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# Bubbly-ice densification in ice sheets: II. Applications

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## Abstract

A mathematical model for simulating the densification of bubbly glacier ice is used to interpret the following experimental data from the Vostok (central Antarctica) ice core: two ice-porosity profiles obtained by independent methods and a bubble-pressure profile obtained by direct measurements of air pressure within individual bubbles. The rheological properties of pure polycrystalline ice are deduced from the solution of the inverse problem. The model and the inferred ice-flow law are then validated, using porosity profiles from seven other ice cores drilled in Antarctica and Greenland, in the temperature range from -55° to -20°C. The following expression is adopted for the constitutive law: 2ė = (τ/μ1 + τα/μ2) exp[Q(1/Ts - 1/T)/Rs] where ė and τ are the effective strain rate and stress, respectively, α is the creep exponent taken as 3.5, Rs is the gas constant and T(Ts) is the temperature (standard temperature). The numerical values obtained for the "linear" and "non-linear" viscosities are: μ1 = 2.9 ± 1.3 MPa year and μ2 = 0.051 ± 0.019 MPaα year, and the apparent activation energy Q is confirmed to be 60 kj mole-1. The corresponding flow law is in good agreement with results of both mechanical tests and independent estimations based on the analysis of different natural phenomena associated with glacier-ice deformation. When the model is constrained by the porosity and bubble-pressure profiles from Vostok, the mean air content in Holocene ice is inferred to be about 0.088 cm3g-1. The corresponding mean air pressure in bubbles at the end of pore closure is about 0.083 MPa, whereas the atmospheric pressure at this depth level would be 0.063 MPa. The influence of the climatic change on the ice-porosity profile is discussed. It resulted in an increased air content in ice at Vostok during the Last Glacial Maximum: 0.096 cm3g-1.