Research Networking Programmes

Science Meeting – Scientific Report

Scientific report (one single document in WORD or PDF file) should be submitted online within two months of the event. It should not exceed seven A4 pages.

***Proposal Title**: MICRODICE special session on "Microdynamics of Ice" to be held at the 18th International Conference on DEFORMATION MECHANISMS, RHEOLOGY & TECTONICS 16-18 September 2013, Leuven, Belgium*

Application Reference N°: 4968

1) Summary (up to one page)

A successful special session on Microdyamics of ice was held at the DRT2013 conference in Leuven, Belgium. The goal of the special session was to increase communication between scientists working on similar processes in ice, snow and rocks. The session consisted of six oral presentations. The topics covered were deformation mechanisms, textures and microstructures of ice and techniques to study microstructure. The session generated extensive discussion and made new links between glaciologists and geologists working on similar problems of understanding flow behavior.

2) Description of the scientific content of and discussions at the event (up to four pages)

The Leuven DRT meeting was devoted to the study of deformation behaviour and rheology of minerals, rocks and in the MicroDICE special session snow and ice. The common factor is that deformation processes on all scales of observation – from a crystallographic defect to the field scale – are the subject of discussion. The DRT brought together researchers in the broad fields of structural geology, geodynamics, rheology , material sciences and glaciology. Dialogue was developed between field geologists, experimentalists and modelers on problems and questions posed by natural structures and microstructures.

In the microDICE session there were two invited speakers funded by ESF funds, Dr Lars Hansen and Dr Mark Peternell. Dr. Hansen reviewed recent work on the importance of grain boundary sliding in geological materials, in particular on olivine and ice where a deformation regime has been identified that involves coupled grain boundary sliding and dislocation motion. Creep models and data in this regime indicate stress exponents of 2 to 3 and grainsize exponents of 1 to 2 for the flow law. In olivine a strong crystallographic texture develops in this regime, which is similar to that found in many naturally deformed mantle rocks. Hansen concludes that this hybrid mechanism is ubiquitous in many Earth environments, portions of ice sheets, and in icy planetary interiors.

Dr S.Piazolo et al. reported on novel insitu deformation experiments, where neutron diffraction was used to monitor texture and microstructure development during deformation. Results show a dynamic system where steady state rheology is not necessarily coupled to microstructure and textural stability. During deformation strong textures developed with a girdle distribution at 35 degrees to the compression axis. The textures were attributed to a combination of slip on basal and pyramidal slip. With decreasing strain rate grain boundary migration was more important and associated with stronger texture development. This study highlights the need to link the dynamics of process competition to rheological and textural behaviour.

Dr M. Montagnat presented work on deformation heterogeneities during creep and dynamic recrystallization of ice. In this study ice is used as a model material to understand the processes of recrystallization in materials. Experiments were conducted on 2D columnar ice and 3D polycrystals. Local strain fields were mapped with digital image correlation techniques, with related studies of microstructure and texture using light microscopy and large area EBSD. These observations demonstrated the important link between between dynamic recrystallization, the internal stress field and the dislocation fields.

In the second invited talk Dr. M Peternell, presented results on fabric analyser based microstructure evaluation during insitu deformation tests on ice. Combined with dedicated scripts the microstructure and texture are completely quantified. Results from constant strain rate tests showed that the distribution of plastic activity is initially dominated by grain boundary migration during primary creep, flowed by nucleation of dynamic recrystallization during secondary creep and and further cycles of nucleation and growth in the teriary creep regime. Tests with cyclic strain rate show similar microstructural evolution. The microstructural evolution is mainly a function of local and bulk variations in strain energy. Changes in the strainrate accommodated by recrystallization processes accompany stress cycling, control creep mechanics and the resultant microstructure. Microstructural evolution is remarkably similar to that high temperature deformation of quartz.

In the final presentation Dr. H. de Bresser, returned to the theme of the first invited talk on the role of grain size in the rheology of water ice. Static grain growth and deformation tests were conducted on fine-grained ice. The grain growth laws and creep data were used to develop a composite flow law approach including both dislocation creep and grain boundary processes. The new data were used to see if a composite flow law approach results in better extrapolation of lab data to natural conditions in ice sheets. Natural microstructures from Dronning Maud land were investigated, taking account of the distributions of grain size in the samples. At

constant strain rate the composite flow laws indicate that grain sze sensitive processes are significant along the ice core. The results show that GSS mechanism might be operative in ice over a range of conditions but that dislocation mechamisms will remain important.

A last contribution on EBSD of ice was scheduled, however this was presentation was cancelled as the speakr was unable to attend the conference.

3) Assessment of the results and impact of the event on the future directions of the field (up to two pages)

This was first time a session on the microdynamics of ice has been held within the DRT conference. The session was very successful in highlighting common interests of geologists and glaciologists. In particular the role of grain boundary deformation processes in the earth and ice sheets remains and interesting and controversial topic. The Micro Dice session attracted great interest in the DRT community and it would be good to consider arranging a similar session at the next DRT meeting in Aachen in 2015.

4) Annexes 4a) and 4b): Programme of the meeting and full list of speakers and participants

Session 4: Microdynamics of Ice – Micro-Dice (1/2)
Chair: Hans de Bresser

16:00 – 16:30 **Hansen L.N.**, Goldsby D.L., Kohlstedt D.L.
keynote The importance of grain-boundary sliding during deformation of geological materials

16:30 – 16:50 **Piazolo S.**, Wilson C.J.L., Luzin V., Brouzet C., Peternell M.
Dynamics of ice mass deformation: Linking processes to rheology, texture and microstructure

16:50 – 17:10 **Montagnat M.**, Grennerat F., Chauve T., Barou F., Castelnau O., Vacher P.
Deformation heterogeneities during creep and dynamic recrystallization in ice

Session 8: Microdynamics of Ice – Micro-Dice (2/2)
Chair: Rudy Wenk

16:30 – 16:00 **Peternell M.**, Wilson C.J.L., Dierckx M., Hammes D.M., Piazolo S.

keynote	Microstructural evolution of polycrystalline ice using in situ deformation experiments and FAME
16:00 – 16:20	**de Bresser H.**, Diebold S., Durham W. Using composite flow laws to investigate the role of grain size in the rheology of water ice
16:20 – 16:40	**Seidemann M.**, Lilly K., Easingwood R., Prior D. Practical Cryo-EBSD on Fine-Grained Polycrystalline Ice: Obstacles and Solutions