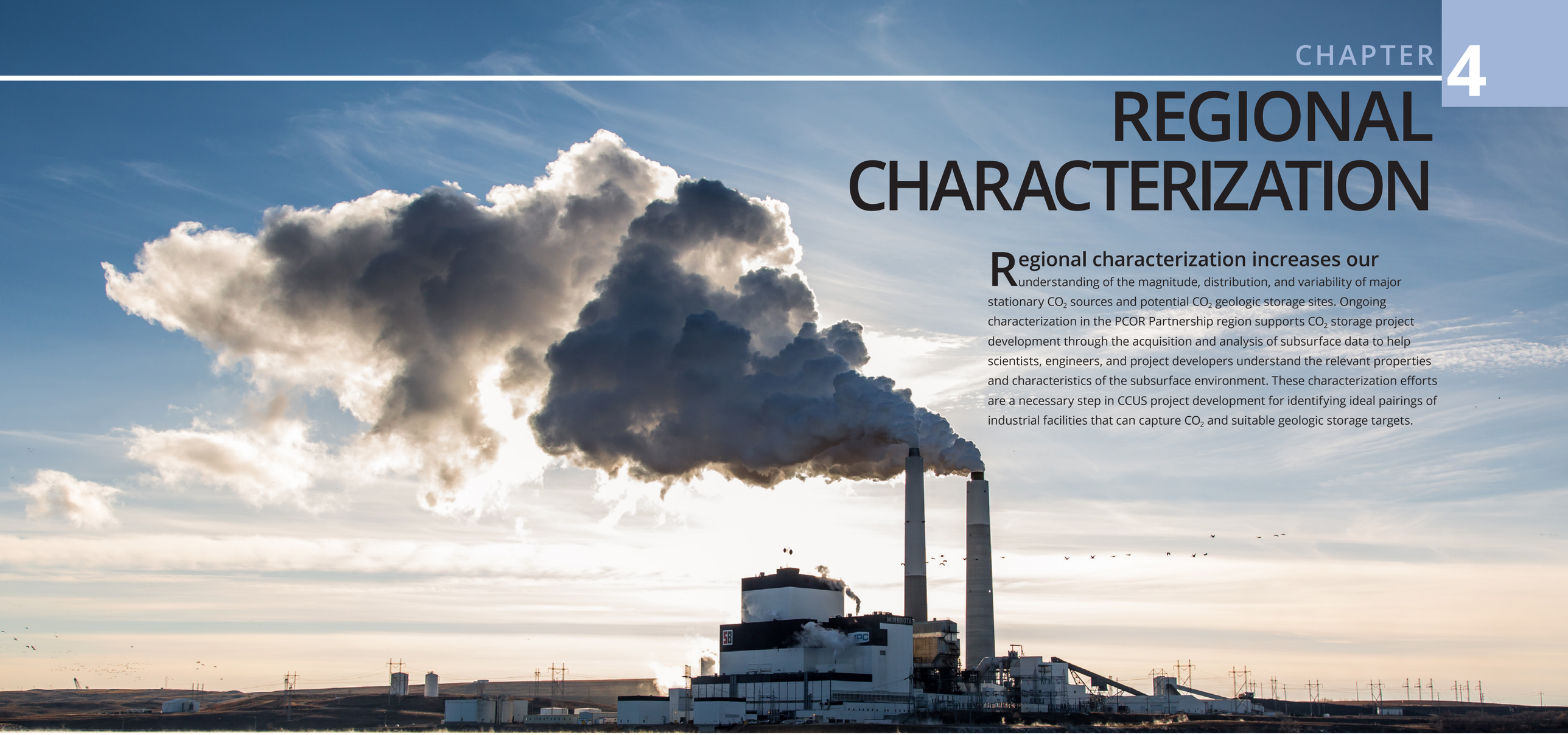
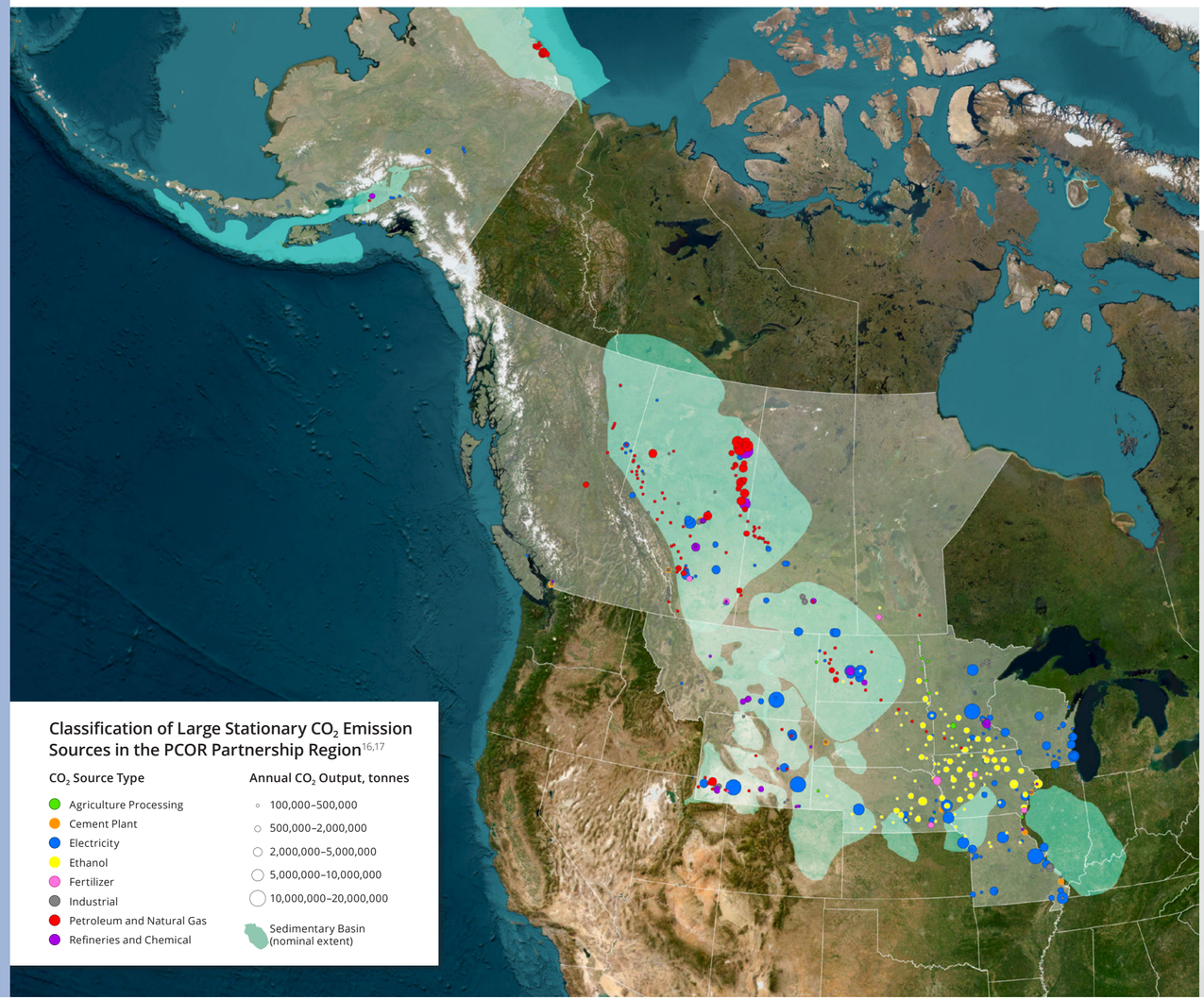
CHAPTER 4

REGIONAL CHARACTERIZATION



Regional characterization increases our understanding of the magnitude, distribution, and variability of major stationary CO_2 sources and potential CO_2 geologic storage sites. Ongoing characterization in the PCOR Partnership region supports CO_2 storage project development through the acquisition and analysis of subsurface data to help scientists, engineers, and project developers understand the relevant properties and characteristics of the subsurface environment. These characterization efforts are a necessary step in CCUS project development for identifying ideal pairings of industrial facilities that can capture CO_2 and suitable geologic storage targets.

DISTRIBUTION OF LARGE STATIONARY CO_2 SOURCES



Classification of Large Stationary CO_2 Emission Sources in the PCOR Partnership Region[16,17]

CO_2 Source Type

- Agriculture Processing
- Cement Plant
- Electricity
- Ethanol
- Fertilizer
- Industrial
- Petroleum and Natural Gas
- Refineries and Chemical

Annual CO_2 Output, tonnes

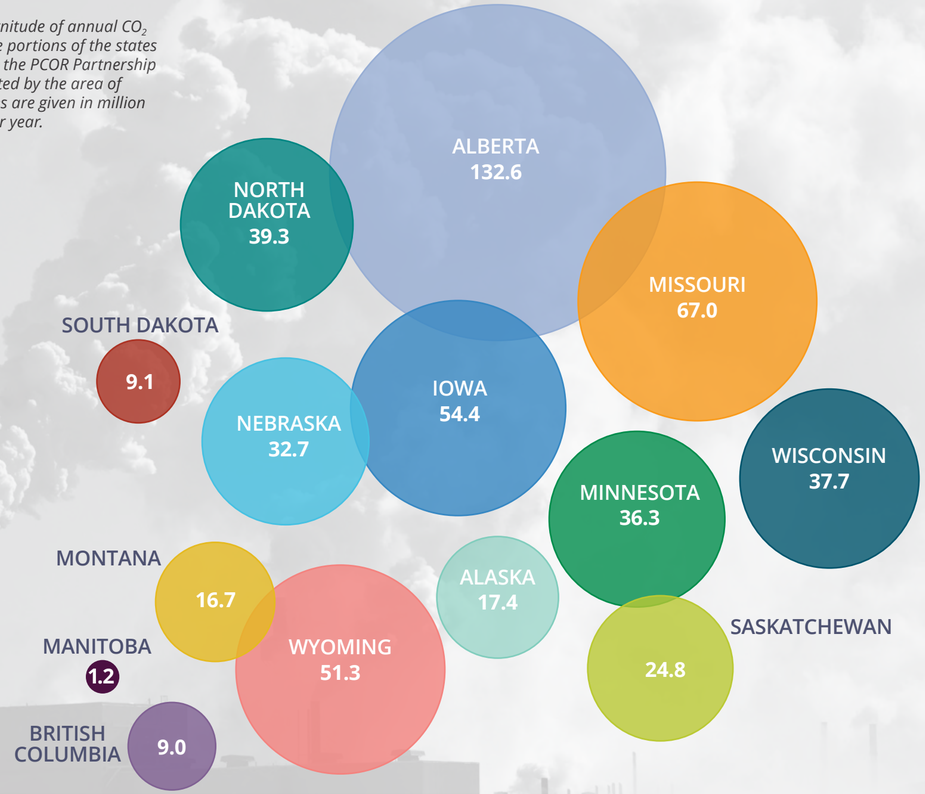
- 100,000–500,000
- 500,000–2,000,000
- 2,000,000–5,000,000
- 5,000,000–10,000,000
- 10,000,000–20,000,000
- Sedimentary Basin (nominal extent)

CO_2 SOURCES

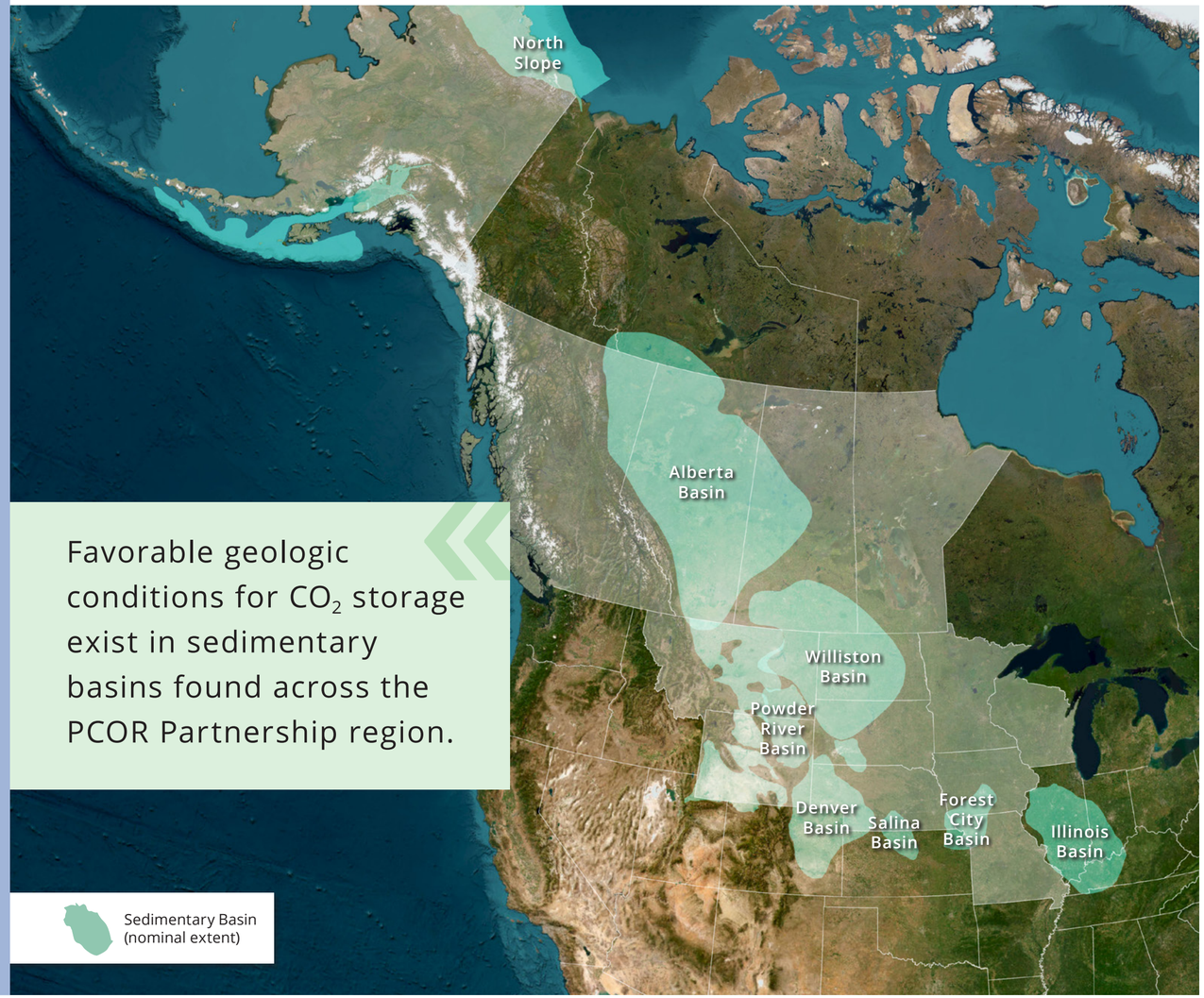
The PCOR Partnership has identified, quantified, and categorized 565 stationary sources in the region that have an annual output greater than 100,000 tonnes of CO_2. These stationary sources have a combined annual CO_2 output of over 529 MMt. Although not a target source of CO_2 for geologic storage, the transportation sector in the U.S. portion of the PCOR Partnership region contributes nearly 242 million additional tonnes of CO_2 to the atmosphere every year.[16,17,35–39]

The annual output from the various large stationary sources ranges from 100,000 tonnes for industrial and agricultural processing facilities that make up the majority of the sources in the region to over 15 MMt for the largest coal-fired electric generation facility. Fortunately, many of the large point sources are located in areas that are favorable for CO_2 storage because of their concurrence with deep sedimentary basins, such as those areas in Alberta, North Dakota, Montana, and Wyoming.

The relative magnitude of annual CO_2 emissions for the portions of the states and provinces in the PCOR Partnership region are depicted by the area of the circles. Values are given in million tonnes of CO_2 per year.



MAJOR REGIONAL SEDIMENTARY BASINS

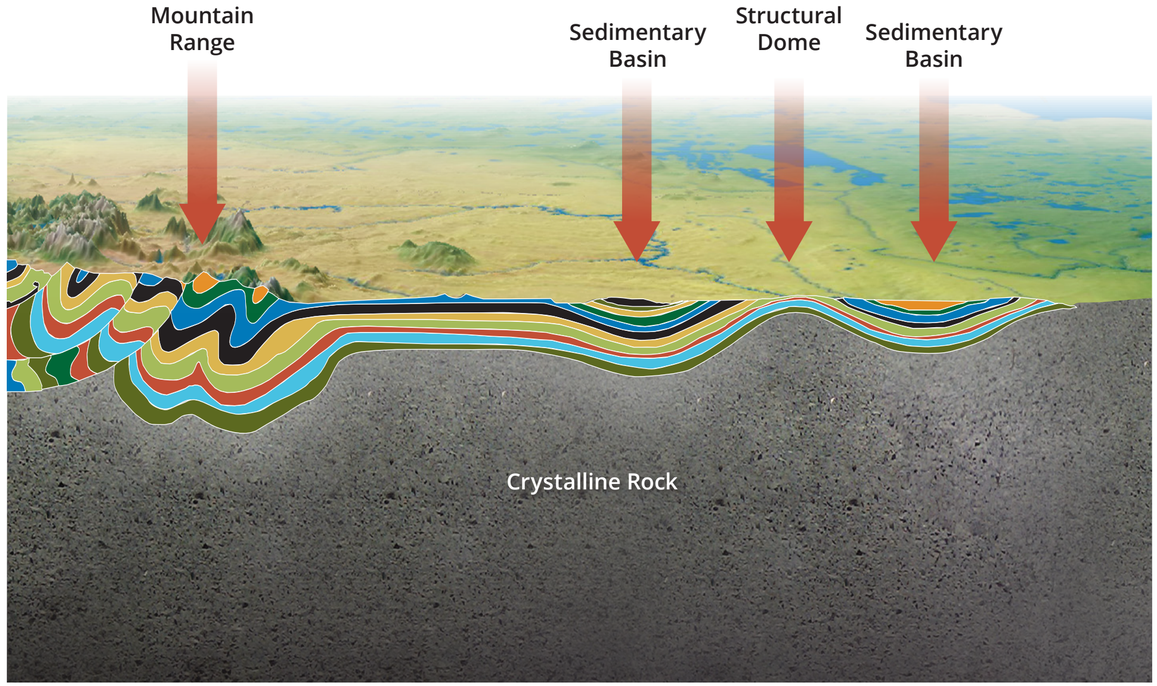


Favorable geologic conditions for CO_2 storage exist in sedimentary basins found across the PCOR Partnership region.

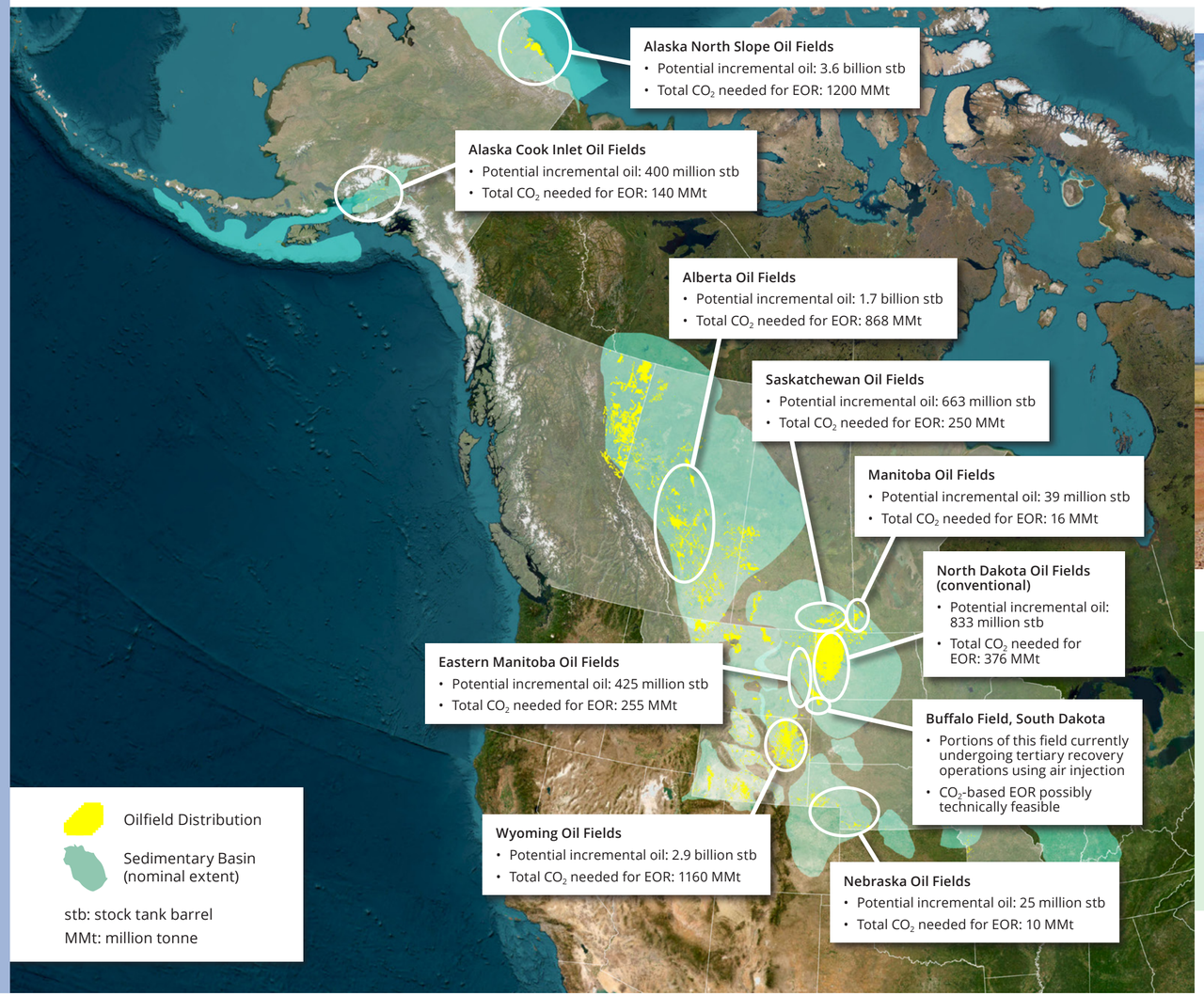
CO_2 STORAGE OPPORTUNITIES

Sedimentary basins are large regional depressions in Earth's crust. These depressions accumulate a considerable thickness of sediment that can cause further subsidence and allow for even more sediment to accumulate. As the sediments are buried, they compact under increasing pressure and then begin the process of lithification (changing to rock). Sedimentary basins vary in configuration from bowl-shaped to elongated troughs. If organic-rich sedimentary rocks occur in combination with appropriate depth, temperature, and duration of burial, hydrocarbon generation can occur within the sedimentary basin. The rich set of options for the safe, long-term geologic storage of CO_2 in the PCOR Partnership region is found in the deep portions of its extensive sedimentary basins.

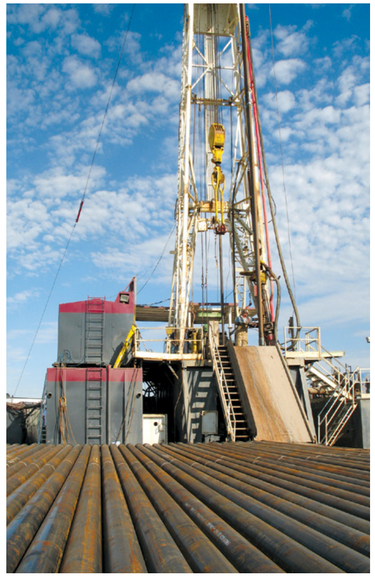
Oil and gas reservoirs and deep saline formations are the two primary CO_2 storage options found within sedimentary basins. These storage formations are commonly situated vertically one above another and separated by sealing formations, an arrangement referred to as stacked storage. Stacked storage offers the potential to store the same total volume of CO_2 but with a smaller geographic footprint.



EOR POTENTIAL



CO_2 STORAGE IN OIL FIELDS

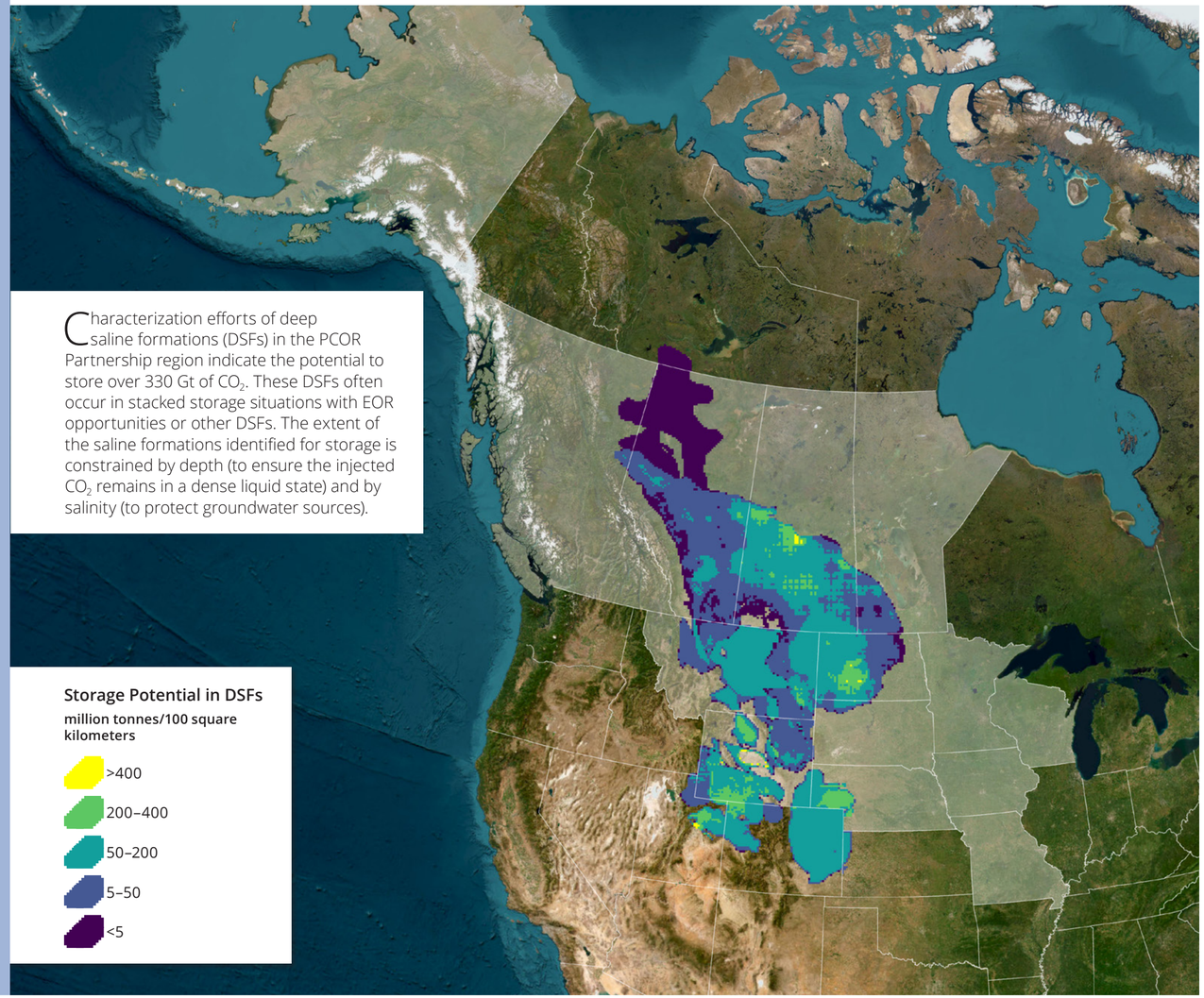


Although oil was discovered in the PCOR Partnership region in the late 1800s, significant development and exploration did not begin until the late 1920s. The body of knowledge gained in the nearly 100 years of exploration and production of hydrocarbons in this region is a significant step toward understanding the mechanisms for secure storage of significant amounts of CO_2. Today, oil is drawn from the many oil fields in the PCOR Partnership region from depths ranging from as little as 60 m to approximately 8000 m below ground level.

While the use of CO_2 in conventional reservoirs is a widely applied practice, the use of EOR in unconventional (or tight) oil reservoirs like the Bakken petroleum system (Bakken and Three Forks Formations) is a relatively new concept. Initial laboratory and field testing offers promising results that CO_2 for EOR in the Bakken may be a viable option. Current research is evaluating approaches to use CO_2 to improve Bakken oil production through field-scale injection testing. If proven viable, CO_2 EOR in unconventional reservoirs presents an opportunity for tremendous volumes of CO_2 storage and increases in oil production.

The region has over 3700 MMt of CO_2 storage potential in conventional oil fields and 10.2 billion stb of incremental oil potential.

CO_2 STORAGE IN SALINE FORMATIONS



Characterization efforts of deep saline formations (DSFs) in the PCOR Partnership region indicate the potential to store over 330 Gt of CO_2. These DSFs often occur in stacked storage situations with EOR opportunities or other DSFs. The extent of the saline formations identified for storage is constrained by depth (to ensure the injected CO_2 remains in a dense liquid state) and by salinity (to protect groundwater sources).

STACKED STORAGE

Sedimentary basins comprise layers of unique geologic formations that can serve as potential storage targets (i.e., saline formations, developed oil and gas reservoirs) or as impermeable sealing formations (e.g., shales). When two or more CO_2 storage targets are present in the subsurface at the same geographic location, a storage project may choose to pursue a stacked storage approach. Stacked storage will typically include some combination of dedicated storage in DSFs and EOR in hydrocarbon-bearing formations.

Stacked storage allows for greater volumes of storage in a given area, and the approach also allows for a smaller project area as the volumes of CO_2 can be divided amongst the different storage formations. The reduced project area would reduce the project's monitoring area, number of legacy wellbores, and number of landowners in the project area. By placing more than one injection well at a location (i.e., multiwell pads), surface facilities and CO_2 distribution systems can be consolidated, which can minimize environmental risks and impacts.

While stacked storage projects have yet to start operating in the PCOR Partnership region, multiple projects in various stages of development are considering stacked storage scenarios. These projects include DOE CarbonSAFE (Carbon Storage Assurance Facility Enterprise) projects in North Dakota, Wyoming, and Nebraska, and they are in multiple sedimentary basins, including the Williston, Powder River, and Denver–Julesburg. Additionally, in Canada, the Alberta Basin is estimated to have stacked storage capacity for up to ten deep saline formations. As these developing projects come online, they will provide additional insight and guidance for future stacked storage projects.