data:** | **min:** | 0.924 | **max:** | 1.085 | |
| **Vitrinite Only:** | **min:** | 0.924 | **max:** | 1.085 | **V-types:** 2 |

## COMMENT

Standard: YAG [0.901]; Lean but some larger macerals for measurement; macerals are dark around the edges.

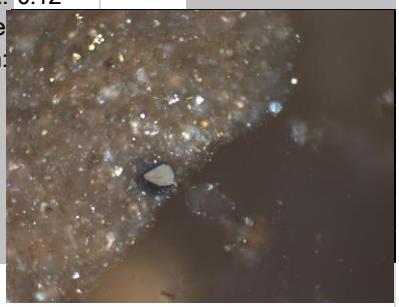
## SAMPLE INFORMATION

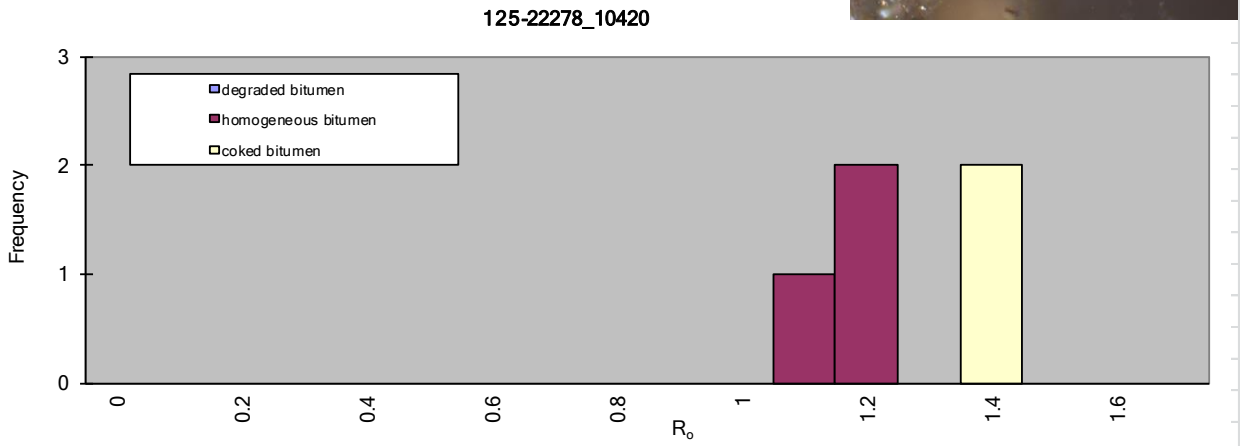
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10420 |
| Lab ID: | 125-22278_10420 |
| Sample Type: | shale |
| Date Analyzed: | 10/21/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 5 |
| maceral type: | bitumen |
| $R_o$: | 1.21 |
| s.d.: | 0.12 |

Example Photograph:






## DATA

| |
|---|
| 1.074 |
| 1.118 |
| 1.171 |
| 1.306 |
| 1.382 |

**All Data:** min: 1.074 max: 1.382

**Vitrinite Only:** min: 1.074 max: 1.382 V-types: 4

## COMMENT

Standard: YAG [0.901]; lean with some larger macerals for measurement; larger macerals are dark around the edges.

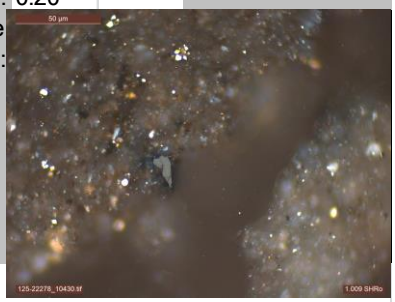
## SAMPLE INFORMATION

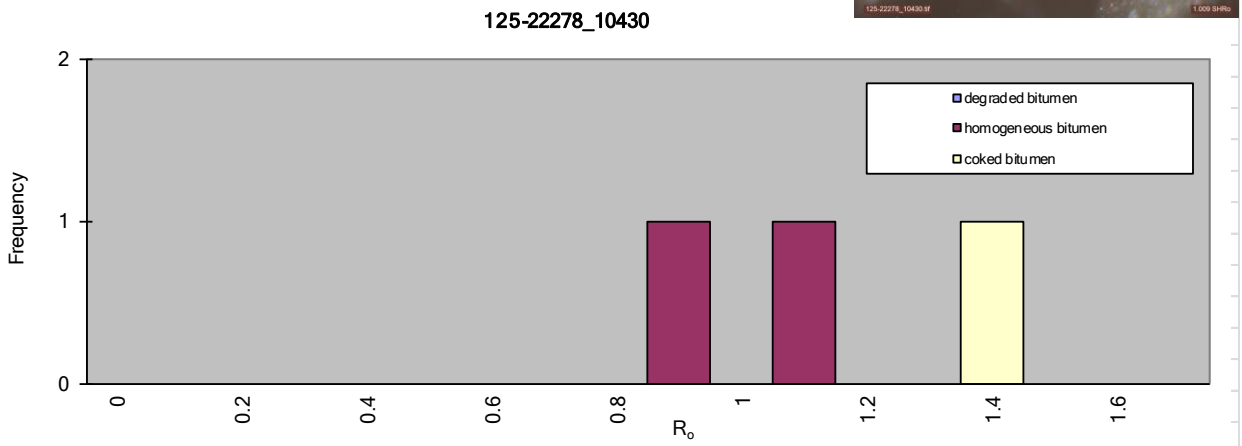
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10430 |
| Lab ID: | 125-22278_10430 |
| Sample Type: | shale |
| Date Analyzed: | 10/21/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 3 |
| maceral type: | bitumen |
| $R_o$: | 1.09 |
| s.d.: | 0.20 |

Example Photograph:






## DATA

| |
|---|
| 0.885 |
| 1.009 |
| 1.366 |

**All Data:** min: 0.885 max: 1.366

**Vitrinite Only:** min: 0.885 max: 1.366 V-types: 6

## COMMENT

Standard: YAG [0.901]; some unknowns; smaller macerals and small fill structures

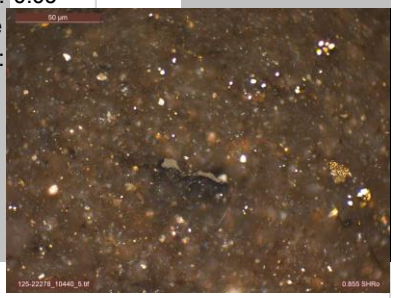
## SAMPLE INFORMATION

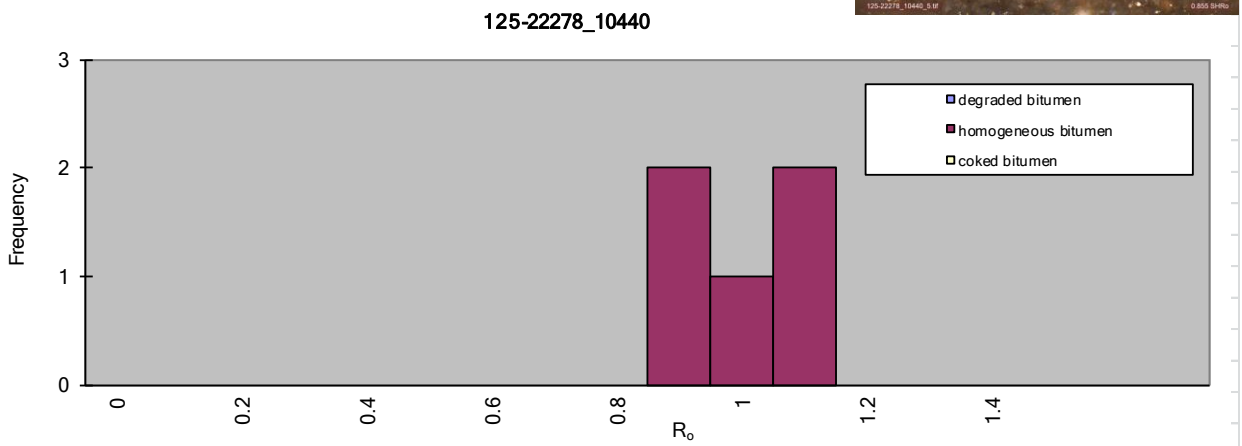
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | **125-22278_10440** |
| Lab ID: | 125-22278_10440 |
| Sample Type: | shale |
| Date Analyzed: | 10/21/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 5 |
| maceral type: | bitumen |
| $R_o$: | 0.97 |
| s.d.: | 0.09 |

Example Photograph:






## DATA

| |
|---|
| 0.855 |
| 0.889 |
| 0.944 |
| 1.060 |
| 1.095 |

**All Data:** **min:** 0.855 **max:** 1.095

**Vitrinite Only:** **min:** 0.855 **max:** 1.095 **V-types:** 3

## COMMENT

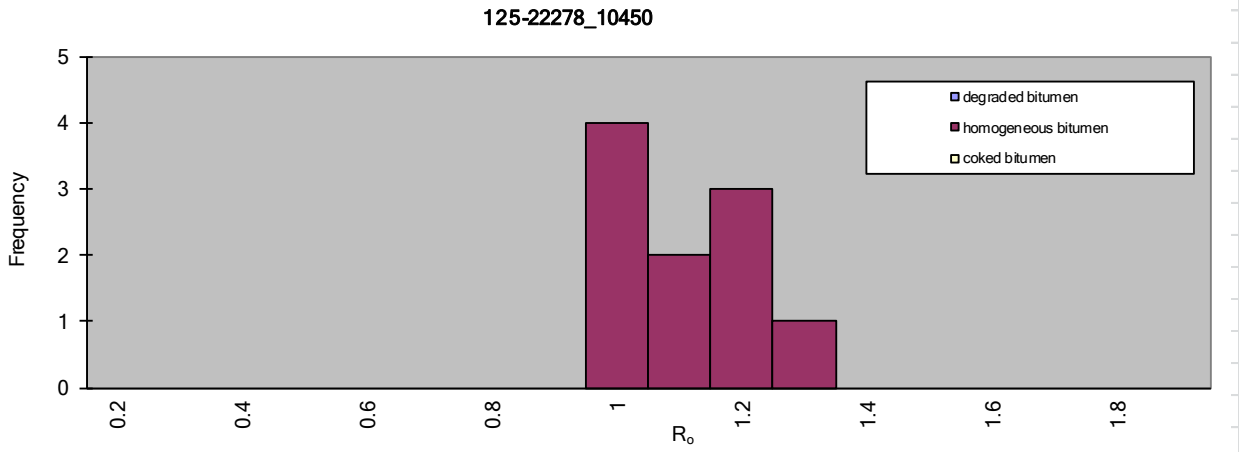
Standard: YAG [0.901]; pyrite framboids appear to be infilled by bitumen; most macerals are very small, but some appear to be possible graptolite fragments; a lot of red, rusty colors in the clay matrix.

## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10450 |
| Lab ID: | 125-22278_1045 |
| Sample Type: | shale |
| Date Analyzed: | 10/16/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 10 |
| maceral type: | bitumen |
| $R_o$: | 1.06 |
| s.d.: | 0.11 |
| Example Photograph: | |




## DATA

| |
|---|
| 1.114 |
| 1.274 |
| 0.949 |
| 1.064 |
| 1.103 |
| 1.064 |
| 1.181 |
| 0.985 |
| 0.914 |
| 0.943 |

**All Data:** **min:** 0.914 **max:** 1.274

**Vitrinite Only:** **min:** 0.914 **max:** 1.274 **V-types:** 4

## COMMENT

Standard: YAG [0.901]; Some very small macerals. Many smaller macerals appear dark acround the edges with very high SHRo values; abundant pyrite framboids.

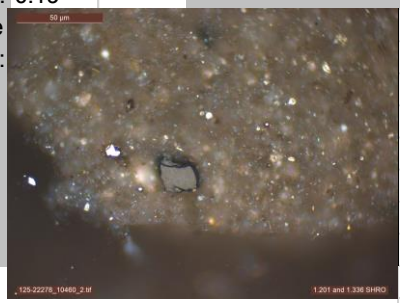
## SAMPLE INFORMATION

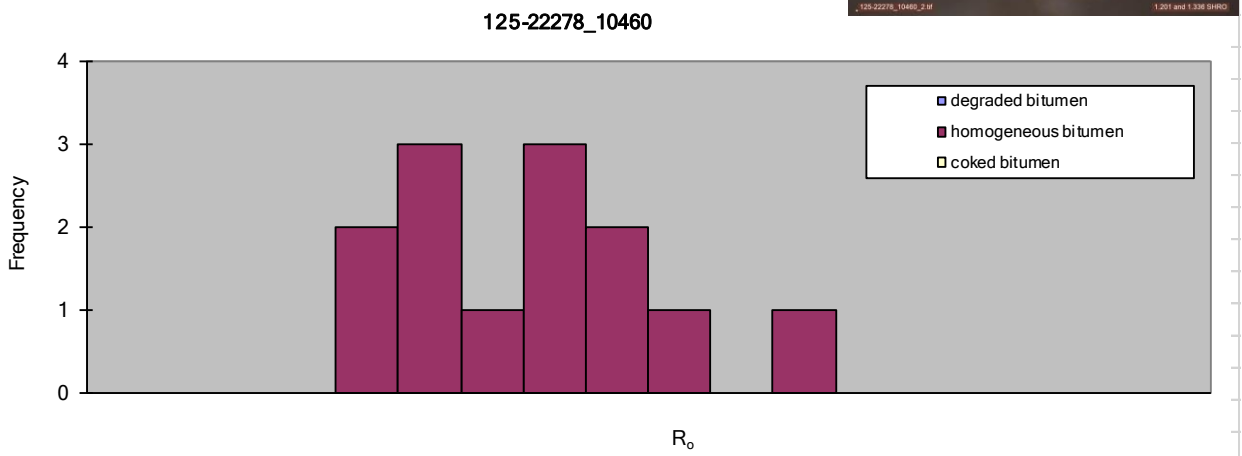
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10460 |
| Lab ID: | 125-22278_1046 |
| Sample Type: | shale |
| Date Analyzed: | 10/23/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 13 |
| maceral type: | bitumen |
| $R_o$: | 1.22 |
| s.d.: | 0.19 |

Example Photograph:






## DATA

| | |
|---|---|
| 0.980 | 1.397 |
| 0.993 | 1.456 |
| 1.017 | 1.602 |
| 1.046 | |
| 1.069 | |
| 1.150 | |
| 1.201 | |
| 1.272 | |
| 1.292 | |
| 1.336 | |

**All Data:** min: 0.980 max: 1.602

**Vitrinite Only:** min: 0.980 max: 1.602 V-types: 8

## COMMENT

## DISPERSED VITRINITE REFLECTANCE REPORT

Run

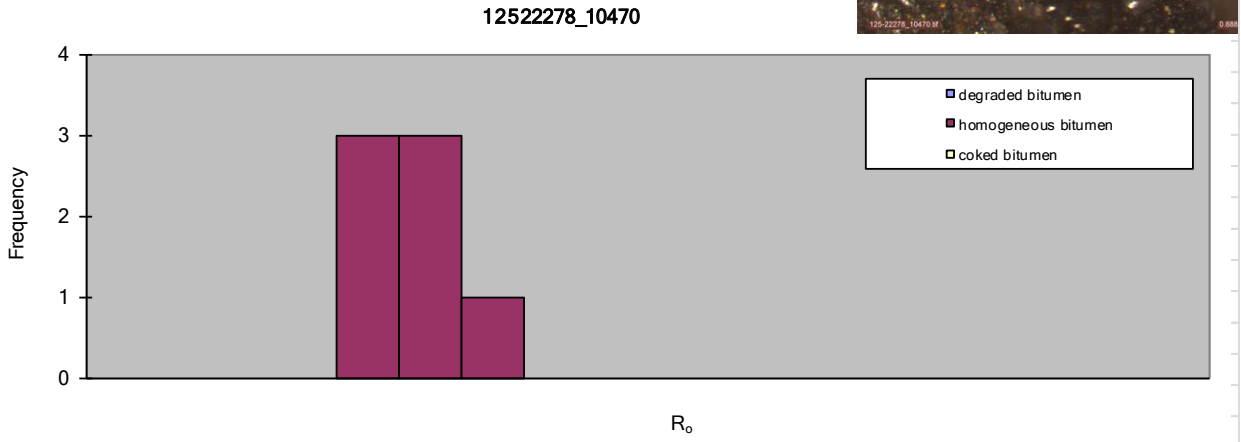
### SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10470 |
| Lab ID: | 125-22278_10470 |
| Sample Type: | shale |
| Date Analyzed: | 10/30/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

### RESULTS

| | |
|---|---|
| No. measurements: | 7 |
| maceral type: | bitumen |
| $R_o$: | 0.93 |
| s.d.: | 0.08 |

Example Photograph:




### DATA

| |
|---|
| 0.805 |
| 0.888 |
| 0.892 |
| 0.911 |
| 0.941 |
| 0.973 |
| 1.070 |

| | | | | | | |
|---|---|---|---|---|---|---|
| All Data: | min: | 0.805 | max: | 1.070 | | |
| Vitrinite Only: | min: | 0.805 | max: | 1.070 | V-types: | 3 |

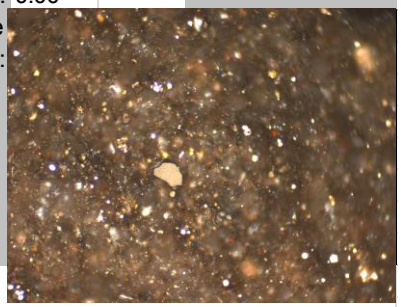
## SAMPLE INFORMATION

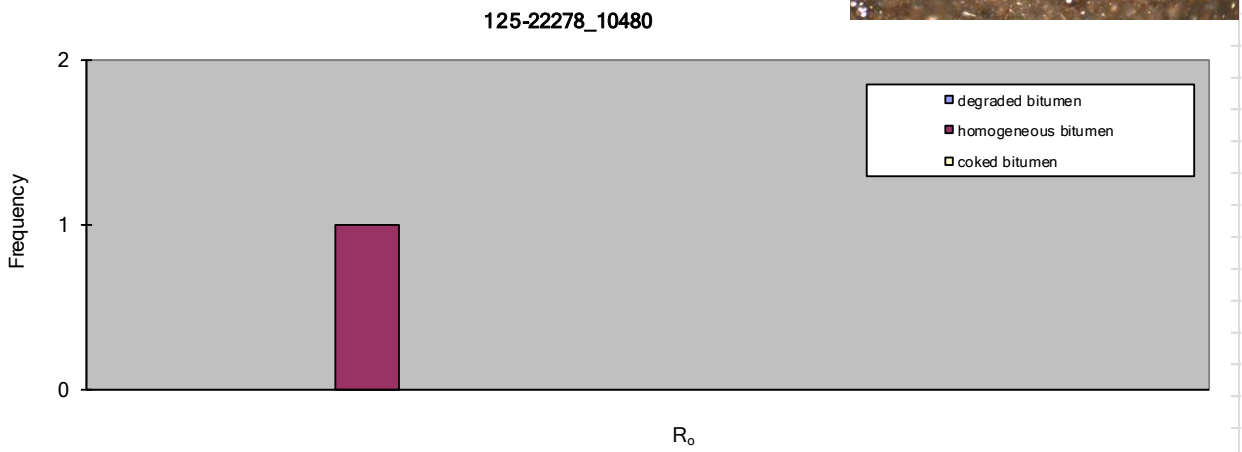
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10480 |
| Lab ID: | 125-22278_1048 |
| Sample Type: | shale |
| Date Analyzed: | 11/1/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 1 |
| maceral type: | bitumen |
| $R_o$: | 0.84 |
| s.d.: | 0.00 |

Example Photograph:






## DATA

| |
|---|
| 0.841 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **All Data:** | **min:** | 0.841 | **max:** | 0.841 | | |
| **Vitrinite Only:** | **min:** | 0.841 | **max:** | 0.841 | **V-types:** | 1 |

## COMMENT

Standard: YAG [0.901]; Very lean, mostly small macerals.

Starvaggi – API# 3712522278 – Washington County, PA

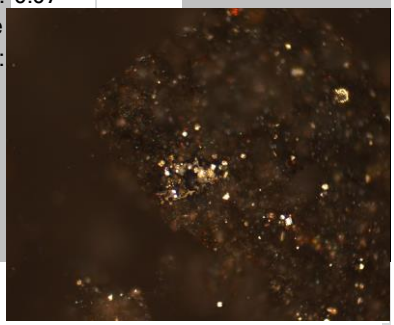
## SAMPLE INFORMATION

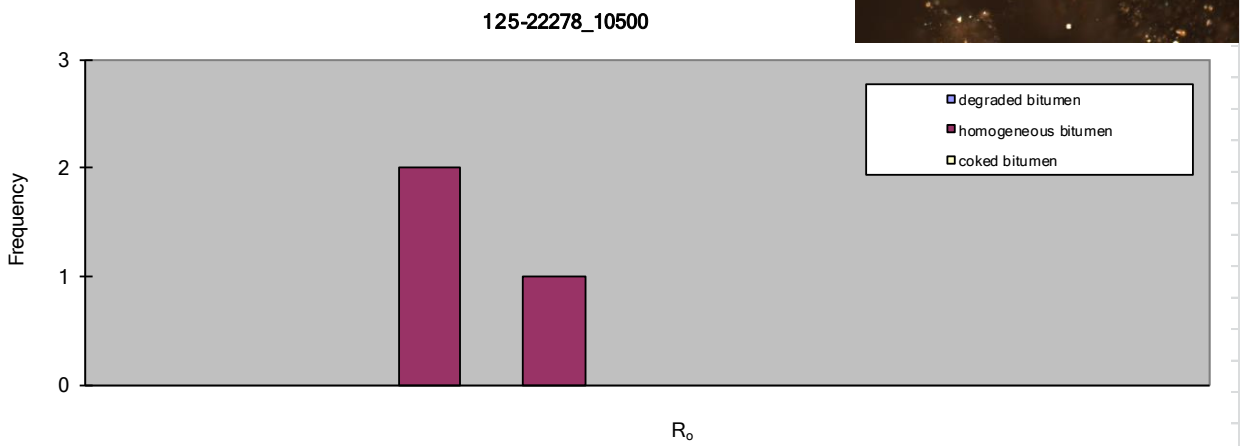
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10500 |
| Lab ID: | 125-22278_10500 |
| Sample Type: | shale |
| Date Analyzed: | 11/1/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 3 |
| maceral type: | bitumen |
| $R_o$: | 1.02 |
| s.d.: | 0.07 |

Example Photograph:






## DATA

| |
|---|
| 0.962 |
| 0.979 |
| 1.121 |

| | | | | | |
|---|---|---|---|---|---|
| **All Data:** | **min:** | 0.962 | **max:** | 1.121 | |
| **Vitrinite Only:** | **min:** | 0.962 | **max:** | 1.121 | **V-types:** 3 |

## COMMENT

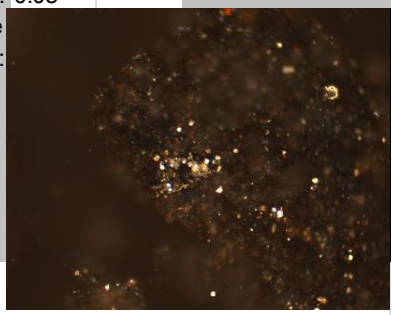
## SAMPLE INFORMATION

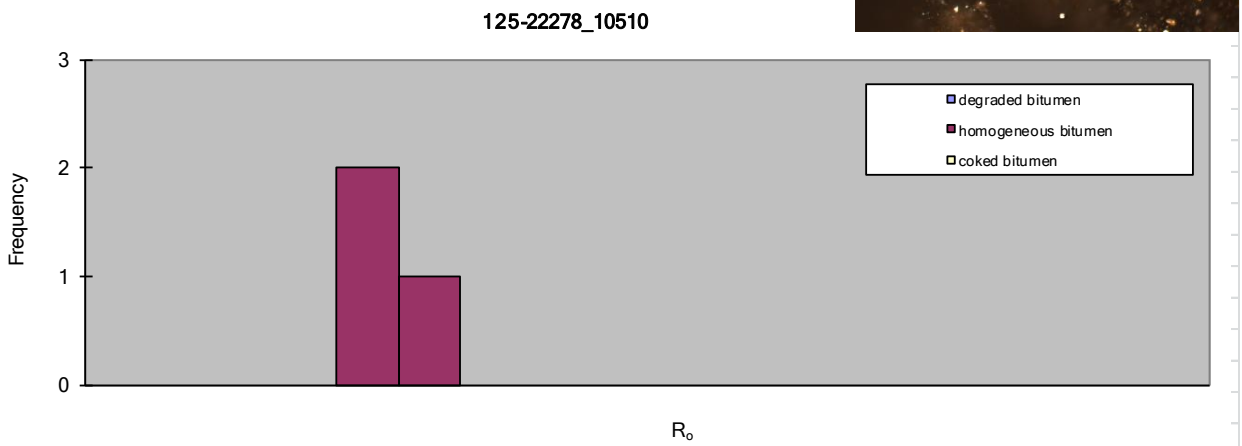
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10510 |
| Lab ID: | 125-22278_10510 |
| Sample Type: | shale |
| Date Analyzed: | 11/4/2013 |
| Operator: | M. Coomey |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 3 |
| maceral type: | bitumen |
| $R_o$: | 0.89 |
| s.d.: | 0.03 |

Example Photograph:






## DATA

| |
|---|
| 0.860 |
| 0.879 |
| 0.935 |

| | | | | | |
|---|---|---|---|---|---|
| **All Data:** | **min:** | 0.860 | **max:** | 0.935 | |
| **Vitrinite Only:** | **min:** | 0.860 | **max:** | 0.935 | **V-types:** 2 |

## COMMENT

Standard: YAG [0.901]; Very small macerals and fill structures. Most macerals too small to measure.

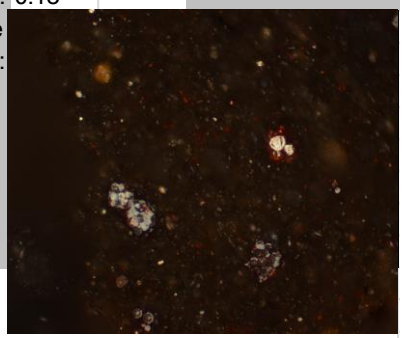
## SAMPLE INFORMATION

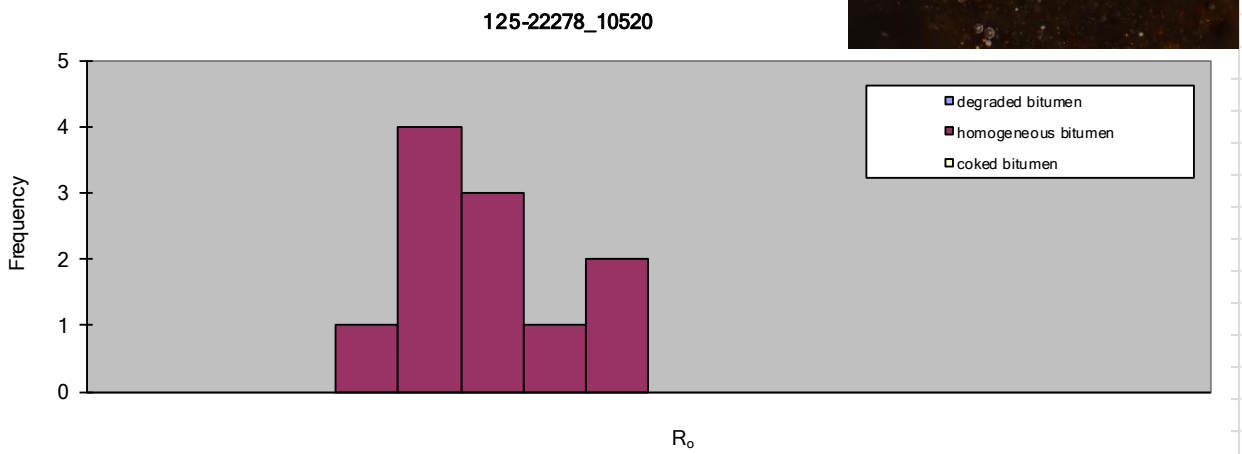
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10520 |
| Lab ID: | 125-22278_1052 |
| Sample Type: | shale |
| Date Analyzed: | 11/4/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 11 |
| maceral type: | bitumen |
| $R_o$: | 0.95 |
| s.d.: | 0.13 |

Example Photograph:






## DATA

| | |
|---|---|
| 0.788 | 1.178 |
| 0.802 | |
| 0.844 | |
| 0.852 | |
| 0.881 | |
| 0.973 | |
| 0.978 | |
| 0.983 | |
| 1.091 | |
| 1.130 | |

**All Data:** **min:** 0.788 **max:** 1.178

**Vitrinite Only:** **min:** 0.788 **max:** 1.178 **V-types:** 5

## COMMENT

Standard: YAG [0.901]; numerous fill structures; significantly more bitumen but the structures are too small to measure.

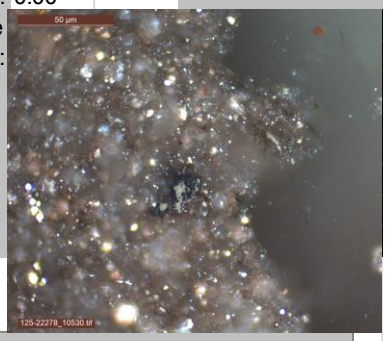
## SAMPLE INFORMATION

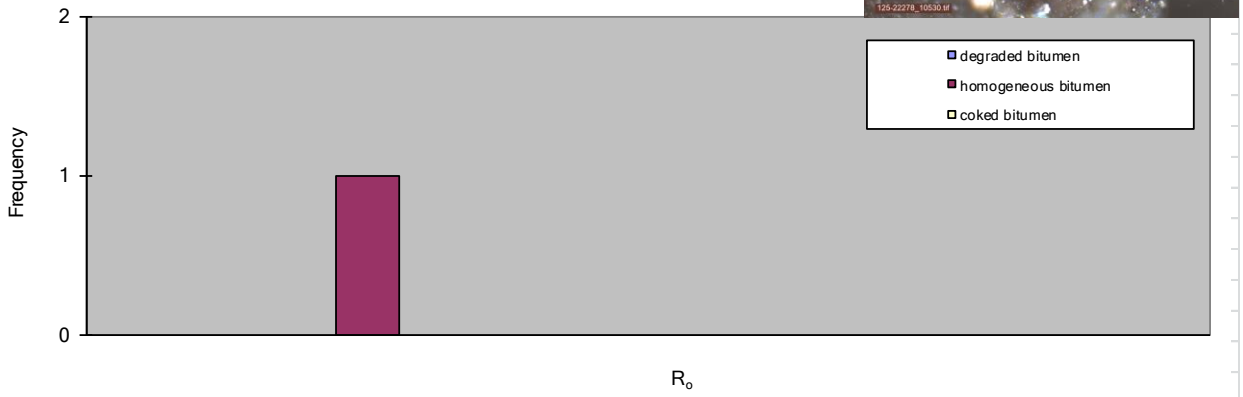
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | **125-22278_10530** |
| Lab ID: | 125-22278_10530 |
| Sample Type: | shale |
| Date Analyzed: | 11/4/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 1 |
| maceral type: | bitumen |
| $R_o$: | 1.08 |
| s.d.: | 0.00 |

Example Photograph:






## DATA

| |
|---|
| 1.075 |

**All Data:** min: 1.075 max: 1.075

**Vitrinite Only:** min: 1.075 max: 1.075 V-types: 1

## COMMENT

Standard: YAG [0.901]; Very lean sample.

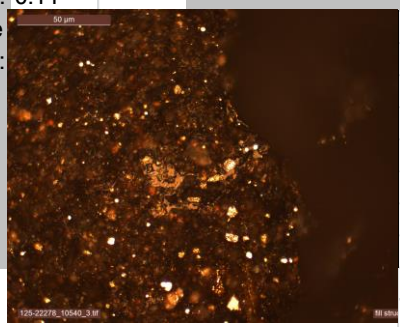
## SAMPLE INFORMATION

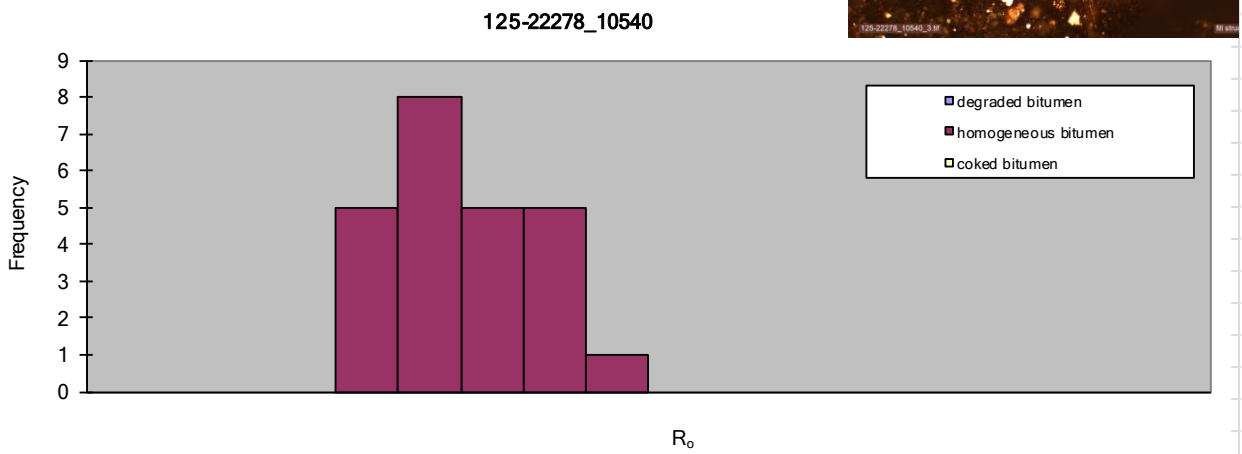
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10540 |
| Lab ID: | 125-22278_1054 |
| Sample Type: | shale |
| Date Analyzed: | 11/5/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 24 |
| maceral type: | bitumen |
| $R_o$: | 1.00 |
| s.d.: | 0.11 |

Example Photograph:




## DATA

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0.846 | 0.965 | 1.134 | | | | | | | |
| 0.859 | 0.970 | 1.149 | | | | | | | |
| 0.875 | 0.990 | 1.191 | | | | | | | |
| 0.889 | 1.000 | 1.203 | | | | | | | |
| 0.897 | 1.006 | | | | | | | | |
| 0.901 | 1.054 | | | | | | | | |
| 0.929 | 1.062 | | | | | | | | |
| 0.937 | 1.073 | | | | | | | | |
| 0.950 | 1.118 | | | | | | | | |
| 0.963 | 1.125 | | | | | | | | |

**All Data:** min: 0.846 max: 1.203

**Vitrinite Only:** min: 0.846 max: 1.203 V-types: 5

## COMMENT

Standard: YAG [0.901]; Small macerals and fill structures in darker clay mineral assemblages.

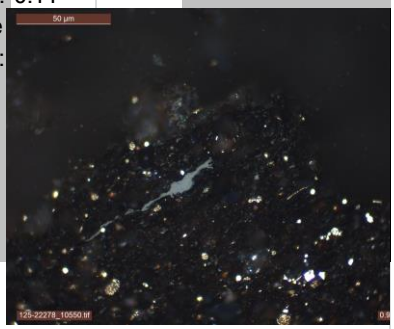
## SAMPLE INFORMATION

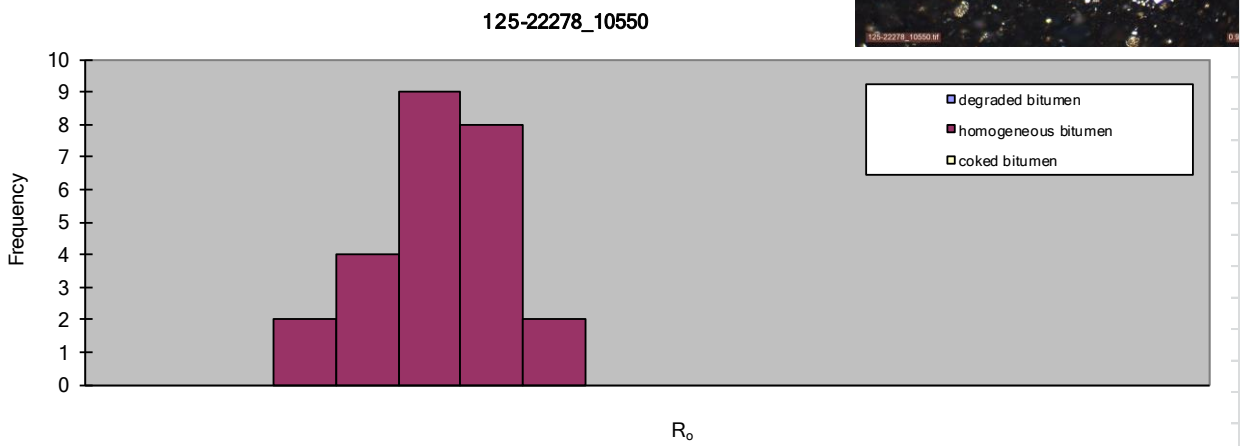
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10550 |
| Lab ID: | 125-22278_10550 |
| Sample Type: | shale |
| Date Analyzed: | 11/5/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 25 |
| maceral type: | bitumen |
| $R_o$: | 0.97 |
| s.d.: | 0.11 |

Example Photograph:






## DATA

| | | |
|---|---|---|
| 0.720 | 0.958 | 1.077 |
| 0.788 | 0.971 | 1.080 |
| 0.806 | 0.973 | 1.088 |
| 0.841 | 0.991 | 1.159 |
| 0.875 | 0.998 | 1.173 |
| 0.888 | 1.012 | |
| 0.916 | 1.036 | |
| 0.927 | 1.038 | |
| 0.927 | 1.071 | |
| 0.936 | 1.072 | |

**All Data:** min: 0.720 max: 1.173

**Vitrinite Only:** min: 0.720 max: 1.173 V-types: 5

## COMMENT

Standard YAG [0.901]; Some larger macerals; mostly small fill structures.

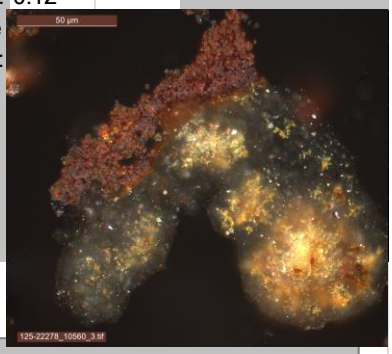
## SAMPLE INFORMATION

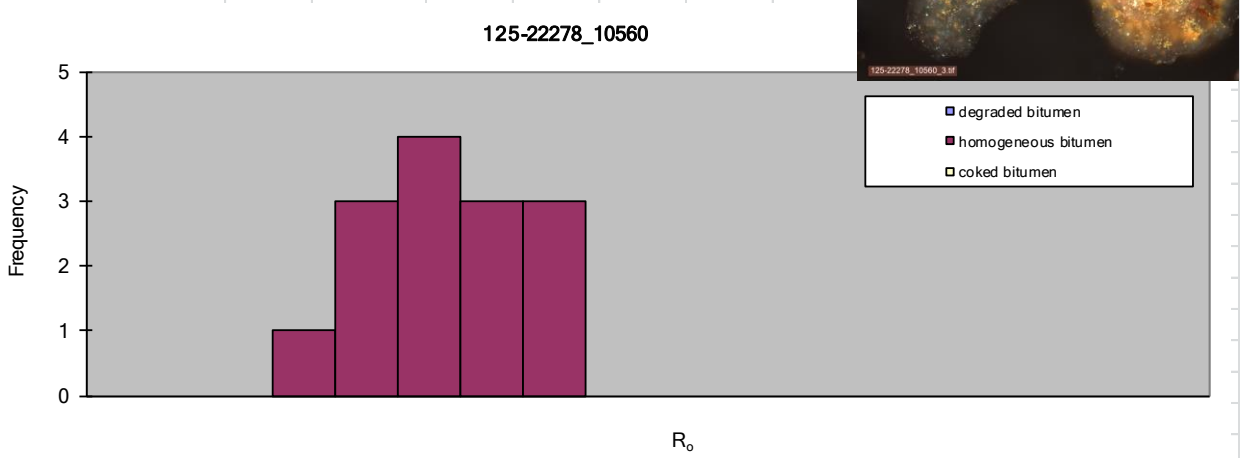
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10560 |
| Lab ID: | 125-22278_10560 |
| Sample Type: | shale |
| Date Analyzed: | 11/5/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 14 |
| maceral type: | bitumen |
| $R_o$: | 0.98 |
| s.d.: | 0.12 |

Example Photograph:




## DATA

| | |
|---|---|
| 0.771 | 1.064 |
| 0.818 | 1.132 |
| 0.820 | 1.142 |
| 0.831 | 1.148 |
| 0.929 | |
| 0.974 | |
| 0.983 | |
| 0.984 | |
| 1.027 | |
| 1.047 | |

**All Data:** min: 0.771 max: 1.148

**Vitrinite Only:** min: 0.771 max: 1.148 V-types: 5

## COMMENT

Standard: YAG [0.901]; Abundant fill structures with some larger macerals.

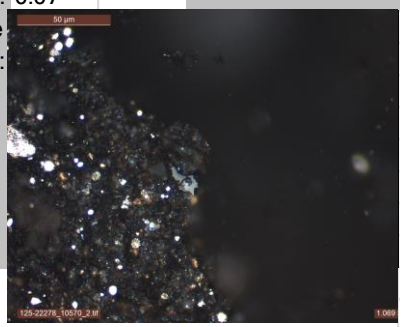
## SAMPLE INFORMATION

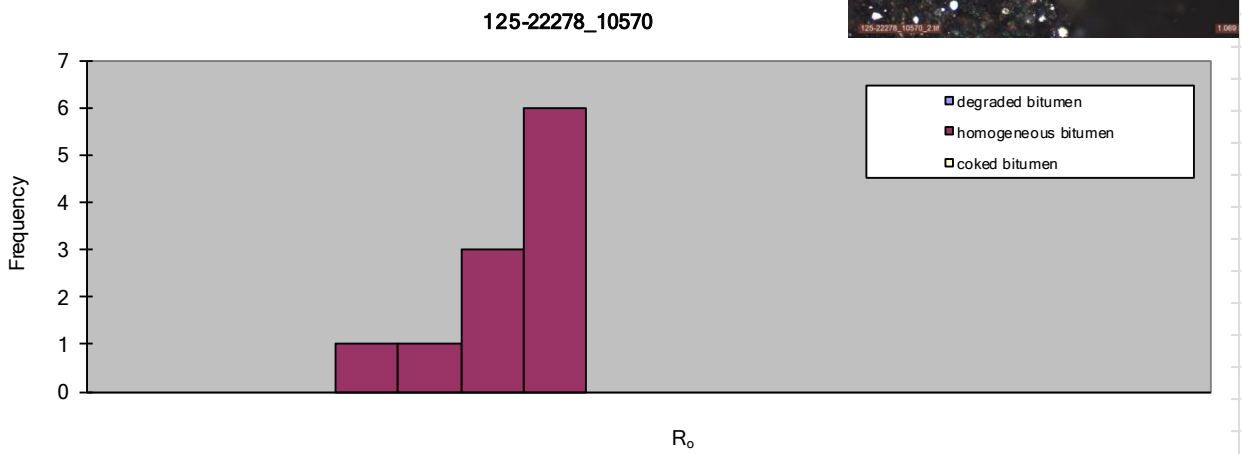
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10570 |
| Lab ID: | 125-22278_1057 |
| Sample Type: | shale |
| Date Analyzed: | 11/6/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 11 |
| maceral type: | bitumen |
| $R_o$: | 1.06 |
| s.d.: | 0.07 |

Example Photograph:






## DATA

| | |
|---|---|
| 0.889 | 1.125 |
| 0.946 | |
| 1.023 | |
| 1.050 | |
| 1.069 | |
| 1.101 | |
| 1.103 | |
| 1.104 | |
| 1.115 | |
| 1.124 | |

**All Data:** min: 0.889 max: 1.125

**Vitrinite Only:** min: 0.889 max: 1.125 V-types: 4

## COMMENT

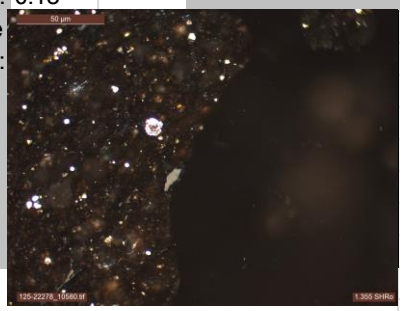
## SAMPLE INFORMATION

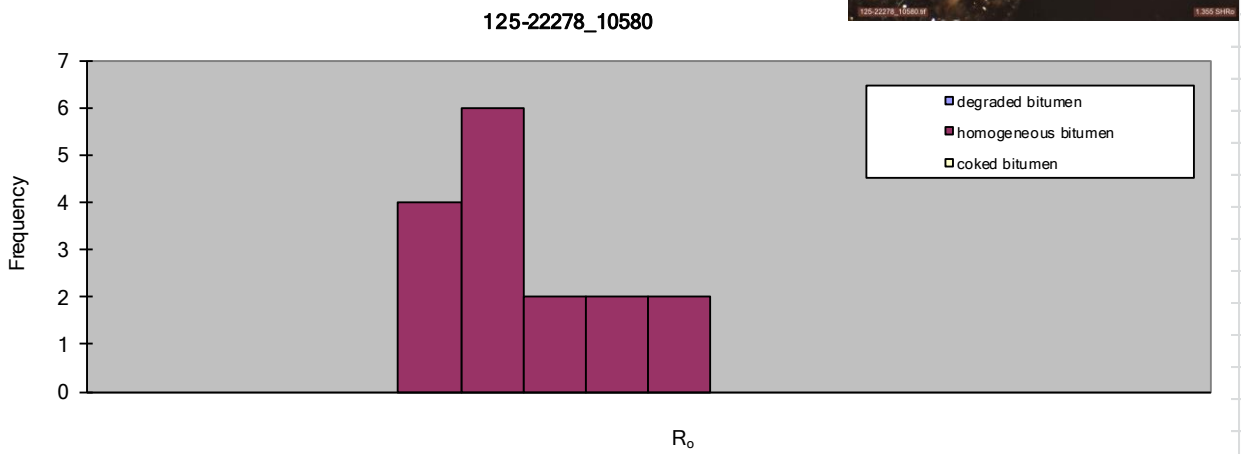
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10580 |
| Lab ID: | 125-22278_1058 |
| Sample Type: | shale |
| Date Analyzed: | 11/6/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 16 |
| maceral type: | bitumen |
| $R_o$: | 1.10 |
| s.d.: | 0.13 |

Example Photograph:






## DATA

| | |
|---|---|
| 0.926 | 1.142 |
| 0.927 | 1.152 |
| 0.981 | 1.269 |
| 0.988 | 1.270 |
| 1.018 | 1.311 |
| 1.023 | 1.355 |
| 1.029 | |
| 1.057 | |
| 1.079 | |
| 1.099 | |

**All Data:** min: 0.926 max: 1.355

**Vitrinite Only:** min: 0.926 max: 1.355 V-types: 5

## COMMENT

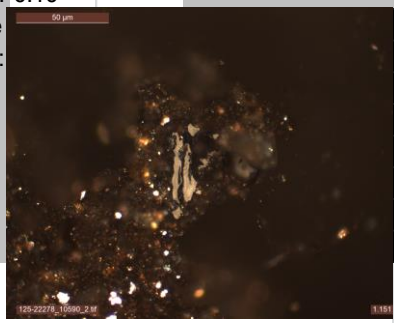
## SAMPLE INFORMATION

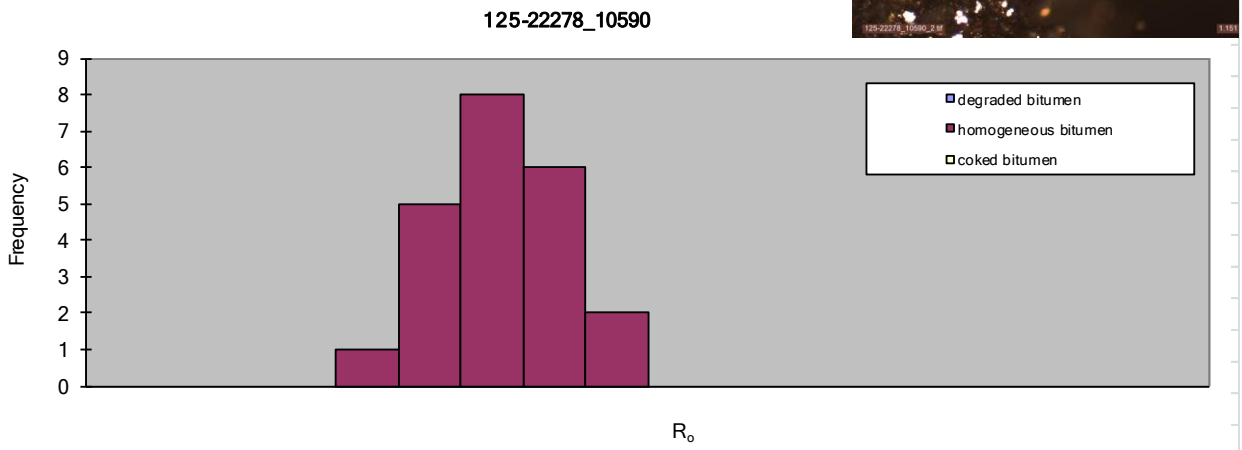
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10590 |
| Lab ID: | 125-22278_1059( |
| Sample Type: | shale |
| Date Analyzed: | 11/6/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 21 |
| maceral type: | bitumen |
| $R_o$: | 1.06 |
| s.d.: | 0.10 |

Example Photograph:






## DATA

| | | |
|---|---|---|
| 0.871 | 1.051 | 1.285 |
| 0.915 | 1.068 | |
| 0.925 | 1.079 | |
| 0.952 | 1.096 | |
| 0.977 | 1.115 | |
| 0.983 | 1.127 | |
| 1.017 | 1.151 | |
| 1.020 | 1.165 | |
| 1.023 | 1.185 | |
| 1.031 | 1.198 | |

**All Data:** min: 0.871 max: 1.285

**Vitrinite Only:** min: 0.871 max: 1.285 V-types: 5

## COMMENT

Standard: YAG [0.901]; Similar to other samples - numerous fill structures with sporadic larger macerals.

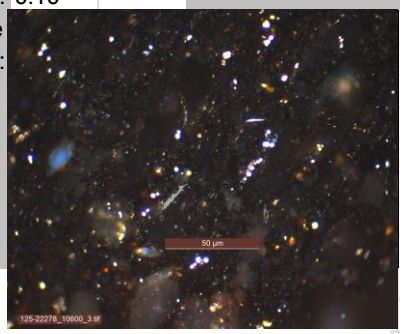
## SAMPLE INFORMATION

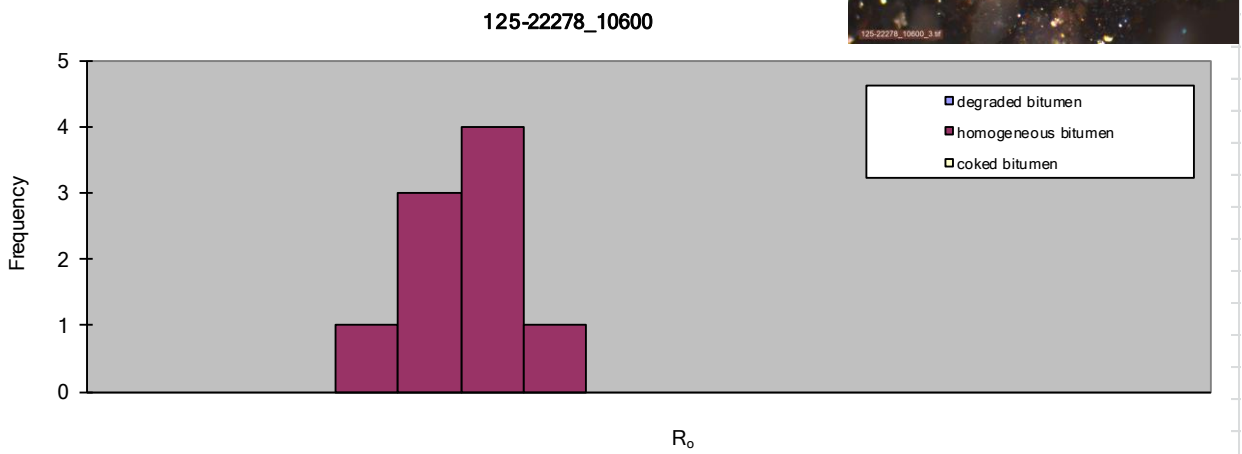
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10600 |
| Lab ID: | 125-22278_1060 |
| Sample Type: | shale |
| Date Analyzed: | 11/7/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 10 |
| maceral type: | bitumen |
| $R_o$: | 1.04 |
| s.d.: | 0.10 |

Example Photograph:






## DATA

| |
|---|
| 0.868 |
| 0.942 |
| 0.966 |
| 0.984 |
| 1.003 |
| 1.069 |
| 1.092 |
| 1.098 |
| 1.171 |
| 1.173 |

**All Data:** min: 0.868 max: 1.173

**Vitrinite Only:** min: 0.868 max: 1.173 V-types: 4

## COMMENT

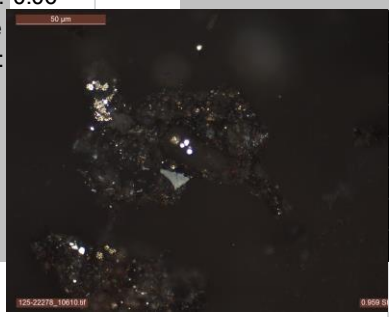
## SAMPLE INFORMATION

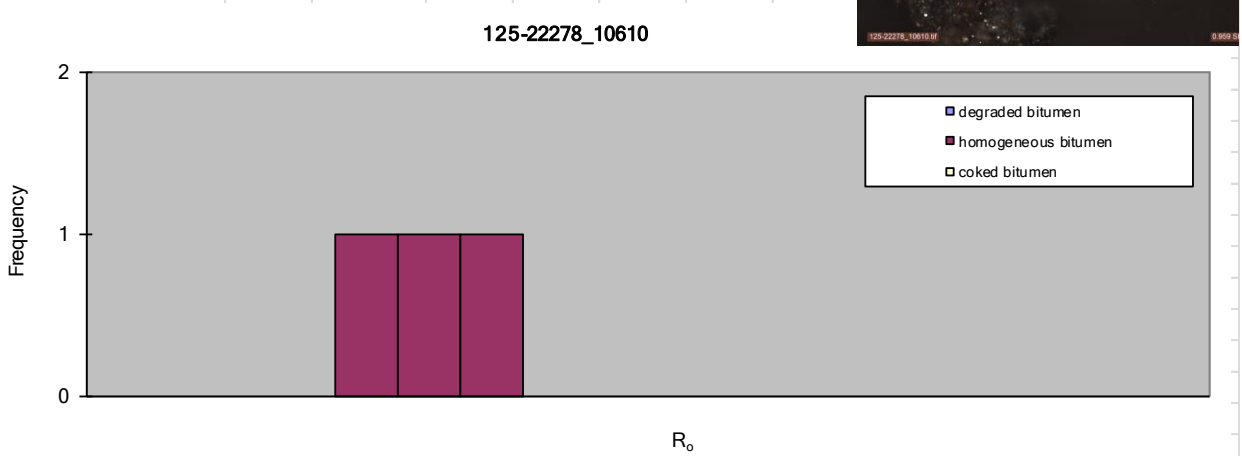
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10610 |
| Lab ID: | 125-22278_10610 |
| Sample Type: | shale |
| Date Analyzed: | 11/6/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 3 |
| maceral type: | bitumen |
| $R_o$: | 0.96 |
| s.d.: | 0.06 |

Example Photograph:






## DATA

| |
|---|
| 0.889 |
| 0.959 |
| 1.024 |

**All Data:** min: 0.889 max: 1.024

**Vitrinite Only:** min: 0.889 max: 1.024 V-types: 3

## COMMENT

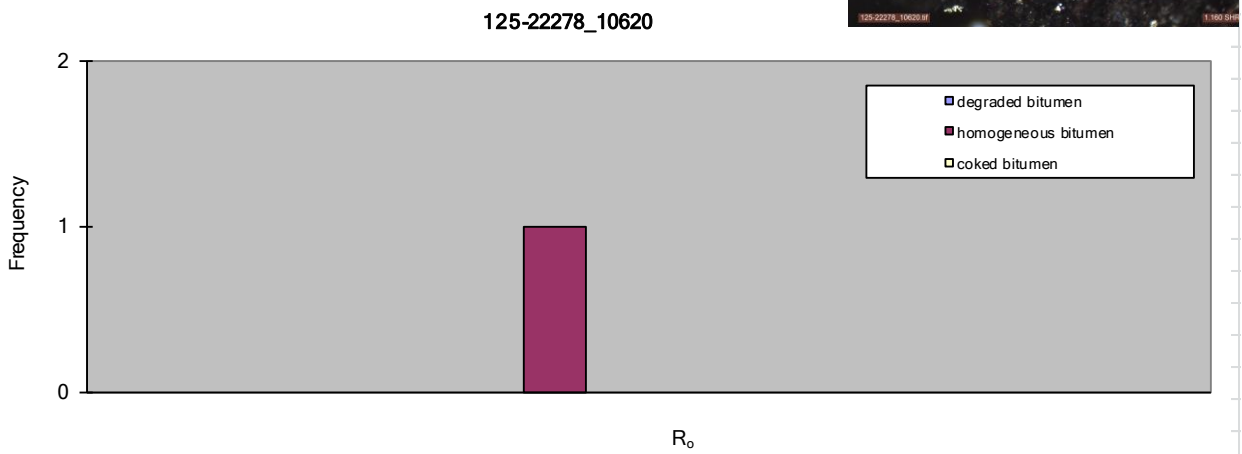
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10620 |
| Lab ID: | 125-22278_1062 |
| Sample Type: | shale |
| Date Analyzed: | 11/7/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 1 |
| maceral type: | bitumen |
| $R_o$: | 1.16 |
| s.d.: | 0.00 |

Example Photograph:


## DATA

| |
|---|
| 1.160 |

**All Data:** min: 1.160 max: 1.160

**Vitrinite Only:** min: 1.160 max: 1.160 V-types: 1

## COMMENT

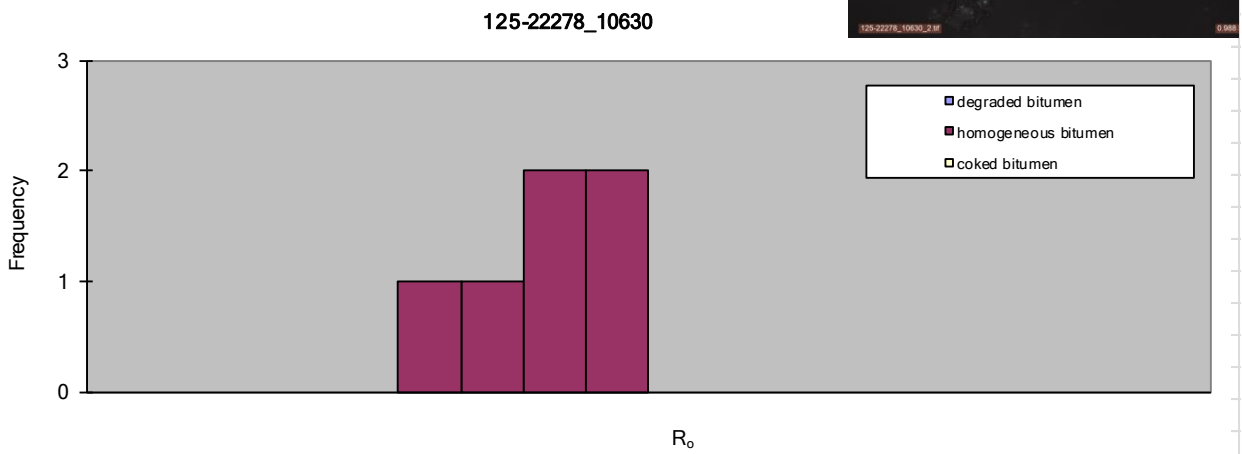
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10630 |
| Lab ID: | 125-22278_1063 |
| Sample Type: | shale |
| Date Analyzed: | 11/7/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 6 |
| maceral type: | bitumen |
| $R_o$: | 1.14 |
| s.d.: | 0.10 |

Example Photograph:


## DATA

| |
|---|
| 0.988 |
| 1.059 |
| 1.105 |
| 1.166 |
| 1.232 |
| 1.277 |

**All Data:** min: 0.988 max: 1.277

**Vitrinite Only:** min: 0.988 max: 1.277 V-types: 4

## COMMENT

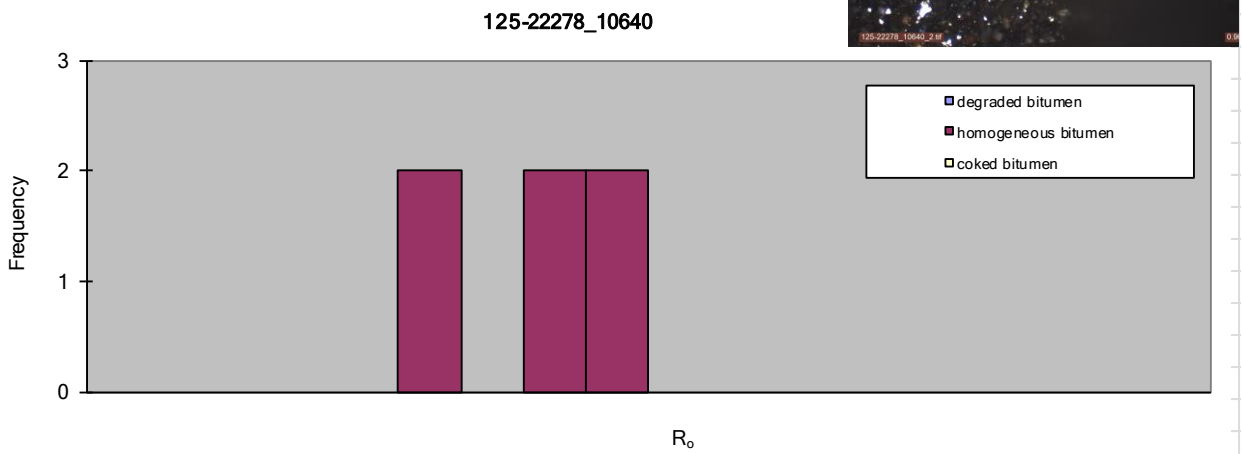
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Consortium |
| Sample ID: | 125-22278_10640 |
| Lab ID: | 125-22278_1064 |
| Sample Type: | shale |
| Date Analyzed: | 11/7/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 6 |
| maceral type: | bitumen |
| $R_o$: | 1.11 |
| s.d.: | 0.13 |

Example Photograph:




## DATA

| |
|---|
| 0.930 |
| 0.961 |
| 1.123 |
| 1.173 |
| 1.213 |
| 1.276 |

**All Data:** min: 0.930 max: 1.276

**Vitrinite Only:** min: 0.930 max: 1.276 V-types: 4

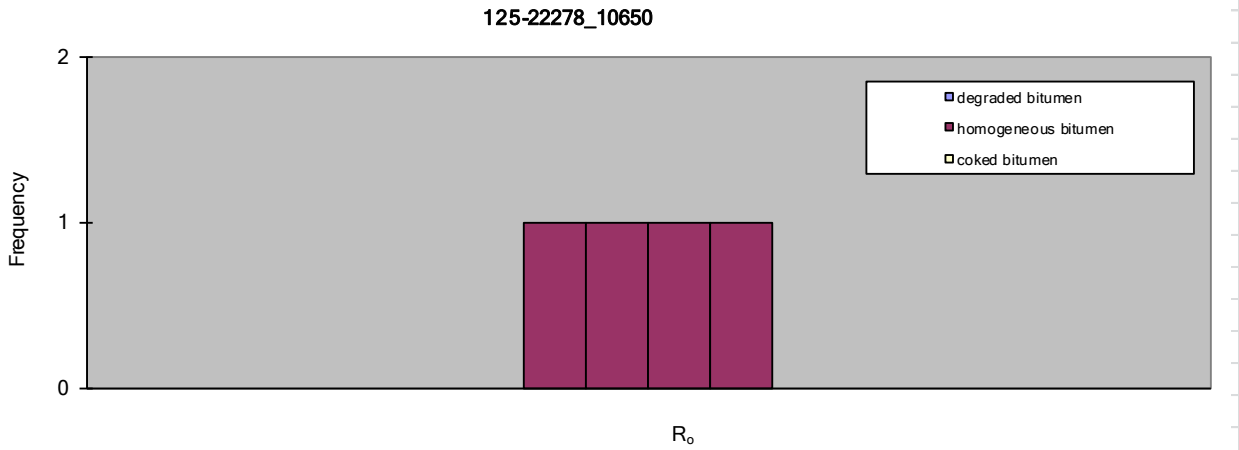
## COMMENT

## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Project |
| Sample ID: | 125-22278_10650 |
| Lab ID: | 125-22278_1065 |
| Sample Type: | shale |
| Date Analyzed: | 11/7/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 4 |
| maceral type: | bitumen |
| $R_o$: | 1.31 |
| s.d.: | 0.10 |
| Example Photograph: | N/A |




## DATA

| |
|---|
| 1.172 |
| 1.255 |
| 1.372 |
| 1.432 |

**All Data:** min: 1.172 max: 1.432

**Vitrinite Only:** min: 1.172 max: 1.432 V-types: 4

## COMMENT

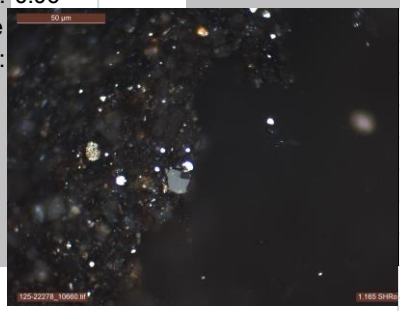
## SAMPLE INFORMATION

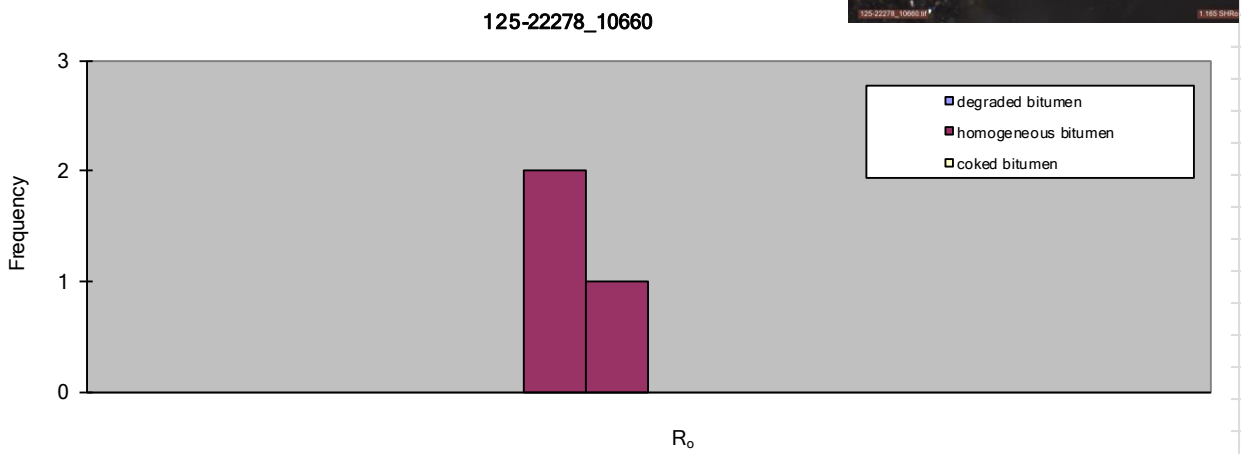
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10660 |
| Lab ID: | 125-22278_1066 |
| Sample Type: | shale |
| Date Analyzed: | 11/7/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 3 |
| maceral type: | bitumen |
| $R_o$: | 1.20 |
| s.d.: | 0.06 |

Example Photograph:






## DATA

| |
|---|
| 1.164 |
| 1.165 |
| 1.284 |

**All Data:** min: 1.164 max: 1.284

**Vitrinite Only:** min: 1.164 max: 1.284 V-types: 2

## COMMENT

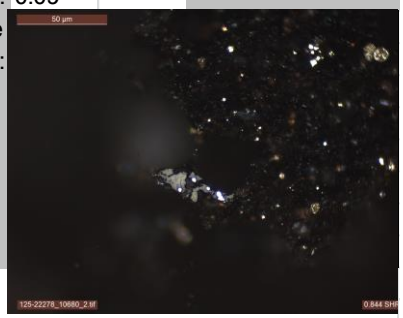
## SAMPLE INFORMATION

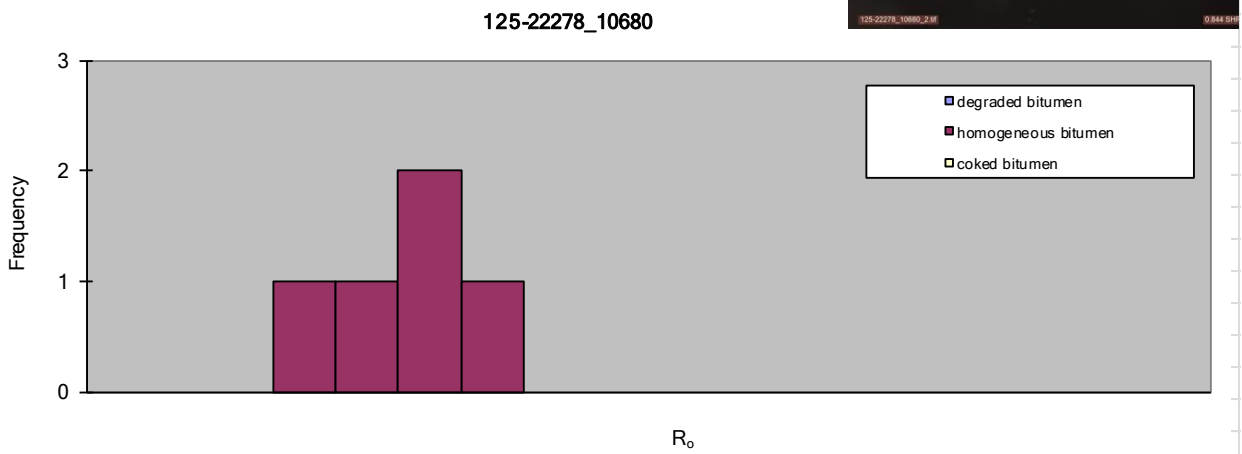
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10680 |
| Lab ID: | 125-22278_1068 |
| Sample Type: | shale |
| Date Analyzed: | 11/13/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 5 |
| maceral type: | bitumen |
| $R_o$: | 0.90 |
| s.d.: | 0.09 |

Example Photograph:






## DATA

| |
|---|
| 0.768 |
| 0.844 |
| 0.908 |
| 0.971 |
| 1.033 |

**All Data:** **min:** 0.768 **max:** 1.033

**Vitrinite Only:** **min:** 0.768 **max:** 1.033 **V-types:** 4

## COMMENT

Standard: YAG [0.901]; Some fill structures. Hardly any large macerals.

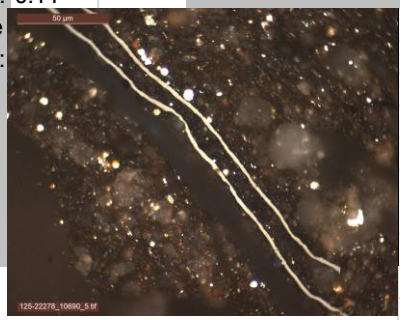
## SAMPLE INFORMATION

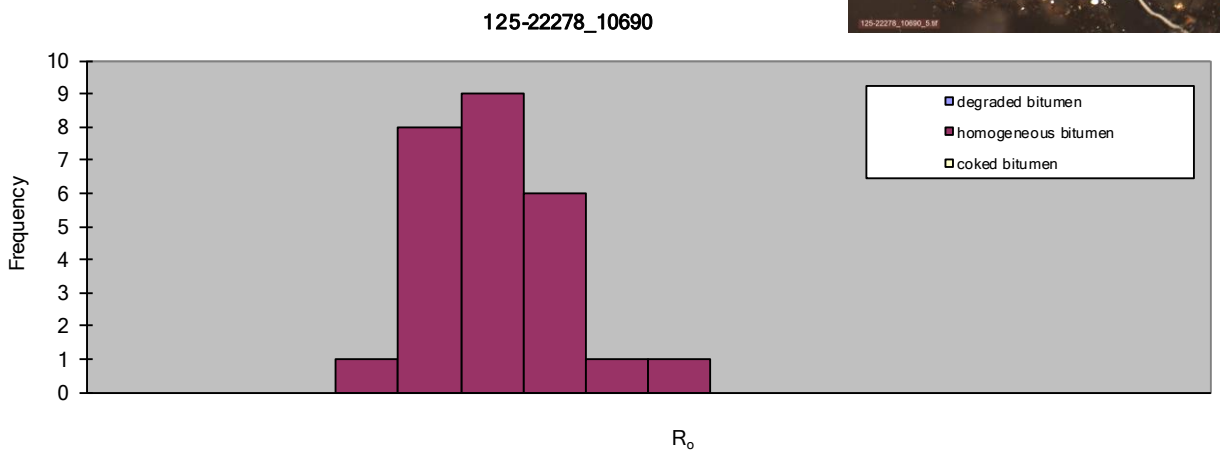
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10690 |
| Lab ID: | 125-22278_1069 |
| Sample Type: | shale |
| Date Analyzed: | 11/13/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 26 |
| maceral type: | bitumen |
| $R_o$: | 1.06 |
| s.d.: | 0.11 |

Example Photograph:






## DATA

| | | |
|---|---|---|
| 0.856 | 1.026 | 1.128 |
| 0.902 | 1.048 | 1.139 |
| 0.954 | 1.055 | 1.168 |
| 0.973 | 1.067 | 1.176 |
| 0.974 | 1.068 | 1.270 |
| 0.982 | 1.083 | 1.369 |
| 0.984 | 1.089 | |
| 0.988 | 1.097 | |
| 0.997 | 1.104 | |
| 1.007 | 1.127 | |

**All Data:** **min:** 0.856 **max:** 1.369

**Vitrinite Only:** **min:** 0.856 **max:** 1.369 **V-types:** 6

## COMMENT

Standard: YAG [0.901]; Some fossil fragments. A few scattered but very large macerals.

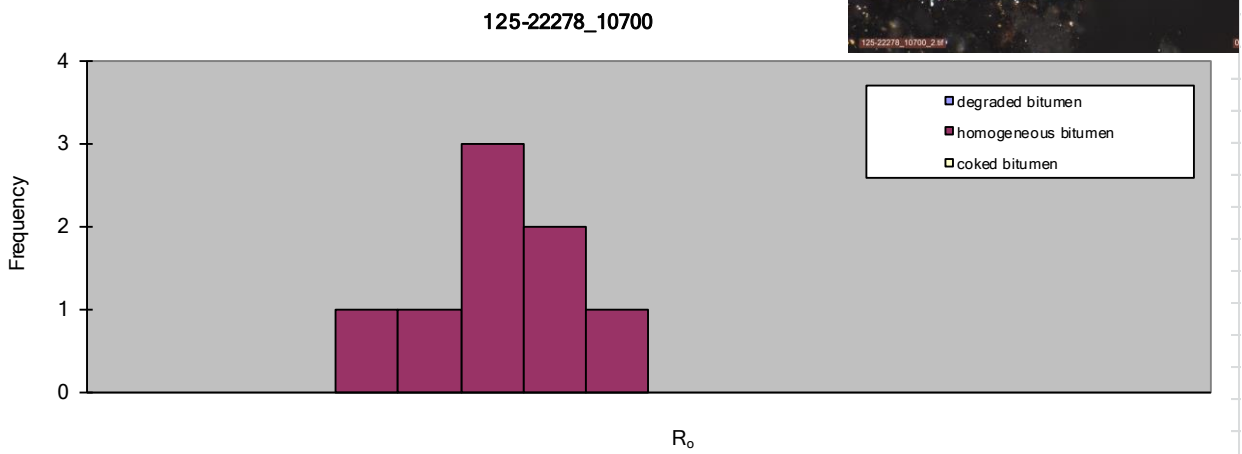
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10700 |
| Lab ID: | 125-22278_107( |
| Sample Type: | shale |
| Date Analyzed: | 11/13/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 8 |
| maceral type: | bitumen |
| $R_o$: | 1.07 |
| s.d.: | 0.11 |

Example Photograph:




## DATA

| |
|---|
| 0.879 |
| 0.970 |
| 1.027 |
| 1.085 |
| 1.098 |
| 1.108 |
| 1.119 |
| 1.286 |

**All Data:** min: 0.879 max: 1.286

**Vitrinite Only:** min: 0.879 max: 1.286 V-types: 5

## COMMENT

Standard: YAG [0.901]; Very lean

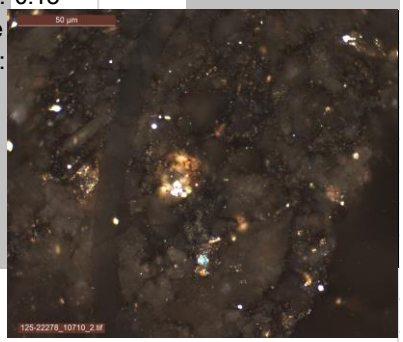
## SAMPLE INFORMATION

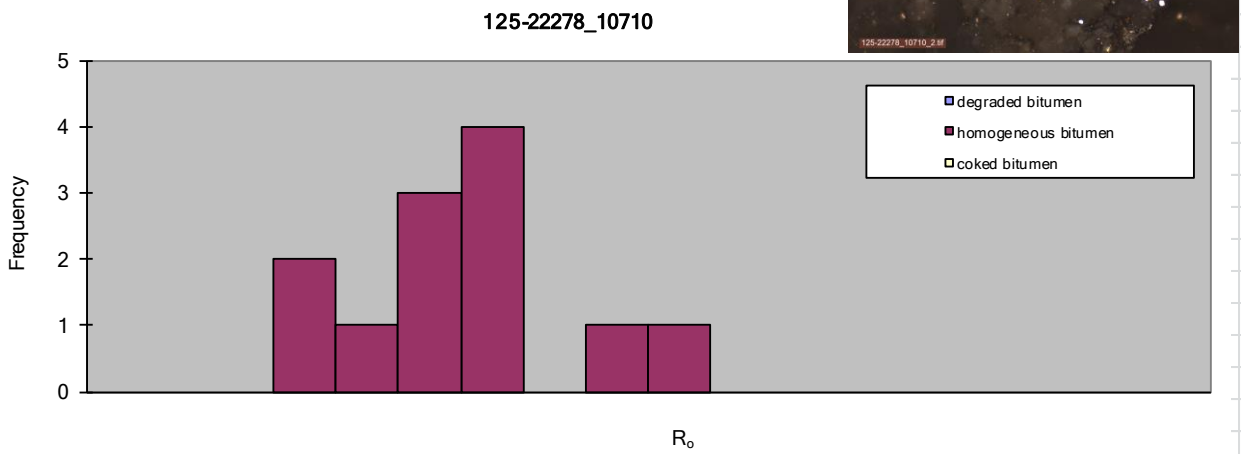
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10710 |
| Lab ID: | 125-22278_107 |
| Sample Type: | shale |
| Date Analyzed: | 11/13/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 12 |
| maceral type: | bitumen |
| $R_o$: | 1.00 |
| s.d.: | 0.15 |

Example Photograph:




## DATA

| | |
|---|---|
| 0.763 | 1.217 |
| 0.791 | 1.303 |
| 0.869 | |
| 0.933 | |
| 0.949 | |
| 0.989 | |
| 1.026 | |
| 1.051 | |
| 1.060 | |
| 1.066 | |

**All Data:** **min:** 0.763 **max:** 1.303

**Vitrinite Only:** **min:** 0.763 **max:** 1.303 **V-types:** 7

## COMMENT

Standard: YAG [0.901]; Not a lof of bitumen, but a lot of fossil fragments.

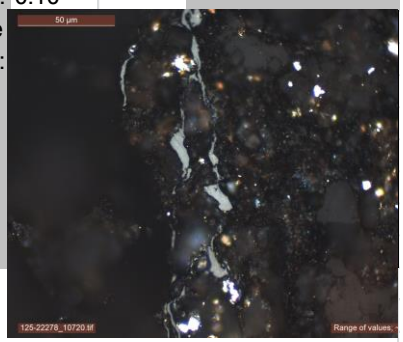
## SAMPLE INFORMATION

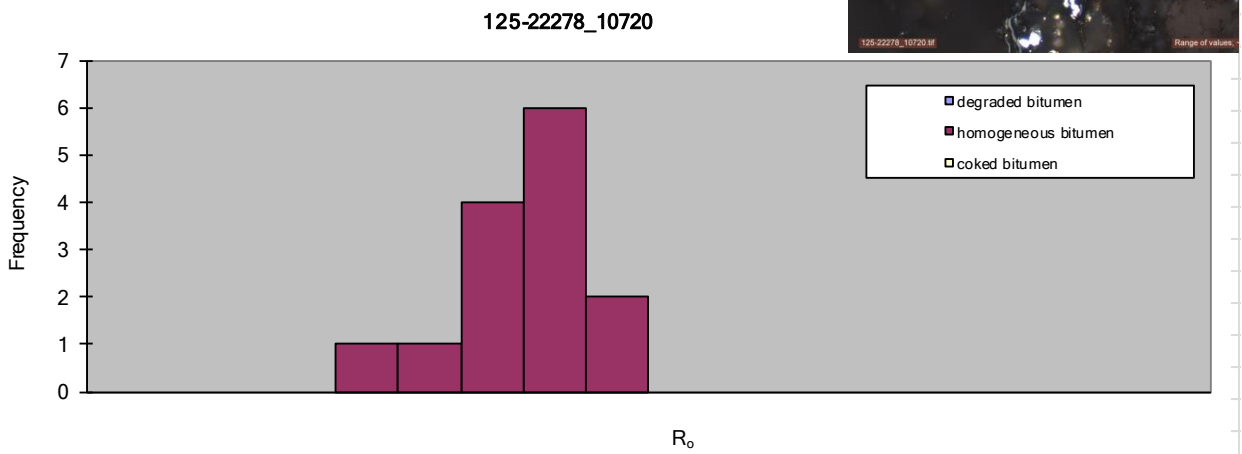
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10720 |
| Lab ID: | 125-22278_1072 |
| Sample Type: | shale |
| Date Analyzed: | 11/13/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 14 |
| maceral type: | bitumen |
| $R_o$: | 1.10 |
| s.d.: | 0.10 |

Example Photograph:




## DATA

| | |
|---|---|
| 0.874 | 1.143 |
| 0.954 | 1.191 |
| 1.012 | 1.221 |
| 1.038 | 1.298 |
| 1.096 | |
| 1.099 | |
| 1.101 | |
| 1.114 | |
| 1.124 | |
| 1.128 | |

**All Data:** **min:** 0.874 **max:** 1.298

**Vitrinite Only:** **min:** 0.874 **max:** 1.298 **V-types:** 5

## COMMENT

Standard: YAG [0.901]; fossil fragments and some larger macerals.

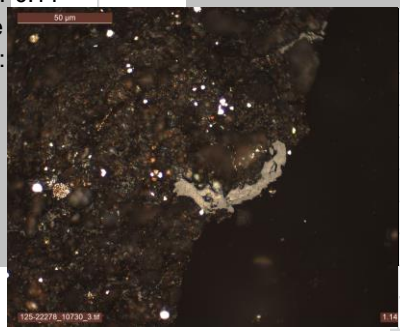
## SAMPLE INFORMATION

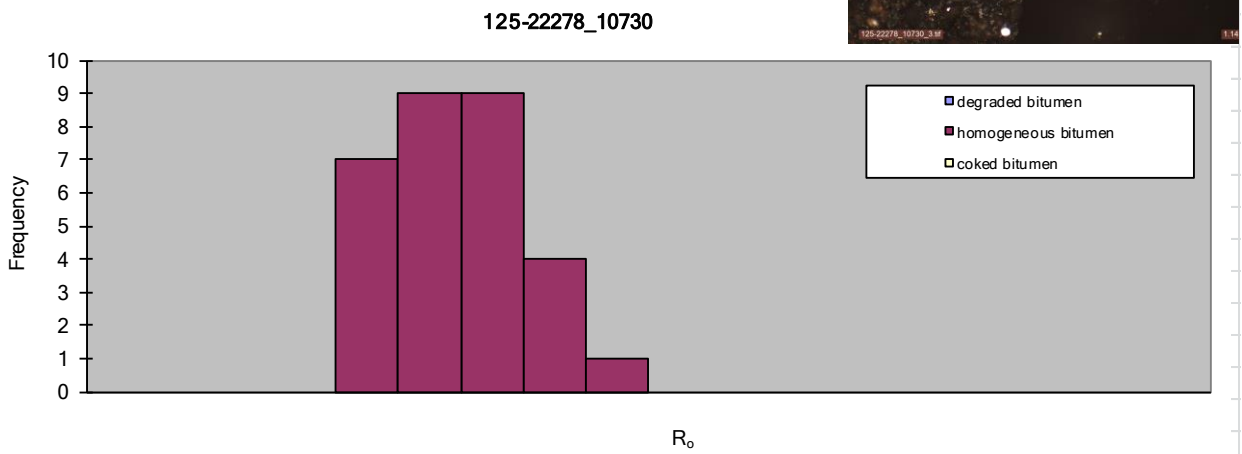
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10730 |
| Lab ID: | 125-22278_1073 |
| Sample Type: | shale |
| Date Analyzed: | 11/14/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 30 |
| maceral type: | bitumen |
| $R_o$: | 1.00 |
| s.d.: | 0.11 |

Example Photograph:






## DATA

| | | |
|---|---|---|
| 0.803 | 0.931 | 1.067 |
| 0.805 | 0.959 | 1.086 |
| 0.829 | 0.968 | 1.086 |
| 0.873 | 0.985 | 1.090 |
| 0.878 | 0.989 | 1.091 |
| 0.895 | 0.989 | 1.100 |
| 0.899 | 1.006 | 1.138 |
| 0.910 | 1.013 | 1.141 |
| 0.925 | 1.032 | 1.155 |
| 0.931 | 1.049 | 1.266 |

**All Data:** min: 0.803 max: 1.266

**Vitrinite Only:** min: 0.803 max: 1.266 V-types: 5

## COMMENT

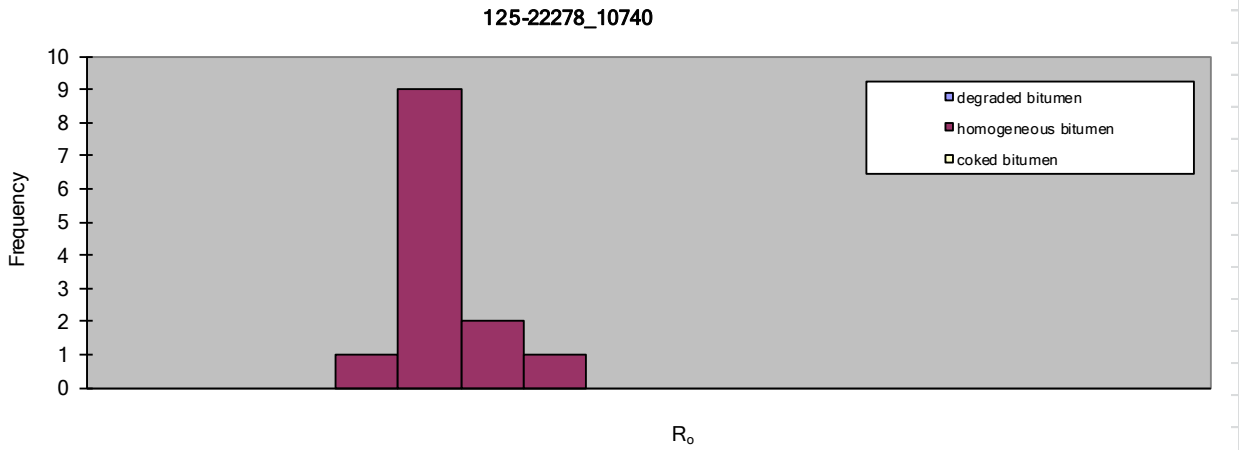
Standard: YAG [0.901]; fossil fragments; fill stcutures; abundant bitumen macerals.

## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10740 |
| Lab ID: | 125-22278_107 |
| Sample Type: | shale |
| Date Analyzed: | 11/14/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 13 |
| maceral type: | bitumen |
| $R_o$: | 0.97 |
| s.d.: | 0.06 |
| Example Photograph: | N/A |




## DATA

| | |
|---|---|
| 0.830 | 1.000 |
| 0.919 | 1.008 |
| 0.933 | 1.116 |
| 0.942 | |
| 0.951 | |
| 0.969 | |
| 0.969 | |
| 0.970 | |
| 0.989 | |
| 0.993 | |

**All Data:** min: 0.830 max: 1.116

**Vitrinite Only:** min: 0.830 max: 1.116 V-types: 4

## COMMENT

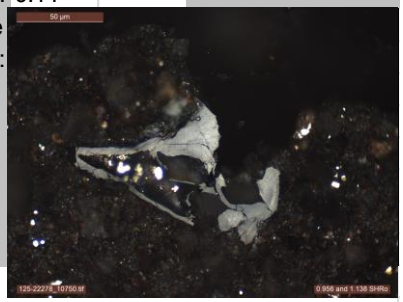
## SAMPLE INFORMATION

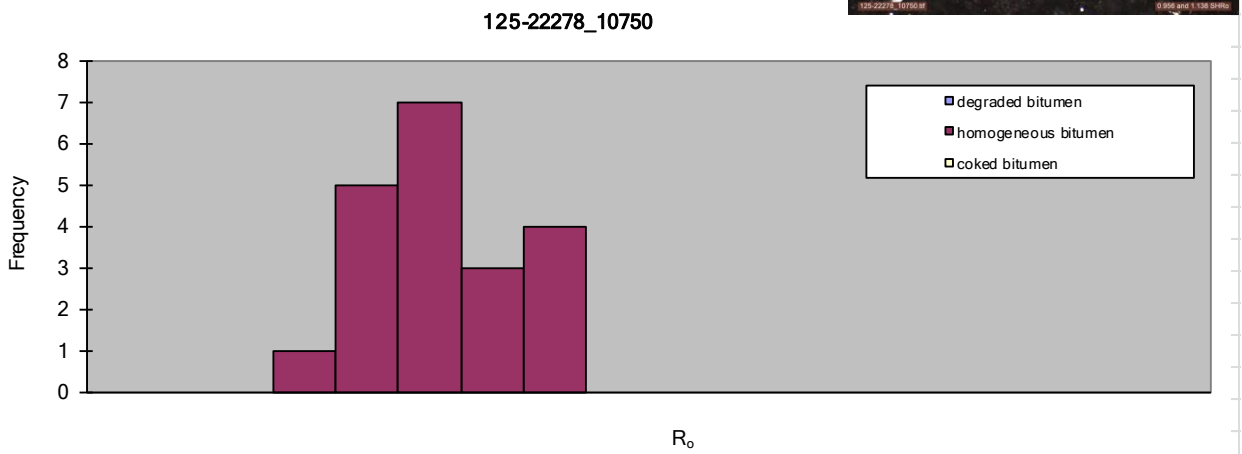
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10750 |
| Lab ID: | 125-22278_1075 |
| Sample Type: | shale |
| Date Analyzed: | 11/14/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 20 |
| maceral type: | bitumen |
| $R_o$: | 0.97 |
| s.d.: | 0.11 |

Example Photograph:






## DATA

| | |
|---|---|
| 0.788 | 0.962 |
| 0.839 | 0.971 |
| 0.845 | 0.991 |
| 0.849 | 1.027 |
| 0.873 | 1.053 |
| 0.882 | 1.066 |
| 0.916 | 1.102 |
| 0.920 | 1.126 |
| 0.942 | 1.135 |
| 0.956 | 1.138 |

**All Data:** **min:** 0.788 **max:** 1.138

**Vitrinite Only:** **min:** 0.788 **max:** 1.138 **V-types:** 5

## COMMENT

Standard: AYG [0.901]; Abundant fossil fragments.

## DISPERSED VITRINITE REFLECTANCE REPORT

Run

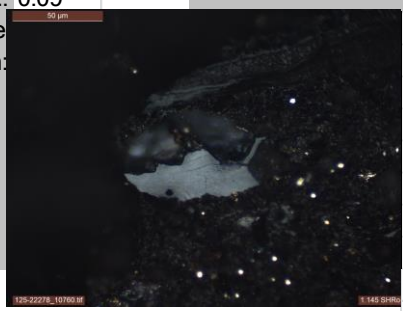
### SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | Range Resources |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Consortium |
| Sample ID: | 125-22278_10760 |
| Lab ID: | 125-22278_1076 |
| Sample Type: | shale |
| Date Analyzed: | 11/14/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

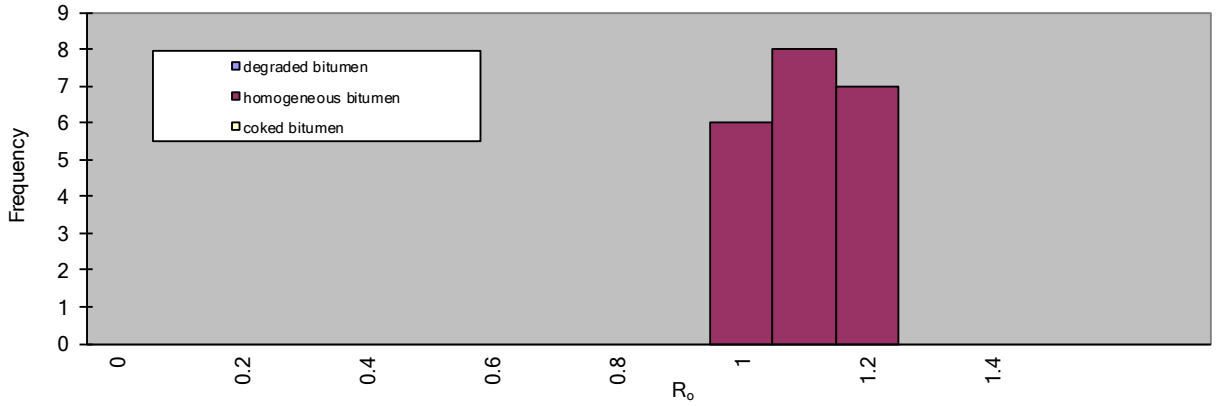
### RESULTS

| | |
|---|---|
| No. measurements: | 24 |
| maceral type: | bitumen |
| $R_o$: | 1.07 |
| s.d.: | 0.09 |

Example Photograph:



125-22278_10760




### DATA

| | | |
|---|---|---|
| 0.910 | 1.079 | 1.149 |
| 0.924 | 1.088 | 1.220 |
| 0.944 | 1.090 | 1.248 |
| 0.963 | 1.093 | 1.253 |
| 0.979 | 1.100 | |
| 0.979 | 1.107 | |
| 1.023 | 1.118 | |
| 1.025 | 1.124 | |
| 1.029 | 1.131 | |
| 1.073 | 1.145 | |

**All Data:** min: 0.910 max: 1.253

**Vitrinite Only:** min: 0.910 max: 1.253 V-types: 4

### COMMENT

Small fossil fragments; larger bitumen macerals and some small fill structures; most appear homogeneous

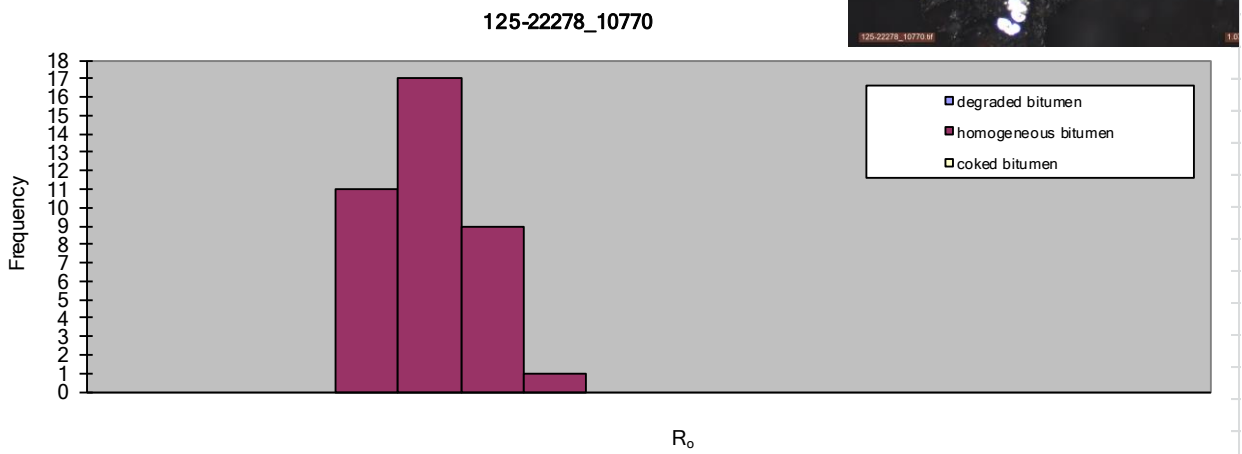
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10770 |
| Lab ID: | 125-22278_1077 |
| Sample Type: | shale |
| Date Analyzed: | 11/14/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 38 |
| maceral type: | bitumen |
| $R_o$: | 0.94 |
| s.d.: | 0.08 |

Example Photograph:


## DATA

| | | | |
|---|---|---|---|
| 0.801 | 0.897 | 0.934 | 1.038 |
| 0.813 | 0.901 | 0.935 | 1.043 |
| 0.824 | 0.909 | 0.936 | 1.065 |
| 0.830 | 0.911 | 0.954 | 1.072 |
| 0.832 | 0.916 | 0.958 | 1.072 |
| 0.846 | 0.917 | 0.960 | 1.089 |
| 0.857 | 0.917 | 0.975 | 1.091 |
| 0.869 | 0.919 | 0.991 | 1.105 |
| 0.878 | 0.927 | 1.003 | |
| 0.883 | 0.931 | 1.009 | |

**All Data:** **min:** 0.801 **max:** 1.105

**Vitrinite Only:** **min:** 0.801 **max:** 1.105 **V-types:** 4

## COMMENT

Standards: YAG [0.901]; Abundant bitumen macerals of all shapes and sizes.

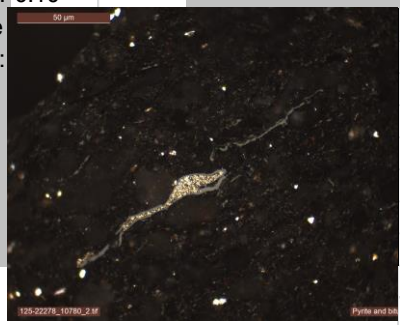
## SAMPLE INFORMATION

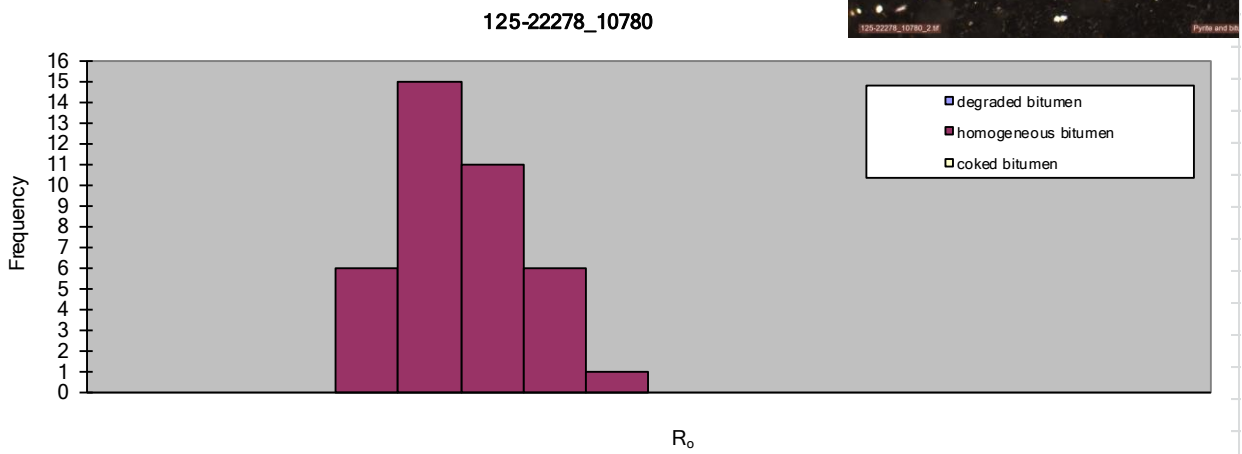
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10780 |
| Lab ID: | 125-22278_1078 |
| Sample Type: | shale |
| Date Analyzed: | 11/15/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 39 |
| maceral type: | bitumen |
| $R_o$: | 1.00 |
| s.d.: | 0.10 |

Example Photograph:




## DATA

| | | | |
|---|---|---|---|
| 0.810 | 0.936 | 0.998 | 1.064 |
| 0.827 | 0.950 | 1.004 | 1.094 |
| 0.831 | 0.953 | 1.008 | 1.105 |
| 0.843 | 0.968 | 1.021 | 1.107 |
| 0.866 | 0.979 | 1.022 | 1.118 |
| 0.870 | 0.983 | 1.024 | 1.142 |
| 0.921 | 0.984 | 1.027 | 1.151 |
| 0.932 | 0.984 | 1.037 | 1.176 |
| 0.934 | 0.991 | 1.040 | 1.212 |
| 0.934 | 0.991 | 1.042 | |

**All Data:** **min:** 0.810 **max:** 1.212

**Vitrinite Only:** **min:** 0.810 **max:** 1.212 **V-types:** 5

## COMMENT

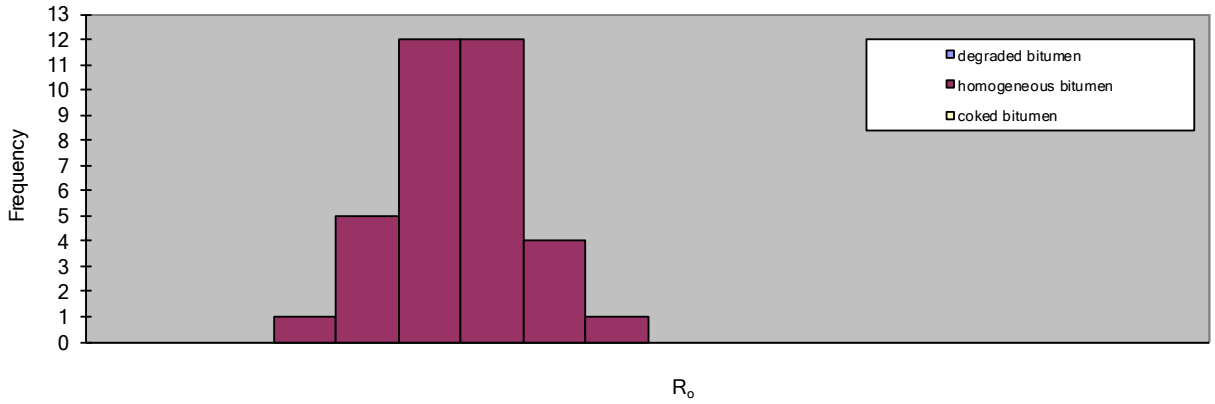
Standard: YAG [0.901]; Abundant pyrite and bitumen; large macerals and fill structures.

## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Consortium |
| Sample ID: | 125-22278_10790 |
| Lab ID: | 125-22278_1079( |
| Sample Type: | shale |
| Date Analyzed: | 11/15/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 35 |
| maceral type: | bitumen |
| $R_o$: | 1.00 |
| s.d.: | 0.10 |
| Example Photograph: | N/A |




## DATA

| | | | |
|---|---|---|---|
| 0.757 | 0.949 | 1.017 | 1.107 |
| 0.847 | 0.950 | 1.020 | |
| 0.871 | 0.968 | 1.029 | 1.150 |
| 0.878 | 0.970 | 1.034 | 1.195 |
| 0.889 | 0.978 | 1.053 | 1.215 |
| 0.896 | 0.985 | 1.056 | |
| 0.925 | 0.990 | 1.065 | |
| 0.930 | 0.998 | 1.067 | |
| 0.935 | 1.000 | 1.092 | |
| 0.942 | 1.001 | 1.098 | |

**All Data:** min: 0.757 max: 1.215

**Vitrinite Only:** min: 0.757 max: 1.215 V-types: 6

## COMMENT

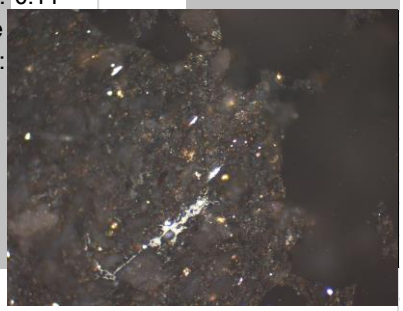
## SAMPLE INFORMATION

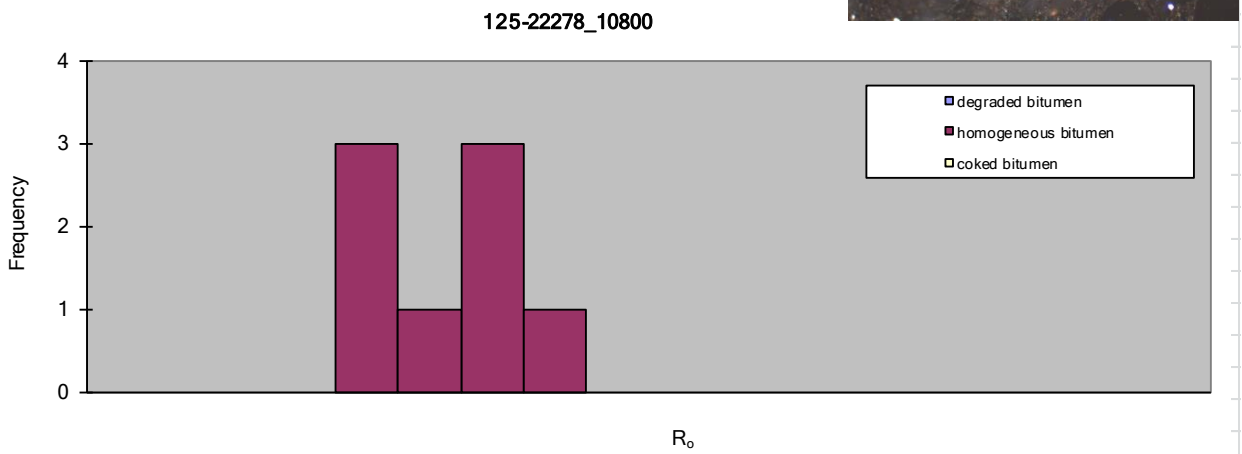
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10800 |
| Lab ID: | 125-22278_108( |
| Sample Type: | Shale |
| Date Analyzed: | 11/15/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 8 |
| maceral type: | bitumen |
| $R_o$: | 0.99 |
| s.d.: | 0.11 |

Example Photograph:






## DATA

| |
|---|
| 0.850 |
| 0.883 |
| 0.890 |
| 0.988 |
| 1.022 |
| 1.035 |
| 1.043 |
| 1.216 |

**All Data:** min: 0.850 max: 1.216

**Vitrinite Only:** min: 0.850 max: 1.216 V-types: 5

## COMMENT

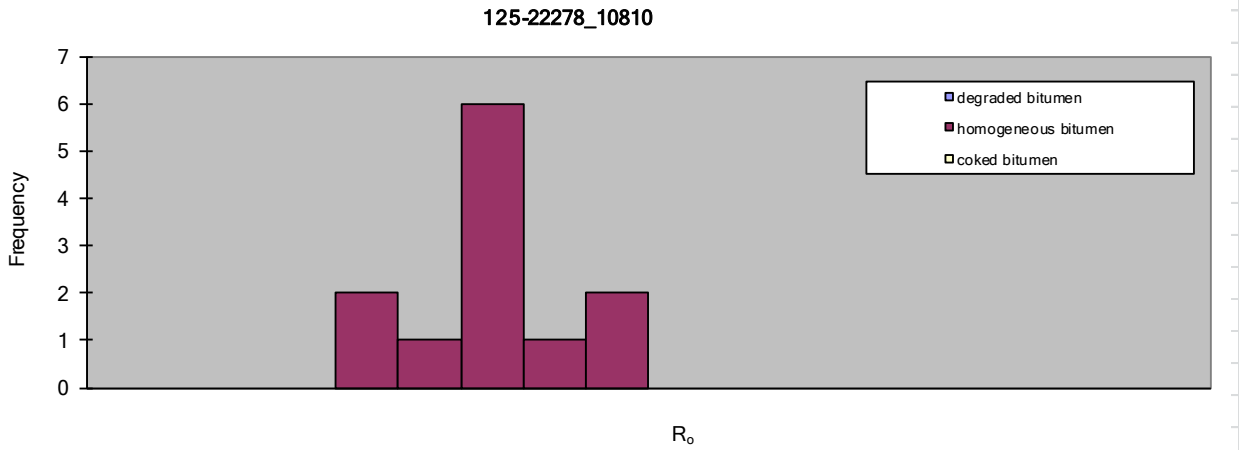
Standard: YAG [0.901]; very small fill structures

## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10810 |
| Lab ID: | 125-22278_108 |
| Sample Type: | shale |
| Date Analyzed: | 11/15/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 12 |
| maceral type: | bitumen |
| $R_o$: | 1.06 |
| s.d.: | 0.11 |
| Example Photograph: | N/A |




## DATA

| | |
|---|---|
| 0.878 | 1.203 |
| 0.889 | 1.256 |
| 0.997 | |
| 1.031 | |
| 1.035 | |
| 1.064 | |
| 1.075 | |
| 1.086 | |
| 1.096 | |
| 1.121 | |

**All Data:** min: 0.878 max: 1.256

**Vitrinite Only:** min: 0.878 max: 1.256 V-types: 5

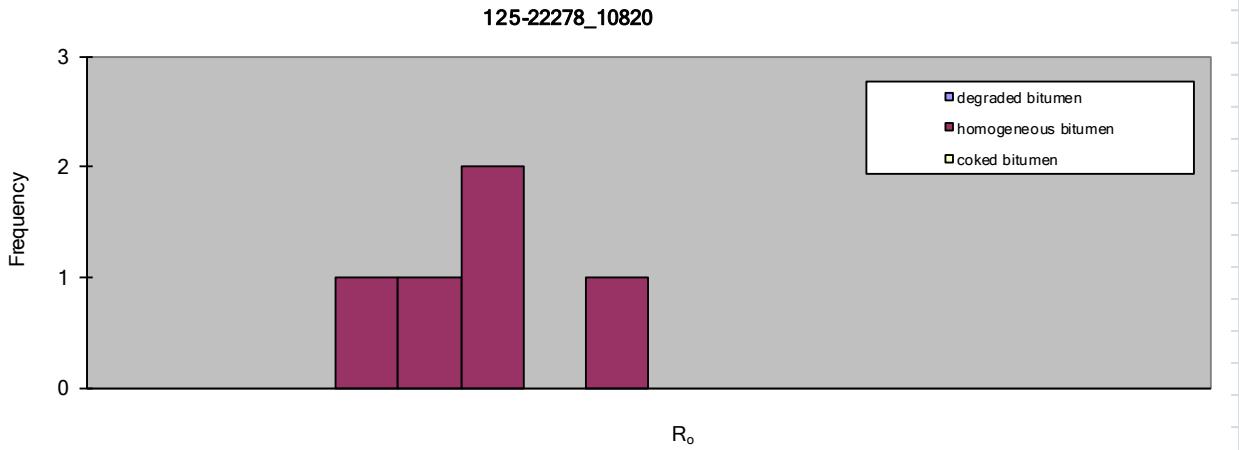
## COMMENT

## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10820 |
| Lab ID: | 125-22278_1082 |
| Sample Type: | shale |
| Date Analyzed: | 11/15/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 5 |
| maceral type: | bitumen |
| $R_o$: | 1.04 |
| s.d.: | 0.14 |
| Example Photograph: | N/A |




## DATA

| |
|---|
| 0.868 |
| 0.964 |
| 1.004 |
| 1.059 |
| 1.292 |

**All Data:** min: 0.868 max: 1.292

**Vitrinite Only:** min: 0.868 max: 1.292 V-types: 5

## COMMENT

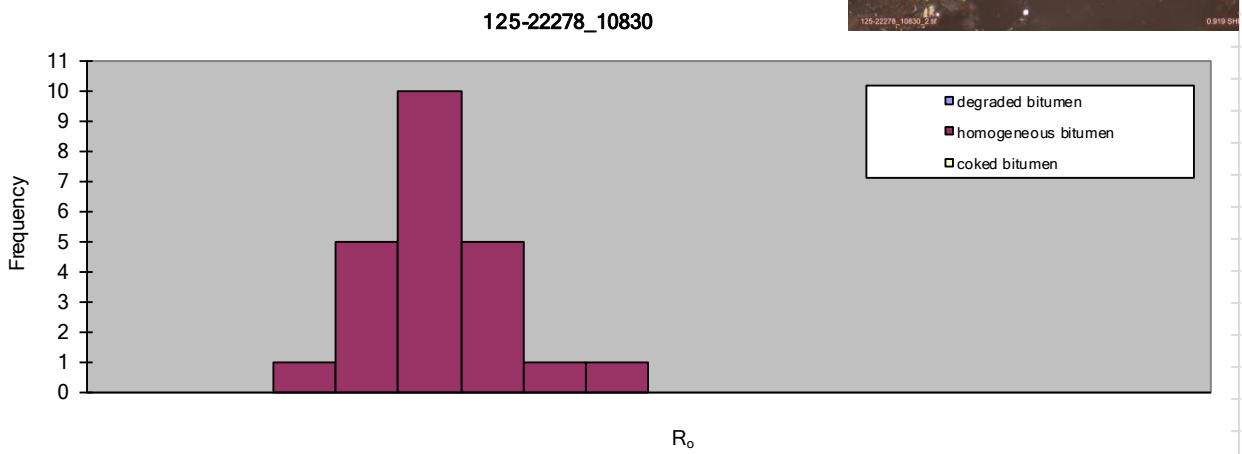
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10830 |
| Lab ID: | 125-22278_1083 |
| Sample Type: | shale |
| Date Analyzed: | 11/18/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 23 |
| maceral type: | bitumen |
| $R_o$: | 0.96 |
| s.d.: | 0.11 |

Example Photograph:




## DATA

| | | |
|---|---|---|
| 0.733 | 0.940 | 1.086 |
| 0.829 | 0.942 | 1.140 |
| 0.846 | 0.945 | 1.242 |
| 0.873 | 0.974 | |
| 0.885 | 0.983 | |
| 0.894 | 0.985 | |
| 0.901 | 1.031 | |
| 0.905 | 1.033 | |
| 0.915 | 1.037 | |
| 0.919 | 1.070 | |

**All Data:** **min:** 0.733 **max:** 1.242

**Vitrinite Only:** **min:** 0.733 **max:** 1.242 **V-types:** 6

## COMMENT

Standard: YAG [0.901]; Small fill structures; large macerals but reflectance values seem fairly low. Abundant fill structures - most too small to measure.

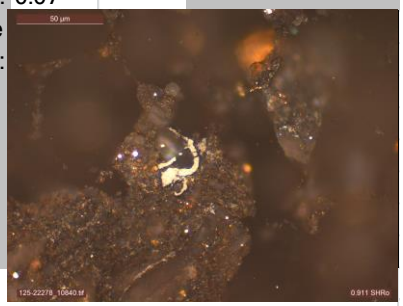
## SAMPLE INFORMATION

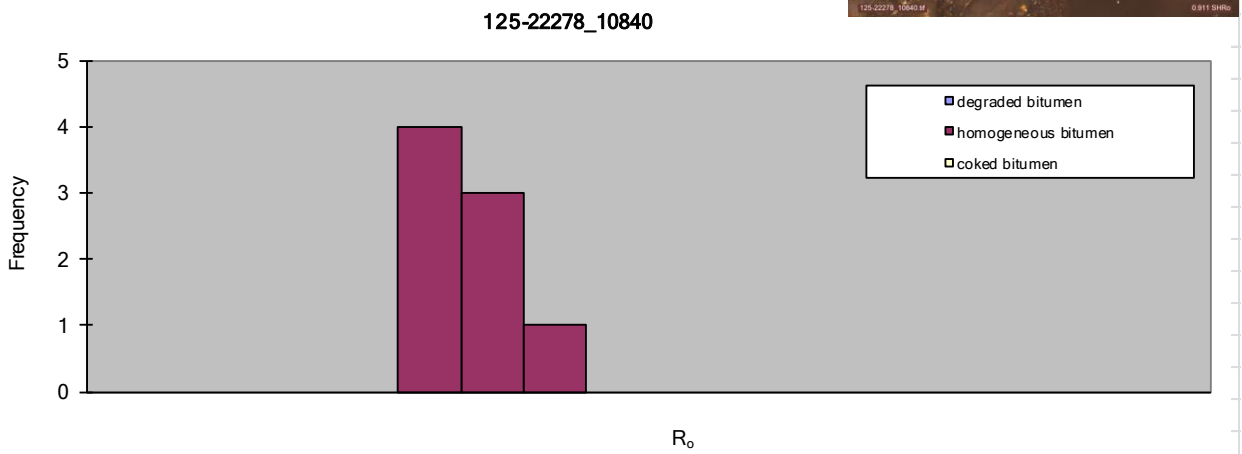
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10840 |
| Lab ID: | 125-22278_108 |
| Sample Type: | shale |
| Date Analyzed: | 11/18/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 8 |
| maceral type: | bitumen |
| $R_o$: | 1.01 |
| s.d.: | 0.07 |

Example Photograph:






## DATA

| |
|---|
| 0.911 |
| 0.932 |
| 0.932 |
| 0.995 |
| 1.017 |
| 1.059 |
| 1.091 |
| 1.123 |

**All Data:** **min:** 0.911 **max:** 1.123

**Vitrinite Only:** **min:** 0.911 **max:** 1.123 **V-types:** 3

## COMMENT

Standard: YAG [0.901]; Small fill sturctures but very lean.

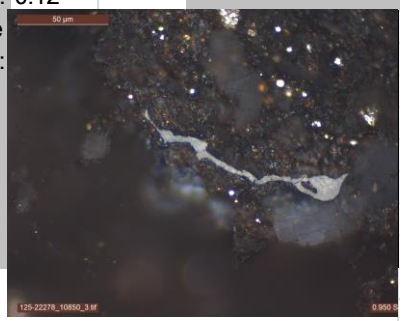
## SAMPLE INFORMATION

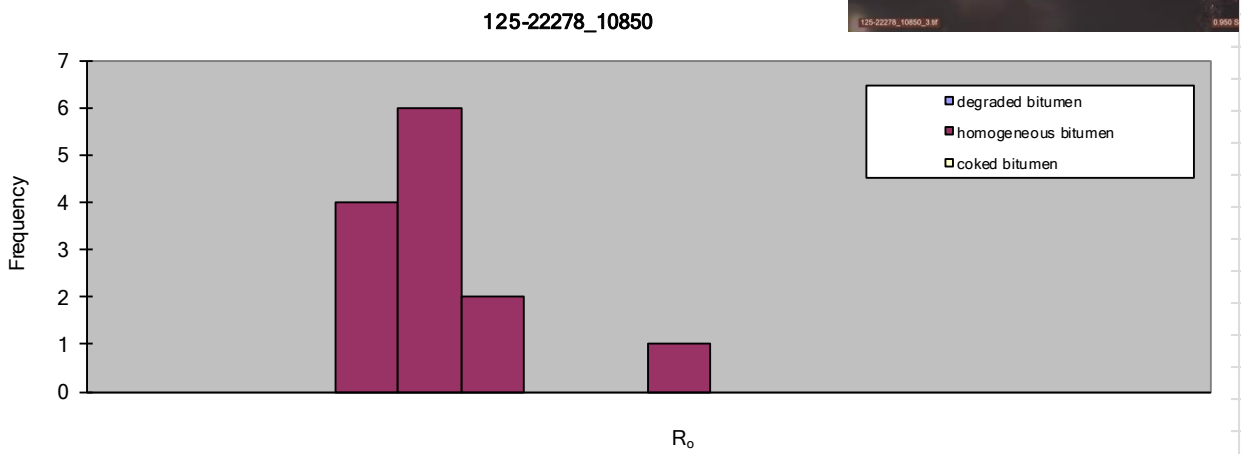
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10850 |
| Lab ID: | 125-22278_1085 |
| Sample Type: | shale |
| Date Analyzed: | 11/18/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 13 |
| maceral type: | bitumen |
| $R_o$: | 0.97 |
| s.d.: | 0.12 |

Example Photograph:






## DATA

| | |
|---|---|
| 0.811 | 1.025 |
| 0.875 | 1.047 |
| 0.883 | 1.313 |
| 0.891 | |
| 0.929 | |
| 0.950 | |
| 0.955 | |
| 0.956 | |
| 0.991 | |
| 0.991 | |

**All Data:** min: 0.811 max: 1.313

**Vitrinite Only:** min: 0.811 max: 1.313 V-types: 6

## COMMENT

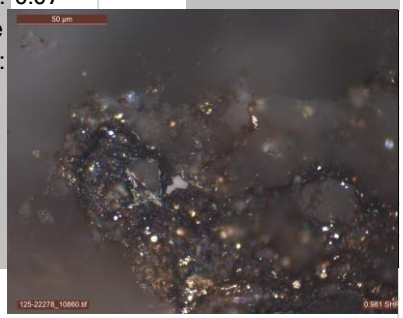
## SAMPLE INFORMATION

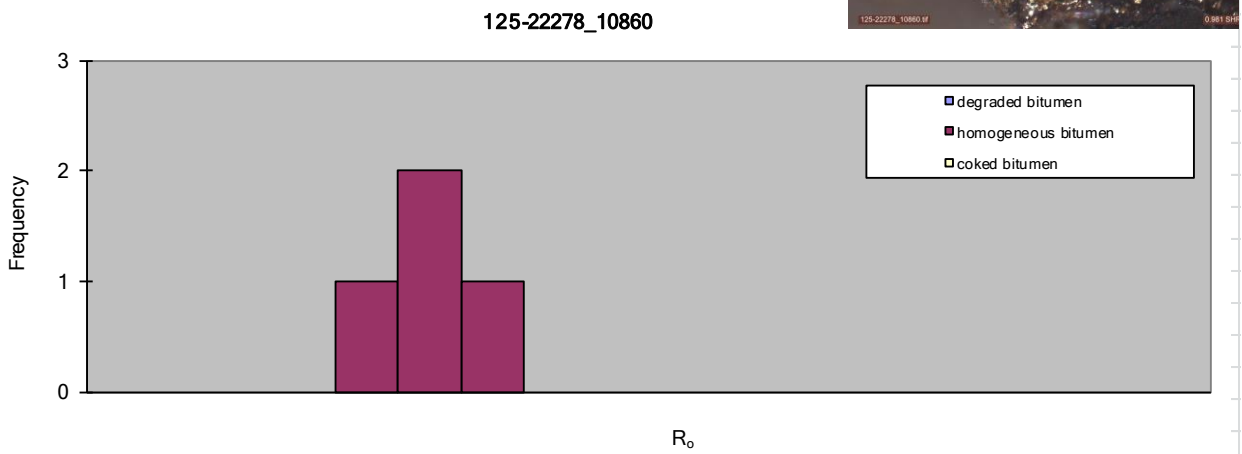
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10860 |
| Lab ID: | 125-22278_1086 |
| Sample Type: | shale |
| Date Analyzed: | 11/18/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 4 |
| maceral type: | bitumen |
| $R_o$: | 0.94 |
| s.d.: | 0.07 |

Example Photograph:




## DATA

| |
|---|
| 0.834 |
| 0.926 |
| 0.981 |
| 1.022 |

**All Data:** min: 0.834 max: 1.022

**Vitrinite Only:** min: 0.834 max: 1.022 V-types: 3

## COMMENT

Standard: YAG [0.901]; Large, red unknowns

Starvaggi - API# 3712522278 - Washington County, PA

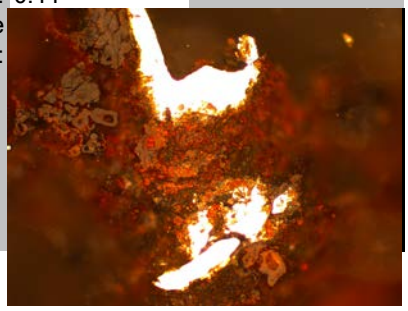
## SAMPLE INFORMATION

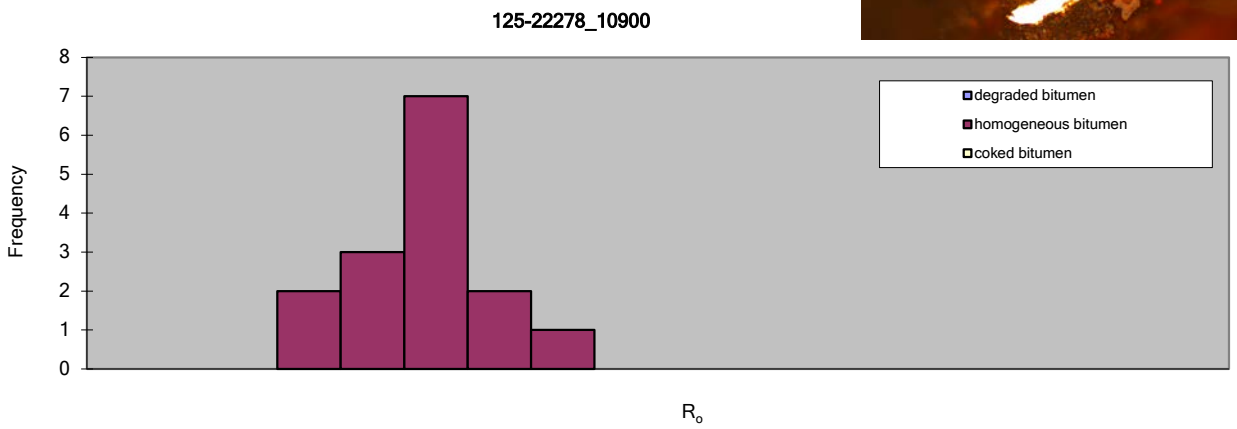
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10900 |
| Lab ID: | 125-22278_10900 |
| Sample Type: | shale |
| Date Analyzed: | 11/18/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 16 |
| maceral type: | bitumen |
| $R_o$: | 0.95 |
| s.d.: | 0.11 |

Example Photograph:






## DATA

| | |
|---|---|
| 0.779 | 0.968 |
| 0.794 | 0.982 |
| 0.807 | 1.078 |
| 0.859 | 1.088 |
| 0.869 | 1.108 |
| 0.918 | 1.113 |
| 0.929 | |
| 0.932 | |
| 0.950 | |
| 0.961 | |

**All Data:** **min:** 0.779 **max:** 1.113

**Vitrinite Only:** **min:** 0.779 **max:** 1.113 **V-types:** 5

## COMMENT

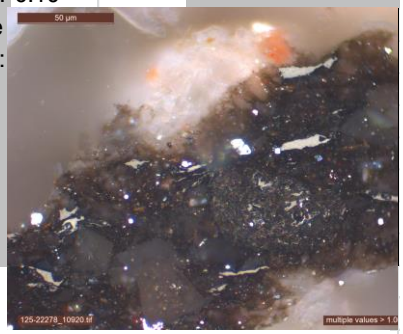
## SAMPLE INFORMATION

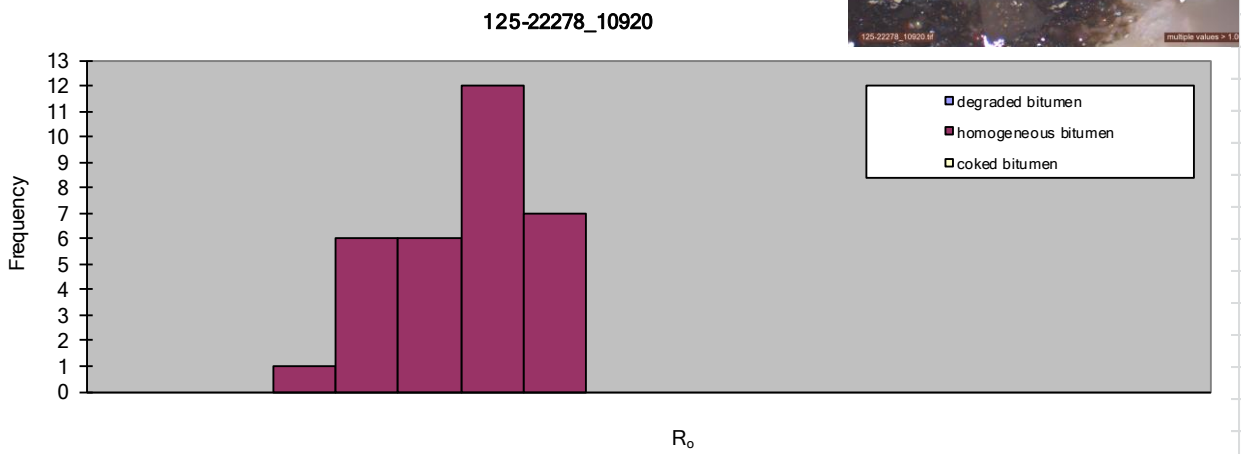
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10920 |
| Lab ID: | 125-22278_1092 |
| Sample Type: | shale |
| Date Analyzed: | 11/18/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 32 |
| maceral type: | bitumen |
| $R_o$: | 1.01 |
| s.d.: | 0.10 |

Example Photograph:






## DATA

| | | | |
|---|---|---|---|
| 0.797 | 0.967 | 1.050 | 1.141 |
| 0.836 | 0.984 | 1.062 | 1.142 |
| 0.850 | 0.988 | 1.080 | |
| 0.866 | 1.004 | 1.083 | |
| 0.872 | 1.017 | 1.084 | |
| 0.889 | 1.020 | 1.119 | |
| 0.894 | 1.026 | 1.120 | |
| 0.909 | 1.035 | 1.122 | |
| 0.948 | 1.036 | 1.126 | |
| 0.959 | 1.042 | 1.131 | |

**All Data:** **min:** 0.797 **max:** 1.142

**Vitrinite Only:** **min:** 0.797 **max:** 1.142 **V-types:** 5

## COMMENT

Standard: YAG [0.901]; Abundant, small macerals. Less clay mineral assemblages and more carbonate.

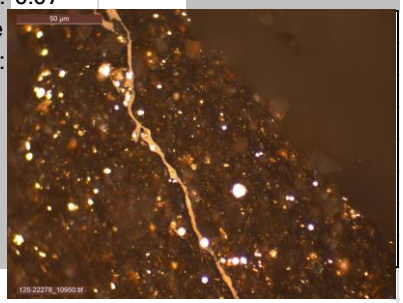
## SAMPLE INFORMATION

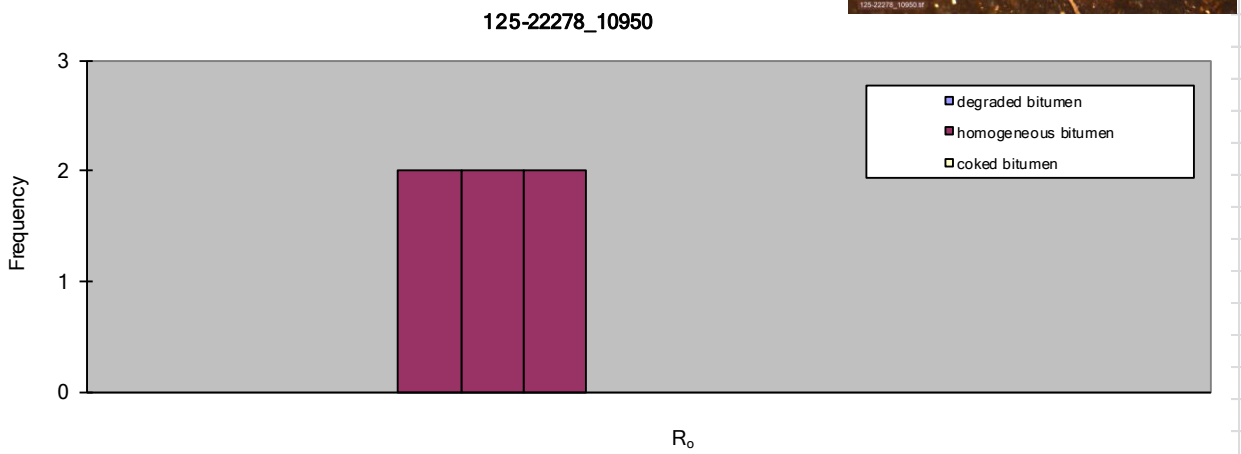
| | |
|---|---|
| Submitted by: | M.Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10950 |
| Lab ID: | 125-22278_1095 |
| Sample Type: | shale |
| Date Analyzed: | 11/18/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 6 |
| maceral type: | bitumen |
| $R_o$: | 1.04 |
| s.d.: | 0.07 |

Example Photograph:






## DATA

| |
|---|
| 0.952 |
| 0.957 |
| 1.006 |
| 1.077 |
| 1.100 |
| 1.132 |

**All Data:** min: 0.952 max: 1.132

**Vitrinite Only:** min: 0.952 max: 1.132 V-types: 3

## COMMENT

Starvaggi – API# 3712522278 – Washington County, PA

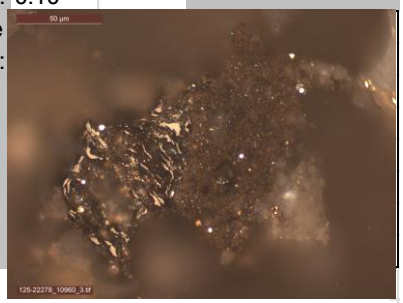
## SAMPLE INFORMATION

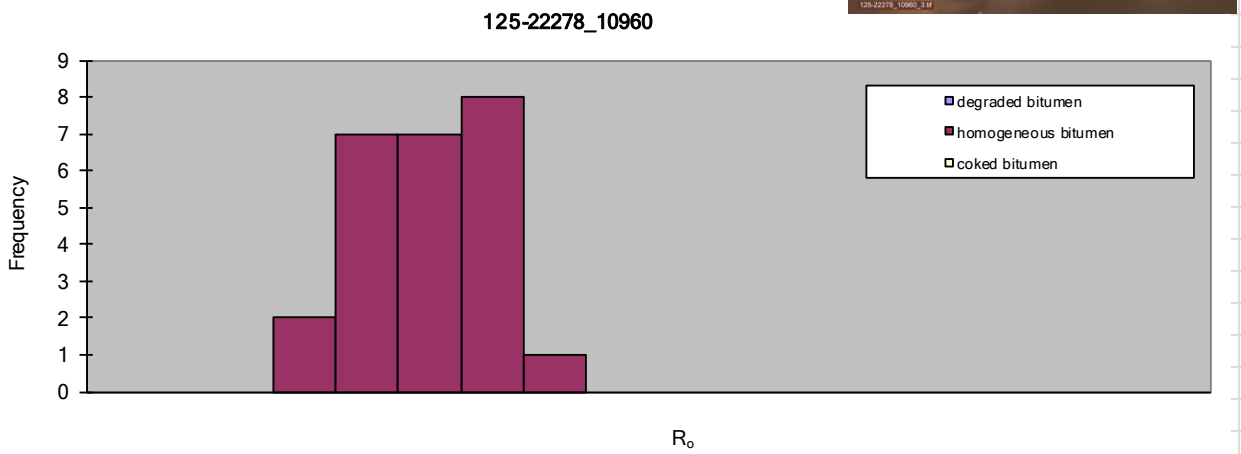
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10960 |
| Lab ID: | 125-22278_1096 |
| Sample Type: | shale |
| Date Analyzed: | 11/18/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 25 |
| maceral type: | bitumen |
| $R_o$: | 0.94 |
| s.d.: | 0.10 |

Example Photograph:






## DATA

| | | |
|---|---|---|
| 0.704 | 0.932 | 1.047 |
| 0.780 | 0.964 | 1.056 |
| 0.801 | 0.967 | 1.072 |
| 0.824 | 0.972 | 1.074 |
| 0.834 | 0.992 | 1.103 |
| 0.857 | 0.994 | |
| 0.860 | 1.016 | |
| 0.863 | 1.023 | |
| 0.895 | 1.025 | |
| 0.921 | 1.032 | |

**All Data:** **min:** 0.704 **max:** 1.103

**Vitrinite Only:** **min:** 0.704 **max:** 1.103 **V-types:** 5

## COMMENT

Standards: YAG [0.901]; Most macerals appear to be smaller and degraded. Very abundant carbonate.

Starvaggi – API# 3712522278 – Washington County, PA

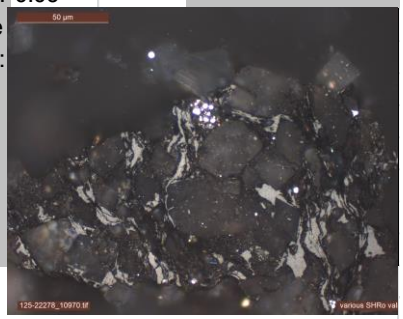
## SAMPLE INFORMATION

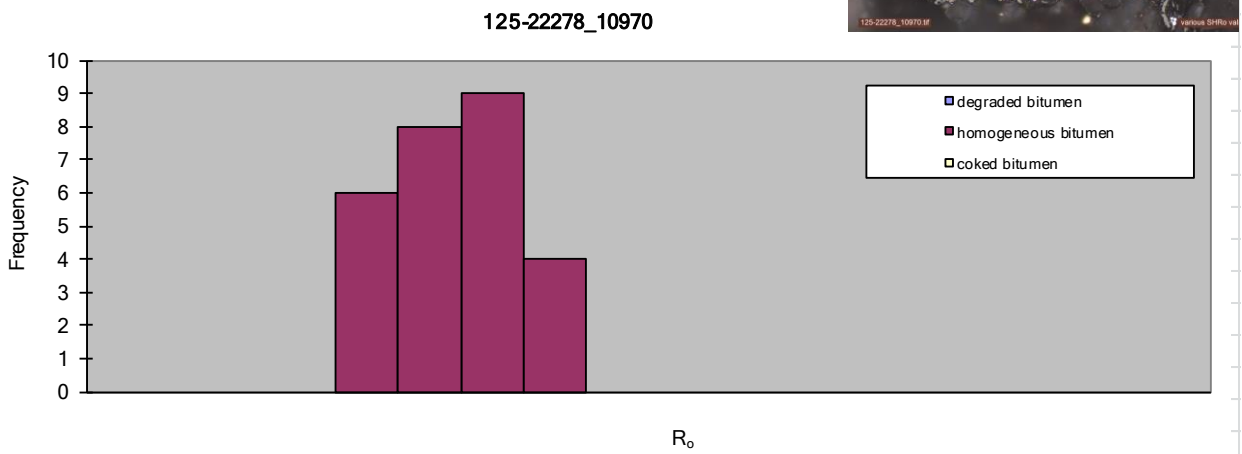
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10970 |
| Lab ID: | 125-22278_1097 |
| Sample Type: | shale |
| Date Analyzed: | 11/18/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 27 |
| maceral type: | bitumen |
| $R_o$: | 0.99 |
| s.d.: | 0.09 |

Example Photograph:






## DATA

| | | |
|---|---|---|
| 0.828 | 0.961 | 1.068 |
| 0.868 | 0.972 | 1.072 |
| 0.887 | 0.983 | 1.076 |
| 0.891 | 0.994 | 1.119 |
| 0.898 | 1.003 | 1.121 |
| 0.899 | 1.011 | 1.142 |
| 0.918 | 1.029 | 1.161 |
| 0.932 | 1.035 | |
| 0.937 | 1.036 | |
| 0.945 | 1.039 | |

**All Data:** **min:** 0.828 **max:** 1.161

**Vitrinite Only:** **min:** 0.828 **max:** 1.161 **V-types:** 4

## COMMENT

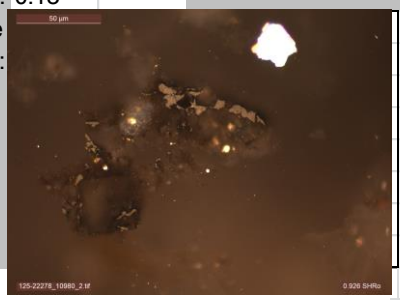
## SAMPLE INFORMATION

| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10980 |
| Lab ID: | 125-22278_1098 |
| Sample Type: | shale |
| Date Analyzed: | 11/19/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

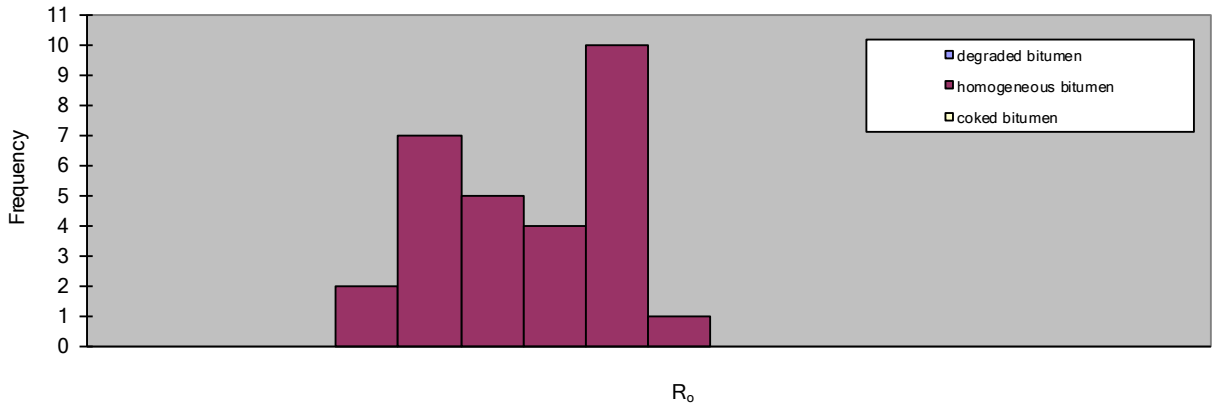
## RESULTS

| | |
|---|---|
| No. measurements: | 29 |
| maceral type: | bitumen |
| $R_o$: | 1.09 |
| s.d.: | 0.13 |

Example Photograph:



125-22278_10980




## DATA

| | | |
|---|---|---|
| 0.865 | 1.039 | 1.208 |
| 0.882 | 1.072 | 1.216 |
| 0.909 | 1.088 | 1.219 |
| 0.917 | 1.132 | 1.220 |
| 0.918 | 1.142 | 1.225 |
| 0.926 | 1.159 | 1.233 |
| 0.967 | 1.184 | 1.245 |
| 0.969 | 1.201 | 1.339 |
| 1.000 | 1.202 | #REF! |
| 1.031 | 1.208 | |

**All Data:** min: #REF! max: #REF!

**Vitrinite Only:** min: 0.865 max: 1.339 V-types: 6

## COMMENT

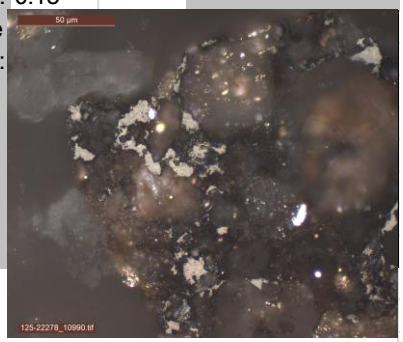
## SAMPLE INFORMATION

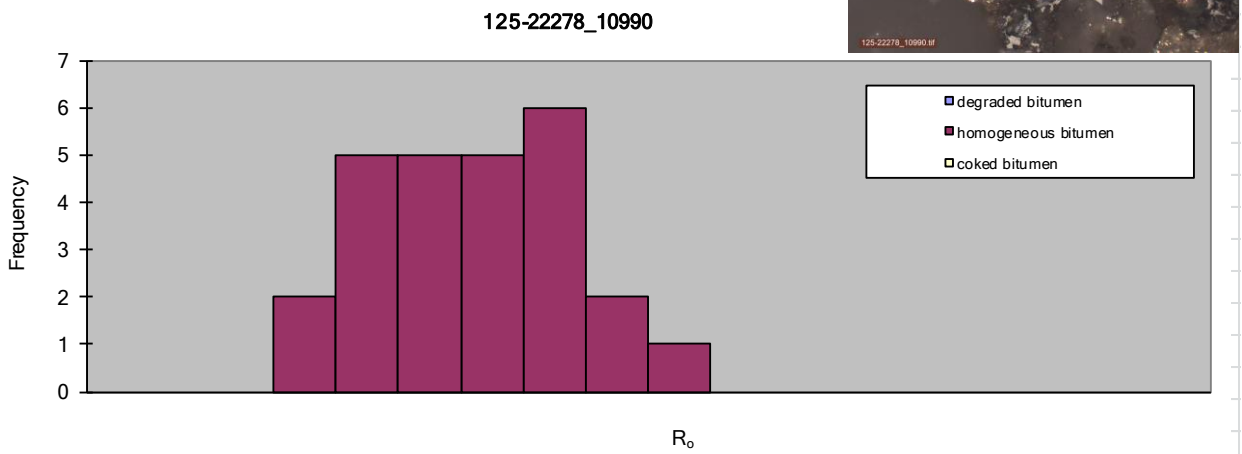
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_10990 |
| Lab ID: | 125-22278_1099 |
| Sample Type: | shale |
| Date Analyzed: | 11/19/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 27 |
| maceral type: | bitumen |
| $R_o$: | 1.03 |
| s.d.: | 0.15 |

Example Photograph:




## DATA

| | | |
|---|---|---|
| 0.764 | 0.982 | 1.146 |
| 0.771 | 0.992 | 1.157 |
| 0.846 | 1.012 | 1.195 |
| 0.855 | 1.047 | 1.196 |
| 0.859 | 1.054 | 1.227 |
| 0.867 | 1.061 | 1.264 |
| 0.883 | 1.074 | 1.344 |
| 0.918 | 1.105 | |
| 0.934 | 1.111 | |
| 0.953 | 1.133 | |

**All Data:** min: 0.764 max: 1.344

**Vitrinite Only:** min: 0.764 max: 1.344 V-types: 7

## COMMENT

Starvaggi – API# 3712522278 – Washington County, PA

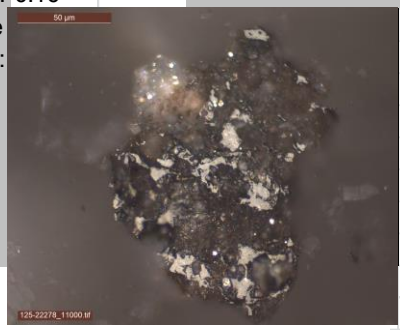
## SAMPLE INFORMATION

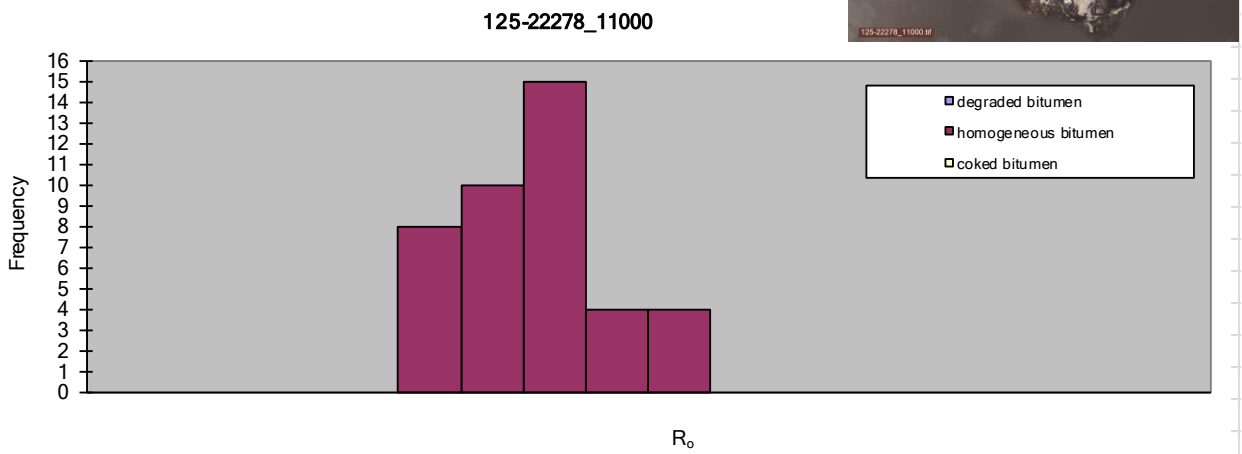
| | |
|---|---|
| Submitted by: | M. Cooney |
| Date Submitted: | 10/16/2013 |
| Project: | Utica Shale Playbook |
| Sample ID: | 125-22278_11000 |
| Lab ID: | 125-22278_1100 |
| Sample Type: | shale |
| Date Analyzed: | 11/19/2013 |
| Operator: | M. Cooney |
| Standard: | ASTM D2798 7708 |

## RESULTS

| | |
|---|---|
| No. measurements: | 41 |
| maceral type: | bitumen |
| $R_o$: | 1.05 |
| s.d.: | 0.16 |

Example Photograph:




## DATA

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.921 | 1.028 | 1.136 | 1.332 | #REF! | | | | | | |
| 0.922 | 1.035 | 1.148 | 1.378 | | | | | | | |
| 0.938 | 1.048 | 1.158 | #REF! | | | | | | | |
| 0.946 | 1.051 | 1.197 | #REF! | | | | | | | |
| 0.967 | 1.059 | 1.224 | #REF! | | | | | | | |
| 0.983 | 1.069 | 1.227 | #REF! | | | | | | | |
| 0.997 | 1.080 | 1.249 | #REF! | | | | | | | |
| 0.999 | 1.092 | 1.282 | #REF! | | | | | | | |
| 1.006 | 1.104 | 1.301 | #REF! | | | | | | | |
| 1.022 | 1.131 | 1.331 | #REF! | | | | | | | |

**All Data:** **min:** #REF! **max:** #REF!

**Vitrinite Only:** **min:** 0.725 **max:** 1.378 **V-types:** 7

## COMMENT