Use of Sequence Stratigraphic Concepts to Correlate Across Nonmarine Successions without Thick Coals in the Pennsylvanian of Southeastern Ohio*

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Abstract

Traditional approaches to mapping the Pennsylvanian strata within the Appalachian foreland basin of the eastern United States have been based on the tracing of key marine zones and coal beds. This is difficult where thick coal beds and marine limestones are mostly absent in some portions of the continental strata of the late Pennsylvanian in the northern Appalachian basin. The subdivision and mapping of marine/terrestrial strata based on unconformity-bounded sequences using sequence-stratigraphic methods can potentially produce good stratigraphic correlations. Sequence stratigraphic applications to solely nonmarine rocks have involved floodplain facies using paleosol horizons as unconformity-bounded sequences, but this requires detailed geochemical work and extensive core/outcrop data. The recognition of three types of nonmarine systems tracts of (1) channel-dominated, low-accommodation, (2) paleosol-dominated, low accommodation, and (3) lacustrine-dominated, high-accommodation system tracts indicates that lacustrine sequences can be considered for stratigraphic correlation.

The Stewart Quadrangle in Athens County, situated in southeastern Ohio, contains Pennsylvanian to Permian rocks of the upper Conemaugh, Monongahela, and Dunkard Groups characterized as “cyclothems” that are interpreted as low-gradient distal deposits of a foreland basin containing siliciclastic and carbonate rocks with rare thin coals. The siliciclastics comprise paleosols, siliciclastic lake deposits, and channel sandstones while the carbonates are interpreted as lacustrine and palustrine limestones. The correlation potential of the freshwater limestones has never been studied.

A detailed, bedrock-geologic map of the Stewart 7.5-minute Quadrangle in Athens County, Ohio, was prepared in order to test the application of nonmarine sequence stratigraphic methods for correlation. Mapping data included measured stratigraphic sections, geologic maps, drillers’ logs,
continuous bedrock core descriptions, and aerial photographs. In order to identify similar sequences from one location to the next, logs were evaluated based on the presence of siliciclastic vs. carbonate lithologies. Limestones were identified as lacustrine-dominated system tracts with the other discontinuous siliciclastic lithologies grouped into one package of paleosol- and channel-dominated system tracts because differentiation between these system tracts is difficult. Correlation across this quadrangle was accomplished through six identified limestone units. This method can be extended to neighboring quadrangles to correlate across the region where coals are thin or absent.
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INTRODUCTION

Traditional approaches to mapping the Pennsylvanian strata within the Appalachian foreland basin of the eastern United States have been based on the tracing of key marine zones and coal beds. This is difficult where thin coal beds and marine shales are interbedded or in some portions of the late Pennsylvanian in the northern Appalachian basin. Therefore, a project was undertaken to test the potential of using sequence-stratigraphic methods to map and correlate nonmarine sequences in southeastern Athens County, Ohio. This work was prepared in order to test the applicability of nonmarine sequence-stratigraphic methods, especially noting the presence of unconformity-bounded sequences using sequence-stratigraphic methods.

PALEOGEOGRAPHY

During the Late Pennsylvanian, the northern part of this basin was characterized by a net seaward shift across the region. Following regression, marine transgression advanced across the study area. Due to high subsidence rates, the early Late Pennsylvanian was marked by a net depocenter located in southeastern Athens County in southeastern Ohio within the northern Appalachian Basin. The northern Appalachian basin can be divided into two distinct depositional zones. To the east is the Pocahontas basin, representing the most proximal trough of the foreland basin. In the western portion of the basin resides the Dunkard synclinorium, characterized as “cyclothems” that are interpreted as low-gradient distal deposits of a foreland basin situated in southeastern Ohio.

LOCATION

The Stewart Quadrangle in Athens County, Ohio, represents a portion of the northern Appalachian Basin containing a sequence of upper Late Pennsylvanian strata. The Quadrangle is located in southeastern Athens County, Ohio. It is characterized by a net depocenter located in southeastern Athens County, Ohio within the northern Appalachian Basin. The northern Appalachian basin can be divided into two distinct depositional zones. To the east is the Pocahontas basin, representing the most proximal trough of the foreland basin. In the western portion of the basin resides the Dunkard synclinorium, characterized as “cyclothems” that are interpreted as low-gradient distal deposits of a foreland basin situated in southeastern Ohio.

TECTORIC OVERVIEW

The paleogeography of the study area, which includes the Stewart Quadrangle, was determined using available geological maps, satellite imagery, and field observations. The map shows the late Pennsylvanian paleogeography of North America. Yellow represents the Appalachian orogenic belt, and green represents the stable parts of the craton.

REGIONAL STRATIGRAPHY

The regional stratigraphy of the Stewart Quadrangle is divided into three main stratigraphic units: the Conemaugh, Monongahela, and Dunkard Groups. Each group contains distinct lithologic and sedimentologic features, allowing for detailed mapping and correlation.

DEPOSITIONAL ENVIRONMENT

The Pennsylvanian record of fluvial deposits and lacustrine-dominated environments is characterized by the presence of cyclothems. Constrained sections of these cyclothems are used for the presentation of sequences. Conodonts and fusulindans are useful for the correlation of strata. The early and late Late Pennsylvanian are characterized by marine transgression and regression, respectively. The middle Late Pennsylvanian is marked by an unconformity-bounded sequence.

LACUSTRINE LIMESTONES

Nonmarine carbonate deposits are typically associated with lacustrine or palustrine settings. These environments are characterized by the presence of freshwater to brackish water conditions. Carbonates can be distinguished based on their textural and compositional characteristics.

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METHODOLOGY

A new bedrock-geology map of the Stewart 7.5-minute quadrangle was generated using published and unpublished data on file at the Division of Geological Survey (OGS), supplemented with additional field work. Existing sources of data included: measured stratigraphic sections, geologic maps, drillers' logs, continuous bedrock core descriptions, and aerial photographs. Additional field work included new measured sections, an evaluation of existing measured sections, and surveying by total station and portable global positioning system (GPS) to gather coordinates and elevations of geologic contacts.

Outputs for each mappable unit comprising the stratigraphic section of the new bedrock-geology map included: a three-dimensional geologic block model, structure contours, bedrock topography, isopach thickness, and a volumetrics report digitally extracted from the geologic block model. Each geologic output was digitally compiled onto a geographic information system (GIS) with topographic base map features in coordinates including areal photos, hydrology, and infrastructure.

OUTCROP PATTERN

FIELD WORK

GEOSPATIAL MODELING

MAP PRODUCTION

CONCLUSIONS

A new paradigm was needed to identify mappable units in the field. In order to apply sequence stratigraphic techniques to the strata of the Stewart Quadrangle, a more generalized and lower resolution approach worked as a first approximation. The identification of maximum flooding surfaces/interervals as lacustrine-dominated system tracts initially helped to shape the correlation of units as a first step. The efficacy of using principally palustrine limestones as maximum flooding intervals for correlation, separating the siliciclastic strata of the paleosol- and channel-dominated strata from the carbonate strata was successful at the quadrangle-scale.