Rockfall occurrence at the southern border of the Tauern Window – structural, lithological and geomorphologic aspects

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The southern part of the central Tauern Window with the main tectonic units Sub-Penninic and Penninic nappes are overthrusted by Austroalpine nappes (SCHMID et al., 2004; PESTAL et al., 2009). Therefore the tectonic and lithological heterogeneity in this region results in a variety of areas with different lithological and structural anisotropies and consequently geotechnical-lithological properties (MELZNER et al., 2012). This fact has fundamentally influenced the landscape evolution: The area is characterized by two main strike slip fault systems. These tectonically predefined weak zones have been subject to glacial and glacio-fluvial erosion processes. Nowadays the valleys follow the main faults in NW–SE- or WSW–ENE-striking directions, and also related syn- und antithetic faults, respectively (LINNER et al., 2009).

The varying anisotropy affects the spatial distribution and extent of potential rockfall source areas within the study region (MELZNER et al., 2012):

Due to the young landscape evolution an almost preserved, oversteepened glacial and post-glacial relief can be recognized. Hence, nearly all of the lithological units form cliffs starting from 48 or 50 degree of slope inclination. However, more competent rock has greater proportions of steeper terrain than less competent rock.

Typically, steep cliffs occur within the Upper Austroalpine Prijakt-Polinik complex (LINNER & FUCHS, 2005; PESTAL et al., 2009). The lithological properties of this complex and the orientation of its rock mass structure (gently dipping from the NW to NE) favour the development of significant rockfall source areas. Field investigations demonstrated that these cliffs are generally very susceptible to rockfalls due to the heterogeneous anisotropy of this lithological unit. The heterogeneous anisotropy results in a range of failure mechanisms as well as considerable diversity in block size and shape:

- Small-scaled transitions between competent and less competent rock together with the ongoing process of detachment along a few widely spaced discontinuities sets are likely to cause selective weathering and subsequent susceptibility to comparatively large volume rockfalls.
- The number of brittle faults increases from the Prijakt-Polinik complex towards the Melenkopf complex. This results in rockfall source areas that are very small but highly fractured and loosened.
- Some cliffs have been constructed from a sequence of scarps generated by several large volume rockfall events. It is striking that the scarps follow the same orientation as some of the dominant fault planes, which occur with a high degree of separation.

Several rockfall areas are associated with deep-seated slope deformations. These mass movement types shape the landscape in the Tauern Window and have their origin (in regard to mechanism, location etc.) in the varying anisotropy of rock as mentioned above. Depending on the mass movement type (e.g. rock slides, rock creep, rock spreads, etc.) and its stage of development rockfall either occurs within the scarp area, along/ within the body or along the oversteepened front parts of the slope deformations.

Due to the glacial and postglacial landscape evolution, most of the slopes are covered by moraine deposits or scree. The (re-)mobilization of boulders caused by erosion processes, mass movements or wind throw, are common processes. Such „secondary“ rockfalls can be triggered nearly everywhere throughout the whole study area.

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Deformation and metamorphism of blueschists within the Phyllite-Quartzite Unit of the External Hellenides, Greece: a comparative study on fluid inclusions

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The Phyllite-Quartzite Unit, exposed in the southernmost part of the Mani peninsula, occurs between the medium-grade metamorphosed Plattenkalk Unit and the low-grade metamorphosed Tripolitsa Unit. The unit contains blueschists arranged as boudins which are surrounded by chloritoid-bearing micaschists. HP/LT metamorphism resulted from subduction of the Adriatic plate beneath the Eurasian plate during Eocene time. Structural mapping indicates three phases of folding. Stage F1 is rarely preserved and results from uniaxial stretching by holding steep SW-plunging fold axes. Superposition of folding events F2 and F3 form a large km-scale fold interference pattern with tight S- to SE and shallow W-E plunging fold axes, respectively.

On microscale, blueschists contain glaucophane+chloritoid+phengite+quartz. The surrounding rocks consist of chloritoid+phengite+paragonite+chlorite+quartz. Mineral chemical analysis of chloritoid indicates a prograde growth. Chloritoide porphyroblasts reflect an earlier foliation S1 (D1) and show locally pseudomorphic transformations to phengite and chlorite that are accompanied with SSW-directed shearing (D2). D2 is responsible for the penetrative foliation S2.

Constraints for the post-peak P-T evolution of the Phyllite-Quartzite Unit have been performed by fluid inclusion studies on late-stage boudin necks close to the blueschists. Necks consist of coarse grained quartz aggregates. Fluid inclusions (FIs) show a frequent occurrence of aqueous saline inclusions predominantly with halite daughter crystals. FIs occur up to 3-phase (S,L,V) and indicate the chemical system H_2O-NaCl-$CaCl_2$. The system is established by eutectic temperatures Te and Raman spectroscopy. Te shows always very low temperatures in the range of -72°C which is interpreted as metastable phase behaviour or crystallization stage. Last ice melting of about -49°C occurs earlier than hydrohalite melting (~-35°C) which coincides well with respective Raman spectra. This indicates a fluid composition around 47 mass% H_2O, 36 mass% NaCl and 17 mass% $CaCl_2$. Densities lie between 1.24 and 1.17 g/cm3. Assuming proposed maximum peak temperatures from blueschists from this area of about 550°C, conditions for extension of boudin necks can be established due to fluid density isochore calculations between 7 and 9 kbar. This fluid inclusion study will now be compared with fluid inclusions in concordant quartz veins which act as host rocks of the blueschist boudin structures.