Depositional and Burial Domain Influences on Microporosity Modalities in Carbonaceous Mudstones of the Upper Cretaceous Colorado Group, Western Canada Foreland Basin*

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Abstract

The fabric characteristics of intrinsic and secondary microporosity in carbonaceous mudstones provides insight into contrasting depositional and burial domain processes in the foredeep and back-bulge segments of a foreland basin. In particular, the relationship between disseminated organic matter and clay aggregates during deposition apparently influences the preservation of reactive kerogen as revealed by subsequent organic matter microporosity development during burial-related catagenesis. Laterally correlative strata spanning a foreland basin system offer the opportunity to evaluate how microfabric characteristics preserve evidence of distinct depositional and burial processes of different foreland basin segments.

The study is based on secondary electron and backscatter electron microscopy of 319 ion-milled cross-sectional surfaces from 43 samples. These samples are a representative gamut of Upper Cretaceous Colorado Group carbonaceous mudstones from thirteen cored wells spanning the Western Canada Foreland Basin (WCFB). Approximately 2600 SEM photomicrographs were acquired and evaluated in order to construct a comprehensive database of pore types. These fall into the broad categories of intercrystalline, intraparticle, organic matter and dissolution pores.

Understanding the relationship between organic matter porosity development and thermal maturity has been a principal focus of this work, with the intent to develop a generalized model for predictive purposes. The initial hypothesis posited a linear relationship between increasing thermal maturity and corresponding increase in organic matter microporosity in a transect from the back-bulge through the foredeep of the WCFB. The results, however, reveal very high degrees of spatial heterogeneity with respect to different modes of microporosity. This heterogeneity, in part, results from depositionally imposed modes of organic matter preservation and related advective transport of clay aggregates.
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Abstract

Fabric characteristics of organic and accessory minerals, as well as variations in the abundances, compositions, and crystallographic textures of microporosity modalities, are important parameters that control the reservoir quality of carbonaceous mudstones. Published data on the Upper Cretaceous Colorado Group, Western Canada Foreland Basin (WCFB), contain information that can be used to develop the appropriate reservoir model for the basin. The goal of this research is to develop a generalized model for predicting microreservoir properties in carbonaceous mudstones. This involves a detailed examination of the depositional and burial domain influences on microporosity modalities in carbonaceous mudstones.

2. Setting

Our study area is the Western Canada Foreland Basin (WCFB), which extends throughout the Tonian and Neocomian. The WCFB contains a complex system of foreland basins that developed in response to the collision of the North American plate with the Pacific plate. The basin is characterized by a series of tectonic features, including the Sweetgrass Arch (SGA) and Bow Island Arch (BIA), which are located in the central and southern parts of the basin, respectively. The SGA and BIA mark the approximate position of the foreland basin that resulted from flexure of the North American plate and associated mantle dynamics.

3. Database

The database consists of 43 samples from the Upper Cretaceous Colorado Group, which are located in the Western Canada Foreland Basin. The samples were collected from different foreland basin segments and provide information on burial processes of different foreland basin segments. The burial processes of the different foreland basin segments are characterized by variations in burial-related catagenesis. Laterally correlative strata spanning a uniform thickness of the WCFB have been identified as a means to constrain the burial-related catagenesis.

4. Method

The database was constructed from a combination of log characteristics and qualitative elemental data for confirmation of mineralogies. A limited number of samples was conducted using the LEO (Zeiss) 1540XB Cross-Beam Scanning Electron Microscope (XSEM) and an FEI Quanta 200 FIB-SEM. The XSEM was used to capture topographical and compositional information, respectively. A limited number of samples was conducted using the LEO (Zeiss) 1540XB Cross-Beam Scanning Electron Microscope (XSEM) and an FEI Quanta 200 FIB-SEM. The XSEM was used to capture topographical and compositional information, respectively.

5. Mineral Matrix Pores

Mineral matrix pores are defined as pores within the crystal matrix of the host rock, which can be classified as intercrystalline or intraparticle pores. Intraparticle pores within the matrix can be classified as pyrite framboids, pyrite intraparticle dissolution rims, and moldic pores.

6. Organic Matter (OM) Pores

Organic matter (OM) pores are defined as pores within the organic matter, which can be classified as interparticle or intraparticle pores. Interparticle pores within the OM can be classified as pyrite intraparticle dissolution rims, and moldic pores.

Figure 5.7. Secondary electron photomicrograph showing interparticle porosity within the chambers of a foraminifer (yellow arrows). Figure 5.8. FIB-SEM secondary electron photomicrograph showing porosity within a clay aggregate grain (yellow arrows). This is a rare, and ineffective, mode in the carbonate matrix. Figure 6.3. FIB-SEM secondary electron photomicrograph of the Upper Cretaceous Colorado Group, showing intraparticle porosity within the chambers of a foraminifer (yellow arrows). Figure 6.6. FIB-SEM secondary electron photomicrograph showing intraparticle porosity due to molds after pyrite dissolution (yellow arrows). Figure 6.7. FIB-SEM secondary electron photomicrograph showing intraparticle porosity due to molds after pyrite dissolution (yellow arrows).
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7. Clay Aggregates

- Figures 1-4: Examples of clay aggregate cross sections
- Figure 5: Depositional and burial domain influences on microporosity modalities in carbonaceous mudstones of the Upper Cretaceous Colorado Group, Western Canada Foreland Basin

8. Qualitative Observations

- Figure 6: Qualitative evaluation of the deposit sequences of the Lower Cretaceous and Clay fabric of fluid-mud deposits from laboratory and field observations (Imaging work was conducted in the Western University Liquids-Rich Research Consortium)

9. Discussion

- The observations presented in this poster represent a progress report of work being conducted as part of the Western University Liquids-Rich Research Consortium in the field of microporosity modalities in carbonaceous mudstones of the Upper Cretaceous Colorado Group, Western Canada Foreland Basin.

10. Conclusions

- Our observations support that the diversity of microporosity modalities in carbonaceous mudstones of the Upper Cretaceous Colorado Group, Western Canada Foreland Basin is influenced by deposition and burial domain factors.

References

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