INFLUENCE OF CO2 PHASE BEHAVIOR ON SEQUESTRATION IN A DEPLETED GAS RESERVOIR

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Problem

- Studies show that the increase in greenhouse gases, such as CO2, in our atmosphere has been negatively impacting the Earth's natural greenhouse effect (Lindsey, 2020).
- A study conducted in 2019 shows that the production of oil and gas of that year contributed to approximately 24% of total emissions in 2019 (Environment and Climate Change Canada, 2021).
- A viable solution to reducing the CO2 produced through oil and gas actives is to sequestrate it. Through this project, we aim to understand CO2 phase behavior as it is injected and store in a depleted gas reservoir in order to successfully reduce its presence from the atmosphere.

Introduction & Methodology

- The goal of this project is to investigate the influence of CO2 phase behaviour on sequestration in a depleted gas reservoir.
- Through achieving the goal, the following questions will be answered; How does CO2 behave when it is injected into a reservoir? Is sequestering CO2 in a depleted gas reservoir an effective method for reducing CO2 emissions from our environment?
- The methodology approach for this project is to combine literature review with actual field data.
- In collaboration with our supervisor Dr. Zhao, the best way to set ourselves up for success was to identify the scope of the project and its deliverables because the conversation around CO2 can be quite large starting from carbon capture, transportation, injection on the surface and sequestration in the reservoir. Therefore, we concentrated our efforts on the subsurface aspects as it was an area that sparked our interest the most.
- The approach to capturing actual field data started with selecting a depleted gas reservoir. The project reach was to remain within Saskatchewan borders. As many prior studies have taken place in the SE Saskatchewan area, this was the optimal area for our project needs. Figure 1 displays the optimal areas for CO2 sequestration around the world.

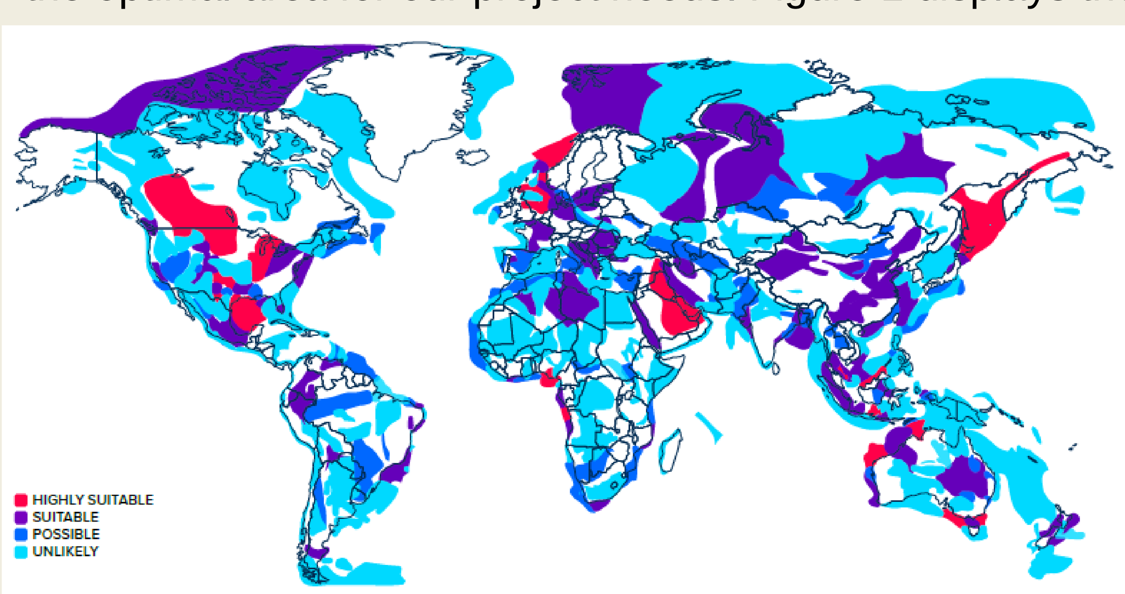

Figure 1: Suitable storage regions of the world based on the global CCS institute's storage basin assessment database (Global Status of CCS, 2021)

- Through the use of AccuMap, the base values for well depth, formation porosity and permeability, temperature and formation type were concluded upon.
- CMG was the primary application used to build fluid model, reservoir model and conduct simulation. All PVT analysis was simulated using WinProp in order to evaluate the behaviour of CO2 gas – CH4 gas mixture at initial conditions.
- The applications used based on the objectives of this report were two-phase envelope, constant volume depletion, general EOS model (GEM) and gas compressibility ratio to pressure. Builder was used to design the reservoir model. The theory behind the model was to be able to simulate a depleted gas reservoir that is undergoing CO2 injection with the purpose of sequestration, hence no producing wells. A 20 x 20 grid system with 3 injection wells in the shape of an equilateral triangle was used in the analysis to achieve efficient distribution of CO2.

Results

PT (Pressure – Temperature) diagram that describe the phase envelope of a CO2 and gas mixture reservoir is highlighted in Figure 1. It illustrates the effect the presence of CO2 has in the reservoir over a range of temperatures and pressures from 20 mole % to 50 mole % of carbon dioxide. A fluid mixture of liquid and vapor is represented within the envelope curve. Outside of this two-phase region fluids can be either single-phase gas, single phase liquid or a critical fluid that sits above the curve and falls at very high temperatures. We can gather the following from figure 2:

- We see that with increasing carbon dioxide concentration in the reservoir, the PT envelope shrinks
- Cricondenbar decreases with the increase of carbon dioxide concentration
- With the carbon dioxide concentration increase the critical pressure point decreases while the critical temperature point increases
- Cricondentherm slightly increases with increasing carbon dioxide concentration

The decrease of the two-phase envelope highlights the "drying-effect" phenomena of carbon dioxide in the reservoir. This suggests the partial revaporization of the liquids condensed into the gaseous phase. The cricondenbar decrease trend with increasing carbon dioxide explains that the tendency for liquid to move into its vapor phase is now easier. The critical point trends indicate that fluids can now be in a mixed phase (liquid and gas) at higher temperatures but slightly lower pressures. As we see, majority of these trends strongly suggest the "drying-effect" of carbon dioxide in the reservoir.

After the 10-year injection period is complete, figure 3 illustrates the phase behaviour journey CO2 undergoes from surface conditions to reservoir conditions. We can gather the following from figure 3:

- At surface conditions, CO2 is relatively a vapour with temperatures around 20°C and pressure of 860 psi
- Once at the wellhead, CO2 becomes a liquid ready for injection into the reservoir
- After a 10-year period of injection CO2 transitions into a super critical fluid

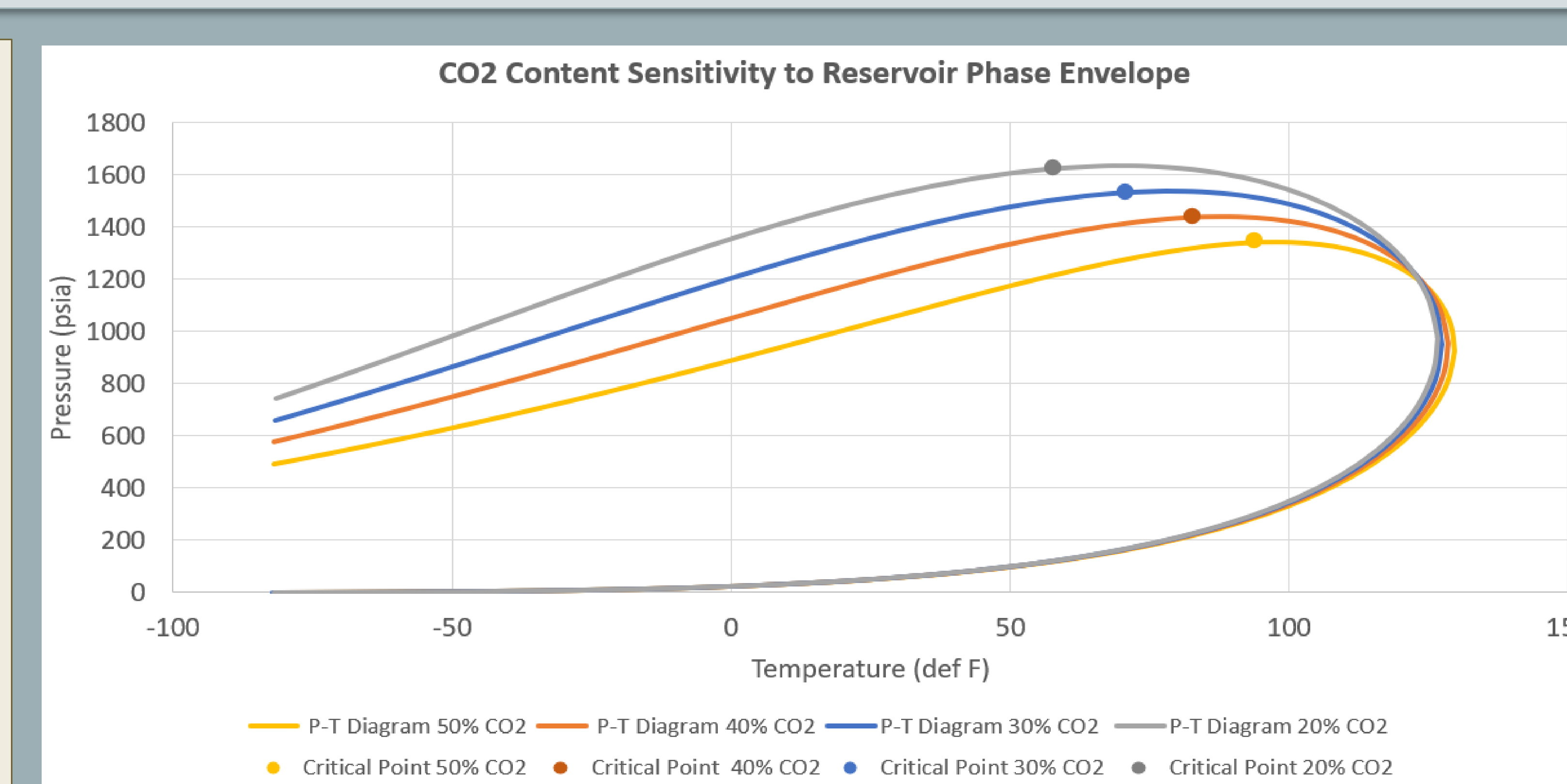

Figure 2: Effect of CO2 – Gas mixture on two phase envelope

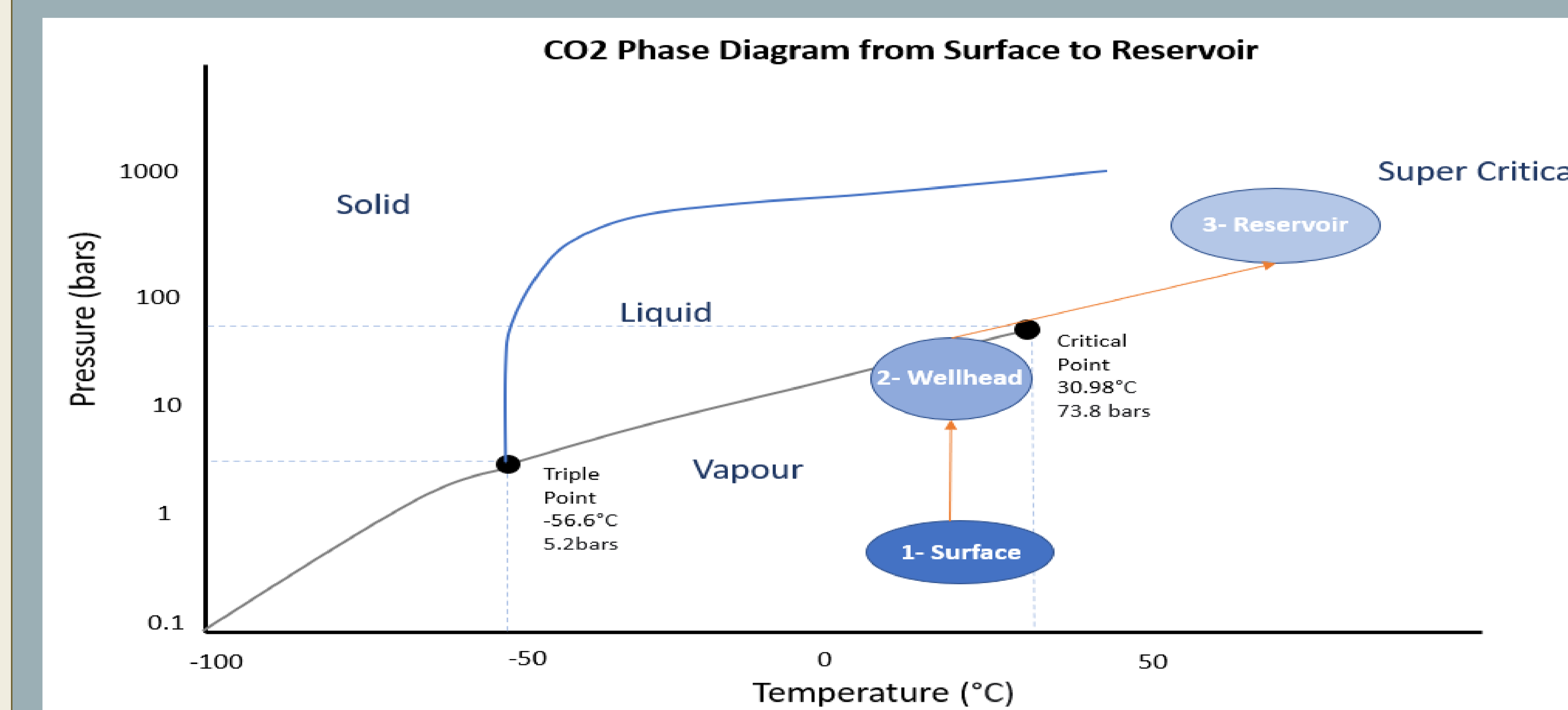

Figure 3: CO2 Phase Diagram from Surface to Reservoir

Conclusion

- From the PVT analysis, we observe that with increasing percentage of carbon dioxide the two-phase envelope shrinks. These trends show the positive impact depleted gas reservoirs have when sequestering carbon dioxide.
- Carbon dioxide goes from vapor at surface conditions to liquid while injection and super critical once in the reservoir.

References

Environment and Climate Change Canada. (October, 29, 2021). *Greenhouse gas emissions.* Retrieved from https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html

Lindsey, Rebecca. (August 14, 2020). *Climate Change: Atmospheric Carbon Dioxide.* Retrieved from https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide

Global Status of CCS 2021. (2021). *CO2 Geological Storage.* CCS Accelerating to Net Zero. p.7

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