

Testing Carbon Capture and Storage using Stable Isotope Measurements of CO₂ in the Atmosphere

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Project Purpose

Carbon sequestration is an important aspect of the response of the United States to the problem of anthropogenically induced global warming. The technology of sequestering CO₂ into underground reservoirs is known as Carbon Capture and Storage (CCS). However, assessment of the efficiency, safety, and long term fate of CO₂ sequestered into various types of geologic reservoirs remains a challenge. In this project we will deploy field instruments capable of measuring the stable isotopic composition of CO₂ in order to ascertain leakage from storage sites.

Scope of Work

Portable instruments capable of measuring the stable carbon isotopic composition of CO₂ (Cavity Ring Down Spectrometers; CRDS) will be deployed at sites where CO₂ is being actively pumped into underground storage reservoirs. These instruments will transmit their data through the internet to Miami and record a continual record of possible leakage from the reservoir. In addition background surveys will be made on a monthly basis to determine local variation in the $\delta^{13}\text{C}$ of local CO₂.

Key Deliverables

The geochemical work will be combined with geophysical data (GPS, Seismic, and In-SAR) to ascertain the effectiveness of CCS.

Project Description

During CCS liquefied CO₂ is pumped into underground reservoirs. The assumption is that the CO₂ will remain in the gaseous form and be trapped in the reservoir. However the possibility exists that the CO₂ will leak out of the reservoir and reach the surface. The escape of gas during sequestration will be monitored using a CRDS. This instrument can analyze both the concentration and $\delta^{13}\text{C}$ of CO₂. As fossil fuel-derived CO₂ has a characteristic carbon isotopic signature (-25 to -30 ‰) (Deines, 1980) relative to normal atmospheric CO₂ (-7 to -8 ‰), this technique can identify escaping fossil derived CO₂. While there are other processes which can also produce the negative carbon isotopic signature, such as respiration of organic material, large increases in the concentration of CO₂ in association with pronounced negative carbon isotopes over prolonged periods, would confirm escape of the sequestered gas. In order to identify isotopic anomalies resulting from the escape of CO₂ it will be important to obtain information on the background levels and isotopic composition of CO₂.

The CRDS system uses the absorption of a laser signal coincident with the vibration frequency of the ¹³C-¹²C and ¹²C-¹²C bonds in the CO₂ molecule. Gas is injected into a cell and laser light is passed into the cell reflect off three mirrors. One of these mirrors

allows a small amount of loss of light and the signal emitted from this mirror is monitored (ring down). The ring down or the loss of signal is proportional to the absorption of the laser signal by the ^{13}C - ^{12}C bonds (Figure 1). Modern instruments are very robust and can attain precision approaching those measured using a standard stable isotope mass spectrometer. The plan will be to purchase two of these instruments (CRDS) and deploy one at the sequestration site in conjunction with GPS and seismic equipment. The CRDS instrument will continually monitor the $\delta^{13}\text{C}$ and concentration of the CO_2 at the site. On a monthly basis surveys over a 10 km x 10 km area will be made using a second instrument installed in a vehicle. This survey data will give us a 2-D picture of concentration and isotopic variation at the site.

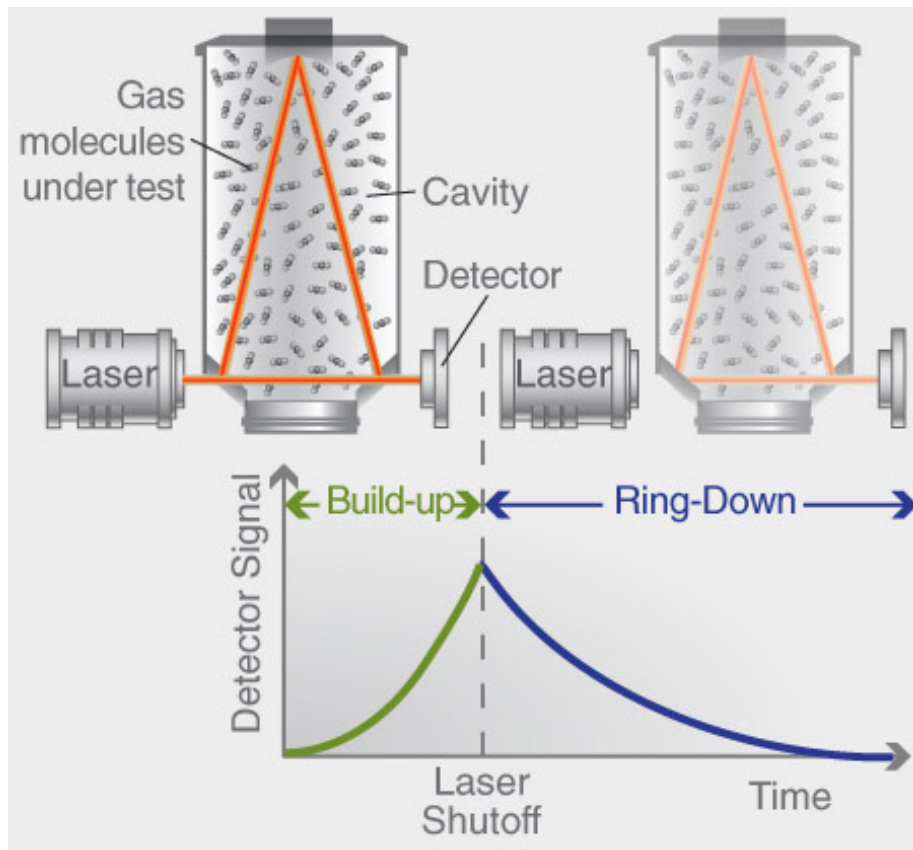


Figure 1. Schematic of a CRDS. The signal coming from the cavity is detected using a photo diode and is proportional to the concentration of the isotope absorbing the signal. The cell is 25 cm high, but the laser light bounces between the three mirrors giving an effective path of 25 km.

References

Deines, P. (Ed.) 1980, The isotopic composition of reduced organic carbon, 329-405 pp., Elsevier, Amsterdam.