Oselitzenbach Torrent – Reppwand Landslide

(Michael Lotter)

Coordinates: UTM WGS8433N: 369000 E 5159900 N
Site, county: Tröpolach-Nassfeld/Gail Valley/Carnic Alps, Carinthia
Type of the slope failure: complex; predominantly rock slide – debris slide, deep-seated creep (“valley closure”/“Talzuschub”)
Other specifications: highly active toe zone (scarps, ridges, cracks) with different slope failure scenarios; very low to not active upper parts of the landslide; remedial measures to prevent undercutting by the torrent
Specific area: slope between Reppwand (main scarp) and Oselitzenbach (toe), 1700-760 m asl
Volume: different estimations acc. to different geotechnical models; maybe around 150 Mio. m³
Age: Lateglacial to Holocene, possibly older than the last glacial maximum

---

The catchment area of the Oselitzenbach torrent (approx. 28 km²) in the Naßfeld region (Carnic Alps; Fig. 1) is endangered by large-scale and deep-seated gravitational slope deformations (DGSD, “Talzuschub”= ”valley closure”, sagging, rock spread; WEIDNER, 2000, with references). The mass movements involve an area of approx. 8 km² and are caused by the geotechnical properties of the lithological units, the glacial shaped relief and the high annual precipitation with intense rainfall events (>2000 mm/a; 300-400 mm within 48 hours have been registered in the past as a maximum amount). A post-Variscan Upper Carboniferous and Lower Permian sequence indicates an alteration of brittle and weak sedimentary rocks, consisting of shales, siltstones, sandstones, conglomerates, marls and limestones (Fig. 2, 3, 4). Within the mass movements these rocks are highly deformed, intensely fractured or completely disintegrated by long-term slow sliding and creeping processes at displacement rates mainly of few centimetres per year.

The dominant mass movements are the Reppwand landslide, the Schlanitzenalm landslide, and the Treßdorfer Höhe rock spread area (KAHLER & PREY, 1963; GLAWE & MOSER, 1990; GLAWE et al., 1993; AMATRUDA et al., 2004; TENTSCHERT et al., 2005; LOTTER & MOSER, 2007). Furthermore, small-scale landslides and rock fall areas can be observed. During intense rainstorms major or even catastrophic debris flows can originate from the toe zone of the mass movements along the torrents Oselitzenbach and Rudnigbach. The major alluvial fan at the village of Tröpolach, where the Oselitzenbach torrent forces the Gail River to undercut the opposite valley slope and to trigger mass movements (REITNER et al., 1993), provides evidence of such events.

The Naßfeld road is an important touristic traffic route between Carinthia and Italy. It crosses the active toe zone of the Reppwand landslide and has been damaged or even interrupted in the past by repeated undercutting of the toe of the landslide and flooding (Fig. 1, 2, 7). Therefore, extensive remedial measures have been realised to stabilise the toe of the landslide together with the road as well as to prevent infrastructure in the nearby Gail Valley from catastrophic debris flows (Fig. 5, 6).

The Reppwand landslide, which covers an area of approx. 2.4 km², is a complex mass movement and part of a large-scale slope failure system towards the torrents of Rudnigbach and Oselitzenbach (Fig. 1, 2, 3). It shows typical features of “valley closure” phenomena, for which the German landslide term “Talzuschub” according to STINI (1941) is in use. Despite the existence of a bulging toe in big parts of the landslide, it is not characterized to be a sagging mass ("Sackung") as defined by ZISCHINSKY (1966, 1969). In fact, following VARNES (1978) and CRUDEN & VARNES (1996), the landslide mechanisms can be described as a combination of deep creep, and a "mosaic" of multiple rotational and translational sliding processes in a mixed material which shows mechanical properties of bedrock as well as of engineering soil. The mean slope angle is low with around 17° between the toe at Oselitzenbach and the foot of the up to 350 m high rock face of the Reppwand. The toe itself is oversteepened (up to 40°) through the incised river bed. At the Reppwand, which is the main scarp resp. the crown of the landslide, rock fall/topple and rock spread, "feeding" the landslide mass down slope, complete the list of mass movement phenomena.

During the excursion course we will stop at three different sites within the Reppwand landslide (Fig. 1):

The first stop (location 1 in Fig. 1) is located at the toe of the landslide, proximate to the Oselitzenbach (Fig. 5, 6). A catastrophic flood event occurred in September 1983, with debris flows on the alluvial fan into the Gail Valley, destruction of the Naßfeld road along the landslide toe and of old transverse structures in the river bed. Undercutting of the toe caused high settlements and displacements of several meters through secondary slides over the following years. The most significant consequence was the (re-)activation of the Quellenbach slide in August 1987 with a material discharge of 70.000 m³ through the torrent (Fig. 8). The remedial measures (1988) to prevent undercutting and to stabilise the toe included a man-made relocation of the river bed away from the toe to the north within stable rock ("rock channel") on a length of 400 m, and a backfill of 170.000 m³ with material taken from the opposite slope. In the course of time a significant slowdown of the displacements proved the success of the measures, but parts of the toe still show remarkable displacements of several centimetres per year (Fig. 9, 10). Therefore, the Naßfeld road is affected to date (Fig. 7). It is assumed, that the basal shear zone of the recent movements surfaces at the river bed. The soil mechanical properties feature low plasticity, an effective angle of friction of approx. 18°, and an effective cohesion of approx. 14 kN/m² (WEIDNER, 2000).

Our second stop is located at the natural monument of Lake Bodensee (Fig. 11; location 2 in Fig. 1). From the toe to this medium level of the landslide gradual decreasing displacements have been detected. Significant scarps, particularly downward the slopes, are observed in the area (Fig. 12). Possible causes of the existence of the lake itself (and a former smaller lake to the East) in this part of the landslide will be discussed in the field (e.g. crop-out of springs because of near-surface stable rock, and/or course of secondary shear planes, and/or dense till material covering the landslide, etc.). As no drilling exists which penetrates the landslide to its basal surface of rupture, very different estimations of its thickness are in discussion, and there is still few knowledge of its spatial structure (Fig. 3).

To reach the third stop, we come along a forest road upward to the foot of the rock face of the Reppwand, passing a system of deep-seated scarps, cracks and ridges, which are overlain by rock fall material in the upper parts (location 3 in Fig. 1; Fig. 13, 14, 15). Processes and phenomena of specific mass movements along the main scarp of the landslide can be observed, as described above. The Reppwand reveals an impressive South Alpine normal lithological sequence reaching from the Lower Permian Grenzland Fm. to the Middle Triassic Muschelkalk Conglomerate at the Kammleiten site (=Kühweger Köpfl in Fig. 3; 1998 m asl.). The red beds of the Middle to Upper Permian Gröden Fm. and the Lower Triassic Werfen Fm. are striking sections of clastic influence within the rock face. The sequence is completed by the Middle to Upper Triassic Schlern Dolomite of the Gartnerkofel Mountain (2195 m asl.) to the south of the landslide area (see Fig. 2, 3, 4, 13).

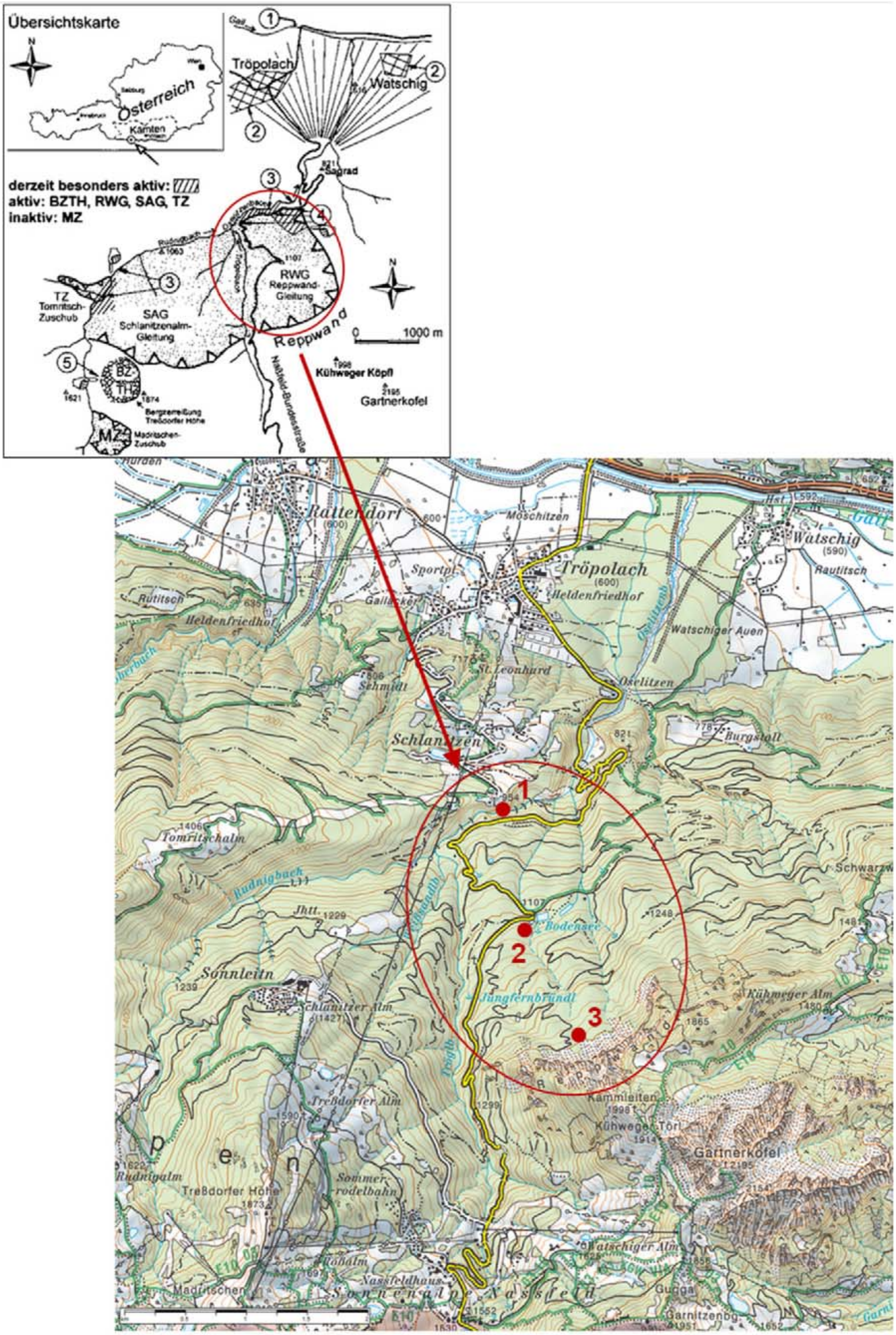

Figure 1. Topographic map with the locations along the excursion route. The sketch above (mod. after MOSER et al., 1988) indicates the significant slope failures within the catchment area of the Oselitzenbach.

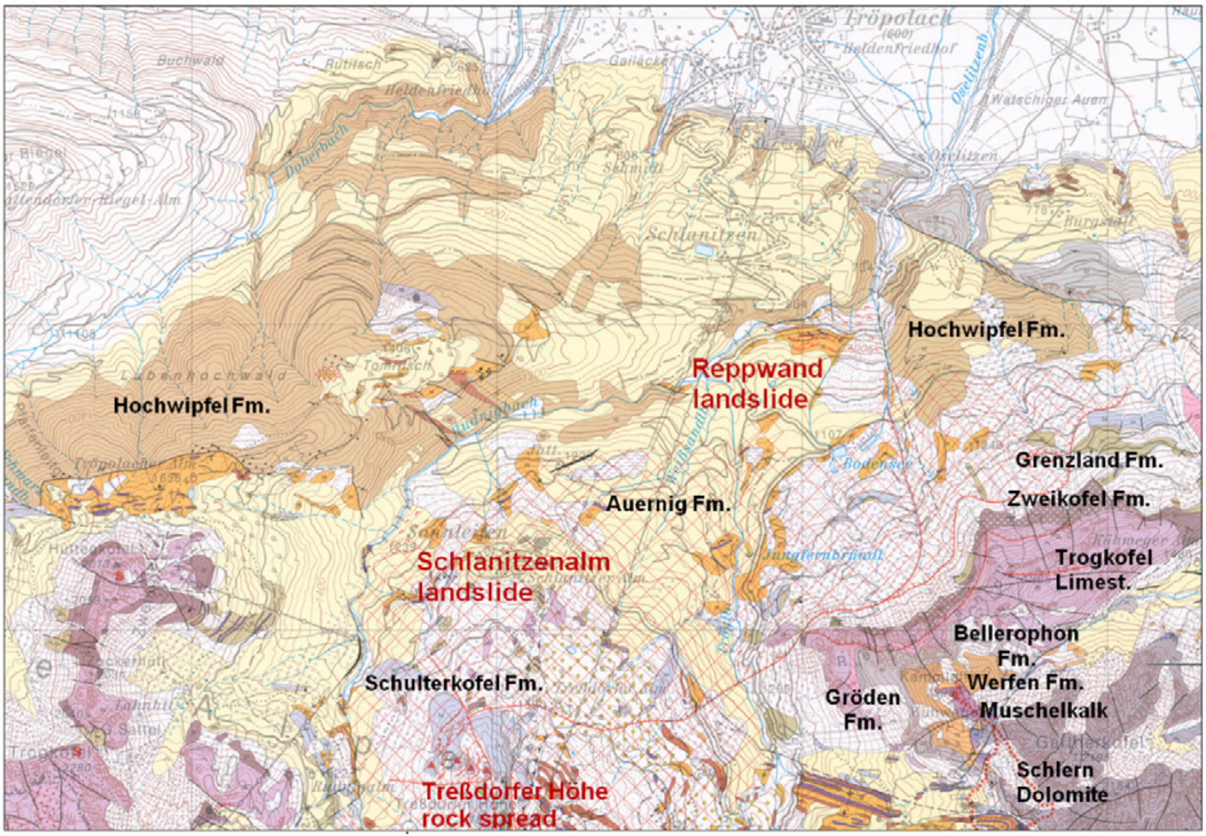

Figure 2. Detail of the geological map (SCHÖNLAUB, 2006) with the main lithological units indicated at the Reppwand landslide (explanation of stratigraphy see Fig. 4).

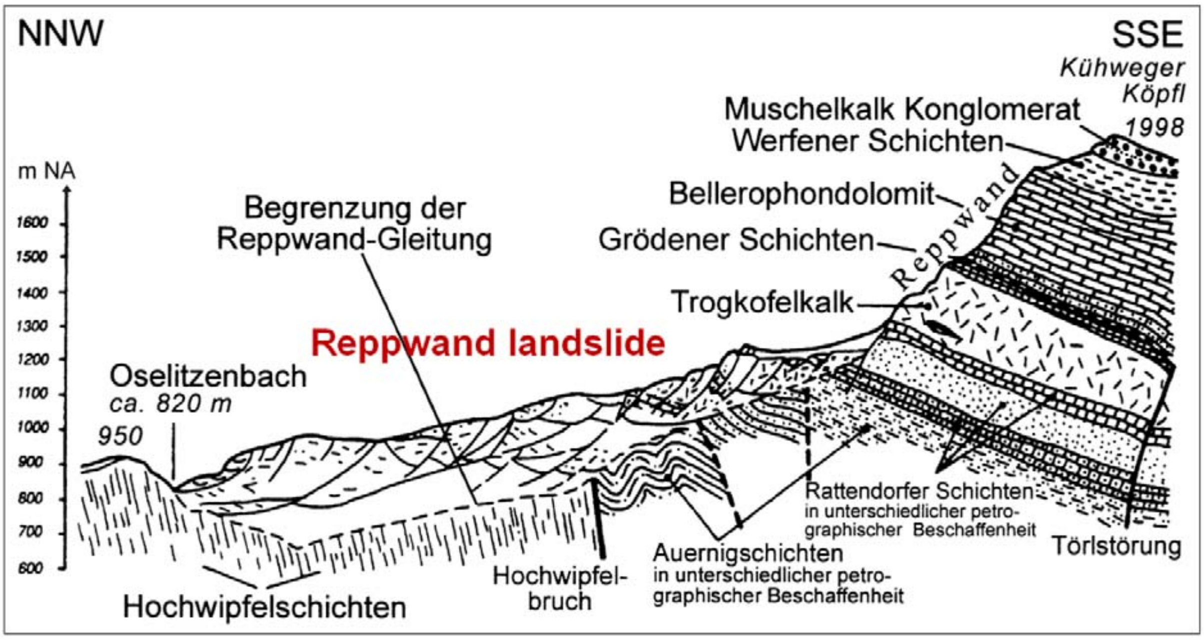

Figure 3. Geological cross section Oselitzenbach – Reppwand – Kühweger Köpfl, which illustrates the probable extent of the Reppwand landslide (WEIDNER, 2000, mod. after KAHLER & PREY, 1963).

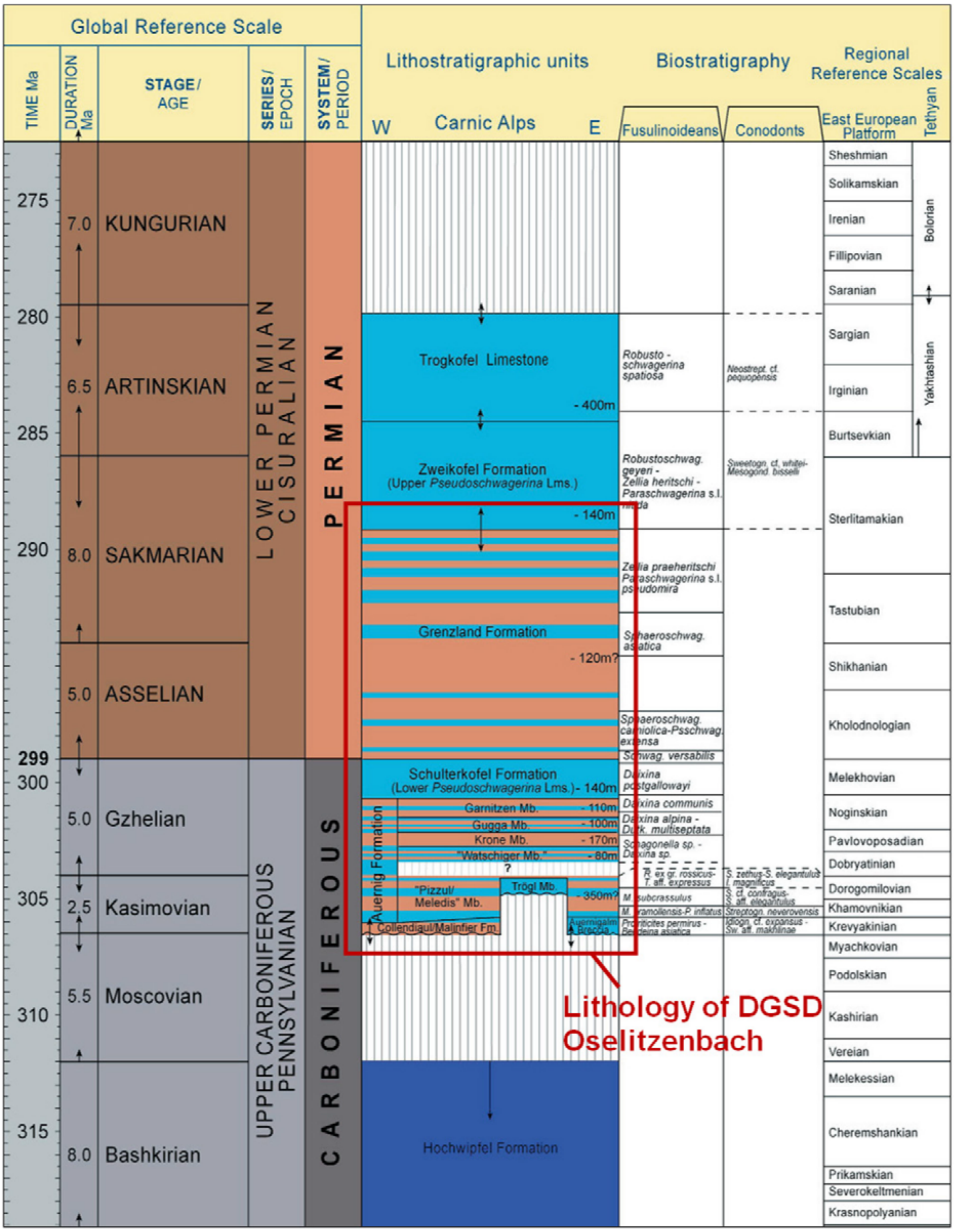

Figure 4. Litho-, bio- and chronostratigraphy of the post-Variscan Upper Carboniferous and Lower Permian sequence of the Carnic Alps (SCHÖNLAUB & FORKE, 2007). The red rectangle points out the main lithostratigraphic units which are involved in the mass movements of the Oselitzenbach catchment area.

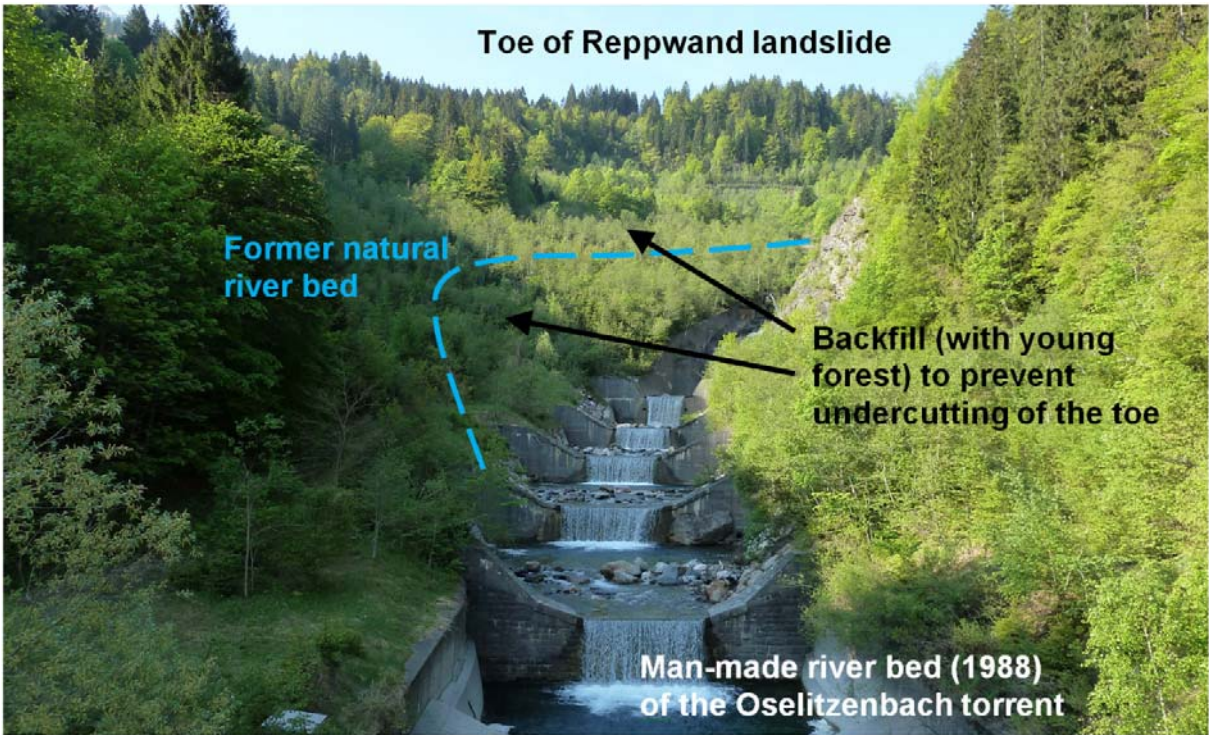

Figure 5. Morphological and geotechnical setting (May 2011) at the toe of the Reppwand landslide with remedial measures to stabilise the toe which is crossed by the Naßfeld road (170.000 m³ backfill, shift of the river bed to the north at a length of 400 m within stable rock of Hochwipfel Fm., high density of transverse structures).

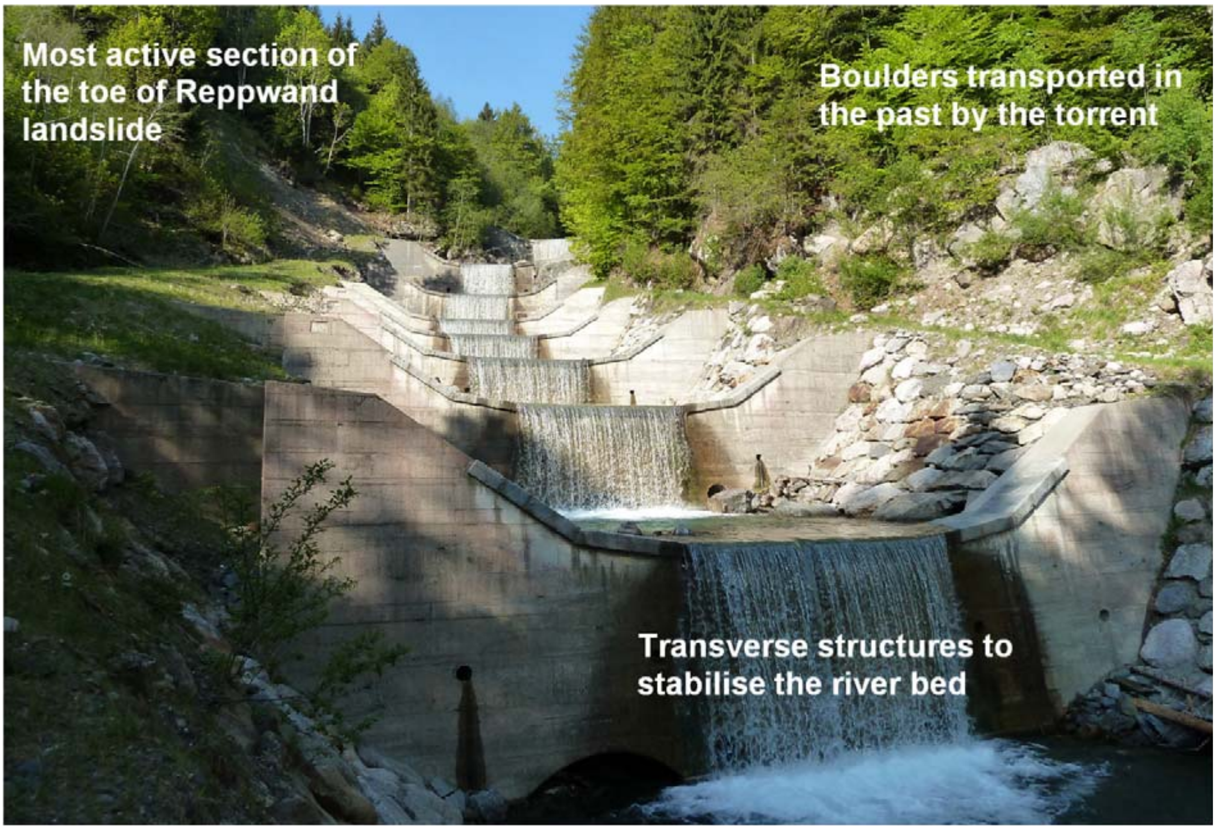

Figure 6. Morphological and geotechnical setting (May 2011) at the most kinematic active section at the toe of the Reppwand landslide (location 1 in Fig. 1). The more recent transverse structures in this section have been constructed between 2000 and 2004.

Figure 7. Damage of the Naßfeld road (May 2011) where it crosses the most kinematic active section at the toe of the Reppwand landslide. Average velocities of horizontal displacement of more than 7 cm/a have been detected between 1991 and 2006 (see also Fig. 10).

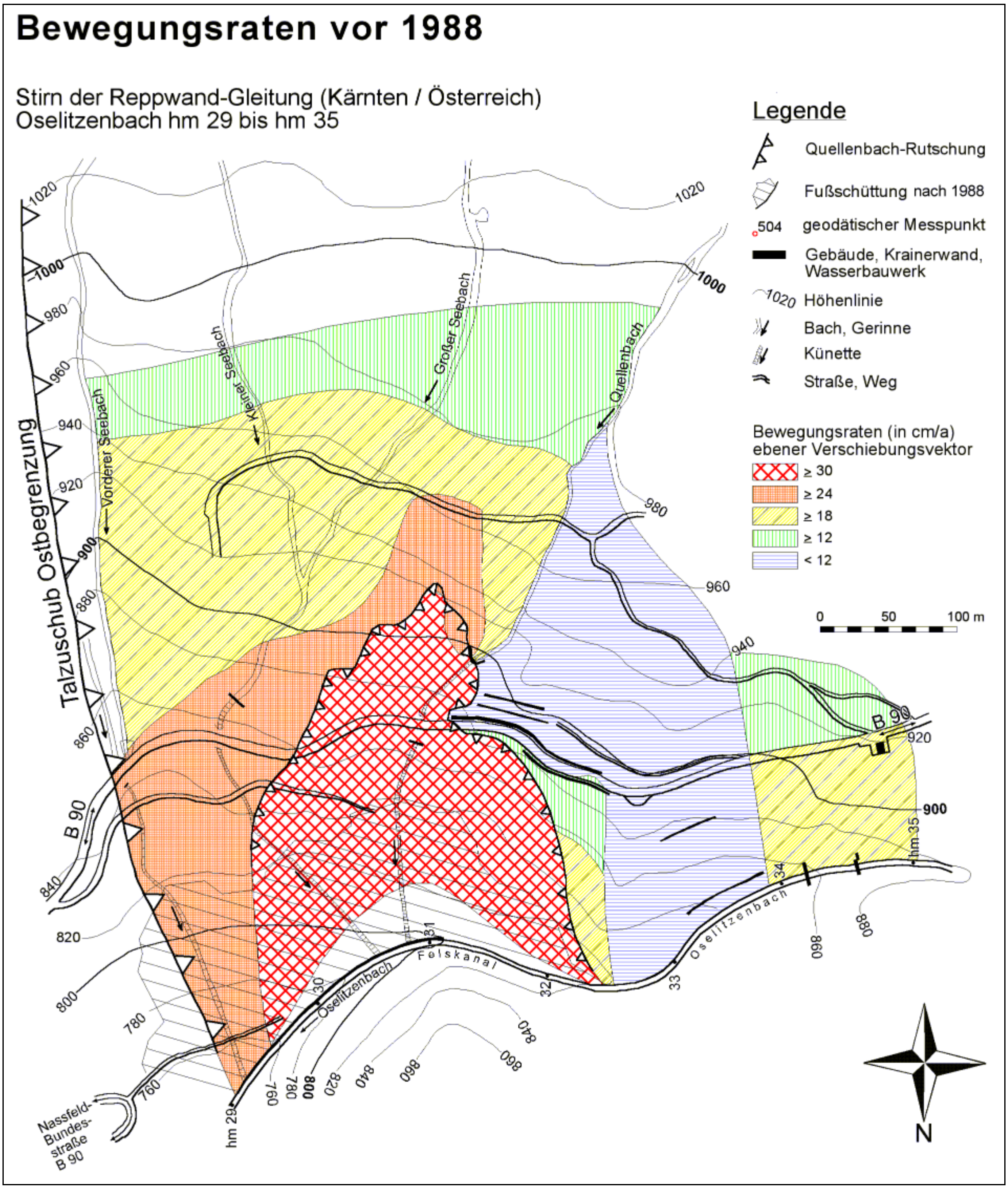

Figure 8. Rates of horizontal displacement (cm/a) at the north-eastern toe of the Reppwand landslide before 1988, i.e. before the remedial measures (shift of the torrent to the south in a man-made stable river bed and backfill of 170.000 m³ to stabilise and to prevent undercutting of the slope) have been undertaken (WEIDNER, 2000).

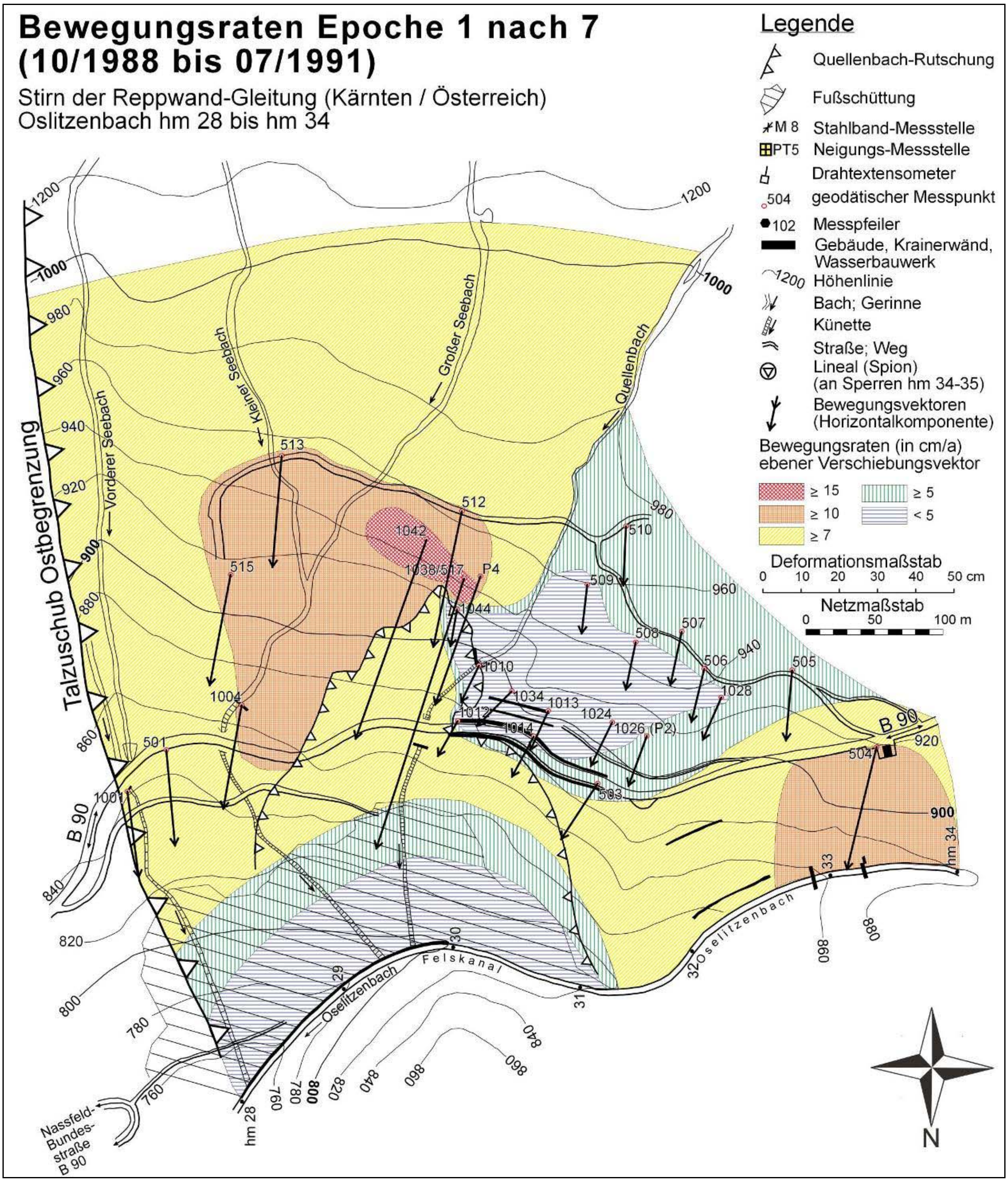

Figure 9. Rates of horizontal displacement (cm/a) at the north-eastern toe of the Reppwand landslide from 1988 to 1991, i.e. 0 to 3 years after the remedial measures have been undertaken (LOTTER & MOSER, 2007).

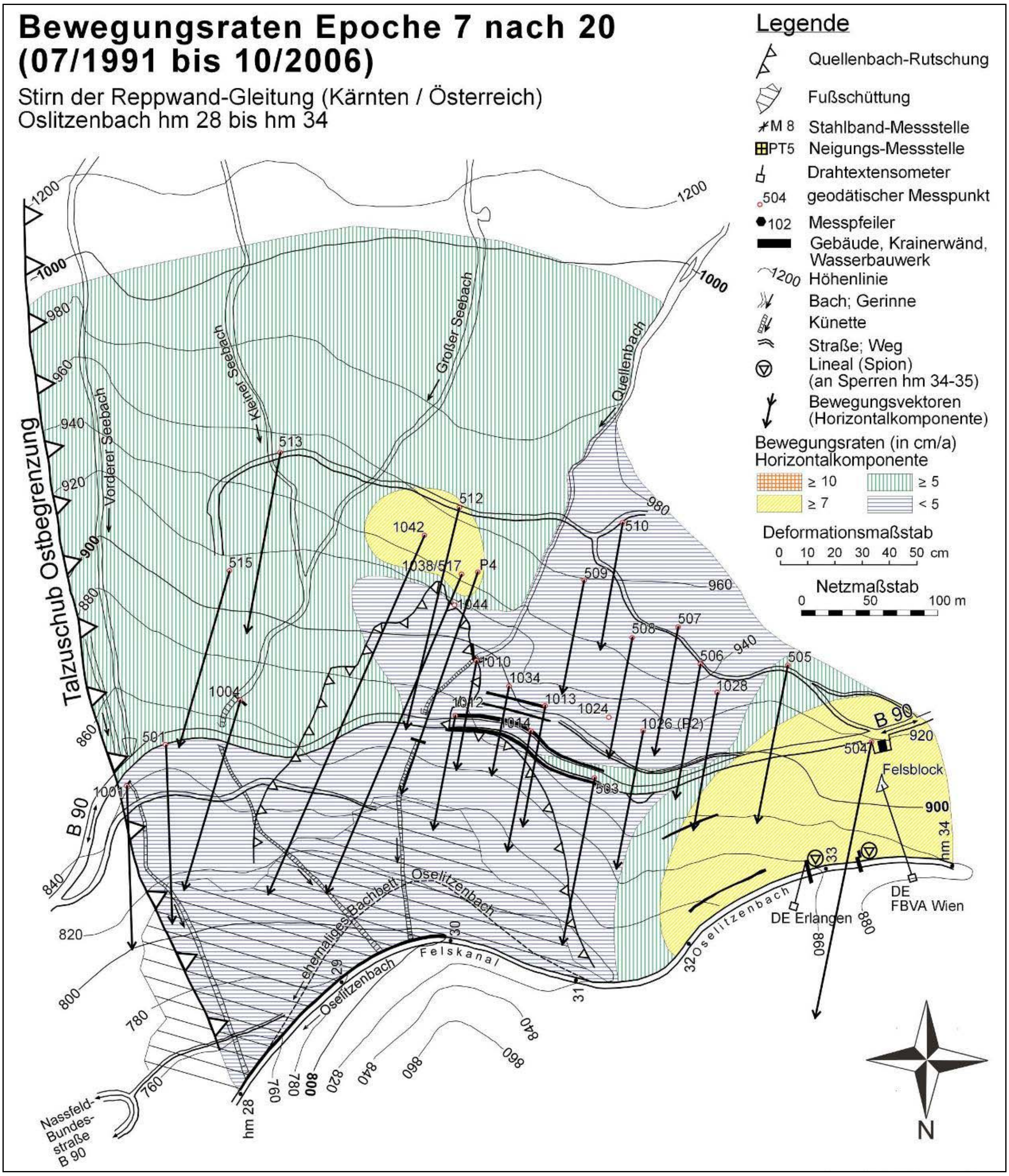

Figure 10. Rates of horizontal displacement (cm/a) at the north-eastern toe of the Reppwand landslide from 1991 to 2006, i.e. 3 to 18 years after the remedial measures have been undertaken (LOTTER & MOSER, 2007).

Figure 11. The natural monument of Lake Bodensee (location 2 in Fig. 1), situated in the middle part of the Reppwand landslide. From the toe up to this area recent kinematic activity is detected.

Figure 12. Signs of active slide processes in the easternmost part of the Reppwand landslide close below the level of Lake Bodensee.

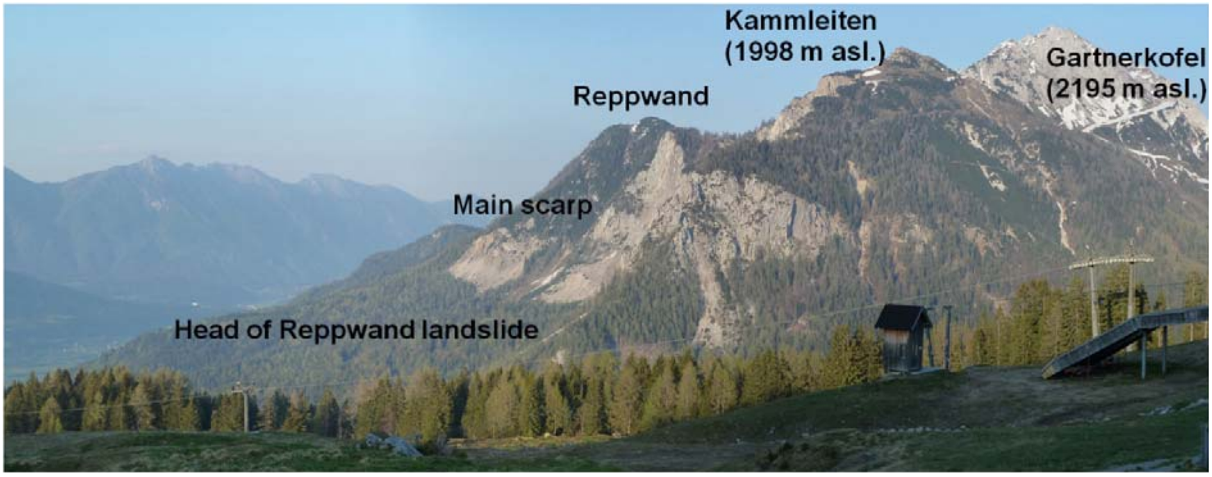

Figure 13. Head of the Reppwand landslide (left half of the photo) with the main scarp (rock face of Reppwand) and the surroundings.

Figure 14. Foot of the rock face of Reppwand (left photo view to the East, right photo view to the West; location 3 in Fig. 1), which indicates the main scarp of the landslide. Rock fall, topple and rock spread processes are evident.

Figure 15. Signs of deep-seated gravitational slope deformation (minor scarps, transverse cracks and ridges) within the head of the Reppwand landslide.

References:

AMATRUDA, G., CASTELLI, M., HURLIMANN, M., LEDESMA, A., MORELLI, M., PIANA, F., PIRULLI, M., POISEL, R., POLINO, R., PRAT, P., PREH, A., ROTH, W., SCAVIA, C., TENTSCHERT, E. (2004): The Oselitzenbach landslide. In: BONNARD, CH., FORLATI, F. & SCAVIA, C. (Eds.): Identification and Mitigation of Large Landslide Risks in Europe. Advances in Risk Assessment. European Commission Fifth Framework Programme, IMIRILAND Project, 137-180; A.A. Balkema Publishers.

CRUDEN, D.M. & VARNES, D.J. (1996): Landslide types and processes. In: TURNER, A.K. & SCHUSTER, R.L. (Eds.): Landslides: investigation and mitigation. Transportation Research Board, Spec. Rep. 247: 36-75; National Academy of Sciences, Washington, DC.

GLAWE, U. & MOSER, M. (1990): Geotechnische Untersuchungen an den Großhangbewegungen im hinteren Rudniggraben - Naßfeldgebiet/Kärnten. Carinthia II, 180./100. Jg.: 405-425; Klagenfurt.

GLAWE, U., ZIKA, P., ZVELEBIL, J., MOSER, M. & RYBAR, J. (1993): Time prediction of a rock fall in the Carnic Alps. Quarterly Journal of Engineering Geology, 26: 185-192; London.

KAHLER, F. & PREY, S. (1963): Erläuterungen zur Geologischen Karte des Naßfeld-Gartnerkofel-Gebietes in den Karnischen Alpen. Geol. B.-A., 116 p.; Wien.

LOTTER, M. & MOSER, M. (2007): Die Massenbewegungen der Naßfeldregion. Abh. Geol. B.-A., 61: 159-173; Wien.

MOSER, M., ANGERER, J. & SEITZ, S. (1988): Geotechnische Untersuchungsergebnisse im Rahmen des Verbauungsprojektes Oselitzenbach/Kärnten. Int. Symp. Interpraevent 1988, 3: 77-102; Graz.

REITNER, J., LANG, M. & VAN HUSEN, D. (1993): Deformation of high slopes in different rocks after würmian deglaciation in the Gailtal (Austria). Quaternary International, 18: 43-51.

SCHÖNLAUB, H.P. (2006): Geologische Karte des Jungpaläozoikums der Karnischen Alpen 1:12500 Blatt Ost. Geol. B.-A.; Wien.

SCHÖNLAUB, H.P. & FORKE, H.C. (2007): Die post-variszische Schichtfolge der Karnischen Alpen – Erläuterungen zur Geologischen Karte des Jungpaläozoikums der Karnischen Alpen 1:12500. Abh. Geol. B.-A., 61: 3-157; Wien.

STINI, J. (1941): Unsere Täler wachsen zu. Geol. u. Bauwes., 13: 71-79; Wien.

TENTSCHERT, E., POISEL, R., PREH, A. & ROTH, W. (2005): The Oselitzenbach landslide (Austria) – triggering, runout and risk evaluation. Geophysical Research Abstracts, 7: 13 p.; European Geosciences Union.

VARNES, D.J. (1978): Slope movement types and processes. In: SCHUSTER, R.L. & KRIZEK, R.J. (Eds.): Landslides, analysis and control. Transportation Research Board, Spec. Rep. 176: 11-33; National Academy of Sciences, Washington, DC.

WEIDNER, S. (2000): Kinematik und Mechanismus tiefgreifender alpiner Hangdeformationen unter besonderer Berücksichtigung der hydrogeologischen Verhältnisse. Diss. thesis Univ. Erlangen-Nürnberg, X+246 p.; Erlangen.

ZISCHINSKY, U. (1966). On the Deformation of High Slopes. Proceedings of the First Congress of the International Society of Rock Mechanics, 2: 179-185.

ZISCHINSKY, U. (1969). Über Bergzerreißung und Talzuschub. Geologische Rundschau, 58: 974-983.