Glaciers cracking in the presence of carbon dioxide

The well-documented presence of excessive levels of carbon dioxide (CO₂) in our atmosphere is causing global temperatures to rise and glaciers and ice caps to melt.

New research, published today, 11 October, in IOP Publishing’s Journal of Physics D: Applied Physics, has shown that CO₂ 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 CO₂ 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 CO₂ 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.

From Thursday 11 October, this paper can be downloaded from http://iopscience.iop.org/0022-3727/45/44/445302

ENDS

Notes to Editors
Contact

1. For further information, a full draft of the journal paper or contact with one of the researchers, contact IOP Press Officer, Michael Bishop:
   Tel: 0117 930 1032
   E-mail: Michael.bishop@iop.org

Carbon dioxide enhances fragility of ice crystals

2. The published version of the paper ‘Carbon dioxide enhances fragility of ice crystals’ (Zhao Qin and Markus J Buehler 2012 J. Phys. D: Appl. Phys. 45 445302) will be freely available online from Thursday 11 October. It will be available at http://iopscience.iop.org/0022-3727/45/44/445302

Journal of Physics D: Applied Physics

3. This weekly journal is concerned with all aspects of applied physics research, from magnetism, plasmas and semiconductors to the structure and properties of matter.

IOP Publishing

4. IOP Publishing provides publications through which leading-edge scientific research is distributed worldwide. IOP Publishing is central to the Institute of Physics (IOP), a not-for-profit society. Any financial surplus earned by IOP Publishing goes to support science through the activities of IOP. Beyond our traditional journals programme, we make high-value scientific information easily accessible through an ever-evolving portfolio of community websites, magazines, conference proceedings and a multitude of electronic services. Focused on making the most of new technologies, we’re continually improving our electronic interfaces to make it easier for researchers to find exactly what they need, when they need it, in the format that suits them best. Go to http://ioppublishing.org/.

The Institute of Physics

5. The Institute of Physics is a leading scientific society promoting physics and bringing physicists together for the benefit of all.

It has a worldwide membership of around 40 000 comprising physicists from all sectors, as well as those with an interest in physics. It works to advance physics research, application and education; and engages with policymakers and the public to develop awareness and understanding of physics. Its publishing company, IOP Publishing, is a world leader in professional scientific communications. Go to www.iop.org

Michael Bishop
Press Officer
IOP Publishing
Temple Circus
Temple Way
Bristol
BS1 6HG

Tel: 0117 930 1032
http://ioppublishing.org