Glaciers cracking in the presence of carbon dioxide

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(Phys.org)—The well-documented presence of excessive levels of carbon dioxide (CO_2) in our atmosphere is causing global temperatures to rise and glaciers and ice caps to melt. New research, published today in the *Journal of Physics D: Applied Physics*, has shown that CO_2 molecules may be having a more direct impact on the ice that covers our planet.

Researchers from the Massachusetts Institute for Technology have shown that the material strength and fracture toughness of ice are decreased significantly under increasing concentrations of CO_2

molecules, making ice caps and glaciers more vulnerable to cracking and splitting into pieces, as was seen recently when a huge crack in the Pine Island Glacier in Antarctica spawned a glacier the size of Berlin.

Ice caps and glaciers cover seven per cent of the Earth—more than Europe and North America combined—and are responsible for reflecting 80-90 per cent of the Sun's light rays that enter our atmosphere and maintain the Earth's temperature. They are also a natural carbon sink, capturing a large amount of CO2.

"If ice caps and glaciers were to continue to crack and break into pieces, their surface area that is exposed to air would be significantly increased, which could lead to accelerated melting and much reduced coverage area on the Earth. The consequences of these changes remain to be explored by the experts, but they might contribute to changes of the global climate," said lead author of the study Professor Markus Buehler.

Buehler, along with his student and co-author of the paper, Zhao Qin, used a series of atomistic-level computer simulations to analyse the dynamics of molecules to investigate the role of CO2 molecules in ice fracturing, and found that CO2 exposure causes ice to break more easily.

Notably, the decreased ice strength is not merely caused by material defects induced by CO2 bubbles, but rather by the fact that the strength of hydrogen bonds—the chemical bonds between water molecules in an ice crystal—is decreased under increasing concentrations of CO2. This is because the added CO2 competes with the water molecules connected in the ice crystal.

It was shown that CO2 molecules first adhere to the crack boundary of ice by forming a bond with the hydrogen atoms and then migrate through the ice in a flipping motion along the crack boundary towards the crack tip.

The CO_2 molecules accumulate at the crack tip and constantly attack the water molecules by trying to bond to them. This leaves broken bonds behind and increases the brittleness of the ice on a macroscopic scale.

More information: 'Carbon dioxide enhances fragility of ice crystals,' Zhao Qin and Markus J Buehler 2012 J. Phys. D: Appl. Phys. 45 445302. iopscience.iop.org/0022-3727/45/44/445302

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