Geophysical Research Abstracts,
Vol. 10, EGU2008-A-11492, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-11492
EGU General Assembly 2008

The roles of rheology, fracture and marine ice in ice shelf stability

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The disintegration of ice shelves in the Antarctic Peninsula over the past two decades demonstrated unambiguously the link between the removal of ice shelves and the acceleration of their tributary glaciers. This increased discharge of continental ice to the ocean contributes directly to global sea level rise and emphasizes the need for improved understanding of ice shelf evolution in a warming climate.

In our investigations of ice shelf dynamics and stability, we combine satellite radar interferometric observations with numerical flow models to infer ice rheology (flow law parameter B). The resulting, often highly variable, spatial distributions reveal much about the structure and behavior of ice shelves. Thus, in the case of the Larsen B Ice Shelf, we discuss the interactions among ice rheology, fracture, front retreat, and ice shelf flow acceleration, and their roles in the disintegration of Larsen B in 2002.

After that event, the question arose as to whether the much larger Larsen C Ice Shelf, further south along the east coast of the Antarctic Peninsula, could meet the same fate. We therefore discuss the case of Larsen C.

Another important factor in ice shelf stability is the extent of marine ice presence and its effect on shelf flow and mechanical integrity. Brunt Ice Shelf on the east coast of the Weddell Sea presents the rare setting of visible, large expanses of an ice mélange largely composed of marine ice. Crystallographic structure and salinity and impurity contents should give marine ice a distinct rheology. We therefore apply the data assimilation method described above to test the hypothesis that meteoric and marine

ice bodies composing the ice shelf have different rheologies, and examine the implications for the mechanical competence and flow of the ice shelf. We further use the inferred rheology distribution to locate the zones of weakness in the ice shelf, many of which are cut by large rifts filled with a mélange, and their influence on ice shelf stability.

These studies demonstrate the importance (and difficulty) of deriving realistic rheologies to simulate reliably ice shelf flow by numerical methods, as well as the valuable insights to be gained into the state of Antarctic ice shelves.

This work was performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration, Cryospheric Sciences Program.