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Blatt 121 Neukirchen am Großvenediger

Bericht 2016 über geologische Aufnahmen quartärer Sedimente und Formen auf den Blättern 121 Neukirchen am Großvenediger und NL 33-01-19 Neukirchen am Großvenediger

Elijah Dippenaar

This is the complementary report to the quaternary geological map of the Kurzer Grund and Fromm Grund Valleys. The Kurzer Grund mapping area covers a surface area of 12.6 km^2 on the orographic left flank of the valley, which lies in the Kelchsau Valley in the Kitzbühler Alps. A geological map (Heinisch & Panwitz, 2007) was used as a basis for this Quaternary geological map, which was mapped at a scale of 1:10,000. Their base map contains Quaternary deposits but does not include a stratigraphic sequence thereof.

According to Heinisch & Panwitz (2007) the very north of the mapping area is dominated by the Löhnersbach Formation (alternate bedded phyllites, metasandstone and metasiltstone). Overlying the Löhnersbach Formation to the south is the Schattberg Formation (argillaceous schists, metasiltstones and metasandstones). In the mapping area the contact zone between the two Formations is covered by Quaternary deposits which reach an altitude of c. 1,100 m a.s.l. The Schattberg Formation forms a large part of the slope, reaching an altitude of 1,600 m a.s.l. and extends south until the Niederkaseralm is reached. The Schattberg Formation is overlain by Innsbruck Quarzphyllit, which extends beyond the southern limits of the mapping area. The Schattberg Formation-Innsbruck Quarzphyllit contact is the boundary between the Greywacke Zone and the Innsbruck Quarzphyllit Zone. In a general sense the quarzphyllit is a quartz rich phyllite with bands of sericite quartzite that are found throughout the zone. Macroscopically the quarzphyllit shows a large amount of small scale folding with multiply generations of deformation occurring. The result of this is the absence of a common folding or joint/fault orientation within the Innsbruck Quarzphyllit (Heinisch & Panwitz, 2007).

Mapping of Quaternary geology aims to unravel landscape development by looking at the deposition of sediments. By analysing the composition of sedimentary deposits and morphological features, the processes that controlled the landscape development can be inferred and a stratigraphic sequence can be constructed. The stratigraphic sequence in this report is based on glacial stadial deposits, beginning in the Late Pleistocene with the Last Glacial Maximum (LGM), followed by the Phase of ice-decay, the Gschnitz stadial and the Egesen stadial (equivalent to the Younger Dryas cold period) (Reitner et al., 2016). There were no Little Ice Age (LIA) deposits found in the Kurzer Grund. This is due to the terrain lying below the snowline of the LIA. The closest known LIA snowline, which lies in the Gerlostal (20 km south of the Kurzer Grund), is at 2,600 m a.s.l. (Gross et al., 1977) and the highest peak in the mapping area is at 2,447 m a.s.l. In general, all the subglacial traction tills have been assigned to the time phase "LGM–Lateglacial" unless otherwise stated.

By using high resolution topographic laser scans from TIRIS, morphological features such as lateral moraines, rock glaciers and mass movements were identified. To verify the identified morphological features a field analysis was conducted by describing their morphology, location, altitude and their internal composition by using the lithofacies code by Keller (1996). The mass movements were analysed to understand their failure mechanisms and their extent. This was done by looking at their morphology, their lithology, by measuring the dip angle and dip direction and by identifying and measuring recurring discontinuities, like fault planes, joints and schistosity.

The Kelchsau Valley forks into two tributary valleys (upstream from Zwiesel hydro power plant), the Langer Grund and Kurzer Grund. The Kurzer Grund valley is a NNW–SSE trending valley that is drained by the Kelchsauer Ache. A N–S trending ridge separates the western lying Langer Grund and eastern lying Kurzer Grund. The altitude of the ridge increases towards the south, where several peaks are evident, they are: the Kreuzjoch (2,071 m a.s.l.), Dürnbergstein (2,205 m a.s.l.), Stanglhöhe (2,276 m a.s.l.), Herzogkogel (2,292 m a.s.l.) and Schafsiedel (2,447 m a.s.l). Some cirques are located below the peaks in the Kurzer Grund. In general, the cirques below the highest peaks are more developed with a broad cirque floors and steep backwalls than those found below the lower peaks. The northern less mature cirques slope outwards and do not have an overdeepened basin whereas the southern cirques display the more "classic" cirque shape of steep headwalls, an overdeepened basin, and in the case of the Kurzer Grund, lead to a gentle downstream slope. The western flank of the Kurzer Grund has experienced multiple mass movements.

The lower slope at the valley mouth (870 m a.s.l.) of the Kurzer Grund is dominated by Lateglacial glacilacustrine to glacifluvial deposits that reach up to c. 1,100 m a.s.l. The glacilacustrine deposits have been understood to be ice-marginal deposits. An active quarry in the vicinity of the Roßaualm provides an insight into the deposits which exposes layered sand and gravel beds dipping at 20°. These beds are underlain by a massive matrix supported diamicton that contains boulders that reach sizes of up to 20 m^3. The matrix consists of medium to course sand. The clasts were primarily quarzphyllit and some greenschist facies meta sandstones were also identified, which leads to the conclusion that the provenance was only from the Kurzer Grund valley. In the distal parts of the ice-marginal deposit (towards the valley mouth) the sediments become finer grained and often contain dropstones (Dippenaar, 2016a, b). The ice-marginal deposits southern extension reaches the Topfalm at an altitude of c. 1,100 m a.s.l. Beyond this point to the south, the valley side becomes increasingly steep and is dominated by alluvial and colluvial fans and also deposits from mass movements (see below).

Manzenkar Area

The Manzenkar cirque is the most extensive and most southerly cirque in the mapping area, covering an area of 4.25 km^2 that extends from an altitude of 1,270 to 2,437 m a.s.l. (a sub peak of the Schafsiedel 2,447 m a.s.l.). The whole cirque lies within the Innsbruck Quarzphyllit Zone. On the north-western flank bands of sericite quartzite are found. Small bands of greenschist crop out on the southern rim of the cirque. The cirque is surrounded by arêtes to the north, the west and the south, whereby the southern border is a ridge that separates the cirque area from a series of paternoster lakes. The cirque develops into a steep valley with decreasing altitude, whereby some but not all the characteristics of a hanging valley are given. A definite step in the terrain from the hanging valley to the wider perpendicular U-shaped valley area is missing. The valley is drained by an eastward flowing river.

LGM

Presumable remnants from the LGM are found 300 m south-east of the Hölzlhütte in the form of glacial striations on the bedrock surface (at 1,458 m a.s.l.), that strike in a north-easterly direction of 040°. This concurs with the ice-flow direction of the LGM that van Husen (1987) postulated and the natural flow direction of a glacier flowing out of this cirque. The possibility also remains that the striations are from the Phase of Ice-decay, however, there is no stratigraphic unit to suggest an age younger than that of the LGM.

LGM subglacial traction till deposits were also found in the section, primarily in the lower lying flatter areas. The subglacial traction till is generally a diamicton with a grey silty to sandy matrix that was massive (Dmm). It contains quarzphyllit and greenschist meta sandstone clasts that are sub-rounded to sub-angular to rounded. The surfaces of these till areas are generally water logged provided that they were not too steep. They were also littered with glacially transported quarzphyllit boulders varying in size and shape, from a few cubic meters to the largest being around 36 m^3.

Gschnitz

On the lower northern flank of the Manzenkar area, a very distinctive ridge can be identified from 1,423 m a.s.l. to 1,482 m a.s.l., which has been interpreted as a lateral moraine. This moraine is not more than 2 m in height and has a rounded crest constituted of rounded boulders (SC – grain supported scree) that are not larger than 2 m^3. They are primarily quarzphyllit. Towards the upper half the lateral moraine develops into a double crested moraine. On the same flank at an attitude of 1,520 m a.s.l. a conspicuous amount of quarzphyllit boulders can be seen. On laserscans and in the field a very delicate ridge structure can be recognised. Because the boulder deposition was on a mountain flank, a typical ridge shape is not given. The boulders form a terrace-like feature that elevates itself from the mountain flank. Beyond this flat area the flank steepens again and the amount of boulders slowly decreases with decreasing altitude. It is this level area that is the delicate ridge structure on the laser scans and has been interpreted as a lateral moraine deposit of Gschnitz age. The altitude of the lateral moraines and their shape solidify this conclusion. Steep valley sides or mountain flanks are not conducive for the preservation of lateral moraines and the partnering moraine on the southern flank of the glacial trough is only partly maintained. From an altitude of 1,600 m a.s.l. to 1,730 m a.s.l. the corresponding lateral moraine can be identified that, has a Dmm (diamicton, massive, matrix supported) internal composition. This moraine is the continuation of a shoulder/lip of the hanging valley that dissipates at 1,600 m a.s.l. The shoulder on the southern flank of the Manzenkar area extends 650 m westwards to an altitude of 1,870 m a.s.l.

Egesen

The Manzenkaralm hut (1,725 m a.s.l.) has been built on the distal part of what has been interpreted to be moraine ridges, which span a length of just under 200 m over an altitude range of 1,700 m to 1,756 m a.s.l. The surface area undulates and is braided with narrow streams and shows a striking contrast to the smooth area made up of subglacial traction till to the east which was for the last time shaped during the Gschnitz stadial. Several quarzphyllit erratic boulders are found on the moraine. This area with ridges differs strongly from the regular latero-frontal moraines, which were typically formed by dumping. Thus, a formation of these ridges by pushing cannot be excluded.

Adjoining this feature is a termino-lateral moraine system at an altitude of 1,756 m a.s.l. The terminal moraine forms a gentle ramp that rises c. 10 m before plateauing over a distance of 110 m. On either side of the plateau area, sharp crested ridges form lateral moraines that rise up to 4 m in height. The lateral moraines can to a certain extent be followed into the cirque of the Manzenkar area. At an altitude of 1,800 m a.s.l. a second termino-lateral moraine system was identified. This terminal moraine has, however, been deposited on a natural step in the landscape that leads into the cirque. It therefore has a steep ramp rising c. 50 m before the lateral moraines can be identified. A further three (latero-frontal) moraine ridges were identified indicating multiply glacial stabilisations during this stadial. This is typical for the Egesen stadial (Ivy-Ochs et al., 2008; Reitner et al., 2016). The dominant internal composition of the moraines was that of a Dcm (diamicton, clast supported, massive). In addition, the facies of a boulder dominated scree (bSC) is evident especially close to the surface.

At the base of the southern ridge of the Manzenkar area an extensive relic rock glacier system is evident that stretches over a width of 500 m and covers an altitude range from 1,941 to 2,090 m a.s.l. The rock glacier deposit evolved from the scree-rich talus fan typical for the quarzphyllit areas. It has multiple ridges and furrows and consists of angular to sub-angular boulders (SC – grain supported scree). The boulders consist primarily of quartz phyllite but on the western end of the deposit some greenschist boulders were identified due to the greenschist band found on the hard rock. A further three rock glacier deposits were identified in the area, two of which were found within the bounds of Egesen moraines. The third was identified on the south facing slope.

On the northern slope of the Manzenkar area, a landslide was identified. The landslide is seemingly very shallow with minimal displacement as there is no prominent scarp. The landslide was identified because of compressional ridges on the eastern edge that can be followed to the toe of the landslide. The compressional ridges, which are well rounded on the surface, partially cover the presumable push moraine at Manzenkaralm hut indicating a younger-than-Egesen maximum age. The internal composition of the landslide is a Dcm (diamicton, clast-supported, massive) with a grey-reddish fine sandy matrix. The components are sub-angular to angular to sub-rounded.

Foissbach Area

The Foissbach area covers an area of 2 km^2 that extends from an altitude of 1,344 to 2,276 m a.s.l. (Stanglhöhe). The entire area lies within the Innsbruck Quarzphyllit Zone. The southern half of the area is dominated by sericite quartzite. Like the Manzenkar area, it too can be described as a valley with some but not all of characteristics of a hanging valley that in a broad sense is boarded by a truncated spur to the north and the south. In the upper reaches of the area at approximately 2,000 m a.s.l. the valley splits into two cirques. The southern cirque is a more mature cirque with steep headwalls and a concave slope. The northern cirque has less developed headwalls and the basin does not form the typical cirque shape.

Gschnitz

On the southern side of the valley at an altitude of 1,344 m a.s.l. a lateral moraine that is c. 10 m high with a Dcm (diamicton, clast-supported, massive) internal composition was identified. The quarzphyllit components are sub-rounded to sub-angular reaching boulder size with a grey silty matrix. According to its altitudinal position within the cirque indicating a rather large glacier extent compared to that of the Egesen stadial (cf. Dippenaar, 2016a, b), these moraines represent most likely the Gschnitz stadial. However, the lateral moraine is sharp crested despite its Gschnitz age, which was most likely caused by post-depositional erosion, by a river that has cut through the moraine at an altitude of 1,445 m a.s.l. The moraine then continues to an altitude of 1,600 m a.s.l. where it has been buried by a scree alluvial fan. The partnering lateral moraine on the northern flank, which has a more rounded crest, is built by a Dmm (diamicton, matrix-supported, massive) with a grey silty matrix and quartz phyllite components that are sub-rounded to sub-angular. This moraine is also intersected by river but reaches an altitude of 1,700 m a.s.l. before a presumably anthropogenic structure terminates the lateral moraine. Furthermore, a subglacial accumulation in the form of two rounded ridges was identified between the lateral moraines.

Egesen

In the southern cirque at an altitude of 1,950 m a.s.l. a 5 m high ridge that is likely to be a terminal moraine was identified which was made up of boulder size scree, clast-supported (bSCc). The components are a mixture of sericite quartzite and quarzphyllit that were mostly sub-angular. The terminal moraine develops into a lateral moraine with increasing altitude reaching a maximum altitude of 2,059 m a.s.l. The bSCc lithofacies is continuous throughout the whole moraine system. Within the confines of the outermost moraine ridge multiple inner ridges were identified. These could also be interpreted as rock glacier deposits. The distinction between deposits of debris covered glaciers and that of rock glaciers is not always straight forward. In the case of the southern cirque in the Foissbach area both cases are possible. According to the altitude of the deposit as an indicator of the relative age in the local context, the rock glacier is most likely of Egesen age. A further rock glacier deposit was identified on the northern (south facing) slope of the cirque.

The northern cirque of the Foissbach area is a less developed cirque in the sense that the headwalls are rather shallow and the typical concave shape with a corrie lake (or tarn) and corrie lip (or threshold) are not present. Remnants of glacial erosion are present in the form of flutes (sub-glacial accumulation ridges). The lithofacies of the flutes was identified as a Dmm (diamicton, matrix-supported, massive) with a grey silty to sandy matrix. A secondary lithofacies of Dcm (diamicton, clast-supported, massive) is also present. The majority of the area of the northern cirque has been shaped by areal scouring. With the exception of a rock glacier deposit, the terrain in the northern cirque undulates in a typical “knock and lochain” fashion. Two very small lakes were counted and some areas were waterlogged. On laser scans the linear scour marks as a result of subglacial erosion can clearly be identified.

Dürnbergalm Area

The Dürnbergalm area is the lowest lying of the cirques, ranging from 1,400 to 2,071 m a.s.l. and covers an area of approximately 1.5 km^2. The primary lithology in this area is the Innsbruck Quarzphyllit which borders the Schattberg Formation (Greywacke Zone) at an altitude of 1,600 m a.s.l. The Schattberg Formation is a massy meta silt/sandstone along the contact zone with very few to no quartz veins. On the north-eastern slope of the area an example of staircase cirques (Benn & Evans, 2010) was identified. The first cirque (the Kreuzjoch cirque) extends from the peak of the Kreuzjoch (2,071 m a.s.l.) to an altitude of 1,850 m a.s.l. From this altitude the second (Weithaglacke cirque) smaller cirque developed that extends to an altitude of 1,690 m a.s.l. There is an adjacent cirque to the Weithaglacke cirque, which is smaller and extends over an altitude range of 1,680 to 1,860 m a.s.l. The two adjacent cirques have not been interpreted as compound cirques (cirques that have two separate upper parts but one drainage system) because they have separate drainage systems. Below the Weithaglacke cirque the fourth, smallest cirque, reaches an approximate altitude of 1,580 m a.s.l. The uppermost of the four cirques is the least “cirque-like” in shape, but there are clear indications that it formed through glacial erosion as well.

LGM

Between the north-east facing Kreuzjoch cirque (the first of the staircase cirques) and the east facing Foissbach cirque, the east facing **Dürnbergalm flank** is found, which ranges from an altitude of 1,500 to 2,000 m a.s.l. In this area the bedrock has been glacially overprinted. On laser scans this can clearly be identified through parallel bedrock channels that run in an easterly direction i.e. downslope. In the field, roches moutonnée shaped outcrops were identified. Below the glacially overprinted area of the Dürnbergalm flank at an altitude of 1,730 m a.s.l., consolidated subglacial traction till was identified that had an internal composition of a Dmm (diamicton, matrix-supported, massive) with sub-angular to sub-rounded clasts containing only quarzphyllit. The matrix was fine sandy to silty. Lower down on the flank at an altitude of 1,553 m a.s.l., another outcrop was found where over-consolidated subglacial till was identified. The lithofacies here was that of a Ds (diamicton, stratified) with glacially striated clasts that were horizontally layered. The clasts in the lower lying outcrop were sub-rounded to sub-angular and the matrix was silty to clayey. These sediment deposits have been correlated to the LGM because there is no evidence to suggest that they were deposited during the Gschnitz or Egesen stages i.e. no accumulation zone, no lateral or terminal moraines which bound the basal till. The over-consolidated basal till also indicates a formation by large ice masses that would have only formed during the LGM.

Phase of Ice-decay

From an altitude of 1,520 to 1,620 m a.s.l. a conspicuous amount of boulders was identified to the north of the gully that leads to the Glasherrnalm. Two very delicate ridges were identified and described with a lithofacies of a bSCc (boulder size, scree, clast-supported) with quarzphyllit boulders that were sub-rounded to rounded to sub-angular. The ridges have been interpreted as lateral moraine deposits from the Phase of Ice-decay. With ice levels of around 2,000 m a.s.l. (van Husen, 1987) in this area one can safely assume that these lateral moraines must have been deposited after the LGM but before the Gschnitz i.e. during the Phase of Ice-decay when climate oscillations led to the advance of local valley glaciers (Reitner, 2007). The lateral moraines are not considered to be of a Gschnitz-age because the accumulation zone needed for a glacier large enough is not given unless the glacier formed during the Phase of Ice-decay. An amount of uncertainty as to the origins of the boulder deposit remains.

Gschnitz

Adjoining the Phase of Ice-decay lateral moraines is a boulder-rich latero-frontal moraine system. It had a frontal ramp rising 10 m and within the bounds of the moraine a number of ridges and furrows formed. The primary lithofacies was identified to be a bSCc (boulder-size, scree, clast-supported) with a secondary facies that varied between a Dmm (diamicton, matrix-supported, massive) to a Dcm (diamicton, clast-supported, massive) with a fine sandy matrix. The clasts were sub-angular to sub-rounded. According to the secondary facies (Dmm, Dcm) this deposit is most likely of glacial origin. To avoid the over-interpretation of the deposit it can safely be described as a deposit of a debris-covered glacier of the Gschnitz stadial.

To the east of the above described moraine system, a rock glacier deposit was identified at the base of the third, lower most cirque of the staircase cirques. The lithofacies was identified as a bSCc (boulder size, scree, clast-supported) with no secondary lithofacies (it showed strong similarities to other rock glacier deposits in the area).

The Weithaglacke cirque has a small corrie lake (also tarn) in it called the "Weithaglacke". The lake has a 1-meter-high scree ridge (bSCc) that bounds it to the north, east and west. A second bSCc (boulder size, scree, clast supported) ridge encloses the first ridge and is approximately 50 m displaced from the 1-meter ridge. It was slightly higher and had a well-rounded crest.

The Weithaglacke cirque II also has a debris rich glacial deposit at the base. There are strong similarities to the moraine deposit that adjoins the lateral moraine deposit from the Phase of Ice-decay.

Directly above the second cirque at an altitude of 1,848 m a.s.l. a moor that covers an area of 4,400 m^2 that is enclosed by moraine deposits to the north and east. The moraine deposits do not form a classic lobe shape but are "pasted" onto the contours of the terrain i.e. on top of the lip of the Weithaglacke cirque. The moraines have a maximum height of 6 m relative to the moor. The crest is relatively sharp because of the shear drop leading into the second cirque. The flank adjoining the Kreuzjoch cirque (uppermost cirque) is comparable to that of the Dürnberg flank in that it too has a glacially overprinted surface. Similar bedrock channels were identified.

Four rock glacier deposits are present along the cirque walls of the Kreuzjoch cirque. Whether they formed during the final phases of the Gschnitz stadial or during the Egesen stadial is difficult to determine because it is not possible to construct a plausible relative chronology.

Mass Movements

A total of three complex mass movements were identified in the mapping area. They are the Hölzlhütte mass movement, the Dürnbergalm mass movement and the Roßaualm mass movement. The Hölzlhütte and Dürnbergalm mass movements showed strong similarities and have been interpreted as rock-slope failures in the type of rock-slides. The Roßaualm mass movement comprises of a series of slides and slumps.

The Hölzlhütte mass movements are ENE facing slope located at the spur separating the Manzenkar and the Foissbach areas. Between an altitude of 2,000 and 1,380 m a.s.l. a series of ridges and depressions have developed. This saw-tooth morphology is due to anti-slope scarps that run parallel to the main valley axis (NNW–SSE) and reach a maximum length of 800 m and are up to 6 m high. In very few depressions was stagnant water found. Some of the depressions curve upslope at their lateral limits. The slope steepens at an altitude of 1,600 m a.s.l. and it is also at this altitude that a rock-fall mass movement was initiated. Because the Innsbruck Quarzphyllit has experienced three metamorphic events with intense small scale folding, it is difficult to determine a common strike or dip orientation for large areas (Heinisch & Panwitz, 2007). In the case of the Hölzlhütte mass movement the schistosity generally dips in a SE direction (between 163° and 132°) and at dip angles that varied between 63° and 34°. Two recurring sets of faults that penetrated the schistosity were identified. The first set generally dips in a SW direction with a mean direction of 230° (210°–268°) at a mean dip angle of 64° (46°–71°). The second set shows a dip towards the NNE with a mean direction of 030° (320°–036°) and a mean dip angle of 53° (76°–43°). The two fault sets and the schistosity (which occasionally acted as a displacement plane) generally occurred over a decimetre to meter range. The first fault set is also the displacement plane (SW dipping plane) that allowed deep-seated toppling failure on this ENE facing slope of the Hölzlhütte mass movement. At the eastern part of the toe, a steep scarp has developed in the area affected by toppling. Below this scarp an area covered with boulders reaches down to the valley floor of the Kurzer Grund creek. Within the scarp area roots were being pulled (under tension) between the displacement plane of the SW falling fault set. It can therefore be concluded that secondary movements of rock-fall type are taking place in an area which was loosened before by a deep-seated gravitational slope deformation and more specifically by toppling. The rock-fall deposit consists of angular boulders ranging in size from < 1 m^3 to 150 m^3.

The fact that very little stagnant water was found in the depressions indicates that the faults responsible for the saw-tooth morphology were deep-seated faults. The SW (230°) dipping faults have been identified as the fault set responsible for this. This fault set is also responsible for the rock-fall mass movement which is strictly speaking a rock topple. Through glacial erosion during the LGM the valley flanks of the Kurzer Grund became over steepened resulting in failure due to debuttressing during the Phase of Ice-decay. This is the most likely trigger for the mass movements.

The Dürnbergalm mass movement is very similar in nature to the Hölzlhütte mass movement. It lies between the Foissbach and Dürnbergalm areas. The saw-tooth morphology typical for toppling begins at the termination of the spur separating the two areas, at an altitude of 1,800 m a.s.l. At 1,500 m a.s.l. a mass movement occurred (similar in position to that of the Hölzlhütte rock-fall mass movement). The fault regime had two fault systems that also penetrated the schistosity planes that also dip in similar directions to that of the Hölzlhütte mass movement. Again, a major scarp of a rock slide is evident in the lower part of the slope. The displaced mass below does not only consist of boulders as is the case in the Hölzlhütte mass movement, but also of basal till. Large boulders reaching sizes of up to 100 m^3 are mixed in with the basal till. The lowermost part of the deposit is characterised by a small bulge, typical of rotational and translational slides. This indicates that a mechanism of the mass movement was complex with possibly both sliding and toppling involved in slope failure process.

The Roßaualm mass movement consists of a series of rotational and translational slides with the largest slide being displaced by approximately 220 m. The mass movements occur in the Schattberg Formation (Greywacke Zone) but bed rock is only exposed in small areas of the main scarp at an altitude of 1,570 m a.s.l. The overwhelming part of the mass movement surface is covered by till, which was passively transported by the mass movement. In the lower reaches glacilacustrine sediments (described above) overlie mass movements, but the overlying glacilacustrine deposit also have mass movements in them, highlighting the complexity of the Roßaualm mass movement. This is regarded as an indication for a synchronicity of the onset of mass movements and the formation of ice-marginal deposits during the Phase of Ice-decay.

Frommgrund Valley

The Frommgrund Valley is a tributary valley of the Langer Grund Valley in the Kelchsautal. The Frommbach creek drains the valley in a north-south direction and bends to the north-west before merging with the Kelchsauer Ache. The drainage area of Frommgrund Valley shares a very short border with the Kurzer Grund to the north-east. The northern most cirque in the valley and downstream thereof (this is also where the river drains in a north-westerly direction) was mapped by Dippenaar 2016a, b). The whole Frommbach Valley lies in the Innsbruck Quarzphyllit Zone. Like in the Kurzer Grund the Innsbruck Quarzphyllit contains small bands of a greenschist quarzphyllit and thin bands of sericite phyllite (Heinisch & Panwitz, 2007).

The mapping area covers the whole eastern flank (except the northern most cirque and downstream thereof) and a small southern portion of the western flank (southwards of the latitude of the Kleefeldalm). The eastern and southern ridge borders the state of Salzburg, while the western ridge borders the Langer Grund. Several of the highest peaks of the Kitzbühel Alps are found along the eastern ridge, such as the Fünfmandling (2,422 m a.s.l.), the Westlicher Salzachgeier (2,469 m a.s.l.), the Kleefeldkopf (2,348 m a.s.l.), along the southern border the Pallscharte (2,310 m a.s.l.) and on the western valley flank the Pallspitze (2,389 m a.s.l.) form the border of the mapping area.

Molterfeldalm Area

This area extends over an altitude range of 1,475–2,422 m a.s.l., from the valley floor to the peak of Fünfmandling. The base of the eastern flank is plastered with sediments of varying composition that reach an altitude of 1,750 m a.s.l. Erratic quarzphyllit boulders were identified, massive and stratified GS (gravel-sand) deposits, Dmm (diamicton, massive, matrix) and Dms (diamicton, matrix, stratified) deposits. All the deposits contain boulders of variable size and the clasts were sub-angular to sub-rounded. Because of the facies which indicates deltaic deposition including subaqueous debris flows and the location of the sediments, it was concluded that these are ice-marginal sediments and must have formed during the Phase of Ice-decay. Along the western flank of the area ice-marginal sediments were also deposited up to an altitude of 1,570 m a.s.l. with the difference that there are multiple springs along this flank.

Gschnitz

From an altitude of 1,720–1,810 m a.s.l. two lateral moraines were identified. The crests of the ridges are well rounded but a terminal moraine is absent. The internal composition of the lateral moraines was that of a Dmm (diamicton, massive, matrix) with a greyish sandy to silty matrix. They also contain boulders that were up to 18 m^3 in size. Because of the shape and general position as compared to the northern neighbouring cirque of the lateral moraines (cf. Dippenaar, 2016a, b) it has been concluded that they are of a Gschnitz age.

From an altitude of 1,900–2,005 m a.s.l. at the base of the cirque, a rock glacier deposit was identified with a bSCc (boulder-size, scree, clast-supported) composition, with a well-rounded ridge. Above this altitude, the cirque flank below the Fünfmandling peak is made up of hard rock or is covered by scree. In a neighbouring cirque to the south of the Fünfmandling peak two rock glacier deposits were identified contiguous to each other. The lower deposit extends over a range of 1,914–1,960 m a.s.l. and the second deposit from 1,960–2,033 m a.s.l. Beyond this rock glacier deposit scree covers the cirque flanks and hard rock outcrops separate the southern adjacent cirque. According to the occurrence of these paleo-permafrost features within an area previously covered by a Gschnitz glacier, the formation of the rock glaciers most likely took place during the Egesen stadial (Younger Dryas).

Frommalm Area

The Frommalm area consists of talus fans that reach from the valley floor (1,570 m a.s.l.) to an average altitude of 1,680 m a.s.l. Above the eastern flanks up to the ridges are made up of hard rock. Just south of Frommalm (Fromm Alp) a boulder field, consisting of angular boulders ranging in size from under one cubic meter to 100 m^3 is found.

Mass Movements

The flank above the boulder field, it consists of boulders in its lower reaches but with increasing altitude the space between the boulders gets closer and closer leading to a loosened rock with open joints. Thus, the level of fragmentation decreases in upslope direction. As of an altitude of 1,850 m a.s.l. cases of rock toppling were recorded which occurred along the 280° dipping displacement plane. At an altitude of approximately 2,050 m a.s.l. the fragmentation ceases and the rock becomes very jointed. Three recurring displacement planes that caused the fragmentation were measured to be 340°/41° (dip-direction/dip-angle), 280°/81° and 210°/85°. It was concluded that this body is a mass movement that reaches from the valley floor where boulders were completely disbanded to being jointed at an altitude at 2,050 m a.s.l. This mass movement is also the cause of the boulder field deposit described above. A secondary direction of movement was noted with rock fragments breaking along the 340° and 210° planes, slightly moving away from the main body. In conclusion, there are three directions of movement along the three discontinuities, leading to the interpretation that this mass movement is a block slide leading into toppling.

Between the Frommalm Mass Movement and the Molterfeldalm area lies a west facing, relatively smooth flank. In the northern upper reaches (bordering the Molterfeldalm area) from an altitude of 1,990–2,300 m a.s.l. a large rock glacier deposit was identified. This deposit contains multiple ridges and furrows. The lithofacies is that of a bSCc (boulder-size, scree, clast-supported) with the components being mostly sub-angular to angular. A second rock glacier deposit occurs on the south side of the flank, ranging from an altitude of 2,060–2,190 m a.s.l. The remaining area between the Frommalm mass movement and the Molterfeldalm area, which extends over an altitude range of 1,800–2,210 m a.s.l., is covered by a subglacial traction till (with a Dmm lithofacies) and an ablation moraine, with boulders that were sub-angular to sub-rounded. The southern half of the subglacial traction till was covered by scree that is angular to sub-angular.

In addition, two separate mass movements were identified on the western flank of the Frommalm area. The more northerly of the two lies in direct contact with the ice-marginal sediments of the Molterfeldalm area. The base of this mass movement shows strong similarities to the Frommalm Mass Movement (a rock slide/rock topple mass movement). The boulders have no common orientation and the whole setting is very similar to that of the eastern flank. The upper reaches of the mass movement will not be described because they extend above the limits of the mapping area.

The second mass movement is to the south (or upstream) of the above described block slide. It is covered by a Dmm (diamicton, matrix-supported, massive). The matrix is a mixture of sand and some silt and the smaller gravel sized components are occasionally sub-rounded but the vast majority of the components are sub-angular to angular. The morphology of this structure resembles that of a bulging foot normally found at the base of a rotational or translational slide with a steep front and terrace-like shoulder, on top of which the ruins of the Oberfrommalm are located.

Kleefeldalm Area

This area lies to the south of the Frommalm area, being separated by the ridge on which the Frommalm mass movement is found. The lower reaches of this area (1,640–1,920 m a.s.l.) are dominated by outcrops of Innsbruck Quarzphyllit. At the location of the Kleefeldalm (1,920 m a.s.l.) mountain pastures extend to an altitude of approximately 2,100 m a.s.l. This area is speckled with boulders of varying sizes and shapes, but they are primarily sub-rounded to sub-angular. Larger boulders that are lodged into the ground show a roche moutonnée shape and hard rock outcrops in the vicinity of the Kleefeldalm have been glacially overprinted with glacial striations clearly visible. A subglacial traction till was also identified consisting of a Dmm (diamicton, matrix-supported, massive) with sub-rounded to sub-angular clasts. This area has been interpreted as a subglacial traction till and ablation moraine. On the northern side of the zone covered by ablation till and the hard rock outcrops, boulder fields or scree fields are easily distinguished. Such talus fans extend into the upper reaches of the area and surround two separate rock glacier deposits. On the northern side from an altitude of 2,100–2,190 m a.s.l. a rock glacier deposit occurs indicating a former flow out of a small cirque-like structure. The deposit consisted of a bSCc (boulder-size, scree, clast-supported) lithofacies with primarily angular components. The second rock glacier deposit extended over an altitude range of 2,000–2,095 m a.s.l. along the southern border of this area. This rock glacier deposit also has a bSCc lithofacies.

Frommbach Headwaters Area

The Frommbach headwaters area (which begins at 1,700 m a.s.l. as measured from the Frommbach) extends from the Nebelkarspitze (2,339 m a.s.l.) on the eastern flank to a peak at 2,266 m a.s.l. just north-east of the Pallspitze (2,389 m a.s.l.), on the western flank. To the north of the Nebelkarspitze, extending into the valley, is another mass movement that is very similar to the mass movement described in the Frommalm Area. It extends over an altitude range of 1,760–2,280 m a.s.l. In its lower section multiple cases of toppling were identified but the rock became less fragmented with increasing altitude. There were three discontinuities that recurred with their average values as follows: 334°/55° (dip-direction/dip-angle), 273°/74° and 220°/80°. The fragmentation of the hard rock occurs along the above mentioned displacement planes, leading to a downward and slightly lateral movement of the rock body.

100 m to the west of the above described mass movement lies a ridge structure, with a well-rounded crest that extends over an altitude of 1,940–2,040 m a.s.l. and is between 4 and 7 m wide. The internal composition of the ridge is that of Dcm (diamicton, clast-supported, massive) with a sand to fine-sand matrix. The clasts are angular to sub-angular and ranged in size from gravel to boulder sized clasts (maximum 3 m^3). A partnering ridge structure 250 m south-west of the above described ridge is present that extends over an altitude range of 1,915–2,040 m a.s.l. The internal composition of this structure is that of a Dcm (diamicton, clast-supported, massive) but also contains pockets of a SC (scree) i.e. the ridge is debris rich. The crest of the ridge is very well rounded and boulders are imbedded in the structure, with the clasts being sub-angular to sub-rounded. However, the genesis of the ridges is not so clear. It remains an open question if these features are lateral moraines or the product of erosion. In between the two ridges, a rock glacier deposit was identified. It ranges over an altitude range of 2,000–2,160 m a.s.l. and has a bSCc (boulder-sized, scree, clast-supported) lithofacies with angular to sub-angular boulders in it.

At the centre of the valley floor from an altitude of 1,790–1,910 m a.s.l. a ridge structure is present that is well-rounded with an internal composition of a Dcm (diamicton, clast-supported, massive), with sub-angular to angular to sub-rounded clasts ranging to boulder size. The ridge structure extends 250 m in a south-easterly direction onto the eastern flank from the valley centre. The extension of the ridge on the western flank only reaches 100 m before an alluvial fan and a river cut off the ridge structure. This structure has been interpreted as a latero-frontal moraine system. Within the limits of the moraines subglacial traction till and also ablation till are found up to an altitude of 2,000 m a.s.l. South of the sub-glacial traction till a mixture of subglacial till and scree occurs with multiple springs feeding into the Frommbach creek. With increasing altitude, the bedrock crops out, that then extends beyond the limits of the map over the Pallscharte (2,310 m a.s.l.).

On the flanks between the peak of the Nebelkarspitze to the Pallspitze multiple tension gaps (Zerrgraben) that range in length from a few decimetres to several hundred metres are present over an altitude range of 1,800–2,300 m a.s.l. Depending on whether the tensional structures are on the east or west flank, the discontinuities responsible therefore dips towards the north-west (340°) or to the north-east (036°) respectively (these are average values). On the western flank of the valley, prominent scarps that reach a maximum magnitude of 200 m in altitude are easily identified. The displacement planes responsible for the displacement have an average orientation of 118°/79° (an average value).

Below the scarp subglacial traction till and ablation moraine deposits were identified. The area between the scarp below the Pallspitze and the lateral frontal moraine system is very conspicuous. The area contains hard rock outcrops that are slightly fragmented and below the outcrops large boulders that are angular are visible. A small bulge at the toe of the area is evident. Measurements taken in this area showed that there are three recurring displacement planes, which are: 141°/41°, 025°/74° and 215°/55° (these are all average values). The main displacement plane responsible for the movement would be the 141° south-east dipping plane. This area has been interpreted as a rock slide close to the surface that was probably induced by physical weathering (frost shattering) and potentially debuttressing.

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Bericht 2016 über geologische Aufnahmen im Innsbrucker Quarzphyllit auf Blatt 121 Neukirchen am Großvenediger

Helmut Heinisch & Claudia Panwitz

(Auswärtiger Mitarbeiter und auswärtige Mitarbeiterin)

Für die Aufnahme am Südrand von Blatt 121 Neukirchen verblieb eine übersichtliche Restfläche von 14 km^2. Wegen der geologisch komplexen Gesamtsituation, sich wechselweise überlappender Aufnahmen und identischer Problemlage konnte nicht zwischen den Teilgebieten der beiden Bearbeiter unterschieden werden. Daraus resultiert ein gemeinsamer Bericht. Zusammen mit den ebenfalls für 2016 vorgesehenen Aufnahmearbeiten von Benjamin Huet (GBA) und Christoph Iglseder (GBA) ist die Geländearbeit am Südrand damit beendet. Potenziell besteht für 2017 noch Handlungsbedarf am Nordrand des Kartenblattes im Umfeld der Hohen Salve. Gegebenenfalls können im Zuge der Kompilation Kontrollbegehungen oder Dünnschliff-Nachbeprobungen notwendig werden.

Zum Zweck der Einarbeitung eines neuen Mitarbeiters in der GBA (Benjamin Huet) in die Problematik des Quarzphyllits und Steinkogelschiefers waren gemeinsame Geländebegehungen vereinbart worden. Weiterhin wurde ein Polarisationsmikroskop vor Ort zur Verfügung gestellt. Damit waren Dünnschliffstudien von bereits beprobten Bereichen in direktem Geländevergleich möglich. Diese Aufgaben nahmen mehrere Tage in Anspruch.

Umgrenzung des Bereiches

Der aufgrund des Neuzuschnittes eher bizarr anmutende Grenzverlauf schließt westlich unmittelbar an die Aufnahmen von 2015 an. Er folgt etwa der Gondelbahntrasse von Neukirchen auf die Gensbichlscharte. Die Westbegrenzung folgt weiter dem Grat, der den Talschluss des Mühlbachtales westlich umrahmt und durch die Seilbahnen des Skigebietes Neukirchen gut erschlossen ist (Gasthof Wolkenstein, Braunkogel, Frühmesser). Daraufhin biegt die Grenze scharf ab zur Herrensteigscharte. Die NE-Begrenzung bildet eine gerade Linie von dieser Stelle zum Wildkogelhaus. Von dort aus verläuft die Grenze wiederum geradlinig zurück in das Salzachtal, wo sie östlich Leiten auf den östlichen Blattrand trifft. Die Südgrenze bildet der Blattschnittrand. Die bewaldete Flanke, zwischen Wildkogelhaus und Hohenbramberg gelegen, macht den Löwenanteil des Gebietes aus. Wie schon aus den La-