Underground or Geologic Carbon Sequestration

In October of 2022, contractors for BP began working in Benton County performing seismic tests to inventory the characteristics and carbon dioxide (CO_2) storage capacity of the Mt. Simon sandstone layer that underlays Benton County at depths beginning at approximately 3000'. This seismic testing was quickly put on hold, but restarted in the summer of 2023 and was concluded in September. BP is interested in this layer of sandstone because they want to transport, via pipeline, CO_2 generated in Whiting, IN and permanently store it in the pore space of our Mt. Simon sandstone layer.

This is a complicated issue and one that elicits strong emotions. A concern shared by many is that we are allowing something to happen that may negatively affect not only us, but future generations of Benton County residents. There is also the suspicion that, yet again, we are being asked to socialize the risks of a business venture while the profits are privatized. Whether intentional or not, the way BP initially handled public relations for this project was far from ideal. They have since held a number of public meetings to explain the project and try to address our concerns. However, from conversations I've had after these meetings, it seems BP has not been successful at reducing the level of animosity and mistrust felt towards them by local folks.

What follows is what I have compiled in an attempt to cover the basics of this proposed geologic carbon sequestration project without getting so mired in the details as to make the topic seem overwhelming.

Jon Charlesworth
ANR Educator
Purdue Extension – Benton and Warren County

Mount Simon Sandstone

Historians study what has happened over decades, centuries or even millennia. Geologists study what has happened over hundreds of millions of years. For a vast stretch of time lasting approximately 300 million years and ending 250 million years before the present, what we now call Indiana was under water. The land was at the bottom of an inland sea. For 300 million years, sediment that was being carried to the sea by rain, wind and rivers was gradually deposited at the bottom of that sea. 300 million years is a long time, long enough to deposit 5000 feet of sedimentary rock on what would eventually become Benton County. The bottom layer of our sedimentary rock, the Mount Simon Sandstone layer, begins at depths ranging from 2500'-3500' and is approximately 2000' thick. The Mt. Simon Sandstone is porous- about 20%-30% pore space that is filled with a mixture of air and salty brine that is 2-3 times saltier than seawater. This briny pore space is a potential place to permanently store CO_2 thus keeping it from being added to the air we breathe. The CO_2 would be transported here through an underground pipeline and pumped down vertical wells to diffuse out into the Mt. Simon Sandstone layer. Over time, some of the CO_2 will become a constituent of the brine, some will become trapped in the rock's pores and some will mineralize and become rock.

Basic Overview of CO_2 Sequestration

Essential Idea

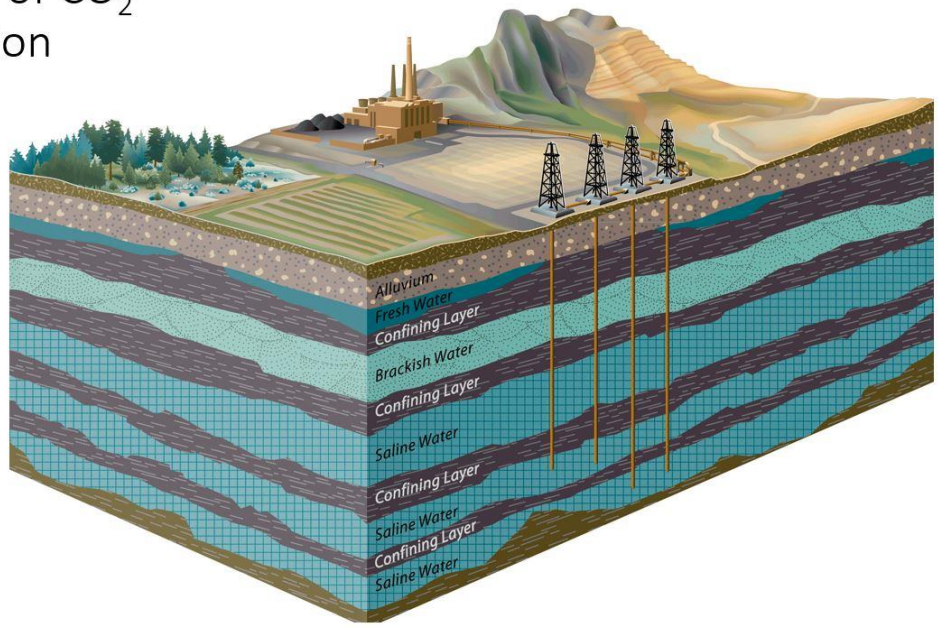
'Capture' CO_2 from large sources of emission

Transport CO_2

'Store' CO_2

Context in Benton County
'Storage' in
deep saline aquifers

Under Benton County
Brines 60000 → 100000 ppm
(drinking water 300-500,
seawater 35000 ppm)



What Is Above and Below the Mt. Simon sandstone?

Above the Mt. Simon Sandstone is the Eau Claire shale caprock formation which is a 700'-750' thick layer of rock with low permeability. Below the Mt. Simon sandstone is precambrian igneous basement rock consisting of hard, heavy, dense and non-porous material such as granite and basalt.

What Would This Operation Look Like? What Would We See?

The CO_2 would be transported via underground pipeline running along the Illinois-Indiana border. From there, the pipeline would branch off and those laterals would also have branches. So, we would see a major earth moving and trenching project. BP representatives have stated that the pipeline will be buried in a right away that runs along the side of roads. At the terminus of the branch would be a vertical bore hole that should be able to service an injection area of about 9 square miles (5760 acres). Obviously, the plume of CO_2 that spreads out underground would not be square. It will be an irregularly shaped blob that will spread faster and further in some directions than others. The structure that will be needed where the horizontal pipeline intersects the bore hole should be fairly minimal. The photo below is of one such structure located in Denmark and operated by the Icelandic company Carbfix.

This is Benton County so we probably shouldn't expect geodesic domes. It may be more realistic to expect block buildings similar in size to the dome pictured. Presumably, each well head structure would be accompanied by a small gravel parking lot and be surrounded with security fencing. Representatives from BP have stated that while the drilling is in progress, an area of 3-5 acres will be needed for each bore hole. After the drilling is complete, this footprint will be reduced to approximately ½ acre per well.

What Are the Risks (That We Know Of)?

Dr. Doug Schmitt with Purdue's Department of Earth, Atmospheric and Planetary Sciences believes most of the risk occurs as the pressurized CO_2 is transported via pipeline but once the CO_2 is in the Sandstone layer, risks are greatly reduced.

Risks Once the CO_2 Is Injected into the Deep Underground Sandstone Layer

- Seismic Activity (Tremors, Earthquakes)– Dr. Schmitt has worked on studies looking at seismic readings around CO_2 storage projects and has not recorded any seismic activity that can be attributed to the CO_2 sequestration activities.
- The CO_2 gas is not contained by the Eau Claire capstone layer and bubbles or diffuses upward. CO_2 bubbling up into the drinking water aquifer would lower the pH of that water. As a result of this lowered pH, numerous elements including manganese, cobalt and nickel that are normally locked in the rock are released into the water of the aquifer. The EPA has standards that set maximum concentrations of various contaminants for drinking water. Concentrations in excess of these standards pose elevated health risks for those that consume the water.
- CO_2 diffusing up into our surface soil in high concentrations could potentially have a profoundly negative effect on plant growth. In 2019 near the town of Apocalypse, California it was discovered that many acres of trees had died. Investigators searching for the cause found that CO_2 levels immediately below the soil surface were at >9000 ppm which is far above the ambient levels of 350-420 ppm normally found in the air we breathe. Elevated levels of CO_2 above ground is actually good for plants, but elevated CO_2 levels below ground interferes with a plant's ability to take up nutrients and respire. It should be noted that these elevated levels of CO_2 in the Apocalypse, CA case were not caused by human activity. They were caused by underground volcanic activity.

- CO_2 escapes to the surface of the Earth. If this *were* to happen here, odds are that the leak would surface in the middle of a farm field. CO_2 that would have been belched out into the air via a power plant chimney, now gets processed and transported to eventually leak into the air through the soil of a corn field. No real harm done, right? Unfortunately, there is also the possibility that the CO_2 will surface in a basement or crawl space of a home or inside a livestock facility. Humans can function just fine breathing CO_2 concentrations of 400-500 ppm, but at concentrations above 1000 ppm, our cognitive abilities become noticeably impaired. At concentrations of 1400 ppm CO_2 our basic decision-making ability can be reduced by 25% and complex strategic thinking is reduced by around 50%. At a CO_2 concentration of 5000 ppm (0.5%) you would feel the effects of oxygen deprivation but you would probably not die until CO_2 concentration in your home gets above 40,000 ppm (4%).

Risks as the Carbon Dioxide (CO_2) is Being Transported via Pipeline

The pipeline would be transporting large amounts of pressurized liquified CO_2 so there would be a risk that a large quantity of the CO_2 could be accidentally released. CO_2 in small amounts is not harmful. The bubbles in carbonated beverages are CO_2 and every breath we take contains CO_2. However, CO_2 in large concentrated quantities is deadly. In general, for an accidental CO_2 release to cause death it takes not only the release of a large quantity of CO_2 but also weather conditions that prevent the CO_2 from dissipating.

If you get on Google to do some "Research" into the risks of CO_2 it will not take long before you happen upon the Lake Nyos Disaster. At Lake Nyos in the west-central African nation of Cameroon on August 21, 1986 a CO_2 bubble that had been trapped on the lake bottom erupted to the surface and then traveled along a valley killing 1746 people and 3500 livestock animals. This disaster was a natural occurrence not related to any human activity and released an estimated 200,000 tons of CO_2 in less than 5 minutes. How does this amount of CO_2 compare to the volume that would be traveling in the pipeline in our county? BP estimates that they would be pumping about 2740 tons of CO_2 down each bore hole per day. If the main trunkline into our county were to be servicing 10 wells and it were to rupture and release 100% of the CO_2 being transported within it for a period of one hour, the amount of CO_2 released would be approximately 1142 tons. 200,000 tons released in less than 5 minutes in Cameroon vs. 1142 tons released in an hour in a potential pipeline rupture here.

An incident that is probably closer to what we should be concerned about in this Benton County project, occurred near the Mississippi village of Satartia. Late on February 22, 2020 a 24-inch pressurized pipeline owned by Denbury Resources carrying liquid CO_2 and hydrogen sulfide ruptured. Weather conditions at the time were such that the cloud of CO_2 did not dissipate much as it traveled nearly a half mile near ground level through the village of Satartia. More than 300 people were evacuated and 46 hospitalized with CO_2 poisoning. A contributing factor in this incident that should not be overlooked is that the topography of the area where this pipeline ruptured is rolling hills with some deep ravines. The rainfall amount experienced in January and February of 2020 was nearly twice the expected average. The hilly topography, wet soils and heavy precipitation led to soil erosion from a hillside leaving the pipeline unsupported by soil from below which contributed to the pipeline buckling and rupturing. The land here is comparatively, much flatter and less prone to washouts.

The geologists, geophysicists and other representatives of BP are very knowledgeable and well-spoken. If you take them at their word, it certainly seems they have thought of everything that can possibly go wrong and have addressed these concerns to minimize the risks to almost zero. Boxer Mike Tyson is credited with the quote "everyone has a plan until they get punched in the mouth." This quote seems to fit well here. Things don't always go as planned and one small miscalculation can spiral into a full-blown catastrophic failure. In recent decades the fossil fuel industry has been involved in a number of these man-made disasters.

- Centralia Pennsylvania was a town with over 1000 residents in 1980. Now it is an abandoned ghost town due to the fact that the coal mining tunnels below the town are on fire.
- Lake Peigneur Louisiana- In November of 1980 a Texaco oil rig drilling into the lake bottom punched into an underlying salt mine. Over the next 3 hours, the resulting sinkhole swallowed the drilling platform, 11 barges, a tugboat, many trees and 65 acres of land. The freshwater from this lake would normally drain into Vermillion Bay in the Gulf of Mexico but for a few days after this accident, the flow was reversed and salt water from the gulf back flowed into the Lake. As a result, the ecosystem of Lake Peigneur has been permanently modified and is now considered a brackish lake.
- The Darvaza gas crater in Turkmenistan is a result of soviet engineers drilling into the rock above a natural gas reservoir. The rock collapsed into a crater and eventually ignited. It is believed that the gas was purposefully ignited to flare off excess but the volume of natural gas present was grossly underestimated. The result is a 65' deep crater 230' in diameter that has been burning since 1971. The locals have a name for the crater that roughly translates as "Door to Hell".
- Deepwater Horizon- This accidental release of oil into the Gulf of Mexico began on April 20th, 2010. The incident began when an oil rig operating 50 miles off the Louisiana coast experienced an explosion and fire. The rig collapsed and oil gushed from the bore hole on the sea floor until it was eventually capped on July 15th of 2010. It is estimated that during this 87-day period, more than 130 million gallons of crude oil was released into the gulf waters. There are damage claims and legal actions resulting from this spill that are still emerging. The total cost of this incident may eventually exceed $60 billion with BP, Transocean and Haliburton as the largest defendants.

It seems fair to say that there are real risks involved with this project. Some risks that we can foresee and likely others that will surprise us and catch us completely off guard. **These risks do NOT ONLY affect people who own land**. Actually, they do not seem to be very tightly correlated at all with how much land one owns. All of us have something at risk here so it should not be only land owners involved in discussions and negotiations with BP.

Is there an Upside? Can we expect any benefit from this Carbon Sequestration Project?

For humanity as a whole, the benefit is that every ton of CO_2 stuffed into the pore space underground is a ton of CO_2 that is not belched out a smokestack into the air. While it is true that plants will actually thrive at elevated CO_2levels, humans and other animals will not. It is in our best interest, solely from a human health aspect, to stop increasing the CO_2 concentration of the air we breathe. The real prize, the overarching reason why removing CO_2 from the atmosphere is so important, is because of its role in climate change. Scientific consensus is that we must slow the rate at which atmospheric CO_2 levels are

increasing and then eventually begin reducing that concentration, if we are to avoid the worst and most dire consequences of global warming or climate change.

That's real nice. But, what's in it for me?

I realize that depending on where you get your information/misinformation/disinformation, you may not see climate change as being a pressing issue and you may even be convinced that it is an outright hoax. Not to worry, for you I have included the following potential benefit of carbon sequestration- Direct payment to landowners for use of their pore space. If you don't own any land these payments will not benefit you but if you own land, then it's essentially found money. You can receive payment for a resource that until recently, you didn't know you had. I believe the BP representatives approaching landowners are asking them to keep the terms of the proposed payment confidential. Just for the sake of conversation though, let's say a good opening, albeit low-ball offer, might be $50/acre up front as a signing bonus and then $0.25 per ton of CO_2 stored. Using estimates for how much CO_2 will be stuffed down each bore hole, landowners would receive an annual payment of $43.50 per acre for use of their pore space. The lifetime of a well would be approximately 20 years. Pulling this altogether, landowners under contract would receive a total of $920 per acre spread over 20 years. Something landowners should consider before entering into such a contract is that it is a 20 year contract and inflation is going to affect the real value of those future dollars. If inflation over the next 20 years is similar to the inflation during the past 20 years, your $43.50 payment in year 20 will have the purchasing power of what $26.50 can buy today. If our current inflation spike turns out to be more than just a blip-if it sets in long term and we have an average annual inflation rate over the next twenty years of 7% then your $43.50 payment in year 20 will have the approximate purchasing power of what $11 can buy today. If the leasing rep from BP includes a 2% or 2.5% annual increase in payment, that's better than nothing but landowners would be wise to insist on having payments tied to the CPI (Consumer Price Index) or some other reliable index of inflation.

Other Questions

Why don't they keep their garbage up there? Why do they think they can dump here?

This is CO_2 which is a waste pollutant from burning various fossil fuels to generate energy. This energy may be used to produce electricity or to drive various industrial processes, but all of us use products produced from fossil fuels so this CO_2 is in actuality a by-product generated from producing things that we all consume. This is not just a waste product from the city being dumped in the country.

There are geologic factors that also enter into the decision to transport the CO_2 rather than store it where it was generated, in Lake County. The porous sandstone layer here is at a greater depth than what is found nearer to Lake Michigan. The deeper the injection site, the quicker the CO_2 plume spreads underground. As a result, deeper injection wells can service larger areas and fewer bore holes are required. So, just looking at geological properties, we are a more desirable location for storage. Make no mistake though, part of the issue is that our state legislature passed house bill 1209 which states that 70% of the surface acreage above a storage site must be owned by people who will sign a contract agreeing to having their pore space utilized for CO_2 storage. Reaching this 70% level is certainly much

easier in a rural area than in the much more densely populated Lake County. Another factor that makes it more attractive to transport the CO_2 to Benton County also stems from our low population density. I did a rough approximation of the foundation footprint of the homes located on the square mile section that I live on. There are 8 homes with a combined foundation footprint of around 14,000 square feet. The total area of a square mile is nearly 28 million square feet. This means that if there is a leak and the CO_2 is released to the surface, there is only about a 1 in 2000 chance that the CO_2 will surface in a basement or crawl space. It probably does not need to be stated, but if CO_2 were to bubble up and surface inside of a home, it would make for a public relations nightmare for BP. I have to also assume that it would make the little bit of folding money that landowners will receive for use of their pore space seem extremely regrettable.

Instead of working to get rid of the CO_2 with schemes like this, why don't they just work to clean it up at the source by moving to renewable energy sources?

Solar and wind power have the drawback of not always being on. They are categorized as "Intermittent" energy sources. The sun only shines part of the day and there are times when the wind does not blow. The technology for storing renewable energy in batteries still has a long way to go before it is really a viable way to store renewable energy. Not to mention that mining for raw materials and producing the batteries is not exactly "green". We are moving towards more renewable energy but this transition will require several decades. Burning fossil fuels will be a necessary part of our energy picture for many years into the future. Sequestering CO_2 underground is an alternative to allowing this CO_2 to be released into the air.

Isn't this effort to reduce our CO_2 emissions useless if China keeps increasing their emissions?

This is valid to a certain extent but as US citizens we should be careful as nobody likes a hypocrite. If we look at historical figures for CO_2 emissions beginning with the onset of the industrial revolution, the US has emitted more than a quarter of the total global emissions. It is true that China now emits twice as much CO_2 as the US, but we had a long head start. It also doesn't help this argument that the US has historically dragged our feet when it comes to action concerning greenhouse gases and their impact on climate change. The US has definitely not been a shining example for the rest of the world to follow. There is a Chinese proverb that states "the best time to plant a tree is 20 years ago, the second-best time is now". The best time to get serious about curbing our CO_2 emissions would have been 40 years ago as Carl Sagan was making his landmark climate change testimony to congress.

How much CO2 can be stored here, under Benton County?

One bore hole servicing 5760 acres (9 square miles) could take 1 million tons CO_2 / year. An average coal-fired power plant, such as the Duke Energy plant at Cayuga, emits approximately 10,000 tons CO_2 per day or 3.65 million tons CO_2 per year. If we were able to put in service 10 wells here in Benton County, we could absorb the output of roughly 3 typical sized coal fired power plants. So, this project definitely does not solve the entire problem. It is just one of many reduction and mitigation solutions being proposed to address greenhouse gas and climate change concerns.

To give you an idea of the 'decarbonization' problem on a global scale-The International Energy Agency (IEA) estimates that human activity emits 40 Gigatons of CO_2 annually and by the end of this century we

will need keep a total of 1200 Gigatons of CO_2 from entering the atmosphere in order to keep mean global temperature increase below 1.5 degrees Celsius.

How does the amount of CO_2 that can be stored in our Mt. Simon sandstone compare to the amount of CO_2 that can be stored in a tree or in the surface soil?

I recently saw a Facebook post that was something along the lines of "I have the perfect CO_2 sequestration machine. It's called a tree". Is there any merit to this? To a limited degree, yes. An acre of mature forest can store approximately 10 tons of CO_2 per year. This means that it would take about 100,000 acres of forest to sequester the amount of CO_2 that can be put down one injection well. It is believed that by avoiding tillage and incorporating winter cover crops into our cropping system, we can increase the amount of CO_2 that is removed from the atmosphere and stored in the top soil as organic matter. A very rough approximation of the amount of CO_2 that can be removed annually from the atmosphere with this cropping system is 0.2 tons of CO_2 per acre. If every farmer in Benton County would refrain from tilling the soil and every acre is planted to winter cover crop, we could remove 52,000 tons of carbon from the atmosphere each year. One of the proposed BP injection wells can take nearly 20X the amount of CO_2 that can be sequestered annually in the top soil of the entire county.

Sequestering CO_2 in organic matter, whether it be in top soil or in a tree, will also have the downside of not being permanent. If the soil is tilled 10 years from now, much of the CO_2 will be released to the atmosphere. Likewise, the CO_2 stored in a tree will be released when the wood is burned.

Sequestration in deep underground saline aquifers is a way to keep additional CO_2 from entering our atmosphere. Sequestering CO_2 in top soil and trees is a possible way to remove some of the legacy CO_2 that was released into the atmosphere in the past. The two are really not directly comparable.