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SUBSURFACE LITHOSTRATIGRAPHY OF THE OIL- AND GAS-PRODUCING REGIONS OF PENNSYLVANIA

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CONTENTS

Page

Introduction 1
Purpose 1
Content 1
Acknowledgments 3
References 4

APPENDIX

(included as separate file)

Appendix 1. Informal names and reservoir activity for selected correlation diagram rock units.

ILLUSTRATIONS

FIGURE

Page

Figure 1. Map of Pennsylvania showing locations of existing oil and gas fields and regions where stratigraphic correlations are generally valid. 2

PLATE

(included as separate file)

Plate 1. Generalized subsurface lithostratigraphic correlation diagram for the oil- and gas-producing regions of Pennsylvania

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INTRODUCTION

This report is provided as a 40th anniversary edition of the *Subsurface Rock Correlation Diagram, Allegheny Plateau, Pennsylvania*, originally authored by Harper (1979) in Pennsylvania Geological Survey Open-File Report OF 79–01. With continued oil and gas activity tracking, reservoir characterization efforts, and subsurface geologic mapping over time, the Survey has periodically revised its stratigraphic interpretations of Pennsylvania's subsurface and evaluated the subsurface geology of larger areas of the state as spurred by oil and gas activity. The second iteration, published by Carter (2007) as Pennsylvania Geological Survey Open-File Report OFOG 07–01.3, was the first digital version of a subsurface stratigraphic correlation diagram for the state, and incorporated relevant content from both state-specific and regional publications, most notably Berg and others (1983), Roen and Walker (1996), and Shultz (1999).

The past 10+ years have seen a significant amount of unconventional shale gas exploration and development in Pennsylvania, along with several research projects that have assessed the state's potential to store greenhouse gases, wastewater, and natural gas liquids in subsurface rocks. The current report integrates data and findings associated with these efforts into the most inclusive subsurface lithostratigraphic correlation diagram yet published for Pennsylvania.

PURPOSE

The purpose of this open-file report is to provide both technical and lay end users a generalized, annotated correlation diagram that shows the relative age, stratigraphic position, naming conventions, and reservoir activity for subsurface rocks in the oil- and gas-producing regions of Pennsylvania. The correlation chart illustrates subsurface lithostratigraphic units that are generally present in northwestern, southwestern, south-central–central, and north-central–northeastern areas of the state, excepting the Broad Top bituminous coal field in south-central Pennsylvania and anthracite coal fields in northeastern Pennsylvania (Figure 1).

CONTENT

This open-file report contains the Survey's current interpretations of subsurface lithostratigraphy and reservoir activity for the western and northern regions of Pennsylvania where oil and gas exploration and development have taken place. This content is based on both the routine oil and gas well document interpretive work performed by Survey geolo-

gists in the Exploration and Development Well Information Network (EDWIN) and the findings of multiple projects with which the Survey has been active since the early 2000s.

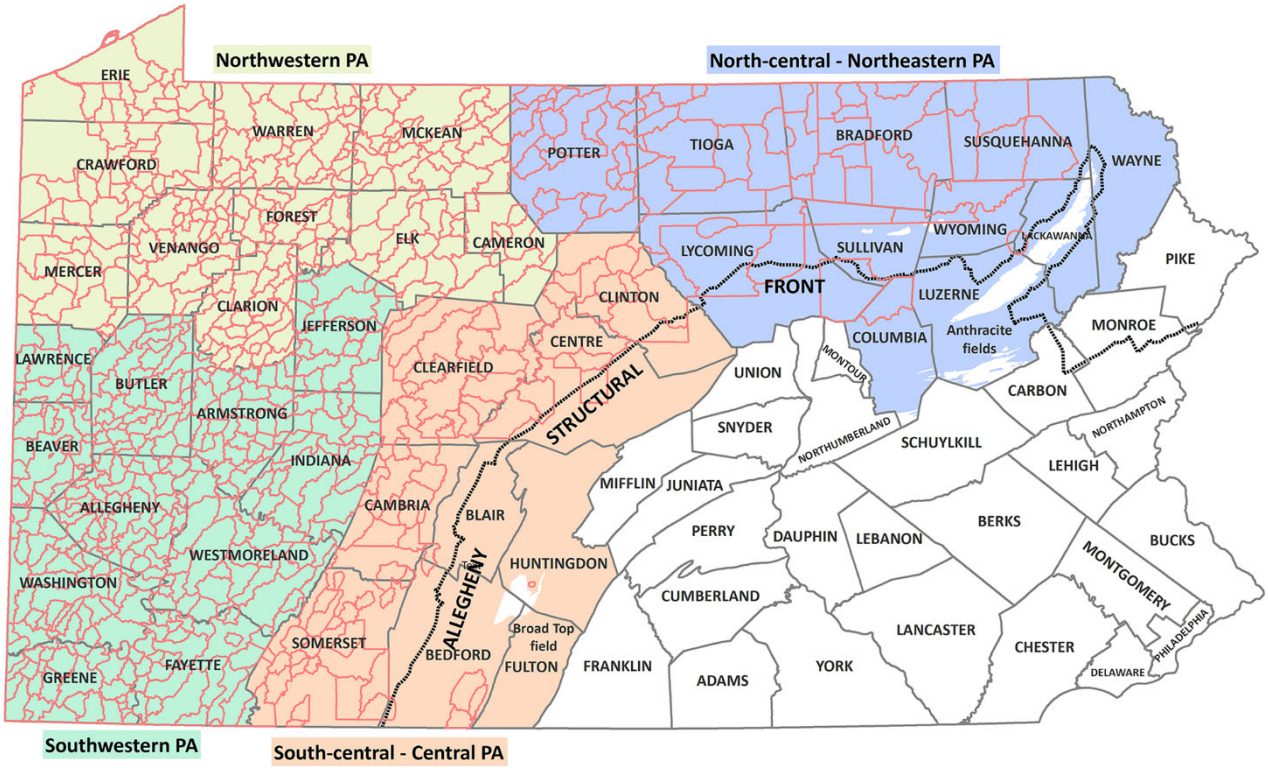

Figure 1. Map of Pennsylvania showing locations of existing oil and gas fields (red boundaries) and regions where subsurface stratigraphic correlations, as presented in this report, are generally valid.

The following publications provided much of the geologic context and reservoir characterization findings used to produce the new correlation diagram: Harper and Laughrey (1987), Markowski (2001), Carter and Harper (2002); Laughrey and others (2003), Laughrey and others (2004), Kostelnik and Carter (2009), Carter and others (2010), Carter and Flaherty (2011), Carter and others (2011), Carter and others (2015), Patchen and Carter (2015), Sminchak and Gupta (2015), Carter and Patchen (2017), Harper and others (2017), and Harper (2018). In addition, portions of the Phase III Appalachian basin topical report, authored by Carter and other members of the Midwest Regional Carbon Sequestration Partnership (currently in review), have been used to inform the content of the correlation diagram.

The correlation diagram (not to scale) is comprised of three parts—age, system, series, and group categories (left side); the lithostratigraphic chart (middle); and reservoir activity and depth details (right side). System ages are given in millions of years before present (mega-annum or MA), based on Orndorff and others (2018). The diagram represents Paleozoic strata of Cambrian through Pennsylvanian age.

The lithostratigraphic chart is marked with formal and informal group, formation, and member names, consistent with subsurface geologic nomenclature used by the Survey in its interpretive work and in EDWIN (Pennsylvania Geological Survey, 2019). This nomenclature may differ from usage in surface mapping efforts. Insofar as rock units serve as petroleum hydrocarbon reservoirs, represent potential or existing storage reservoirs of some kind, or are generally recognized by industry, they have been labeled in the chart and tabulated in Appendix 1.

The diagram is representative of four parts of the state where oil and gas drilling have occurred to date—northwestern, southwestern, south-central–central, and north-central–northeastern Pennsylvania. This represents a noticeably larger geographic footprint than that associated with either Harper (1979) or Carter (2007). The modern Marcellus shale play (and the surge of unconventional shale gas activity in the state that followed) have provided an opportunity to investigate the subsurface more fully and expand subsurface correlations into the northern tier counties.

Reservoir activity, as marked on the right side of the diagram, includes three categories: (1) petroleum hydrocarbon production (i.e., coalbed methane, oil, conventional natural gas, and unconventional natural gas from shale); (2) natural gas storage; and (3) geologic storage opportunities (carbon dioxide storage, wastewater injection, and/or natural gas liquids storage). By and large, the geologic storage opportunities category represents potential activities that may be implemented at some future time, with the exception of wastewater injection, which is currently occurring at a handful of permitted disposal wells in western Pennsylvania.

The depth designation along the right-hand-side of the diagram is used to indicate which units the Survey considers "shallow" versus "deep" in its field and pool mapping and reservoir characterization work. This nomenclature is based on depth relative to the Tully Limestone, is specific to the Survey, and is different from "shallow," "deep," and "conservation" identifiers used by the Pennsylvania Department of Environmental Protection in its regulation of the oil and gas industry.

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