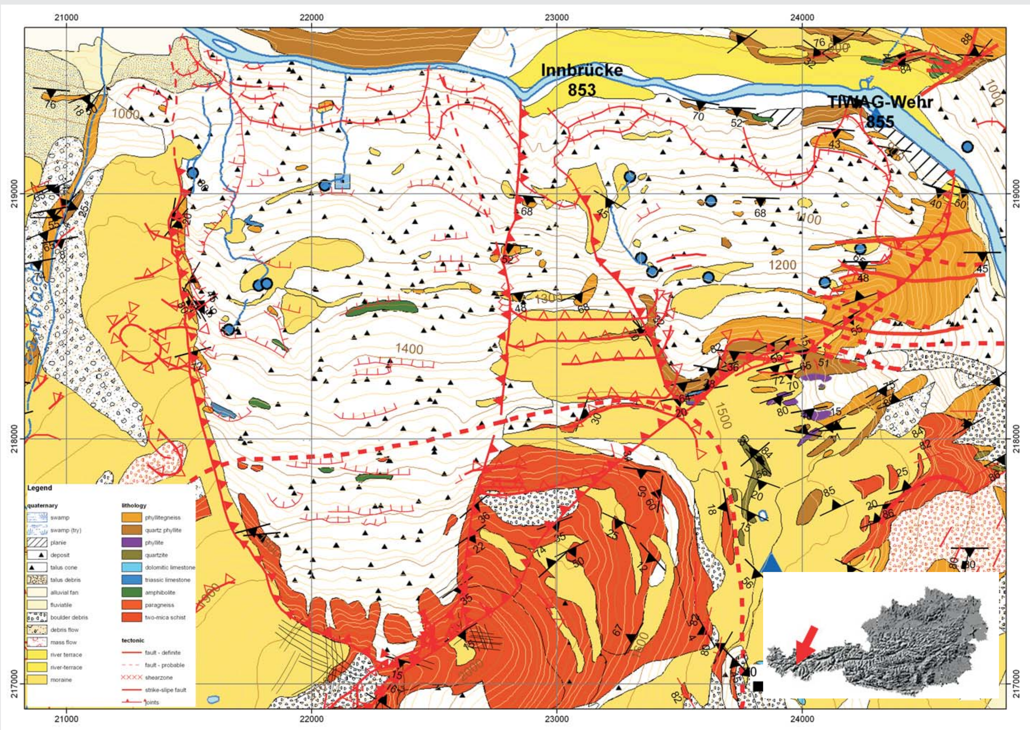
EGU - General Assembly - Vienna, Austria, 2 - 7 April 2006

Kinematics and hazard of the Niedergallmig - Matekopf mass movement

W. Chwatal (1), H. Kirschner (2), E.Brückl (1) and C. Zangerl (2)
1) Institute of Geodesy and Geophysics, Vienna University of Technology, Austria (wchwatal@luna.tuwien.ac.at) (2) alpS GmbH Zentrum für Naturgefahren Management, Austria

Overview



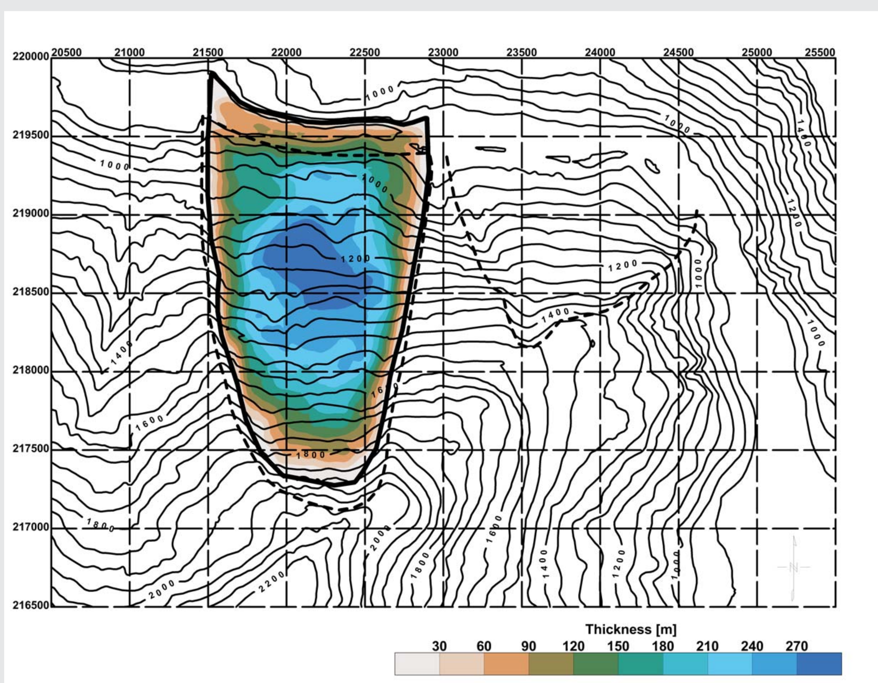
Geological Overview of Niedergallmig- Matekopf

The mass movement Niedergallmigg-Matekopf, located near Landeck in Tyrol (**Austria**), is one of the largest active saggings in the Alpine region. It covers an area of 4.5 km^2 and shows a difference in elevation between the toe and the main scarp of about 1400 m. Results from geodetic measurements (terrestrial and GPS methods) show average surface displacements in the range from 5 to 10 centimetres per year. Actual movements at the lower part of the sagging cause damage of buildings in the hamlet Niedergallmigg. An acceleration of the movement could cause great hazard to the population and infrastructure in this area, especially if the the river Inn is blocked by the toe..

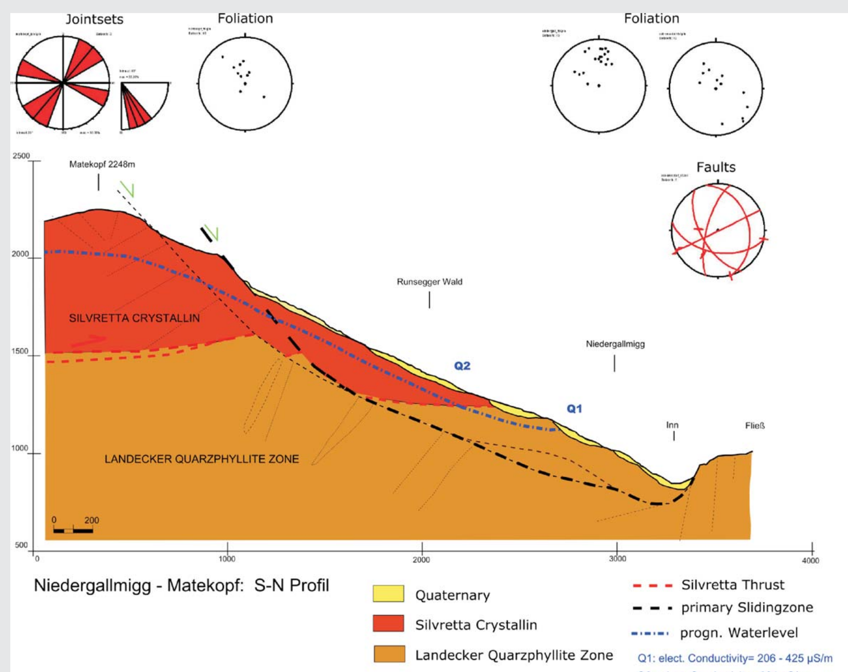
Structural Settings

The Niedergallmigg-Matekopf mass movement can be separated into two moving segments, a greater western part and a smaller eastern part. Our study focuses on the main western part.
It is assumed to have developed after the retreat of the glaciers of the last ice age, in this area (approx. 15 000 b. p.). Morphologic features, in particular the extent of the head scarp, indicate a total displacement of about 180 m. The results of seismic measurements were used to create a map of the sliding surface for the whole area. Further, the maximum thickness (320 m) and the total volume of the creeping rock mass (0,43 km^3) was calculated.
Constraints on the kinematics are also derived from geological observations. The dominating tectonic structures (e.g. Inn valley) are oriented in approx. E-W (e.g. joints, shear faults, b-axes). Conjugated joint systems combined with E-W striking brittle shear zones are observed. The main foliation, which dips steeply (65° to 90°) towards SSE, forms a northvergent anticline-structure and is characterized by intensive internal folding. Therefore the foliation is disregarded as a potential failure plane. The deformation style of the mass movement corresponds to the tectonic structures and not with the metamorphic fabric.

Map of the thickness of the the sliding surface



Geological interpretion of seismic results
SN-section of mass movement



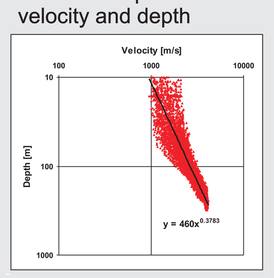
Retro deformation

Retro deformation was applied to reconstruct the pre-failure topography (initial state) of the mass movement. The constraints were the present surrounding geomorphology (scarps, edges etc.), the conservation of the mass, the initial geomorphology (e.g. smoothness of terrain, gradient of the slope) and the dilatation during the creeping phase. To estimate the amount of the dilatation the average present porosity was calculated from the seismic velocities, which depend on the depth, and the average pre-failure porosity was estimated from the thickness of the mass movement. Thereafter the volumes, areas, thicknesses and the center of mass in the direction of the movement of the present and initial state were determined.

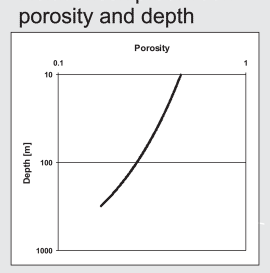
Table of parameters of present and initial state

	Present	Initial
Volume [km^3]	0.43	0.41
Area [km^2]	2.62	2.66
Average Thickness [m]	163	155
Center of mass Y	218590	218331
Center of mass Z	1174	1311
Porosity	0.21	0.06

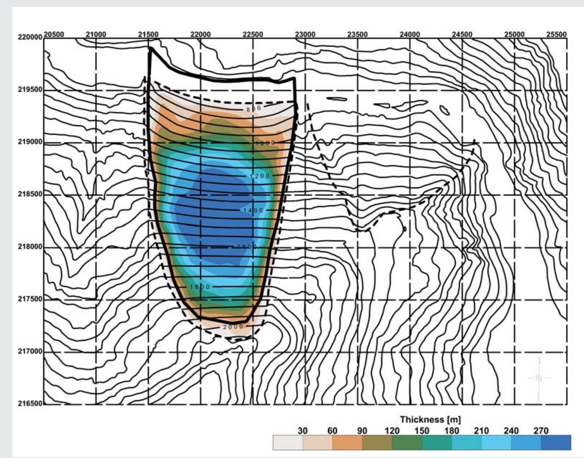
Relationsship between velocity and depth



Relationsship between porosity and depth



Map of thickness between pre-failure topography and sliding surface



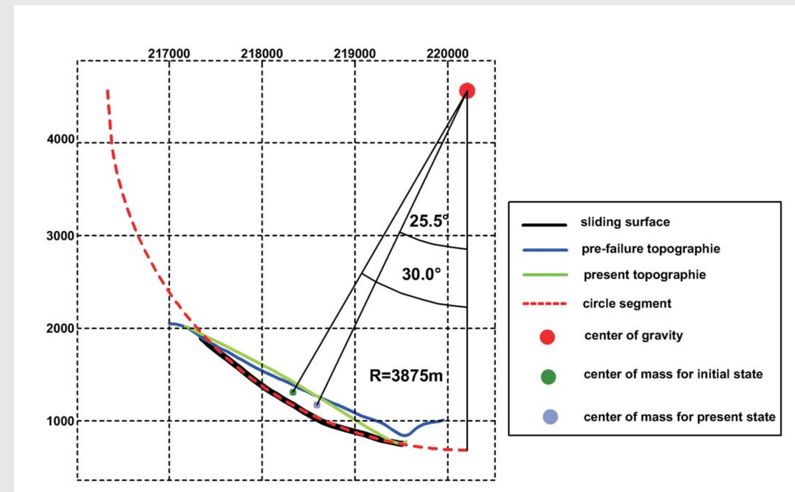
Summary and Next Steps

The results of the seismic measurements provide structural information of the sliding surface and estimations of the porosity of the moving mass, from which the dilatation was calculated. The conservation of the mass and geomorphologic conditions were also used as constraints to apply a retro deformation.
The rotational slider block mode fits observed geodetic displacements well. Thus the assumption that the mass movement moves as a single block is reasonable. The development of the mass movement was modeled with the subcritical crack growth theory and the process of smoothing of the sliding surface. The results show that an active phase of the mass movement from present to the next 2000 years can be expected, but the creeping velocity should stabilize in the far future.
Next steps: The dependency of potential mass loss due to erosion will be analysed. Seismic monitoring systems, which are already installed, will contribute new information about the n behavior of the movement. Dating of the scarp should check validity of our suggested model of the development of the mass movement.

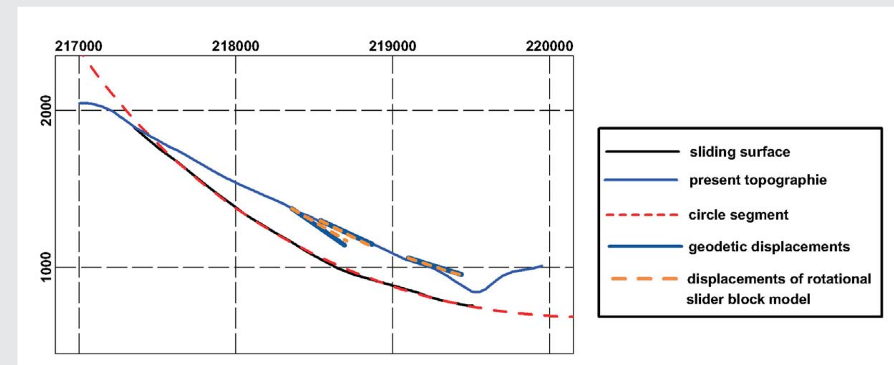
Kinematics

Rotational slider block model

The rotational slider block model assumes that the whole mass movement is advancing as a single block along circular shape sliding planes. For application of this model the center of gravity and the radius (3875m) of the sliding surface were calculated. With the center of gravity and the center of the mass the angle at the initial (30°) and present state (25.5°) was determined. Geodetic measurements show a dip angle of 34° in the upper part, 25° in the middle part and 17° in the lower part of the mass movement for the displacements. These values fit to the dip angle of the rotational slider block model. As a conclusion the whole volume of the sagging, as determined by the seismic measurements, belongs to the currently moving rock mass.



Geometry of rotational slider block model



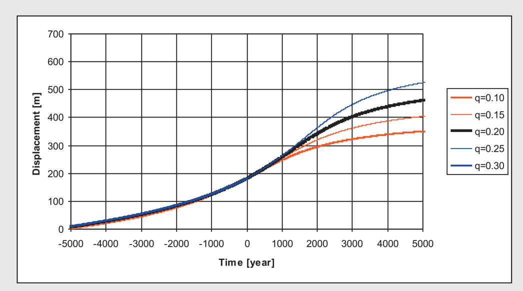
Comparison of real and theoretical displacements

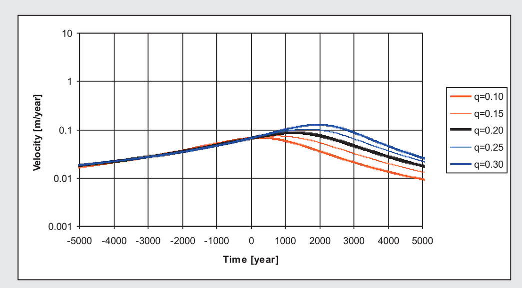
Hazard

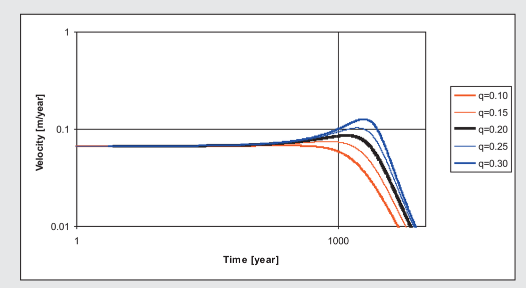
The behavior of the sliding mass was modeled by the process of progressive stress induced damage. Thus the creeping velocity of the mass movement is controlled by subcritical crack growth and the progressive smoothing of the sliding surface. Two smoothing algorithm were applied: Exponential smoothing and a power law relationship (Dieterich-Ruina Law)
The main input parameters are the onset of the development of the mass movement (15000 years ago), the angle of the initial state (30°), the total displacement of the mass movement (182m), the present creeping velocity (0.075m/year) and the angle of the friction (assumed as 25°). Both smoothing algorithms show similar results: The onset of the creeping phase (5500-5000 b.p), increasing activity from present to the next 2000 years and the stabilisation of the mass movement afterwards.

Total displacement from initial state to next 5000 years | Creeping velocity/year from initial state to next 5000 years | Creeping velocity/year from presen t to next 2000 years

Exponential Smoothing







Dieterich - Ruina Law