The sequence of diagenesis cements in sandstones of the Scotian Basin, Canada: a record of fluid circulation and thermal evolution

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Diagenetic minerals in Jurassic–Cretaceous sandstones of the Scotian Basin preserve a record of fluid geochemistry and thermal evolution of the basin. Diagenesis starts at the seabed, in coated grains that include chamosite, francolite, siderite, and pyrite. Early carbonate cement formed in transgressive or highstand firmgrounds. Where marine lowstands allowed circulation of meteoric groundwater, kaolinite, and minor titania cement formed. Silica cement is widespread as overgrowths on quartz framework grains, except where quartz grains have chlorite rims, which probably developed from coats of volcanic ash or soil. Widespread ferroan calcite cement postdates silica overgrowths.

Thick sandstones commonly have pervasive secondary porosity resulting from dissolution of framework quartz and feldspar and early cements. K-feldspar overgrowths on detrital K-feldspars and diagenetic replacement by albite are found from ~1.9–3.0 km depth, below which K-feldspar disappears through dissolution and/or replacement by ferroan calcite ± ankerite. Detrital plagioclase also alters to albite, which predates late ankerite cement. The widespread secondary porosity is partly filled by ankerite and by fibrous illite and chlorite. The last phase of diagenetic cementation includes barite, sphalerite, kutnohorite and a titania mineral.

Within this overall diagenetic paragenesis, five geochemical types of siderite are distinguished. Siderite (1), with negligible Mn and Mg substitution, is found in intraclasts in sandstones and is of brackish or meteoric water origin. Siderite (2) (moderate Mg and Ca substitution) occurs in coated grains, firmgrounds, and as concretions in shale. Siderite (3) (high Mg substitution, moderate Ca substitution) characterises a wide range of permeable sandstones and probably results from recrystallization during early generation of basinal fluids prior to hydrocarbon charge. Siderite (4) with moderate Mn substitution mostly postdates quartz overgrowths. Siderite (5) with high Mn substitution is youngest and fills late secondary porosity.

Fluid inclusion studies show that hydrocarbon charge postdates the main phase of silica and ferroan calcite cementation and may be synchronous with the widespread dissolution. The high salinity of some fluid inclusions, S isotope data and the presence of sphalerite all indicate an important role for brines from the Argo Formation evaporites. The complex thermal history of the basin results from (a) high regional Aptian–Albian heat flow manifested by late Aptian volcanism and (b) episodic Cretaceous–Paleogene up-dip migration of hot brines from the deeper parts of the basin. Changing fluid chemistry and thermal conditions had a strong influence on the diagenetic evolution of the basin and hence reservoir quality.

Atlantic Geology, 2016, Volume 52
Atlantic Geoscience Society Abstracts 42nd Annual Colloquium & General Meeting 2016
doi: 10.4138/atlgeol.2016.004