Facies-related diagenesis and multiphase carbonate cementation and dissolution in the reservoir sandstones of the Sable Subbasin, offshore Nova Scotia

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Lower Cretaceous sandstones of the Scotian Basin, offshore eastern Canada, are important gas reservoirs. To determine the influence of depositional lithofacies, sequence stratigraphy and fluid flux during burial, the spatial and temporal distribution and chemistry of diagenetic minerals have been determined from several wells forming a proximal to distal transect through the basin. Mineral type and paragenesis were characterized using a combination of optical petrography, backscattered electron images, electron microprobe analyses, and bulk geochemistry data.

Grains coated with illite, chlorite, and Fe-calcite and minor siderite, pyrite, and phosphates record the neoformation of minerals through seafloor diagenesis from remineralization of organic carbon. Early kaolinite, predating quartz overgrowths and likely related to meteoric water, is abundant in fluvial and river mouth sandstones. Quartz overgrowths and late carbonate cements are the major mesodiagenetic minerals cementing these sandstones during burial diagenesis. In the same sandstone bed, mesodiagenetic ankerite occurs in some wells and Fe-calcite in others. Nine siderite types (A-I) were distinguished on the basis of textures. Early siderites (A-H) predate the formation of quartz overgrowths and only one late siderite type (I) is synchronous with or postdates quartz overgrowths. Both early and late siderite have similar composition (15–35 mol% $MgCO_3$ and 65–86 mol% $FeCO_3$), with only siderite intraclasts (A) and distinctive diagenetic hemispheres (H) having a low $MgCO_3$ (~20 mol%) content. Low Mg in siderites (A) and (H) is related to a greater contribution of meteoric water. Siderite of all generations is most common where there is high availability of detrital Fe, which is responsible for the unusual presence of early siderite in marine sediments. Late siderite I is controlled by the composition of formation water. Siderite suppresses quartz overgrowths and dissolves to create microporosity. Mesodiagenetic minerals are related to flux of formation water and maturing hydrocarbon products, resulting first in pyrite and siderite I and later in other carbonates.

Seafloor diagenetic minerals are absent in fluvial sandstones. Siderite is abundant in prodeltaic sands and muds, where there was the greatest availability of detrital Fe. Transgressive units have most abundant early Fe-calcite and siderite B. Early kaolinite occurs in proximal lithofacies, where meteoric water was most likely available at the time of or shortly after deposition. There are no systematic differences in kaolinite content in such sandstones from lowstand system tracts (LST) and highstand system tracts (HST), whereas only river mouth sandstones from HST have early siderite cement. Contrary to other studies, we find little impact of sequence stratigraphy on diagenetic minerals except in the transgressive system tract (TST). Rather, lithofacies and the supply of detrital Fe exert a strong influence on both seafloor and eodiagenetic minerals, which in turn influence mesodiagenesis.

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