

DynaQlim

Upper Mantle Dynamics and Quaternary Climate in Cratonic Areas

1. Introduction

We propose an inter-disciplinary project for studying the relationship between Glacial Isostatic Adjustment (GIA), upper mantle structure, dynamics and Quaternary climate. We aim towards an ILP-driven task force which integrates existing data and models from a variety of disciplines that consider processes over a range of spatial and temporal scales. The task force will bring together researchers world-wide with complementary expertise and knowledge to identify key scientific problems relating to the Quaternary evolution of cratonic regions that can be addressed through innovative and multidisciplinary collaboration.

During the Pleistocene, quasi-periodic transitions between glacial and interglacial periods varied with dominant periods closely related to those present in the Earth-Sun orbit. These Milankovich-paced variations in the cryosphere have played a key role in shaping the landscape and driving the geodynamic evolution of cratonic regions such as northern Eurasia and North America during the Quaternary. An extensive and varied suite of observations can be applied to study and understand the key processes involved, including geodetic land uplift measurements, geological observations of sea-level changes and past shore-lines, end moraines and other glacial deposits and various paleoclimatological proxies. These observations have played a vital role in a number of recent advances that have improved our understanding of the structure and dynamics of cratonic regions and the dominant influence of ice sheet growth and ablation.

Recent advances in studies of the glacial history of the northern Europe and Eurasia have significantly improved our understanding of the glaciation and deglaciation histories during the Weichselian and Holocene epochs over the past 100 ka (Svendsen et al. 2004). In addition, developing numerical modelling of glaciations has opened a new view to the processes involved as well as their mutual couplings (Forsström, 2005; Näslund et al., 2006; Zweck and Huybrechts, 2005; SKB, 2006). As a result, the latest generation of ice sheet models are significantly better constrained and more realistic than before.

The phenomenon of glacial isostatic adjustment with its unique temporal signatures is one of the great opportunities in geosciences to get information about earth processes. It contains information about the recent climate forcing, being dependent on the geologically recent on- and off-loading of ice sheets. It gives a unique chance to study the dynamics and rheology of the lithosphere and asthenosphere with an increasing detailed modelling, and it is of fundamental importance in geodesy, since the global reference frames, Earth rotation and Polar motion are influenced by it.

Inversion of deep temperature data in boreholes provides a direct access to ground temperature histories during glaciation times (Kukkonen and Jõelet, 2003). Kimberlite-hosted crustal and mantle xenoliths and seismic velocity models and controlled-source seismic experiments have yielded direct information on the composition and temperature of the lithosphere and asthenosphere (Bruneton et al., 2004, Hjelt et al., 2006, Kukkonen et al., 2003, Olsson et al., 2007, 2006, Pedersen et al., 2006, Stein et al., 1989). These results can be

used to develop more realistic models of mantle temperature and viscosity that are key factors controlling ice sheet dynamics and the Earth's response to ice mass change.

These advances in better constraining ice sheet evolution and upper mantle properties have yet to be incorporated into dynamic models of ice-Earth interaction. A key aim of this project will be to facilitate the development of such models in order to generate more accurate predictions of Earth and ice sheet evolution during the Quaternary. Of course, there still exist many open questions in relation to upper mantle dynamics and composition, rebound mechanism and uplift models, elastic thickness contra lithosphere thickness, as well as ice thickness during the late Quaternary. The proposed task force will serve as a vehicle to identify the gaps in our knowledge that are critical in arriving at an accurate model of ice-earth evolution. Such a model will have a number of applications, including present-day global change as well as future changes in response to a warming climate.