Estimating Mineral Trapping Capacity of Sedimentary Strata in the Georgia Basin, B.C., Canada

Paula, Ramirez-Lopez[1], Shahin E. Dashtgard[1], Marc Enter[2], Matthew Power[2], Maziyar Nazemi[1], and Francyne Bochi do Amarante[1].

[1]Applied Research in Ichnology and Sedimentology (ARISE) Group, Department of Earth Sciences, Simon Fraser University.

[2]Vidence Inc.

Abstract

Among the various options for subsurface carbon storage, siliciclastic rocks are particularly promising due to their widespread occurrence and favorable reservoir properties, which can accommodate significant volumes of CO_2 (Romanov et al., 2015; Ringrose & Meckel, 2019). The Lower Mainland of British Columbia (LMBC) encompasses Metro Vancouver, and most of the Fraser Valley, and the strata below the LMBC form part of a northwest-southeast-oriented forearc depression known as the Georgia Basin. The siliciclastic sedimentary rocks that comprise the fill of the Georgia Basin include the Upper Cretaceous Nanaimo Group (Turonian to Maastrichtian), the Paleogene Huntingdon Formation (Paleocene to Oligocene), and the Neogene Boundary Bay Formation (mainly Miocene). These strata are presently being evaluated for their CO_2 storage potential, including their mineral trapping capacity for CO_2.

Mineral trapping, which immobilizes CO_2 through mineral carbonation reactions, is the most secure form of CO_2 storage as it prevents the return of CO_2 to the atmosphere (Xu et al., 2003). The extent of mineral trapping depends on mineral composition and the availability of reactive surface area (Qin & Beckingham, 2019). Image-based methods for calculating reactive surface area, which consider pore accessibility, enhance the accuracy of geochemical simulations of CO_2 reactions (Beckingham et al., 2017).

Methods

In this study, an Automated Mineralogy system for SEM (AMICS) is used to analyze 88 polished core samples acquired from five wells in the LMBC. These samples are analyzed quantitatively for their bulk mineralogy, mineral size distribution, grain density, and 2D porosity. Samples are also imaged using the backscatter electron imaging (BSE) and cathodoluminescence (CL) signals, which are combined with quantitative measurements of mineralogy to generate detailed mineral maps for each sample. Mineral maps are used to define clast textures (grain size, shape, and sorting), clast mineralogy (Quartz-Feldspar-Lithic fractions), matrix and cement, reactive mineralogy, diagenetic features, and porosity distribution; the resulting data are grouped by formation, depth, and facies (Nazemi et al., in review). Image derived porosity values from AMICS analysis are compared to core-based porosity-permeability measurements to correlate pore-scale data derived in this study to the core-scale. The quantitative mineralogical data enable estimation of the CO_2 mineral trapping potential of sedimentary strata below the LMBC.

Results and Discussion

The 88 samples analyzed show significant petrological heterogeneity, with conglomerate, coarse-, medium-, and fine-sandstone, and mudstone exhibiting poor sorting and low maturity. Grain size variations in samples from the same formation strongly influence the proportions of primary detrital components. Diagenetic processes also played a critical role in modifying reservoir properties, with calcite, chlorite, zeolite, and smectite identified as the dominant diagenetic minerals. Reactive minerals, including carbonates, chlorites, mafic minerals, and plagioclase, are distributed heterogeneously between formations and by depth, but their mineral trapping capacity varies as a function of reactive surface, which, in turn, varies as a function of effective porosity

Pore-mineral associations and reactive surface area are assessed to predict CO_2 mineral trapping capacity of stratigraphic units at different depths. Coarse sandstones from the Boundary Bay Formation and conglomerates as well as coarse sandstones from the Huntingdon Formation exhibit the best combination of porosity and reactive mineralogy with accessible pore space. However, when combined with core-based porosity-permeability measurements, sandstone and conglomerate in the Boundary Bay Fm shows the greatest potential for CO_2 mineral trapping due to having the highest permeability (effective porosity).

Beyond providing insights into carbon storage potential, these data support the development of relationships between reactive surface area, porosity, and clay content in potential reservoir units, and highlight the value of employing automated mineralogical systems in petrographic studies. The data also provide high-resolution quantitative data on the sedimentology, diagenetic history, and provenance of sedimentary strata in the Georgia Basin, and represents the first such study of sedimentary strata below the LMBC.

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