# Unravelling the 'inconvenient truth' of glacier movement

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Predicting climate change depends on many factors not properly included in current forecasting models, such as how the major polar ice caps will move in the event of melting around their edges. This in turn requires greater understanding of the processes at work when ice is under stress, influencing how it flows and moves. The immediate objective is to model the flow of ice sheets and glaciers more accurately, leading in turn to better future predictions of global ice cover for use in climate modeling and forecasting. Progress and future research objectives in the field were discussed at a recent workshop organized by the European Science Foundation (ESF), bringing together glaciologists, geologists, and experts in the processes of cracking under stress in other crystalline materials, notably metals and rocks.

The essential problem is that processes at different scales starting from the molecular and going up to whole ice sheets need to be integrated in order to develop models capable of accurate predictions. While the processes at the molecular level inside individual ice crystals are quite well understood, too little attention has been paid to the properties of ice at the scale of each grain, comprising organized groups of crystals. All crystalline solids, including metals, are comprised of grains, which are about 1 to 3 cms across in the case of ice. The grain is fundamental for ice movement, because of the strong mechanical anisotropy (irregularity) of individual ice grains. "These processes are much less understood, and one could say they are more 'messy'," said Paul Bons, who co-chaired the ESF workshop. "The challenge ahead is to convert the insight gained on the effects of grain-scale processes into improved rheological models."

Rheology is the study of how materials such as ice or rock flow when forces are applied to them.

As Bons noted, such knowledge of grain-level interactions is needed not just to construct better models of ice caps, but also for understanding processes inside the earth's mantle, which could help predict earthquakes and volcanoes. "The interesting thing here is actually the similarity between all these compounds, not the differences," said Bons, himself a geologist. "Essentially the same processes occur in ice, minerals and metals."

The differences lie just in the balance between these processes, with interactions between crystals within grains being more significant in ice than metals or rocks. But as was noted by Sergio Faria, another co-chair, it is important to resolve these issues, since current models can be highly inaccurate in predicting ice flows, as has been found by analysing ice cores drilled into glaciers. "The microstructures observed in ice core samples indicate the deformation mechanisms active in an ice sheet," said Faria. "Depending upon the sort of active mechanisms, the flow of an ice sheet may vary by orders of magnitude. Therefore a precise understanding of ice microstructures - and consequently of active deformation mechanisms - is essential to reduce the current uncertainty in ice sheet flow models."

As a result of recent findings, the current approach to ice flow analysis, the so-called 3-layer model, will have to be revised, according to Sepp Kipfstuhl, the ESF conference's third co-convenor. "It was interesting to see at the workshop that the study of microstructures challenges standard models for polar ice, especially the classical 3-layer model and the standard flow law of ice. This is an 'inconvenient truth' that complicates large-scale ice flow models, and hence impacts on climate modeling," said Kipfstuhl."

As in all branches of science, this inconvenient truth must be faced head on in order to solve the problem of accurate ice flow prediction, which has become all the more pressing in the light of current concerned over the impact of climate change.

Source: European Science Foundation