Carbon Capture & Storage: Overview, Reservoir Options, and Future Possibilities

DALHOUSIE UNIVERSITY
Inspiring Minds

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Introduction

As the global population rises and technology advances, so does the demand for energy. Increasing amounts of fossil fuels are used to meet this demand, with 6 gigatons of carbon are released into the atmosphere each year (Lackner, 2003). Until the world is ready to switch from coal to a cleaner form of fuel, another fuel type needs to be established (Walsh, 2011). If not, the Earth will be facing major climate change in the near future (CAPP, 2009). One significant option to explore is Carbon Capture and Storage.

Carbon Capture & Storage

The process of Carbon Capture and Storage goes through several well defined steps (Figure 1).

1) CO_2 is separated from the emissions released by industrial buildings by adding an amine based liquid filter. This is excellent at absorbing CO_2 from the emissions as it travels up a chimney or smokestack (CAPP, 2009) (Figure 1 a.-b.).
2) Heating of this solution will release water vapor and leave behind concentrated CO_2 (Ronca, n.d.) (Figure 1 b.).
3) This is compressed before it is transported it by tanker truck or pipeline to a well where it will be pumped into the ground and stored (CAPP, 2009) (Figure 1 c.,d.,e.).

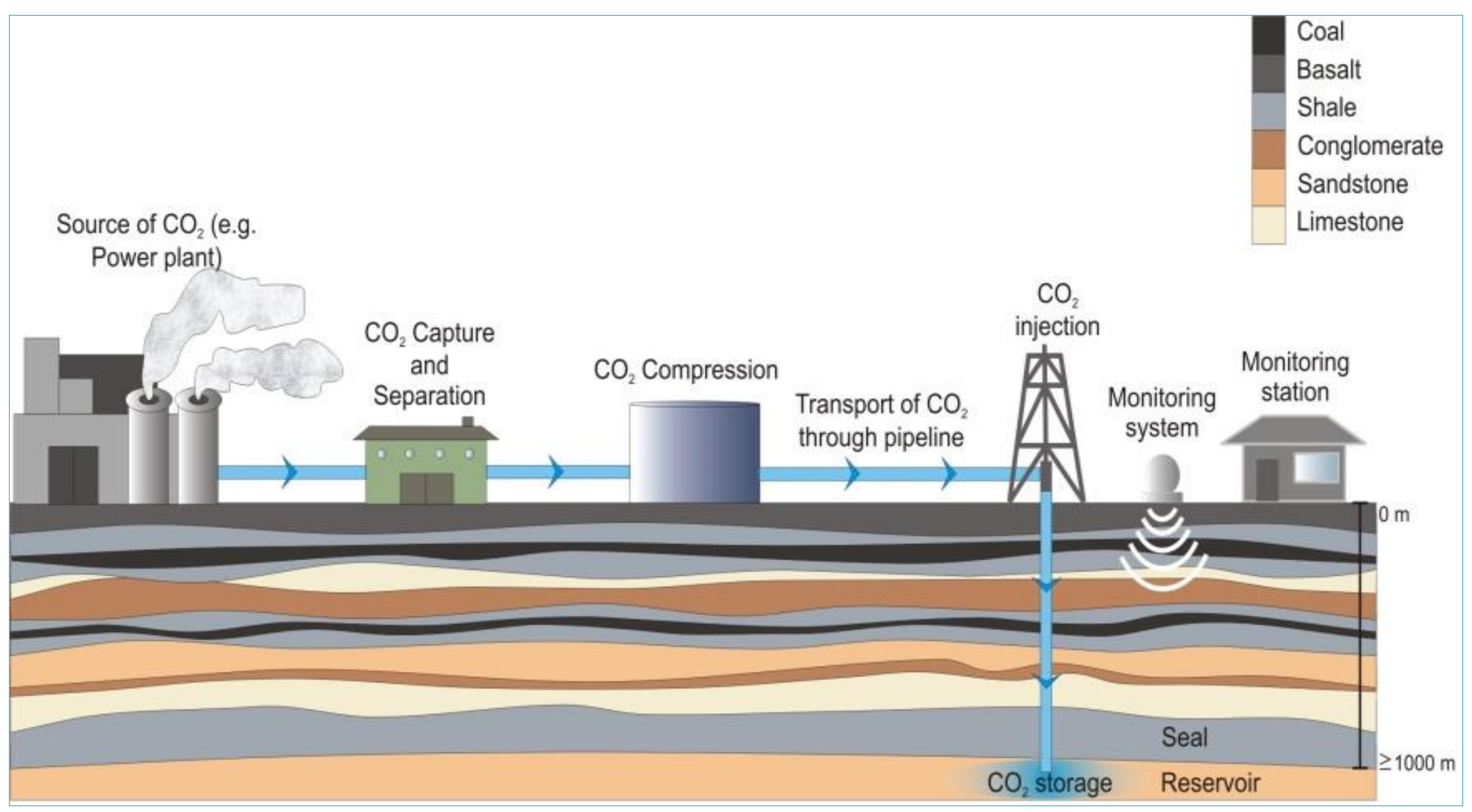

Figure 1. The full process of Carbon Capture and Storage.

Potential reservoir candidates for possible carbon capture and storage are formed in environments that include eolian, alluvial, lacustrine, fluvial, deltaic, shelf (clastic/carbonate), reef, and turbidite (NETLa, n.d.). For the process of storage site characterization see Figure 2.

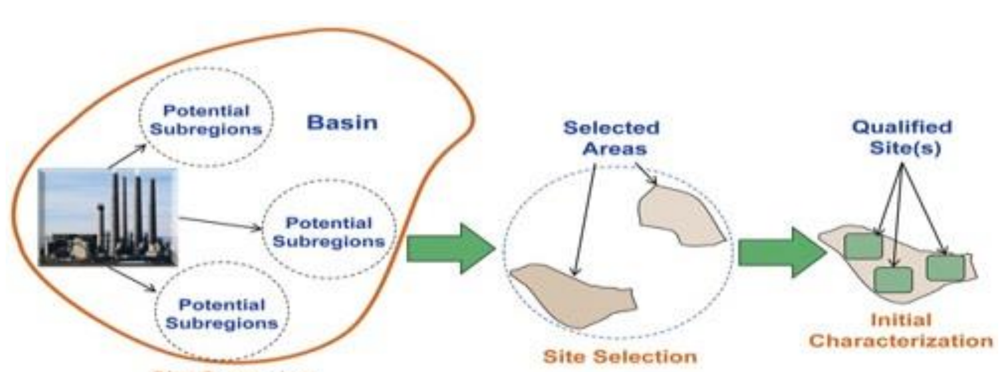

Figure 2. Graphical representation of project site maturation through the exploration phase of the site characterization process (NETLa, n.d.).

Types of CO_2 Storage Reservoirs

Saline formations (Figure 3-3)**:**

- Reservoirs with layers of porous rock, saturated with brine are considered potential CO_2 storage sites.
- Minerals in the brine can react with the CO_2 and cause it to become solid carbonate (NETLb, n.d.) .

Oil and Gas Reservoirs (Figure 3-1, 3-2)**:**

- Oil and gas reservoirs are found where a permeable layer of rock (e.g., sandstone) is overlain by an impermeable layer of rock (e.g., shale/siltstone) which acts as a seal/trap. This is known as reservoir and seal pairing.
- These conditions are also ideal for CO_2 storage.
- The injection of CO_2 into these sites can produce an extra 10-15% more oil. This is called enhanced oil recovery (NETLb, n.d.).

Un-mineable coal seams (Figure 3-4, 3-5)**:**

- Seams that are too thick or thin for economic mining may be candidates for CO_2 storage because coal has various amounts of methane, and injected CO_2 can absorb into the surface of the coal and push out this methane (NETLb, n.d.).

Organic-Rich Shale Basins Figure 3-6)**:**

- Not only can shale act as a seal for carbon storage, but it contains organic matter in the form of hydrocarbons, which can act as an absorbing substrate for CO_2.
- This is similar to the idea associated with un-mineable coal seams (NETLb, n.d.).

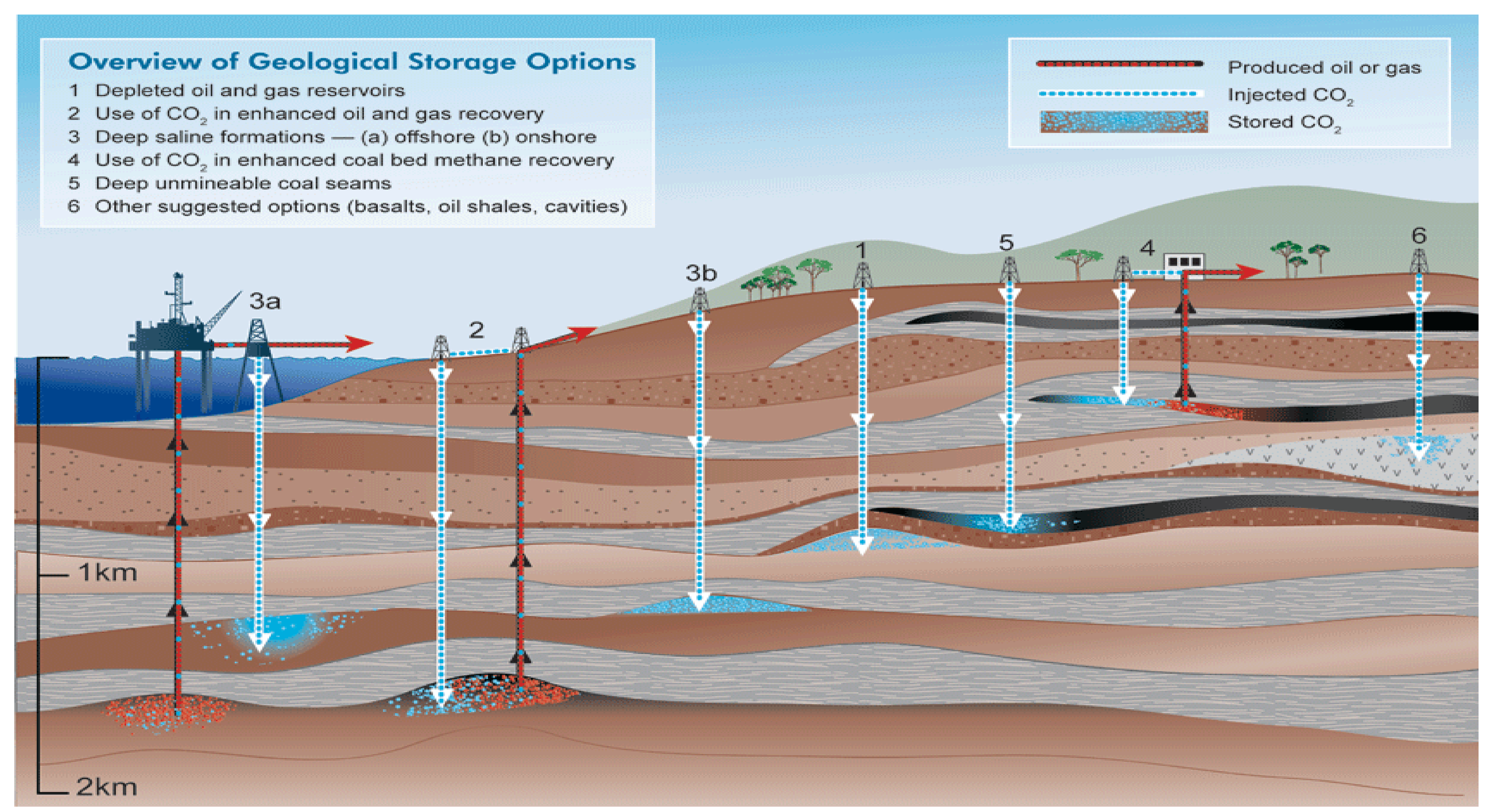

Figure 3. Geological storage options for CO_2 sequestration (Geologic Carbon Sequestration Program, n.d.).

Case Study: Sydney Carboniferous Strata

- Carbon capture and storage is being investigated in the Carboniferous strata of Sydney, Nova Scotia because its lithology comprises of sandstone, siltstone, coal and limestone (Gibling & Tanlon, 1997).
- As previously mentioned, coal seams and porous rock, like sandstone are great at storing CO_2.
- Proper stratigraphic sequencing for carbon storage is found in this area. Therefore, carbon sequestration in Sydney, could be a high possibility if further studies find that there are no issues compromising the stability and integrity of the storage site, e.g., faults.
- This lithology is similar to that found in the Joggins Fossil Cliffs (Kelly, M.Eng. in progress), and by studying the Joggins lithology it may enhance our understanding of the Sydney Reservoir.

Future Possibilities: Basalt Formations

- Another possibility for Carbon Storage is found in basalt formations.
- Basalt is the result of magma that has cooled into formations that are found both on land, and deep in the ocean (Luoma, 2010).
- These basalt formations are filled with vesicles from gases that were escaping as the magma cooled.
- Basalts with high permeability are targeted for injection zones, since their holes are a great place to store injected CO_2 (Matter, 2008), and once contained deep within the formations , the CO_2 can react with the chemicals within the basalt to form solid carbonate material, i.e. a form similar to limestone (Berger, 2010) (Figure 4).
- Dennis Kent, as sited by Luoma (2010), suggested this fact could make basalt formations “the ultimate repository” for carbon capture and storage. This would ensure permanent storage of CO_2 without the possibility of leakage (Berger, 2010).

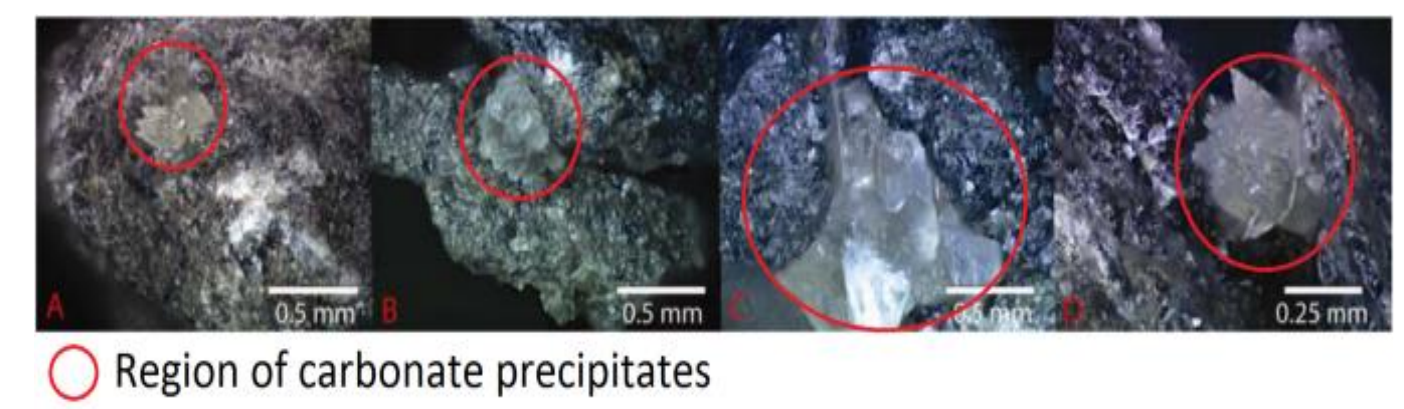

Figure 4. Columbia River Basalt and the increase of carbonate precipitates after exposure to CO_2 for a) 86 days, b) 377 days, c) 777 days, and d) 1,334 days (modified from Plasynski et al., 2008).

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