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A model for the evolution of gas properties during sea ice growth.

F. Brabant, V. Verbeke, J.-L. Tison

Laboratoire de Glaciologie – DSTE, Université Libre de Bruxelles, Belgique
(fbrabant@ulb.ac.be / Fax : +32 2 650 22 26 / Phone : +32 2 650 22 27)

As for continental ice, the study of gas properties in sea ice can provide valuable indications on the growth and decay history of sea ice. In this study we focus on information related to gas total content and gas composition (O_2, N_2) measurements in sea ice during its growing phase. Consequently, we propose a model of gases evolution in sea ice based on O_2/N_2 ratio measurements, in the case where physico-chemical processes dominate and biological processes are of negligible impact on the gas ‘signal’.

We first studied the gas parameters described above for an artificial sea ice time series in the framework of the INTERICE III experiment (NERC–EU project, HSVA, Hamburg, Germany – May 2001) in order to assess the evolution of gas profiles during ice growth. The O_2/N_2ratio is close to the saturation value of these two gases in seawater (0.597) in the first ice increment (5cm) and drifts slowly during ice growth. At the end of the growing phase (26cm), the value of the ratio for the whole profile stabilises at levels between 0.597 and a typical atmospheric value (0.26). This evolution is explained by a combination of three processes: initial dissolved gas entrapment at the ice-ocean interface, ‘post-entrapment’ diffusion processes towards the growing interface and bubble nucleation within the brine inclusions. In accordance with the Fick’s first law, when diffusion of gases is the only process at work and maximised (i.e. for a thick boundary layer and/or for fast growth rates), the ‘post-entrapment’ diffusion process should lead to an O_2/N_2value of 0.485. We show that this is what is observed in mid-winter columnar ice sampled in the Mc Murdo Sound area (Ross Sea, Antarctica – October 1999). Since, in those samples the total gas content is always less than 5ml/ kg ice (ensuring limited occurrence of bubbles), and the biological processes are likely to be negligible, these measurements support the theoretical expectations.

The model proposed provides us with a reference profile against which biological processes in the sea ice cover can be emphasised.