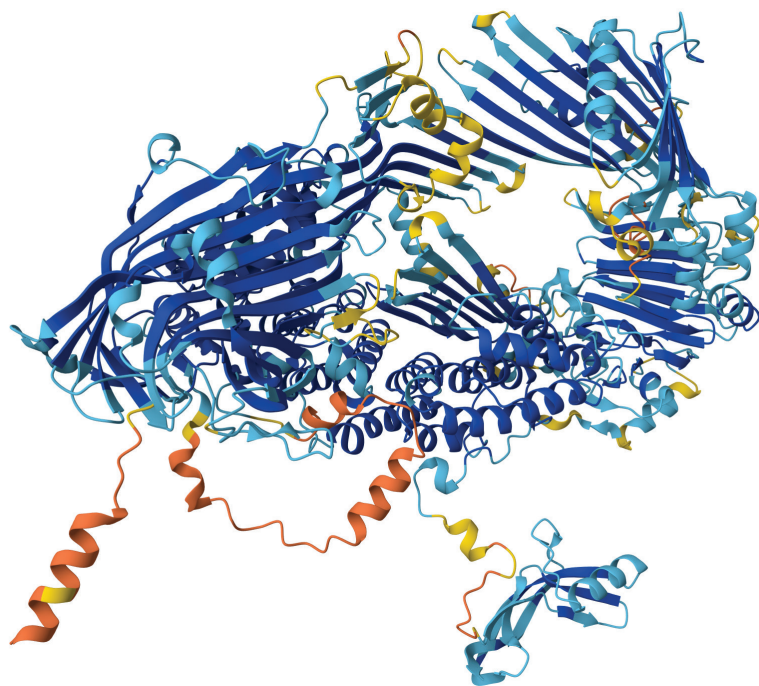




ALPHAFOLD2'S PREDICTED STRUCTURE of the vitellogenin protein, which contributes to immunity in honeybees. The colors represent regions of the protein predicted with high (blue) through low (yellow and orange) confidence. (AlphaFold Protein Structure Database/CC BY 4.0.)

Hassabis has a background in computer science and video game design. Before studying proteins and AI, Jumper majored in physics and mathematics. Only after dropping out of a physics PhD program did he become interested in biology. "I think of myself as a physicist who likes to work on these really complex, really interesting systems of biology," says Jumper. When asked what led him to join DeepMind, he recalls thinking that "machine learning and AI were exciting, and they were possibly going to solve some really important problems, and DeepMind was the most exciting place to do it."

Alex Lopatka

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UPDATES

Carbonate rocks may release more carbon dioxide as climate warms

An analysis of 60 years of water chemistry data from Arctic and subarctic Canadian rivers finds that some regions exhibit a major increase of dissolved sulfates, a product of weathering reactions that also release CO₂.

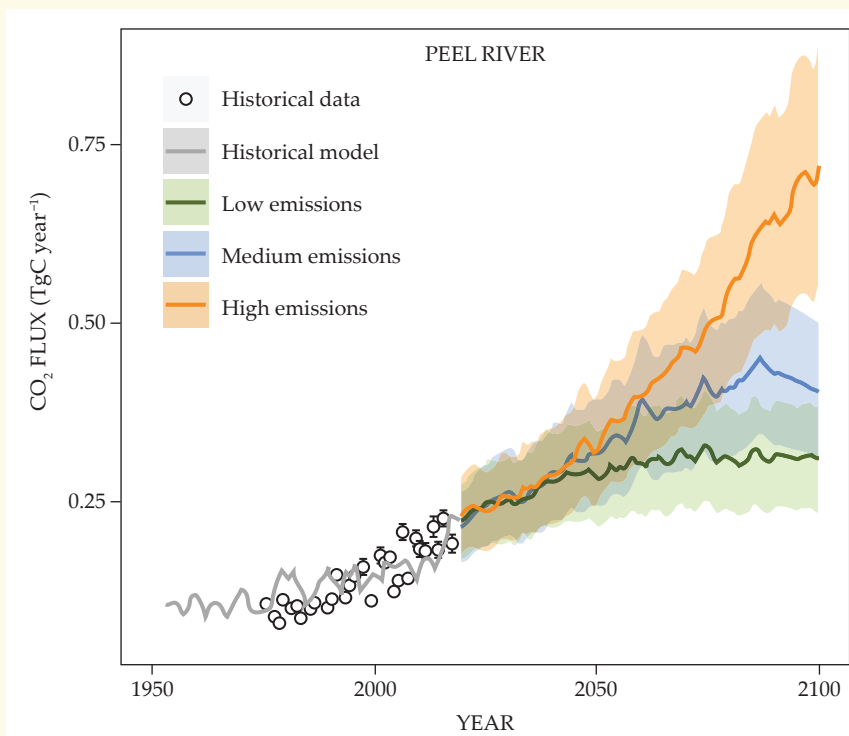
Rocks at Earth's surface experience natural weathering reactions that can both release carbon dioxide into the atmosphere and pull it out. Quantifying those exchanges is a challenge, and climate change throws another confounding factor into the mix: Temperature changes can alter the rates of weathering reactions. That may be especially important in the Arctic, where air temperatures are rising nearly four times as fast as the global average. In a new study, Ella Walsh (at the time at the University of Oxford) and colleagues show that warming temperatures in western Canada over the past six decades have driven increased rates of weathering reactions that release CO₂.

For their analysis, Walsh and colleagues used water chemistry data collected from rivers in the Mackenzie River basin in Canada between 1960 and 2020. The basin, which includes several smaller river watersheds, covers an area of about 1.8 million km², roughly 20% of Canada. A modeling study published over a decade ago had estimated that increased temperatures, rainfall, and vegetation, all associated with climate change, would produce weathering reactions in the basin that would draw more CO₂ from the atmosphere over time. The rocks' silicate and carbonate minerals react with CO₂ to form bicarbonate, which dissolves in

river water and is ultimately delivered to the ocean.

But Walsh says that the contribution of sulfide weathering wasn't factored into those estimates. Oxidation of sulfide minerals, like pyrite, produces sulfuric acid. That acid reacts with carbonate minerals to release CO₂ and dissolved sulfate to river waters. The research team analyzed the sulfate flux for individual river basins, known as catchments, within the larger system. "By looking at this catchment scale, we were able to look at what some of the possible drivers are, why some catchments have greater increases than others," says Walsh.

The Mackenzie River, which is central to the basin, saw a 45% increase in sulfate flux with 2.3 °C of warming over the study period. One catchment had sulfate concentrations that rose by as much as 36% per decade. Others showed no significant changes in sulfate concentrations. Steeper



HISTORICAL ESTIMATES AND FUTURE PROJECTIONS for the flux of carbon dioxide from the Peel River watershed highlight the way that temperature increases over time could increase the release of carbon dioxide from the Arctic landscape. Projections are shown for three emissions scenarios adopted by the Intergovernmental Panel on Climate Change. Black circles represent data collected by Environment and Climate Change Canada. (Adapted from E. V. Walsh et al., *Sci. Adv.* **10**, eadq4893, 2024.)

slopes, more exposed bedrock, and more permafrost were all associated with faster increases of sulfate concentration. Melting permafrost produced major landscape changes—such as a thaw slump observed in the Peel River, shown in the photo—that increased exposure of sulfides to weathering. Peatland cover had the opposite effect. And the types of rocks present control the reactions—places with both sulfide- and carbonate-rich rocks contribute the most to increased CO₂ emissions.

Walsh and colleagues extrapolated their findings to consider how much CO₂ flux in the Mackenzie River basin would result from different climate change emissions scenarios, as shown in the graph. The increases—possibly several teragrams of carbon per year by the end of the century—are large enough to warrant consideration for future carbon budgets and climate models. But the high spatial variability means that accurately representing such fluxes would require conducting similar studies across other regions. Walsh says that understanding how weathering processes are affected by climate change may also be important for assessing concerns about future water quality. (E. V. Walsh et al., *Sci. Adv.* **10**, eadq4893, 2024.)

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