[PS]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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Use of Sequence Stratigraphic Concepts to Correlate across Nonmarine Successions without Thick Coals in the Pennsylvanian of Southeastern Ohio

Panel 1

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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 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.

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, especially noting lacustrine/palustrine rocks, in mapping the floodplain Pennsylvanian succession of rocks in the Appalachian basin of southeastern Ohio.

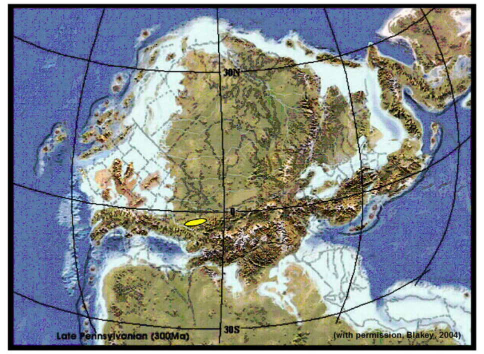
LOCATION

The quadrangle identified for this project is the Stewart Quadrangle (7.5-Minute series) located in southeastern Athens County in southeastern Ohio within the northern Appalachian Basin.

PALEOGEOGRAPHY

Mid- to Late Paleozoic Appalachian orogenic events resulted in the formation of the Appalachian foreland basin.

During the Late Pennsylvanian, the northern part of this basin was located within the equatorial zone approximately 10° latitude, bounded to the southeast by the Allegheny Range of the Central Pangean Mountains, opening toward an epeiric sea to the west.



Late Pennsylvanian paleogeography of North America. Yellow ellipse represents location of study area; modern day geopolitical boundaries are superimposed in approximate locations during the Late Pennsylvanian.

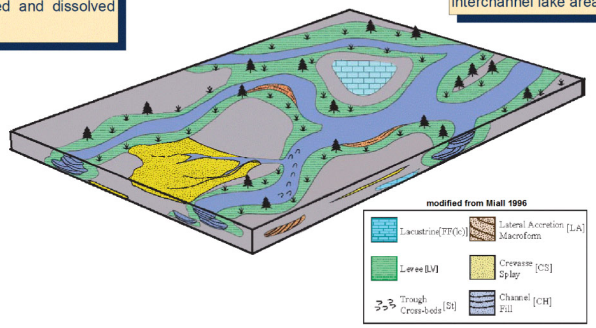
DEPOSITIONAL ENVIRONMENT

The Phanerozoic record of fluvial deposits shows that anastomosing rivers with carbonate-rich provenance situated in distal areas below the spring line are the best environments for floodplain accumulation of significant carbonate lake deposits.

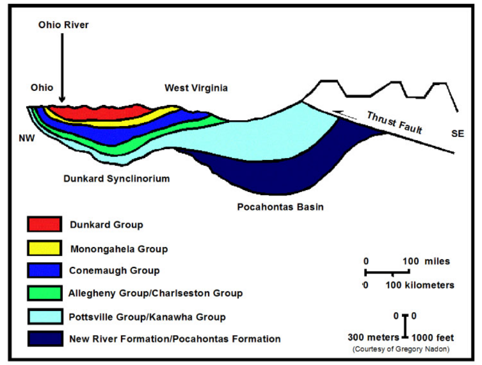
Anastomosing rivers exist below the regional spring line and have isolated flood basins generally protected from bedload by high levees, receiving suspended and dissolved load during flooding events.

Hydrodynamic features promote the existence of isolated areas on the floodplain for the precipitation of carbonate. Concave-upward, interchannel flood basin areas mostly receive dissolved and suspended load during floods, because of relatively high levee systems in an aggradational system.

Bedload only enters these flood basin areas as crevasse splays during a levee breach. Anastomosed river channels are in general stable and the preservational potential of interchannel lake areas is high.



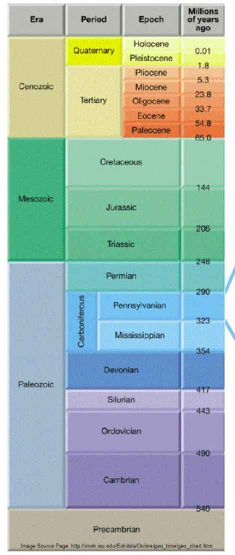
TECTONIC OVERVIEW

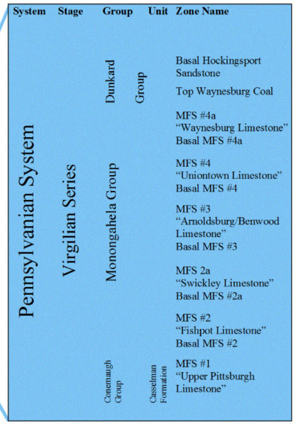


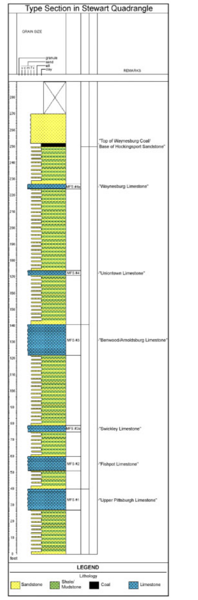
The northern Appalachian basin can be divided into two distinct depositional zones. To the east is the Pocahontas basin, representing the most proximal trough of the foreland basin. In the western portion of the basin resides the Dunkard synclinorium, representing a more cratonic portion of the basin.

Sediment fill within the Pocahontas basin and Dunkard synclinorium is composed of cyclothems containing alternating siliciclastics, carbonates, and coal. The cyclothems are interpreted as marine to nonmarine environments affected by glacial eustatic, tectonic, and hydrologic conditions.

REGIONAL STRATIGRAPHY







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.

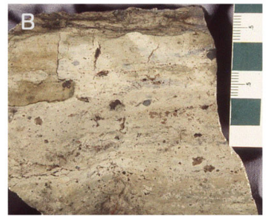
These limestones are identified as lacustrine-dominated system tracts and defined here as the maximum flooding surface (MFS). With limestone units representing the MFS, the other discontinuous siliciclastic lithologies were grouped into one package of paleosol- and channel-dominated system tracts.

Thus, lacustrine-dominated system tracts, i.e. the MFS limestones, are separated by amalgamated paleosol/channel siliciclastic system tracts. Coals were rare and not continuous, so they could not be used for correlation purposes in this quadrangle.

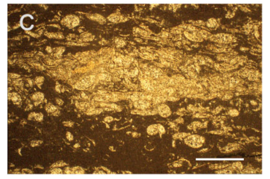
LACUSTRINE LIMESTONES

In the application of sequence stratigraphic concepts to identify system tracts culminating in the MFS intervals to refine the stratigraphy, more detailed sedimentologic information on erosional surfaces, paleosols, and carbonate deposition was necessary to understand cyclothem architecture.

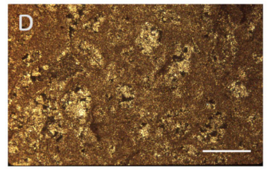
In the Stewart Quadrangle, sedimentologic research also has focused on the nonmarine limestones of the Monongahela and Conemaugh Groups. Nonmarine carbonates contain important data on depositional circumstances, including the impact of climatic change on cyclothem formation. This required petrologic study of the limestones using large thin sections.



B. Rock slab photo of the Fishpot Limestone showing a pedogenically altered palustrine limestone with circular root traces filled with dark micrite (Stewart Quadrangle). Scale at left is in mm and cm.

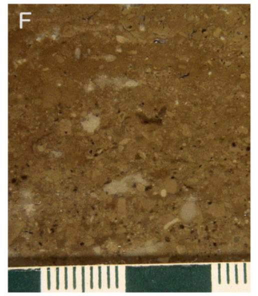


C. Thin section photo of the Fishpot Limestone showing a coquina layer or spar-filled ostracode shells (Stewart Quadrangle). Scale is one mm.



D. Thin section photo of Pittsburgh Limestone showing spar-filled root traces showing clay cutans (Stewart Quadrangle). Scale is one mm.

E. Outcrop of the Upper Pittsburgh Limestone exhibiting a nodular exposure interbedded with shale (Stewart Quadrangle). Meter stick at left for scale.



F. Rock slab photo of the Swickley Limestone showing an accumulation of transported rounded clasts of carbonate mixed with micrite matrix (Stewart Quadrangle). Scale below in mm.

G. Rock slab photo of the Upper Pittsburgh Limestone showing a lacustrine deposit with possible stromatolitic laminae disrupted by circular, micrite-filled root trace (Stewart Quadrangle). Scale at right is in mm.

Late Pennsylvanian lacustrine carbonates of the northern Appalachian Basin were deposited within an equatorial tropical environment. These limestones are interpreted generally as freshwater to brackish in origin. These carbonates have recently been re-evaluated as palustrine/lacustrine deposits on an anastomosing river floodplain.

Re-interpretation of nonmarine carbonates based on stable isotope geochemistry as well as petrography suggests that the paleoclimate was mostly humid rather than predominately arid as previously postulated. Nonmarine carbonates can be deposited in any climate and their textures reflect the extent of exposure.

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Panel 2

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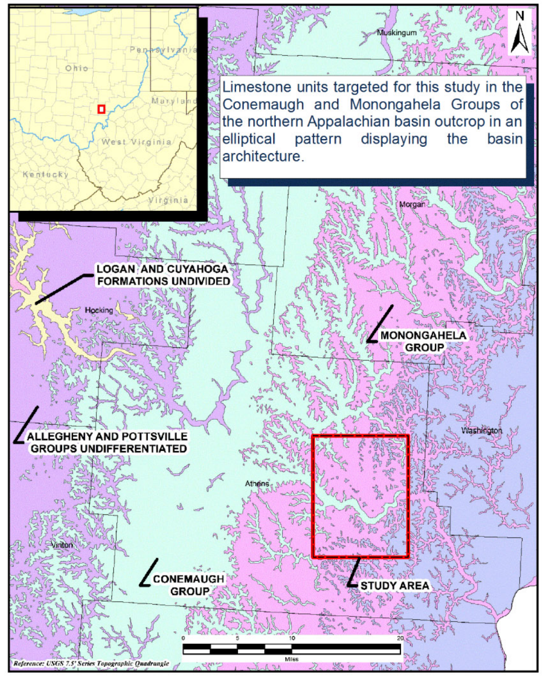
METHODOLOGY

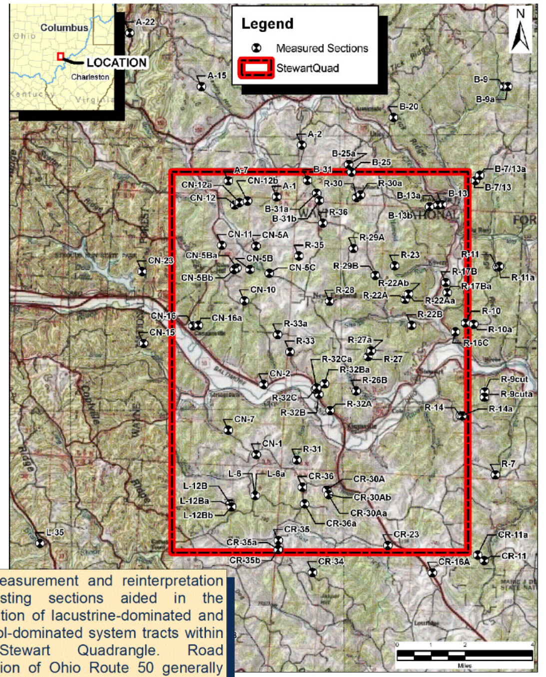
A new bedrock-geology map of the Stewart 7.5-minute quadrangle was generated using published and unpublished data on file at the Division of Geological Survey (OGS), supplemented with additional field work. Existing sources of data included: measured stratigraphic sections, geologic maps, drillers' logs, continuous bedrock core descriptions, and areal 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



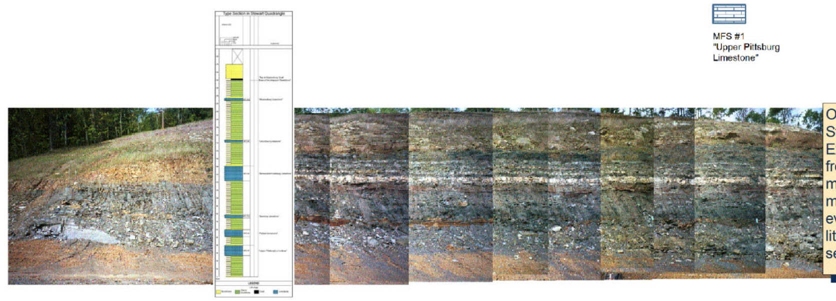
The measurement and reinterpretation of existing sections aided in the recognition of lacustrine-dominated and paleosol-dominated system tracts within the Stewart Quadrangle. Road expansion of Ohio Route 50 generally east-west across the Stewart Quadrangle supplied great lateral control in correlation work and provided a "type-section" for the quadrangle.

Poster References:

Cassle, C.F., 2005, Petrographic analyses of Late Pennsylvanian limestones within the Northern Appalachian Basin, USA: M.S. Thesis, Ohio University, 108 p.

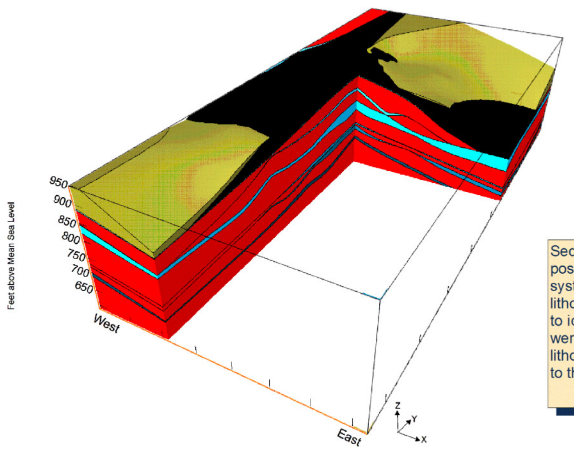
Miall, A.D., 1996, The geology of fluvial deposits: sedimentary facies, basin analysis and petroleum geology. Springer-Verlag, Berlin, 582 p.

Sturgeon, M.T. and associates, 1958. The Geology and Mineral Resources of Athens Coutny, Ohio. Ohio Division of Geological Survey Bulletin 57: 1-600.



Over 90 section locations in and adjacent to Stewart Quadrangle were evaluated. Existing section locations were obtained from Sturgeon et al. (1958) and ODNR's measured section database. The existing measured section locations were re-evaluated to confirm outcrop locations and lithologic descriptions. New measured section locations were also identified in the

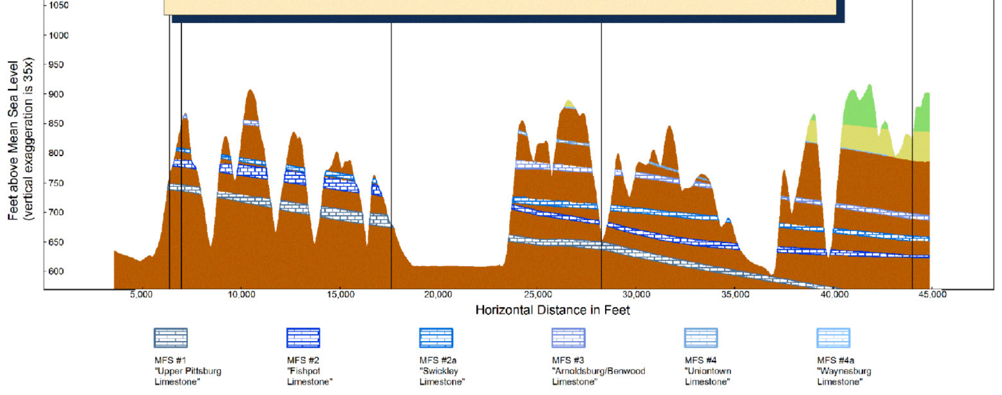
GEOSPATIAL MODELING

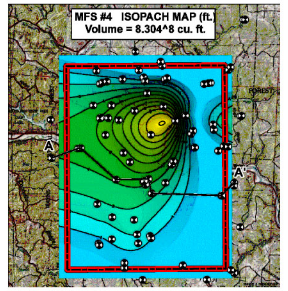


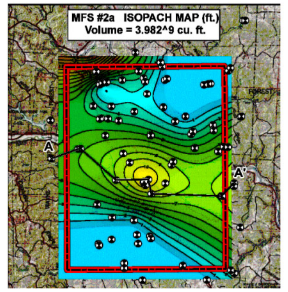
Three-dimensional visual verification provided a unique opportunity to discover fundamental relationships in scattered data, site information, and surfaces hidden in other graphic representations. The data resulting from this synergistic verification process provided an improved data "foundation" for all subsequent modeling and scientific investigation. The three dimensional modeling automated the geologic mapping process and verified hand-contoured map products.

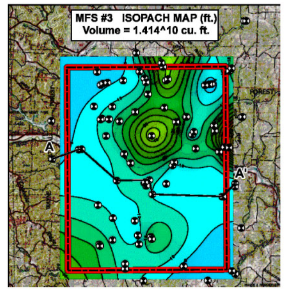
Sequence stratigraphic correlation of similar systems tracts was possible following data compilation into one uniform database system including coordinates (easting and northing), elevations, lithology types and consistent scales on graphic logs. In order to identify similar sequences from one location to the next, logs were evaluated based on the presence of basal siliciclastic lithologies (sandstones, shales, coals, and paleosols) in relation to the stratigraphic position of limestone units.

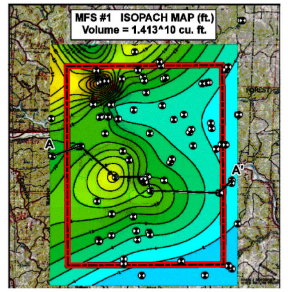
Once the package of basal siliciclastics and the top of the MFS limestone unit were identified for one graphic log, correlation was extended to its adjacent log. This approach was applied to the rest of the logs moving up-section and laterally at the quadrangle scale of approximately 50 square miles. Similar packages of siliciclastics and limestones were then numbered sequentially from the base of the section to the top of the exposed rocks in the study area.







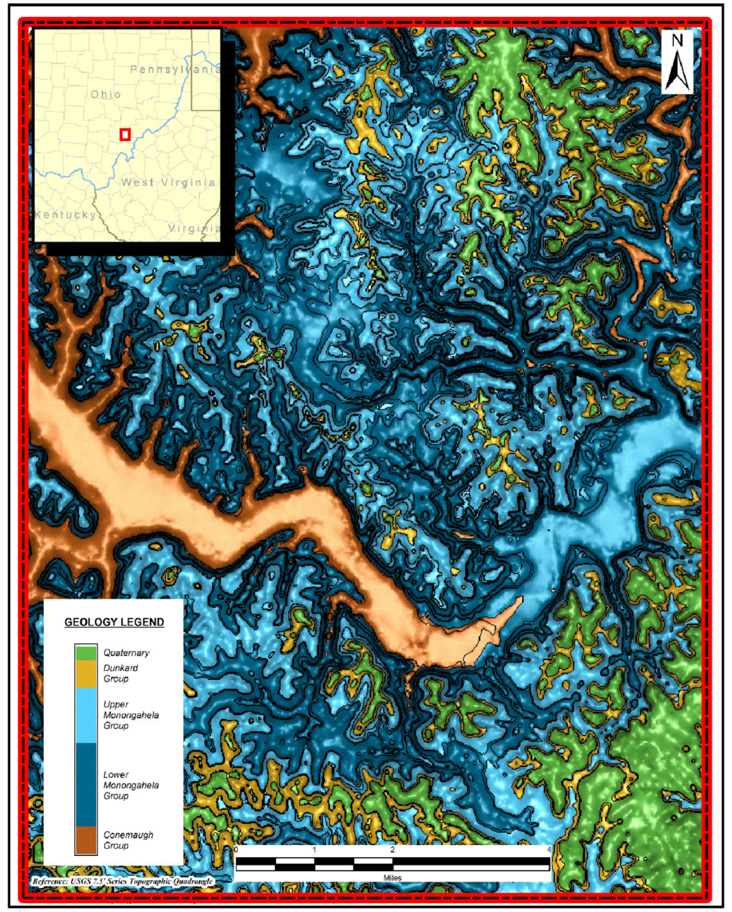




Partial support provided by the U.S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number 98HQAG2097. The views and conclusions are those of the author and should not be interpreted as necessarily the official policies, either expressed or implied, by the U.S. government.

MAP PRODUCTION

Here, 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 using carbonate lacustrine/palustrine rocks in mapping the distal floodplain Pennsylvanian succession of rocks in the northern Appalachian basin of southeastern Ohio. In addition, the extent and volume of these carbonate lake deposits can be quantified.



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/intervals 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.