

Mineralogy and Pore Systems in Cambrian Sandstones and Dolomites in Southwestern Ontario: Carbon Capture and Storage Implications

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Summary

Porosity and permeability data are first-order constraints on the viability of a potential CO₂ sequestration target, but the lithology of the repository is also important. Injected CO₂ forms carbonic acid that will react with carbonate minerals and potassium feldspar (e.g., Luhmann et al. 2014; Rosenqvist et al. 2019) thereby altering pore systems (i.e. storage and injectivity). Mineralogy also plays an important role in controlling wettability, and hence affects multi-phase fluid flow (potentially including brine, hydrocarbons, and injected CO₂) in a porous medium.

Carbon capture and storage (CCS) efforts are in their infancy in southern Ontario. Although the Cambrian section has been recognized as the most suitable CCS target for over 20 years (Shafeen et al., 2004; Carter et al., 2007; Hart, 2024a,b), and has produced oil and gas from small fields and been an exploration target for over 100 years, virtually nothing has been published about pore systems in those rocks.

This presentation, and an associated paper (Hart, *in review*), presents petrographic documentation of mineralogy, pore types, and the relationships between those two variables in Cambrian sandstones and dolomites from a single core that penetrated the entire Cambrian section.

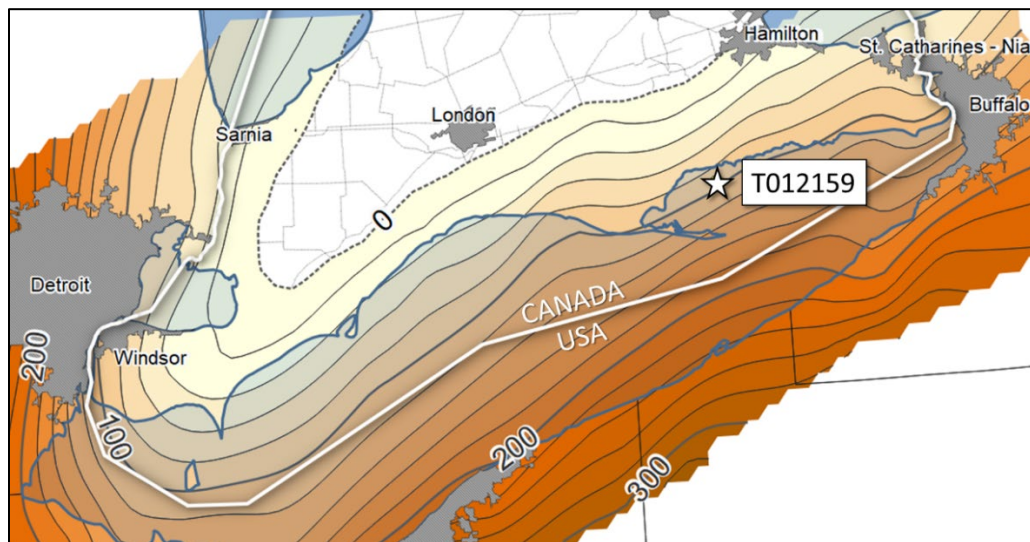


Figure 1. Location of the T012159 cored well superimposed on an isopach map of the Cambrian section (Modified from Hart, 2024a).

Methods

All samples analyzed for this study were obtained from a single core. The Dundee East well (License # T012159), reported as a stratigraphic test, was drilled, logged, and cored in 2012, approximately 10 km offshore in northeastern Lake Erie (Fig. 1). That core was sampled for this project at the Oil, Gas, and Salt Resources core facility in London, Ontario. Samples were prepared for optical petrography and scanning electron microscope work at Surface Science Western, also in London. The SEM work included imaging using both backscatter and secondary electron modes, and elemental mapping using energy dispersive X-ray spectroscopy (EDS).

Results

This paper focuses on SEM imagery. The linkages between SEM images and optical petrography, x-ray diffraction, and core plug measurements (porosity, permeability, grain density) are discussed by Hart (*in review*). A sample secondary-mode SEM image is presented at left in Figure 2. This image clearly defines grains and interparticle pores in a sandstone but provides no mineralogic information. The same image with an EDS overlay is shown at right. Elements in the EDS imagery have been coloured and overlain so that quartz is yellow, potassium feldspar is green, and dolomite is blue. Images of this type are more useful for defining relationships between mineralogy and pore systems. Figure 3 shows selected examples of SEM imagery depicting mineralogy and pore systems. Pore-filling epoxy, impregnated during thin-section preparation, is red (i.e. the element carbon is coloured red) but not all pores filled with epoxy during sample preparation.

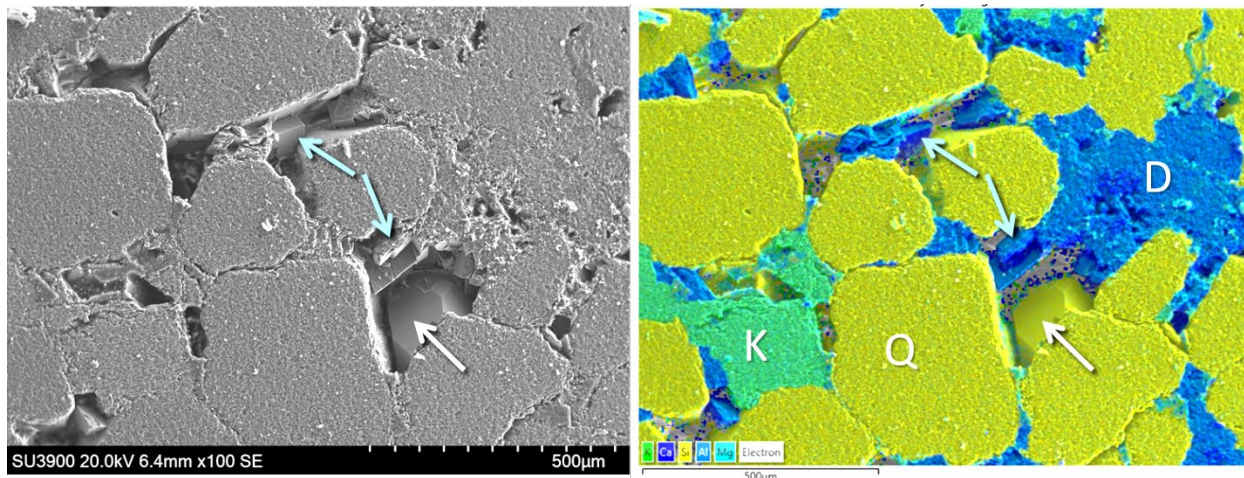


Figure 2. Comparison of a secondary-mode SEM image alone (left) versus the same image with and EDS overlay. In the EDS image, silica is coloured yellow, potassium green, aluminum light blue, magnesium cyan, and calcium dark blue. In this way, quartz (Q) is yellow, potassium feldspars (K) are green, and dolomite (D) is blue. Note euohedral dolomite cement (blue arrows) and euohedral quartz overgrowth (white arrows).

The rocks comprise a range of lithologies, including sandstones, dolomitic sandstones, sandy dolomites, and dolomites. The mixed carbonate-clastic character makes the Cambrian section of southern Ontario lithologically unusual but it is mineralogically not very complex (Fig. 3). Quartz

and potassium feldspars are the primary detrital components. Potassium feldspar contents that can be >50%. Shales are absent and clays of any type (diagenetic or detrital) are not abundant.

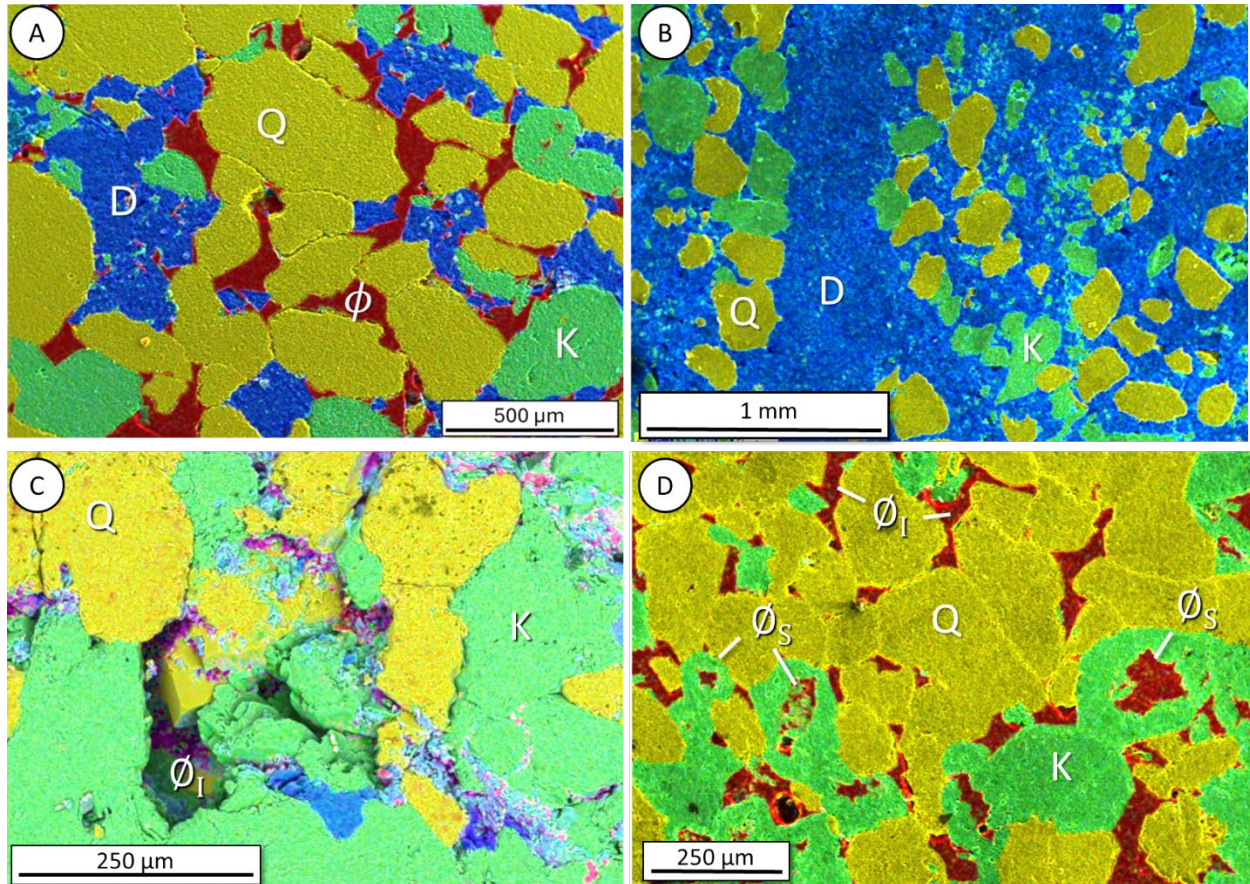


Figure 3. Sample SEM/EDS imagery showing compositional variability and pore systems. A) Combined backscatter SEM and EDS image from a dolomitic sandstone showing quartz (Q) and potassium feldspar (K) grains. Some of the original interparticle pore space is filled with dolomite (D) cement, some is open and was filled with epoxy (ϕ) coloured red in this image. B) Combined backscatter SEM and EDS image from a sandy dolomite (D) with quartz (Q) and potassium feldspar (K) grains. C) Combined secondary-mode SEM and EDS image from a dolomitic sandstone showing quartz (Q) and potassium feldspar (K) grains, and an interparticle pore (ϕ_I). A euhedral quartz overgrowth partly fills that pore. D) Combined secondary-mode SEM and EDS image from a sandstone showing quartz (Q) and potassium feldspar (K) grains. Epoxy-filled pores (red) highlight interparticle porosity (ϕ_I) and secondary porosity (ϕ_S) formed by dissolution of orthoclase grain centers.

Three main pore types are present: intergranular, intragranular, and vugs. The first two are present in sandstones and the vugs are present in dolomites. Intragranular porosity is primarily in orthoclase feldspar grains, where diagenesis removed grain centers. Alteration products are generally lacking in those pores, suggesting basal fluids were moving and able to transport the dissolved material out of the rock. The results are significant because they demonstrate the arkosic nature of the Cambrian sandstones, show that feldspar content is a significant control on

porosity. There are different types of pore-filling cement (e.g., Figs. 2, 3). Dolomite is the most common. Quartz overgrowths and feldspar overgrowths are also present locally. Calcite cements are present at some levels but are uncommon.

Hart (*in review*) integrates this type of SEM imagery with other data to evaluate relationships between mineralogy, porosity, and petrophysical properties. Work is ongoing to extend this type of analysis to other cores to assess spatial variability in pore systems.

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