PREFACE

Microdynamics of ice

Understanding the dynamic behaviour of ice in glaciers, polar ice caps, sea ice and the icy planets of the solar system is a major challenge, especially in a time of changing climate, amplified at the poles, and exciting new space exploration. This themed volume of the Philosophical Transactions of the Royal Society, London, highlights some of the recent advances in the observations, analyses, theories modelling and interpretation of ice microstructures and micro-deformation mechanisms. Grain, sub-grain scale and asperity microstructures, controlling both rheology and transport properties, are the crucial link between atomic-scale processes and the macroscopic behaviour of ice, New technologies, techniques and models are bringing fresh understanding of the evolution and dynamics of large ice bodies, from polar ice caps, mountain glaciers and the sea ice cover to planetary ice. But while ice research is published in glaciology and geophysical journals, no publication is devoted to microstructures and micro-deformation in ice. We hope with this volume to make recent advances in these researches broadly available both inside and outside the ice physics community.

Ice is one of the most common minerals found on the surface of our Earth and also a common rock-forming mineral in the solar system. With global warming becoming a generally accepted theory by scientists, the general public and governments, research into ice has gained increasing importance. The relevance of ice to society is manifold: changes in the flow behaviour of polar ice caps directly influence sea level and climate; glaciers and ice caps store a large proportion of the global fresh-water budget; polar ice and mountain glaciers contain a unique palaeo-climate record, reaching back up to 800,000 years; and traces of extra-terrestrial life may potentially be found in ice. On an important but entirely different note, ice and snow provide the environment for enjoyment and competition in winter sports. Ice research has therefore seen a significant expansion in recent decades. The European community has been strongly involved, with the European Science Foundation project for Ice Coring in Antarctica programme (EPICA) that provided co-ordination for drilling activities at Dome Concordia and Kohnen Station. The North Greenland Eemian Ice Drilling project (NEEM) is an international ice core research project for retrieving an ice core from northwest Greenland that reaches back through the previous Eemian interglacial. The International Partnerships in Ice Core Sciences (IPCS) is a project that was initiated during the International Polar Year and is aimed at creating a network for new coring on the Antarctic coast. The Centre National de la Recherche Scientifique (CNRS) has established a vault to preserve ice from the world's glaciers for scientists in the future. The European Space Agency plans to launch a deep-space mission to explore the icy moons of Jupiter in 2022. While the Norwegian Polar Institute's Young Sea Ice Cruise in 2015 is one of many research programmes aimed at better understanding of the sea ice system.

The research presented in this volume has been done in the context of on-going collaboration across European laboratories, and beyond. The European Science Foundation MicroDIce Research Network (2010-2015) brought together leading researchers in the field, as well as those in related fields, such as metallurgy and geology, through a series of networking activities integrating the research efforts of individual groups within Europe. 10 interdisciplinary workshops were held across Europe to promote this integration. MicroDIce aimed at improving the exchange of new ideas and methods, and particularly the training and mobility of young researchers through workshops, summer schools, and support for visits to other research groups and analytical facilities. More than 100 international young researchers got trained in snow and ice mechanical behaviour and microstructure characterization during four thematic summer schools. 34 research visits and exchanges were supported. The international research conference at the start of the programme highlighted the major questions and challenges that the research community faces, while a second conference towards the end, and sessions and the European Geosciences Union and American Geophysical Union assemblies served to present the achievements of the activities of the network.

This themed volume highlights some of the research carried out during the time of the MicroDIce network. It has 10 contributions starting with a short overview of the microdynamics of ice by Sammonds et al. [1]. The first group of papers cover glacial ice, observations, analysis and modelling. Chauve et al. [2] describe detailed experiments and microstructure studies investigating nucleation processes during dynamic recrystallization of ice using cryogenic electronic backscattered diffraction (EBSD). Llorens et al. [3] describe the dynamic recrystallisation during deformation of polycrystalline ice from the point of view of numerical simulations. Weikusat et al. [4] discuss the physical analysis of an Antarctic ice core (EDML) and the methods towards integrating the micro- and macrodynamics of polar ice. Middleton et al. [5] examine the effect of rock particles in the flow behaviour of ice. But now this time the application is the evolution and dynamics of the icy planets. The next group of papers concerns surface properties and in particular how microstructures control friction. Sammonds et al. [6] discuss this in the context of experiments on saline ice floe friction and the scaling involved. McCarthy et al. [7] examine ice-on-rock friction for realistic glacier conditions,, while Seymour-Pierce et al. [8] discuss the context of microstructures in relation to friction in winter sports. The next group of papers concerns sea ice. Marchenko and Lishman [9] examine the influence of closed brine packets and permeable brine channels on the thermo-elastic properties of saline ice, while Weiss and Dansereau discuss linking across scales in sea ice mechanics. The papers, because of the nature of the subject, all discuss to some extent this micro to macro scaling. As it is after all, understanding this fascinating topic of the micro-physics and micro-mechanics, which will allow us to link across from the atomic scale processes to the evolution and dynamics of ice bodies.

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