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Carbon Dioxide Geo Sequestration - A review of technical and geological aspects

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Carbon dioxide (CO_2) emissions are increasing due to the hydrocarbons produced increasingly around the world. Carbon sequestration is a way to reduce greenhouse gas emissions. It complements two other major approaches for greenhouse gas reduction, namely improving energy efficiency and increasing use of non-carbon energy sources.

Utilization of CO_2 for enhanced oil recovery (EOR) and sequestration processes not only reduces greenhouse emissions but also awards economical benefits. Enhancing oil recovery in a sequestration is an optimization process that requires careful analysis. In CO_2-EOR the main purpose is to maximize oil recovery with the minimum quantity of CO_2 while a maximum amount of CO_2 is aimed to store in a sequestration.

Interest has been increasing in the carbon sequestration option because it is very compatible with the large energy production and delivery infrastructure now in place.

All three approaches will need to make significant contributions in order to meet the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

There are two primary types of carbon sequestration. The first type focuses on carbon dioxide capture and storage, where carbon dioxide is captured at its source (e.g., power plants, industrial processes) and subsequently stored in non-atmospheric reservoirs (e.g., depleted oil and gas reservoirs, unmineable coal seams, deep saline formations, Deep Ocean). The other type of carbon sequestration focuses on enhancing natural processes to increase the removal of carbon from the atmosphere (e.g., forestation).

The most primitive form of carbon sequestration would be to simply plant more trees. Plants naturally take CO_2 from the atmosphere and output oxygen. Much of the carbon from the CO_2 is integrated into their biomass and released safely into the soil upon their deaths.

A more sophisticated version of carbon sequestration would be the pursuit of artificial photosynthesis. If the principles of photosynthesis could be reliably instantiated in solar cell-like devices, they would both generate power and remove excess carbon dioxide from the atmosphere, probably at rates substantially superior to that of plants, which are limited to a certain palette of chemical reactions and approaches.

One of the best places to practice carbon sequestration technologies is right at the source of heavy carbon dioxide emitters. A variety of approaches have been used to lessen the CO2 output of coal power plants, for example.

As mentioned above there are various methods by which carbon Sequestration can be achieved namely:

SOIL SEQUESTRATION:
Enhancing the storage of carbon in Soil where it is estimated that soils contain between 700 gigatonnes (Gt, 10^9 tonnes) and 3000 Gt of carbon, or more than three times the amount of carbon stored in the atmosphere as carbon dioxide. Agricultural usages such as grazing, harvesting and tillage tend to reduce soil carbon, as does increased erosion that often results. Managing agricultural soils to increase their organic carbon content can also improve soil health and productivity by adding essential nutrients and increasing their water-holding capacity.

PLANT SEQUESTRATION:
Enhancing the storage of carbon in forests and other vegetation by the natural process of photosynthesis wherein Plants use the energy of sunlight to convert CO_2 from the atmosphere to carbohydrates for their growth and maintenance.

MINERAL SEQUESTRATION:
Mineral sequestration (otherwise known as mineral carbonation) involves reaction of CO_2 with metal oxides that are present in common, naturally occurring silicate rocks. The process mimics natural weathering phenomena, and results in natural carbonate products that are stable on a geological time scale.

OCEAN SEQUESTRATION:
The ocean represents the largest carbon store on earth. The ocean has been a significant sink for anthropogenic CO_2 emissions of similar magnitude to the land sink but, as with the land sink, the ocean sink will decrease in strength. It has been proposed to bypass the natural ocean CO_2 uptake mechanism and inject CO_2 directly into the deep ocean to utilise its enormous storage capacity.

GEOSEQUESTRATION:
Geosequestration is the injection and storage of greenhouse gases underground, out of contact with the atmosphere. The most suitable sites are deep geological formations, such as depleted oil and natural gas fields, or deep natural reservoirs filled with saline water (saline aquifers). Geosequestration is part of the three-component scheme of carbon capture and storage (CCS), which involves:

- capture of CO_2 either before or after combustion of the fuel
- transport of the captured CO_2 to the site of storage, and
- injection and storage of the CO_2.

This scheme is proposed as a means of reducing to near-zero the greenhouse gas emissions of fossil fuel burning in power generation and CO_2 production from other industrial processes such as cement manufacturing and purification of natural gas. However, of the storage options, geosequestration is thought to be the most promising due to higher confidence in the longevity of storage; large capacity of potential storage sites; and generally greater understanding of the mechanisms of storage.

This paper will focus on the technologies involved and the geological perspectives in the process of Geosequestration and to some extent the economies as well.

CO_2 capture involves:

- ✓ Separation of CO_2 from the hydrocarbon gases.
- ✓ Dehydration and initial compression of CO_2 so that CO_2 is suitable for transport via pipeline.

Chemical absorption is the most widely used technology in exixting plants to separate CO_2 from natural gas stream. Cryogenic, physical adsorption and membrane technologies are also being used, tested and developed.
Generally, separating CO_2 from hydrocarbon gases is a part of the gas processing because CO_2 content must be lowered to about 2% by volume before the gases could be sold. Therefore the cost of capturing CO_2 from hydrocarbon gases essentially involves the cost of dehydration and initial compression of CO_2.

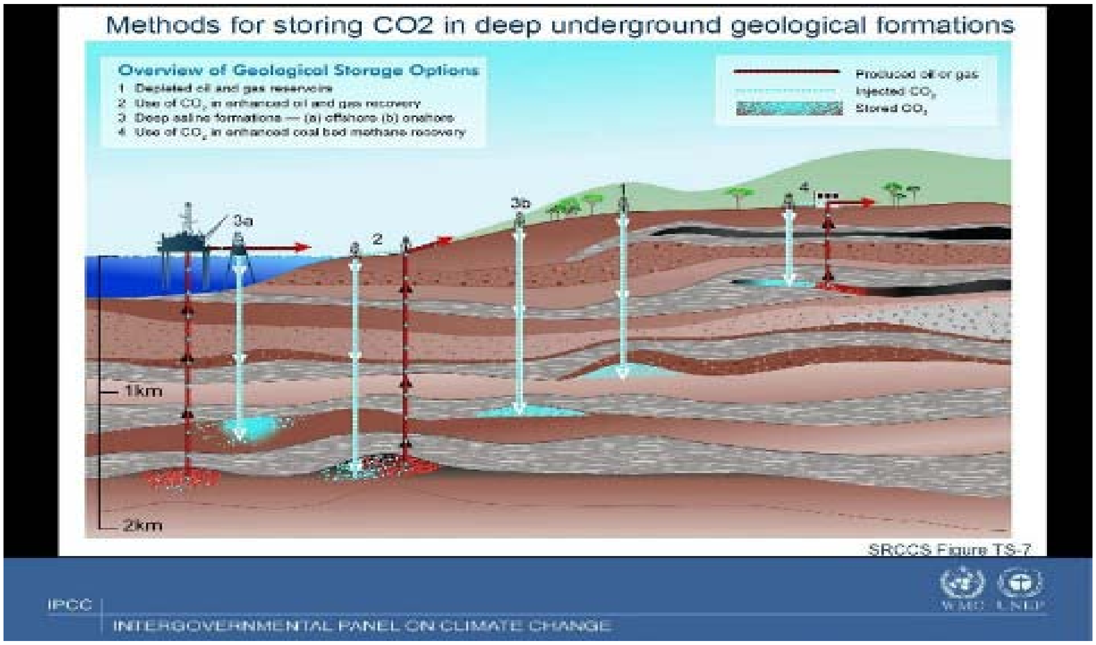
CO_2 geological storage involves:

- ✓ Transporting the CO_2 by pipeline to injection site.
- ✓ Re-compression to maintain CO_2 pressure in the pipeline or to achieve injection pressure if applicable.
- ✓ Injecting it by injection wells.
- ✓ Monitoring the movement of CO_2 in the reservoir during and after sequestration. The storage costs largely depend on the distance of transport, volume of CO_2 and injectivity of the reservoir.

GEOLOGICAL AND RESERVOIR PERSPECTIVES:
Geological study is one important part of CO_2 geological sequestration. The relationships between the sediments, the geometry of the basin, trapping mechanics and flow of fluids within the basin requires clear understanding. It is also required to study the migration pathways of CO_2 and mineral composition of the sediments along these pathways.

Geological study also provides guidelines to estimate the storage capacity of the prospective basins or reservoirs.

The various reservoir perspectives include; firstly CO_2 can be used in EOR. CO_2-EOR accounts for 0.3% of world oil production. Naturally occurred CO_2 reservoirs have provided low supply costs for many EOR projects. Some EOR projects use anthropogenic CO_2 taken from gas processing and fertilizer plants. By this, not only green house emissions are reduced but commercial benefits are achieved. Secondly, CO_2 can also be used to enhance coal bed methane recovery. Coals store CO_2 by adsorption and desorb methane as free gas for recovery. Thirdly, CO_2 can be stored in depleted oil and gas reservoirs. Fourthly, CO_2 can be stored in deep unusable saline acquifers. Researches on CO_2 geological sequestration focus on acquifers as largest storage capacity sinks.



The economics of the process will depend on the amount of CO_2, distance required and other reservoir properties.

This paper gives a detailed review of the technological aspects of carbon sequestration mainly geosequestration, the geological and reservoir perspectives involved in the process and to some extent the economics.