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Climate of the Past Discussions

CPD

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Interactive Comment

Interactive comment on “Change of the ice rheology with climatic transitions – implication on ice flow modelling and dating of the EPICA Dome C core” *by* G. Durand et al.

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This is interesting and important work to an audience of ice core and climate community. This paper presents that the crystallographic orientation fabrics of EDC ice core shows an abrupt and unexpected strengthening during termination II which is different from DF and GRIP cores, and discusses the possible cause of the strengthening associated with the change in recrystallization processes, the change in the initial fabric at the time of deposition, the change in shape of dome and the change in the viscosity of ice related to climate. The authors examine the evolution of ice fabrics by using an anisotropic flow model. They demonstrates that if the EDC ice was subjected to hori-

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zontal shear, the initial difference of viscosity between adjacent layers due to impurity content would have developed the difference of fabric strengthening and viscosity of the layers further in a positive feedback manner (Paterson,1991), which could explain the characteristic fabric strengthening at MIS6 in EDC ice core. The authors also demonstrate with their model simulation that the shear strain rate increases and longitudinal strain rate decreases at high impurity content layers and that this drastic discontinuity of strain rate between layers affects the layer thinning and ice core dating. I enjoyed the paper and support the results of the paper on the whole.

Although I think that the paper could be published in CP if the authors have addressed to specific comments listed below, I recommend the following. In section 5.2, the authors discuss the effects of changes in ice rheology with climatic periods by using their anisotropic flow model. The model reproduces the fabric strengthening as observed in EDC ice core with the transient solution under simple shear deformation. However, the stationary runs both for biaxial (pure shear) and simple shear deformation could not reproduce it. In order to clarify that the positive feedback mechanism of simple shear deformation is a main cause of the characteristic fabric strengthening in EDC, the authors should compare the results from the transient runs under biaxial deformation and simple shear deformation as well. Another recommendation is that if they can calculate not only the viscosity and the strain rate but also the cumulative vertical strain with depth and show any significant difference between layers, this could provide more valuable information to the ice core dating community.

Specific comments

1. In the section 2.2, When they compare the results of crystal fabric of the EDC with those of the GRIP and the DF they uses the cumulative vertical strain for each core. More details for determining the thinning function for each core should be described because this information is imperative for comparison of fabric development at each location.

2. Page 1192, line 18; “This corresponds to the blue circles pointed by arrows on Fig.2”. According to Fig.2 and authors explanation, third arrow (zz ≈ -0.6) appears to MIS6, but this is incorrectly cited. The corresponding depth shown by the arrow is 1560m, whose age is just after MIS5. In the median inclination profile of c-axis of DF core this corresponding depth (1560 m) does not show any exceptional weakening of c-axis concentration (Azuma et al, 1999, 2000).

3. Page 1192, line 19; “ Azuma et al. (1999) proposed the following explanations : (i) under low temperature and low deviatoric stress, diffusional creep rate, which do not contribute to c-axes rotation, becomes comparable with dislocation creep rate, (ii) high recrystallization rate enhances the rotation recrystallization which should weaken the c-axes concentration.” and Page 1196, line 21 - page 1197, line 2; “Rotation recystallization Ĕ.Dome F observations”. This is also not correctly cited. In the paper (Azuma et al, 1999), the authors proposed that (i) under low temperature and low deviatoric stress, the ratio of diffusional creep to dislocation glide becomes significant if the ice contains high concentrations of impurities. This means that if diffusional creep is activated due to fine grains with high impurity concentrations to the point that diffusional creep rate becomes comparable with dislocation creep rate under low-temperature and low-deviatoric stress regimes, c-axes rotation will slow because the diffusional creep does not contribute to it. (ii) High concentrations of impurities enhance rotation recrystallization. This means that high concentrations of impurities impede grain growth so that the highly elongated crystals are subdivided easily by deformation and c-axes concentration could be weakened. But in a succeeding paper (Azuma et al. 2000) the authors demonstrated that the diffusional creep rate in high impurity layers (620, 1920 and 2340 m) reached 30 % to 50 % of the total creep rate and this decreased role of dislocation glide in the total deformation could slow down the c-axis clustering because the diffusion creep does not contribute fabric development.

4. The referencing is not very good. There is a tendency to cite papers from the French group without mentioning other well-known works and more original works from earlier.

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5. Page 1206, line 23; Dxx < 0. Is this right? Dzz must be < 0 ?

6. Page 1206, line 27 - page 1207, line 4; the authors say that “Due to the shear experienced by ice, the fabrics at 30 km of the dome cluster more rapidly than those predicted without shear (at the dome). However, the shape of the curves is very similar, so that it is very difficult to distinguish only by looking at the general behavior of the fabric evolution if ice has been submitted to shear or not.” The model used in this work is one of anisotropic flow models and has not been established. If the authors use other model they may have obtained different results. Therefore the authors should mention about this.

Interactive comment on Clim. Past Discuss., 2, 1187, 2006.