Diagenetic Evolution of the Cherry Valley Member of the Oatka Creek Formation, Marcellus Subgroup, New York*

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Abstract

Textural and compositional heterogeneity within the Cherry Valley Member (CV) of the Oatka Creek Formation (Middle Devonian Marcellus subgroup) reveal a complex diagenetic history of the Appalachian Basin in New York. The CV represents laterally extensive, nodular offshore carbonates composed of pelagic fauna (e.g., goniatites), and it contrasts both lithologically and petrophysically with its bounding mudstones, regionally the East Berne Member of the Oatka Creek Formation (overlying) and Bakoven Member of the Union Springs Formation (underlying). The highly contrasting interfaces between carbonate and mudstone produce porosity- and permeability-controlled fluid flow that has influenced diagenesis. The CV is compositionally dominated by carbonates, all of which are diagenetic. Early diagenesis includes calcareous nodule formation prior to lithification, followed during burial by distinct generations inclusive of calcite, ferroan calcite, ankerite, siderite, barite, and other minerals likely representing distinct phases. The mudstones above and below have mixed matrices of illitic clays and a variable amount of calcite cement, with higher amounts coinciding with microfossil-rich laminae, and exhibit a divergent diagenetic history from the CV. Organic material is largely restricted to these mudstones and is characterized as highly dispersed, kerogenous residue that coats matrix components including pore walls hosted within clay crystallites and cements. Though the Marcellus subgroup is one of the most studied units in the United States, little work has been done to document the changes in lithology, composition, and texture from one portion of the basin to another as a function of diagenesis. The evolution of diagenesis has largely been studied within discrete zones of the basin, identifying compositional trends without specifying the diagenetic stage to which any mineral or chemical product corresponds. The CV provides a good opportunity to examine diagenetic changes to a basin-wide, contemporaneous unit that was subjected after deposition to a range of burial regimes during the Alleghanian orogeny. Qualitative petrographic descriptions and quantitative compositional analyses, including thin section petrography and scanning electron microscopy, are combined to describe the textural and compositional framework of the rocks at a range of scales. Compositional analyses include X-ray diffraction and energy dispersive X-ray spectroscopy.

References Cited


Core information/API: Tioga County Core (formally as “Strong #1”, 31-107-26466); EGSP NY-4 (also named “Valley Vista View 1”, 31-101-15268), Beaver Meadows Core (formally as “Beaver Meadows #1, 31-017-23006); Cargill Salt Core (formally as “Cargill Test #17”, 31-109-13173)
ABSTRACT

Textural and compositional heterogeneity within the Cherry Valley Member of the Oatka Creek Formation (Middle Devonian Marcellus subgroup) reveals a complex diagenetic history within the Appalachian Basin in New York. The highly contrasting interfaces between the carbonate member and its enclosing mudstones produced porosity and permeability controlled fluid flow that has influenced diagenesis. The Cherry Valley Member provides a good opportunity to examine diagenetic changes in a thin, wide, contemporaneous unit that was subjected after deposition to a range of burial regimes during the Alleghanian orogeny and a range of subsequent exhumation and fluid flow regimes. Improved predictability of diagenetic minerals may lead to better models for reservoir risk assessment.

The Cherry Valley Member represents laterally extensive, nodular offshore carbonates composed of pelagic fauna (e.g., goniatites). It contrasts both lithologically and petrographically with its bounding mudstones, regionally the East End Member of the Oatka Creek Formation (overlying) and Back River Member of the Union Springs Formation (underlying). Compositionally, the Cherry Valley Member is dominated by carbonates, all of which are diagenetic. Early diagenesis includes calcareous nodule formation prior to lithification, followed by burial due to distinct generations inclusive of carbonaceous materials, ferromagnesian minerals, and other minerals likely representing distinct phases. The mudstones above and below have mixed matrices of illitic clays and a variable amount of calcite cement, with higher amounts coinciding with microfossil-rich laminae, and exhibit a diverse diagenetic history from the Cherry Valley Member. Organic material is largely restricted to these mudstones and is characterized by highly dispersed, kerogen-rich residues that coat matrix components including pores within clay crystals and cements.

Though the Marcellus subgroup is one of the most studied units in the United States, little work has been done to document the changes in lithology, composition, and texture within the Marcellus subgroup in New York. This paper reports on four cores in New York State, to be followed soon by analysis of five cores from Pennsylvania and West Virginia.

DEPOSITIONAL HISTORY

A vertical succession of marine siliciclastic and carbonate rocks composes the Middle Devonian strata. The Marcellus subgroup overlies the Onondaga Formation, typically a kerogen-rich residue that coats matrix components including pore walls hosted within clay crystallites and cements.

METHODS

Reflectance Spectroscopy

A vertical succession of marine siliciclastic and carbonate rocks composes the Middle Devonian strata. The Marcellus subgroup overlies the Onondaga Formation, typically a kerogen-rich residue that coats matrix components including pore walls hosted within clay crystallites and cements.

The Cherry Valley Member thins to the west and is presently less than 5 m thick in New York (Figure 4, right), compositionally dominated by carbonates, all of which are diagenetic. Early diagenesis includes calcareous nodule formation prior to lithification, followed by burial due to distinct generations inclusive of carbonaceous materials, ferromagnesian minerals, and other minerals likely representing distinct phases. The mudstones above and below have mixed matrices of illitic clays and a variable amount of calcite cement.

Reflectance spectrometry is used to detect compositional changes among bottom water carbonate samples in this section. This method was used to determine the relative proportions of minerals. Sample preparation consists of grinding samples to a fine powder. Micron-sized particles are not analyzed due to the low amount of clay present in the Cherry Valley Member.

GEOLOGIC SETTING AND BACKGROUND

Paleogeographic reconstructions place the eastern margin of North America at 30° S latitude during the time of Marcellus subgroup deposition in the Middle Devonian. The Acadian orogeny affected the eastern margin of North America from 375 to 360 Ma, whereas the Alleghanian orogeny in North America from 360 to 350 Ma. Although these orogenies are both part of the larger Mesozoic cycle, the Appalachian orogeny was more recent and higher magnitude. The Appalachian orogeny affected the eastern margin of North America from 375 to 360 Ma, whereas the Alleghanian orogeny in North America from 360 to 350 Ma. Although these orogenies are both part of the larger Mesozoic cycle, the Appalachian orogeny was more recent and higher magnitude. The Appalachian orogeny affected the eastern margin of North America from 375 to 360 Ma, whereas the Alleghanian orogeny in North America from 360 to 350 Ma. Although these orogenies are both part of the larger Mesozoic cycle, the Appalachian orogeny was more recent and higher magnitude. The Appalachian orogeny affected the eastern margin of North America from 375 to 360 Ma, whereas the Alleghanian orogeny in North America from 360 to 350 Ma. Although these orogenies are both part of the larger Mesozoic cycle, the Appalachian orogeny was more recent and higher magnitude. The Appalachian orogeny affected the eastern margin of North America from 375 to 360 Ma, whereas the Alleghanian orogeny in North America from 360 to 350 Ma. Although these orogenies are both part of the larger Mesozoic cycle, the Appalachian orogeny was more recent and higher magnitude. The Appalachian orogeny affected the eastern margin of North America from 375 to 360 Ma, whereas the Alleghanian orogeny in North America from 360 to 350 Ma. Although these orogenies are both part of the larger Mesozoic cycle, the Appalachian orogeny was more recent and higher magnitude. The Appalachian orogeny affected the eastern margin of North America from 375 to 360 Ma, whereas the Alleghanian orogeny in North America from 360 to 350 Ma. Although these orogenies are both part of the larger Mesozoic cycle, the Appalachian orogeny was more recent and higher magnitude. The Appalachian orogeny affected the eastern margin of North America from 375 to 360 Ma, whereas the Alleghanian orogeny in North America from 360 to 350 Ma. Although these orogenies are both part of the larger Mesozoic cycle, the Alleghanian orogeny was more recent and higher magnitude.

In carbonate, the cation present shifts the resultant spectrum to indicate the respective mineral. To collect a spectrum, core is first cleaned and dried to remove drilling mud or other contaminates that may interfere with the analysis. Spectra of and anal-yses are conducted at 3-4 cm apart, with closer spacing within cores. Mineralogy is assessed by X-ray diffraction, and scanning electron microscope sampling.

The Cherry Valley Member reveals a complex diagenetic history that includes a variety of diagenetic minerals and assists in thin section studies. Samples from the Tioga County core was continuous throughout the Cherry Valley Member while sidewall plugs were chosen only at select hori-zons from the Beaver Meadow (5) and ENSYM (15) cores. Bifurca were mounted to standard glass slides and ground to a thickness of 20 microns. These samples are treated with a dual carbonate etch, including Alkaline FeCl3 and perchloric acid, to high-light carbonates (calcite, dolomite, and aragonite), and organic material (kerogen and pyrite). The proposed protocol is used on the images that are obtained before and after etching. Images are obtained before and after etching. Images are obtained before and after etching. Images are obtained before and after etching. Images are obtained before and after etching.

Scanning Electron Microscopy

The thin section is cleaned with a hydraulic splitter across bedding to expose a fresh surface for electron micro-scopy. The sample, matching the length of the corresponding thin section, is mounted on a standard aluminum SEM pin stub and sputter-coated with a conductive metal such as itetratr, platinum/palladium alloy, or palladium gold alloy. The samples are then imaged in a field emission scanning electron mi-croscope, including a LEO 1530 FE-SEM or FEI Quanta 600 FEG, equipped with an energy dispersive X-ray detector. Scans are viewed primarily with a secondary electron detector, with lesser use of a backscatter electron detector. To describe mineralogical and compositional elements.
DIAGENETIC EVOLUTION OF THE CHERRY VALLEY MEMBER OF THE OATKA CREEK FORMATION, MARCELLUS SUBGROUP, NEW YORK

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EGSP NY-4 Core

TIoga COUNTY Core

BEAVER MEADOWS CORE

CARROLL SALT CORE

REFLECTANCE SPECTROSCOPY XRD

REFLECTANCE MINERALOGY KEY

MINERALOGY

- ankerite
- barite
- calcite
- dolomite
- organic material
- fracture
- fossil

MINERALOGY

- dolomite
- chlorite
- calcite
- barite
- ankerite
- silica
- pyrite
CONCLUSIONS

- The Cherry Valley Member acts as a conduit for fluid flow between its bounding mudstones and has recorded its diagenetic history in distinct stages of authigenic carbonates (Fig. 11, left).
- Diagenetic processes and authigenic mineralization (above) are paragenetically related in the Tioga County (TCC), Beaver Meadows (BMC), and EGSP NY-4 (NY-4) cores. High-resolution reflectance data accurately identifies zones of authigenic mineralization whereas petrography shows that additional phases exist.
- Textural and compositional heterogeneity is a function of burial history in the Cherry Valley Member.
- Compositional results show iron-rich carbonates preferentially crystallize closer to the Appalachian orogenic front in New York (e.g., Tioga County rather than EGSP NY-4).
- Unmixing and interaction with deep meteoric waters may trigger dolomitization, producing calcitized dolomite, where the Cherry Valley Member is shallowest (EGSP NY-4, Beaver Meadows, and Cargill)

This study will expand its research area to include core material of the Cherry Valley Member from central and southwestern Pennsylvania and northeastern West Virginia. An identical suite of analyses is currently in process for these additional rocks. Stable isotope analyses of carbonate cements, fossils, and/or void-fills are planned to better constrain timing and extent of diagenetic processes and authigenic mineralization.

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REFERENCES

Core information/AP: Tioga County Core (formerly as "Strong #1", 31-107-2466); EGSP NY-4 (also named "Valley Vista View 1", 31-101-15288), Beaver Meadows Core (formerly as "Beaver Meadows 1", 31-017-23060); Cargill Salt Core (formerly as "Cargill Test #1", 31-006-13172)