Science Spotlight

Carbon Capture

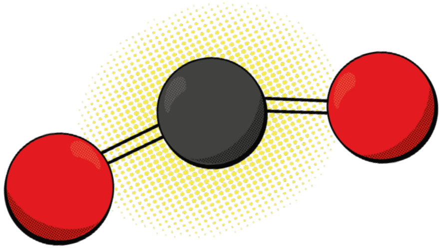
Ready, Set, Go!

Gen Action

This project was undertaken with the financial support of the Government of Canada.

Canada

pacific museum of earth



Carbon Capture: Ready, Set, Go!

Origin Story: THE MANY PATHS OF CARBON DIOXIDE

Photosynthesis is a process used mainly by plants to convert sunlight, water, and carbon dioxide, or CO_2, into oxygen and energy. Through photosynthesis across millions of years, carbon from the atmosphere has been contained in plants and rocks. In the past few decades, humans have been pulling that carbon out of plants and back into the atmosphere in the form of carbon dioxide, mainly through the burning of fossil fuels like coal and oil. CO_2 is the most prevalent greenhouse gas in the atmosphere that is emitted by humans. Greenhouse gases absorb energy as heat and reflect some of it back to Earth's surface, leading to the overall warming of the Earth in the past few decades. Humans have been putting more CO_2 into the atmosphere than natural processes, like photosynthesis, can remove.

Carbon Transformers: TURNING CO_2 INTO ROCK

Carbon mineralization is the process of taking CO_2 from the atmosphere and putting it into solid rocks. Once mineralized, it cannot escape back into the atmosphere. While this process occurs naturally and slowly, it can be sped up artificially. To do this, a very specific environment is needed. This environment should contain ultramafic rocks, which are a type of igneous rock (rocks formed by volcanic magma and lava) that are largely made up of magnesium. When these rocks are brought up to the surface from underground and exposed to the atmosphere, they can release their magnesium. Magnesium, carbon (from the atmosphere), and water then react together to create a solid carbonate mineral. This process is important because carbon as a solid means less carbon dioxide in the atmosphere warming the Earth.

So, how much carbon is actually leaving the atmosphere and going into rocks? Anne-Martine (Marti) Doucet and her team set out to investigate methods that can count, or quantify, how much CO_2 is going into rocks to create more solid rocks, and as a result, how much carbon is being removed from the atmosphere. Until recently, there have been few ways to measure this uptake, or absorption, of CO_2 into rocks; it is labor intensive and takes a lot of time. The methods in this study will allow this process to be quantified continuously and quickly. Their study focuses on two methods that measure CO_2 changes, or flux.

The first method is using soil flux chambers, which are half-domes that are automated to open and close. Once closed, they create a sealed environment overtop soil. In the sealed environment, air circulates to a sensor that measures CO_2 concentrations. This is a relatively simple technique used to measure CO_2 fluxes changing in a field environment. The main downside of this method is that it can only measure a small amount of the atmosphere and rock at a time.

The second method is eddy covariance, which is a common method in atmospheric science to measure the exchanges of gases between ecosystems and the atmosphere. Unlike the first method, this works for a very large control volume of the atmosphere and uses the gas sensor to measure a much larger area between the atmosphere and rocks all at once. Using complex math, the amount of CO_2 moving in and out of this large volume and into the soil can be calculated.

The goal of this study was to compare the results of the two methods in the same field location in northwest British Columbia. While the hope is that they record the same values, it is not a guarantee. As they are measuring two different systems, it is possible that the eddy covariance method picks up fluxes from nearby systems, such as a forest, that the closed flux chamber cannot pickup.

Both methods have their strengths and weaknesses. While the first method is quite reliable because it does not depend on wind and is spatially limited because it can only measure a small area. Meanwhile, the second method can measure a large space all at once, but may pick up nearby systems depending on the wind. The goal of both methods is to quantify carbon mineralization, specifically how much atmospheric CO_2 is going into the minerals. Marti and her team are still analyzing the results from this study, but they hope that the results between the two methods are similar so either method can be used independently in the future!

This Science Spotlight was written based on Doucet, A. M., Jones, F. A., Dipple, G. M., & Mayer, K. U. (2021) Pilot Study Comparing Eddy Covariance and Dynamic Closed-Chamber Methods for Measuring CO2 Fluxes above the Hydromagnesite-Magnesite Playas near Atlin, Northwestern British Columbia (NTS 105N/12). Geoscience BC Summary of Activities 2020: Minerals and Mining, Geoscience BC, 2021(01), 121-128.

Time for GenAction!

Try This at Home:
MINERALIZE YOUR OWN CARBON!

Did you know that you can mimic the trapping of CO_2 by tracing the water cycle? Place a small bowl inside a larger bowl, making sure both bowls can withstand hot water. Safely add boiling water to the larger bowl and create a tight seal with plastic wrap. Add a marble to the center of the wrap and observe water vapor cooling and forming water droplets on the wrap. The water will accumulate on the wrap and roll towards the marble, falling into the smaller bowl. You are watching a gas turn into liquid! Next, freeze the bowl and observe that liquid turn into a solid. Instead of water, Marti and her teams' study investigates a process that takes CO_2 (a gas) and turns it into rock (a solid) in a similar way.

For a more advanced experiment in a school laboratory, try creating precipitate nesquehonite (a goopy magnesium carbonate mineral). In a beaker, create a two mols solution of magnesium chloride (equivalent to 73 grams in 200 millilitres of water). Then, in a separate beaker, create a two mols solution of potassium carbonate (equivalent to 50 grams in 200 millilitres of water). Mix the two solutions together in a 500 millilitre beaker. Observe the texture and color changes. Now, imagine the magnesium chloride is an ultramafic rock and the potassium chloride is atmospheric carbon dioxide. Mix them together in water and watch the CO_2 and Mg combine and form a mineral!

Climate Action:
INVESTIGATE ATMOSPHERIC CO_2 CONCENTRATIONS

CO_2 has been measured at an observatory in Hawaii (Mauna Loa) since 1958. Using this website (Scripps CO_2 Program, Mauna Loa Observatory, Hawaii, in-situ CO_2 data with monthly frequency), write down the CO_2 concentration in the atmosphere from months when five of your family members, such as your parents, aunts and uncles, siblings, and grandparents were born (if born after 1958). Try to get a large spread in years of data collected! Make a simple graph with time on the x-axis and CO_2 concentration on the y-axis. Combine this with data from your classmates for a more complete graph. Look for trends across seasons (for example, does CO_2 increase or decrease in the summer?) and compare CO_2 concentrations from different generations of your family.

Take this a step further and think about ways you can take up or stop the release of CO_2 into the atmosphere to help the planet! For this study, it is growing carbon minerals that capture CO_2 inside rocks. For you, this might be growing your own vegetables or donating your old toys or clothes. Research more ways to help reduce your carbon footprint!

MEET OUR LOCAL SCIENCE HERO
Marti Doucet

Anne-Martine (Marti) Doucet just finished her graduate studies in 2022 and is now a research technician at the University of British Columbia studying Geological and Earth Sciences. She researches technology that measures CO_2 moving in and out of the atmosphere, or CO_2 flux, and how much of that CO_2 becomes mineral form.

From a young age, Marti has enjoyed the outdoors and knew she wanted to study environmental sciences. "Once I went to university, I realized that I really liked the topic of environmental contamination and pollutions caused by human activity" she explains. Specifically, she became interested in the largest form of pollution caused by zinto the atmosphere. Since then, she has known that she wanted to be a part of a small solution to such a big problem.

Climate Change
Past, Present, and Future

Earth is the only planet in the solar system known to support life. What makes our home so special? Earth has an atmosphere, a layer of gases between our planet and space. Some of these gases, like carbon dioxide, are called **greenhouse gases**. They are crucial parts of our atmosphere; they trap in the heat of the sun, similar to how heat is trapped in a greenhouse, or in a car on a hot day. This process, called the **greenhouse effect**, keeps Earth's temperature warm enough for living things to thrive.

The sun's rays hit our round, tilted planet unevenly. This uneven heating of Earth's surface leads to differences in temperature, which drives weather patterns. We call the patterns in temperature and weather over long periods of time **climate**. Different parts of the world have vastly different climates; it depends on how much heat they receive, as well as what landscape features are nearby. Water, mountains, ocean currents, and forests all impact our climate. In turn, living things around the world have adapted to the climate they live in.

Something, though, is changing. Over the past two hundred years, humans have been burning fossil fuels, such as coal and oil, to make energy to power our daily lives. Fossil fuels are made from decomposed plant matter and microscopic life millions of years old. This matter is full of carbon, and, burning it releases, or emits, billions of tonnes of **carbon dioxide** gas into the atmosphere every year. When too much carbon dioxide is emitted, the delicate balance of greenhouse gases maintaining

Earth's climate is upset. More and more heat is trapped, causing the planet to warm. Weather patterns change, water levels rise, storms get worse.

Climate has changed many times throughout Earth's history, from ice ages to periods much hotter than today. So why is this time any different? Scientists agree on two things. One, temperatures are rising faster than they ever have in documented climate history. Two, this climate change is driven by human activities, due primarily to greenhouse gas emissions.
Climate change is already impacting people's ways of life all over the world. Powerful storms, droughts, forest fires, and floods are threatening people's access to food, water, and safe homes.

The most important step we can take to prevent serious climate change is to reduce greenhouse gas emissions. Incredibly brave and caring people around the world are finding new ways to reduce emissions and make our communities climate resilient every single day. And you can join them! These Science Spotlights are here to help us learn more about climate change and how you can take action.

Our Commitment to the Decolonization of Science

Institutions of GenAction initiative respect and affirm the inherent and Treaty Rights of all Indigenous Peoples across what we now know as Canada. We give thanks to the Indigenous Peoples who care for this land since time immemorial and pay respect to their traditions and ways of knowing. We acknowledge their many contributions to innovations in Science, Technology, Engineering, and Mathematics, past and present, and are committed to deepening engagement and collaborating with Indigenous Peoples as partners in order to advance truth and reconciliation and the decolonization of science.

Climate Change: Past, Present, and Future is based on...Delmotte, Masson, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, et al. 2021. "Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change." Intergovernmental Panel on Climate Change. Cambridge University Press. In Press.