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Modelling the Ice Sheet Hydrological System and its Application to the Disposal of Radioactive Waste

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Numerical models of ice sheet behaviour which successfully simulate the characteristics of modern ice sheets are also able to simulate the geological-inferred behaviour of ice sheets which have extended from time-to-time over the middle latitudes of the northern hemisphere. Models which have been independently constrained and tested by geological evidence suggest relatively robust patterns of basal melting which are insensitive to all but a few free parameters.

Meltwater at the base of ice sheets may be discharged through channels at the ice / bed interface or by groundwater flow; the balance between the two being controlled by the hydraulic transmissivity of subglacial beds. It is suggested that esker systems are an index of the state of this balance. Models which couple the ice sheet and subglacial hydraulic system, when applied to ice sheet fluctuations in northern Europe, show systematic patterns of hydraulic evolution. Patterns of head, hydraulic gradient, and flow vectors through glacial cycles are simulated for geohydrological models of glaciated northern Europe.

The patterns of movement of groundwater through such cycles can also be associated with distinctive changes in the geochemistry of recharge. As a consequence, we expect systematic patterns of subsurface hydrogeochemistry which reflect sequences of surface environments and the driving forces which they have imposed on the groundwater system. It is possible to use such data as indexes of the long-term hydrogeological characteristics of bedrock in the vicinity of potential repository sites.

Patterns of stress associated with extension and contraction of large ice sheets can also be simulated and patterns of shear hydrofractures predicted. Many well known structural characteristics of sediments and bedrock in glaciated areas may be attributed to large scale patterns of glacially-induced stress.

Using hindcasting techniques, it is possible to estimate the long-term evolution of the environmental system and its impact on groundwater in such a way as to define scenarios which are appropriate to safety assessments incorporating different levels of detail.