Geophysical Research Abstracts, Vol. 7, 05658, 2005
SRef-ID: 1607-7962/gra/EGU05-A-05658

The brittle to ductile transition of snow

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Snow is a solid foam of ice. Starting with data on the solid (ice), many of the mechanical and physical properties of the foam (snow) can be understood with the theory of cellular materials. The primary and secondary parameters are the density and structure of the foam, respectively. Flow stress, toughness, creep rate are very sensitive functions of the density, but superimposed are variations due to texture and morphology.

At low strain rates (app. 10^{-4} /sec) snow is ductile: it deforms plastically under tensile and shear stresses of the order of 10-100 kPa. At high strain rates ($> 10^{-4}$ /sec) it is brittle and fractures under stress intensity factors KI and KII of the order of 1 kPam$^{1/2}$. Such a brittle to ductile transition (BDT) occurs in many materials (metals, bone, semiconductors and rocks). Although theory leaves much to be desired on the quantitative level, it seems clear that plastification is due to structural rearrangements of matter around a crack tip, for example in metals and semiconductors the activation energy of the BDT coincides with the activation energy of dislocation movement. For snow it is 0.6 eV.

In terms of linear elastic fracture mechanics (LEFM) slab avalanches triggered by skiers are interpreted as a mode II (slip) fracture along a weak interface parallel to the slope either following a primary mode I (tension) fracture perpendicular to the slope or induced by the stress field developed around the skier traces.