für die Aufschüttung unterhalb der felsigen Stufe. Der felsige Karboden zwischen 2.200 und 2.270 m ist mit Moränenstreu bedeckt. In einer kleinen Verflachung auf 2.280 m liegt Ausschmelzmoräne in Form einer 1–2 Meter mächtigen Schutt- und Blockbedeckung, die eine wellige Oberfläche zeigt. Moränenstreu und ein geringmächtiger aber deutlich zu erkennender Moränenwall sind des Weiteren auch auf dem flach ausgebildeten Südwestgrat der Kühkarlspitze zwischen 2.300 und 2.320 m anzutreffen.

Moserkar

Das Moserkar liegt westlich vom Kleinen Kühkar zwischen den schmalen und parallel verlaufenden Südwestgraten der Moserkarspitze (2.533 m) und dem namenlosen Gipfel mit der Höhe 2.526 m. Das Kar ist über eine rund 500 m hohe Karstufe mit dem Tal des Moserkarbachs verbunden. Auf dieser liegt zwischen 1.600 und 1.840 m ein stark erosiv überformter Sedimentkörper aus Diamikt. Im Moserkar ist der zentrale Teil des Karbodens bis auf 2.360 m felsig ausgebildet. Der Hang- und Murschutt, welcher am Fuß des Südwestgrates der Moserkarspitze ansetzt, ist zwischen 2.020 und 2.220 m an einen linksseitigen Moränenwall angelagert, der auf einer Höhe von 2.100 m in einen Endmoränenwall umbiegt. Südlich an den Endmoränenwall ist ein weiterer Wall angeschlossen, der von einem Gletscher stammt, der nach Südwesten vorstieß. Am Osthang der Östlichen Moserkarspitze ist ein von Hangschutt bedeckter, girlandenförmiger Wall ausgebildet.

Raukarl

Dieses größte der vier Kare erstreckt sich zwischen dem kurzen, scharfen Südgrat von Punkt 2.526 m und dem langen und mächtigen Südgrat der Kaltwasserkarspitze. Unter der Kaltwasserkarspitze (2.733 m) und der Westlichen Moserkarspitze (2.660 m) ist das Kar nach Norden ausgebuchtet. Ein Nord–Süd verlaufender Moränenwall trennt den Karboden in einen östlichen und einen westlichen Abschnitt. Im Westen ist dieser als konvexer, rund geschliffener und verkarsteter Felsrücken vorwiegend ohne Sedimentbedeckung. An seiner Ostseite befinden sich drei stark überformte Wallreste. Hingegen ist der östliche Teil als Hohlform angelegt, die überwiegend mit quartären Sedimenten ausgefüllt ist. Über der Felsstufe auf 2.100 m liegt ein Endmoränenwall, der U-förmig Tälchen und Rücken nachzeichnet. Nördlich schließt eine von Toteislöchern übersäte Fläche an, die nach oben in eine blockbedeckte Ausschmelzmoräne übergeht. Im Osten ist diese Fläche durch den oben beschriebenen Wall begrenzt, der den konvexen, östlichen Teil an dessen Nordseite umschließt. Der Wall begrenzt unterhalb von Punkt 2.526 m eine nördlich an ihn anschließende Fläche aus Ausschmelzmoräne, die mit Felssturzblöcken bedeckt ist. Am Westhang dieses Gipfels befindet sich ein kleiner ?aktiver Blockgletscher.

Prozesse

Da der Moserkarbach in einer Klamm verläuft, konnte er die an beiden Talseiten abgelagerten quartären Sedimente nicht weiter erodieren. Die Endmoränenwälle auf der Schwelle über der Klamm (Trogboden), der links- und rechtsseitige Endmoränenwall im mittleren Talabschnitt und die gestaffelten Wälle am Fuß der Karstufe unter dem Raukarl und im Mündungsbereich des Großen Kühkars zeugen von einem schrittweisen Zurückschmelzen der Eiszunge. Nachdem sich die einzelnen Eiszungen aus den Teilkaren separiert hatten, blieb die Gletscherzunge aus dem schattigen Großen Kühkar trotzdem für längere Zeit im Mündungsbereich stabil, wie gestaffelte Moränenwälle beweisen. Eine weitere Staffel deutlich weniger mächtigerer Wälle liegt unterhalb der Einmündung des Kleinen Kühkar. Daraufhin dürfte das Eis in diesem Kar zügig abgeschmolzen sein, da erst wieder auf 2.220 m Höhe ein kleiner Wall anzutreffen ist. Der mächtige Endmoränenwall auf 2.055 m im Kleinen Kühkar zeigt, dass sich die Gletscherzunge stabilisieren konnte, bevor sie sich – bis auf ein kleines Eisfeld abgeschmolzen – in die Senke auf 2.280 m zurückzog. Da auch auf der Hochfläche südwestlich der Kühkarlspitze ein Moränenwall und Moränenstreu zu finden sind, scheint auch hier ein kleines Eisfeld für längere Zeit existiert zu haben. Die Endmoränenwälle am Fuß der Karstufe zum Raukarl zeigen, dass aus diesem großen und günstig exponierten Kar eine mächtige Gletscherzunge die rund 600 Höhenmeter der Karstufe überwinden konnte. So stellt der Sedimentkörper, welcher auf der Karstufe des Moserkar liegt, einen erosiv überprägten seitlichen Endmoränenwall dar, der vom Gletscher aus dem Raukarl abgelagert wurde. Auch deuten die verschiedenen Wallformen und die Bedeckung mit Ausschmelzmoräne im besser geschützten, westlichen Karbereich darauf hin, dass vor dem endgültigen Abschmelzen eine große Fläche des Kares im Westen und unterhalb von Punkt 2.526 m mit Eis bedeckt war. Der konvex ausgebildete östliche Karbereich war schon früher eisfrei. Der Gletscher umfloss diesen Rücken und lagerte im Norden und Osten einen rundum laufenden Moränenwall ab. Hingegen scheint der Gletscher im Moserkar aufgrund seiner Südexposition wesentlich früher zurückgeschmolzen zu sein.

Blatt 2230 Mayrhofen

Bericht 2011 über geologische Aufnahmen von quartären Sedimenten im Floitengrund auf Blatt 2230 Mayrhofen

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In 2011, Quaternary sediments and landforms were mapped over an area of about 38 km^2 in the Floitengrund valley. The valley catchment is built up of homogenous crystalline rocks of the Zentralgneiss; the middle and lower valley sections are incised into the Tux Gneiss core and the upper section into the Zillertal Gneiss core. Bedrock structures and metamorphic foliations are stretching there perpendicular to the valley axis. The valley is a textbook example of a glacial trough, one of the best-developed in the Zillertal Alps, as already noticed by PENCK & BRÜCKNER (Die Alpen im Eiszeitalter, vol. 1, p. 289, 1909).

The Floitengrund is 11 km long, right-hand tributary valley of the Zemmtal valley. It is hanging 60–70 m above the Zemmtal valley in Ginzling village. The Floitengrund valley catchment is relatively narrow in comparison to other Zillertal Alps valleys, e.g., the neighbouring Zemmgrund and Stillupgrund valleys. The distance between the Floitengrund valley-side ridgelines is 3.5 to 4 km; however, valley floor is deeply incised, 1,200–1,600 m below the ridgelines. It gives extremely steep terrain, dominated by rock walls devoid of sedimentary cover. The steepest terrain predominates in almost vertical and 300–400 m high trough walls stretched along both valley sides. Quite well visible are there also gentler sloped, glacial polished rock surfaces that extend above trough walls. They constitute typical morphological zone of an alpine valley where trough shoulders occur. Quaternary sediments are mainly confined to the trough floor and gentler sloping glacial cirques, which occur on both sides of the valley. Floors of valley-side cirques are hanging several hundred meters (500–800 m) above the trough and are hardly accessible. Additionally, wide and relatively gently sloping area, where Lateglacial and Holocene moraines occur, lies in a cirque basin around the trough's end, in the head of the valley. The upper part of the valley is covered with Floitenkees glacier and several smaller, avalanche-supplied niche glaciers located below high walls of the E and NE flank of Großer Mörchner and Kleiner Mörchner massif and north of Roßköpfe.

Evidence of maximum ice extent (LGM)

The limit of vertical extent of glacially moulded bedrock surfaces (trimline) on valley-sided spurs provides evidence of the maximum ice extent during the Last Glacial Maximum (Würm-Hochglazial). In the mouth of the Floitengrund valley, the highest moulded bedrock surface occurs around 2,310–2,320 m on the spur descending from Dristner summit toward SW (cf. ZASADNI, Jb. Geol. B.-A., 151, 138–140, 2011). At a similar altitude (2,330 m), smoothed rock surface occurs on the northern side of Rauher Kopf summit (south of Ginzling village). In the lower section of the Floitengrund valley (north of Böckachalm), glacial erosional overprint on valley-side spurs can be traced no higher than 2,350 m. The trimline is there visible as a sharp border or gradual transition between the lower, smoothed section of valley-side spurs, and the upper, jagged section of the spurs. In few cases trimline is expressed as a nickpoint between the lower, steeper section of the spur and the upper, gentler sloping spur's ridgeline (arête). Such truncated spurs occur in the left-hand side of the valley: at 2,330 m on the spur running eastward from Friderich summit, and at 2,340 m, on the spur located east of Kellerkopf summit. In the upper section of the Floitengrund valley, in valley-side spurs which enclose from the north cirque amphitheater around the trough end, the trimline reaches a level of ca. 2,500 m. On the spur located 700 m east of Nördliche Mörchenscharte notch, glacially moulded rock surface on the spur reaches a level of 2,510 m, and on the spur descending from Gigalitz summit towards SW it can be seen at a level of 2,500 m. At the second location, hardly weathered and frost shattered streamlined bedrock features (roches moutonnées) can be seen close to the highest occurrence of ice-moulded surface. They are directed to the west (azimuth 280°) and are oblique to spur crest.

Lateglacial moraines

Lateglacial latero-frontal moraines and till cover occur in the upper part of the valley, primary in the area of Griesfeld and in some valley-side cirques. Thicker till cover occurs in the northern part of the Griesfeld area. There are also latero-frontal moraines that indicate the position of glacier margin during two subsequent advances. The age of these advances can be considered as an equivalent of the Egesen stadial. These moraines are the first Lateglacial sequence of glacial deposits below the Holocene glacial system. Additionally, they are located quite high, at an elevation of up to 2,400–2,500 m; therefore, their correlation with older advances than the Egesen stadial can be excluded. The position of older moraines indicates that glaciers, which originated in cirque below the Gigalitz summit and in the southern part of the Griesfeld area flowed down to the glacial trough floor. Evidence of this ice movement direction comes also from glacial erosional marks in the southern part of the Griesfeld area, below Holocene glacier forefield. Glacial striae and crescentic gouges are there oriented towards the west (azimuth 255–275). Because of considerable infill of postglacial sediments in the trough floor, the terminal position of the main glacier during this time cannot be traced in geomorphological evidence. In glacial cirques located west of the Greizer Spitze summit and south of the Gigalitz summit, the extent of the second glacial advance was limited to these cirques' floors. Evidence for this comes from prominent, high and blocky latero-frontal moraines. Especially well developed, morphologically fresh moraine with considerable content of large, angular boulders occurs in cirques below the Gigalitz summit. It lies at an elevation of 2,360 to 2,470 m and has relict rock glacier appearance what can be linked to high content of passively transported debris that covered a glacier which formed this moraine. On the left-hand side of the valley, 1 km east of the Mörchenscharte notch, in elevation range between 2,250 and 2,320 m, some Lateglacial till cover and remnants of left lateral moraine occur.

In floor of cirques which hanged above the trunk valley, postglacial talus and debris flow accumulation predominate; however, in some places, patches of till cover and pure developed latero-frontal moraines of hanging Lateglacial glaciers also occur. These glacial sediments are also considered to be an equivalent of the Egesen stadial. The best preserved ridges of lateral moraine can be observed in the northern part of Bichlerkar cirque. There are two closely spaced, left-lateral moraine ridges descending from 2,280 to 2,130 m. A latero-frontal moraine occurs also in the cirque north of Rauher Kopf summit. Small remnants of moraines occur in Sonntagsfeld, Tiefenkar, Äußeres Kelleregg, Friderichkar and Freie Sprünge cirques. In the right-hand valley side, well visible moraines occur in the northern part of Breitstallkar cirque. There occur three blocky latero-frontal moraines, which record three subsequent glacial advances. Fully preserved latero-frontal moraines occur also in Wandeggkar cirque, south of Dristner mountain. In the remaining cirques of the right-hand side of the Floitengrund valley: Brandkar, Grünkar Höhenbergkar, cirque north-west of Floitenturm summit, Bleiarzkar and cirque south-west of Toifler summit, only steep and short sections of lateral moraines can be observed. Most of these cirques have too steep floor to bear full moraine sequence of Lateglacial cirque glaciers. Beside moraines, in the Breitstallkar cirque, also prominent bulge of debris

material interpreted as a relict rock glacier, occurs. It lies at a level of 2,200 m, is 200 m wide and 100 m long, and has well-defined frontal slope as well as barely visible flow structures morphology on the surface.

A conspicuous landform occurs in the Floitengrund valley floor, on the right-hand side of the valley, north-west of Tristenbachalm. The terrace-like landform is stretching there along the valley course over a distance of 600 m. The 50–60 m high edge of this terrace is partially eroded by water which comes from valleys-side ravines. Additionally, at some locations terrace's surface is covered with debris flow and avalanche deposits. The material which builds the terrace is exposed in small landslide niches close to the Floitenbach stream. It reveals compact, massive and matrix supported diamicton with subangular to rounded boulders, up to 1.5 m in diameter. This indicates a glacial origin of this landform (till). Probably, this is a moraine terrace deposited in the ice-marginal position during one of Lateglacial re-advances when the Floitengrund valley glacier reached almost the valley mouth. However, the Zillertal core gneiss lithology in this sediment was not observed, which would confirm a glacial transport from the head of the Floitengrund valley.

Compacted diamicton (till) is also exposed farther down valley (1,050 m), in a small landslide which occurs in the right-hand gorge's slope below the road, 100 m west of the place of water conduit crossing the road. The till lies on bedrock and is covered with rockfall deposits composed of large angular boulders and debris. Beside the above mentioned locations, in the entire valley floor of Floitengrund glacial deposits are lacking. The only exception is the upper section of the valley where Holocene moraines occur.

Holocene moraines

During the 1850 advance (Little Ice Age), the Floitenkees glacier reached the lowest elevation in the Zillertal Alps. Its end moraine occurs at a level of 1,680 m. However, present-day glacier terminus lies at a level of 2,470 m and is located 1,000 m north of Westliche Floitenspitze summit. This implies considerable glacier recession over a distance of 2.7 km during the last 150 years. Quick ice decay resulted in disintegration of the main glacier tongue and emergence of a large, 400 m long, dead ice body in the flat area in the end of the glacial trough. Dead ice lies 1 km south of Greizer Hütte, at an elevation between 2,150 and 2,300 m. The Floitenkees glacier's extent during the 1850 advance can be easily outlined on the basis of moraines, vegetation trimlines and analysis of old topographic maps. During this time, ice masses flowed concentrically down from high elevated ice-field in the head of the valley to the glacial trough, where they started to flow down along the valley course as a main glacier tongue. Additionally, there were two lateral ice-flow units (ice lobes), independent of the main glacier tongue, which deposited latero-frontal moraine systems on the sides of the trough head basin. One of them was a glacier tongue above Griesfeld area, which reached an elevation of 2,430 m, and in the opposite site of the valley there was a glacier tongue below the eastern flank of Großer Mörchner, which extended as high as 2,120 m. The right lateral moraine of the main glacial tongue can be traced over a distance of 1,800 m, from 2,330 to 1,745 m elevation. The left lateral moraine is stretching over a distance of 1,300 m, from 2,130 to 1,730 m. A fragment of the 1850 advance end moraine is preserved in a place where a marked path leading to the Greizer Hütte crosses 1,680 m contour line. The wall of this moraine is 90 m long and 2–4 m high. It is composed of big, several metres in diameter, angular boulders devoid of matrix. Close to this moraine, at a distance of 10–20 m down the valley, remnants of older moraine occur, which is almost entirely covered with talus debris. In the central part of the valley floor, end moraine crests are completely destroyed by an outwash fan. Farther up the valley (1,900–1,950 m), outside prominent right-lateral moraine, close to the point where a path crosses the moraine crest, a moraine older than the 1850 advance can also be traced. South of this point, inside glacier forefield, a 2–3 m high, blocky latero-frontal moraine occurs. It reaches the lowest position at an elevation of 1,880 m. This moraine was deposited during the 1920 advance as can be inferred from old topographic maps. Farther up the valley, approximately at a distance of 1,100 m and at elevations between 2,170 to 2,230 m, a younger moraine occurs, which was likely deposited during the 1970/1980 advance.

A complicated arrangement of end and lateral moraines in the Griesfeld area forefield points to the presence of five smaller lobes. A prominent section of the end moraine crest occurs in the southern part of this forefield, 900 m SE of the Greizer Hütte. It has 60–70 m high frontal slope and is mostly built of rounded and subrounded boulders. Less high is the end moraine section in the northern part of this forefield, 600 m east of Greizer Hütte. Characteristic for this part of the forefield is also a large content of angular boulders and glacial flutings on the till cover. Only in the southern part of the Griesfeld area forefield, a 2–4 m high recessional moraine can be traced. It lies at a distance of 100–300 m from the most extensive end moraine of the 1850 advance. It is also composed of numerous big, up to 3 m across, angular boulders. This moraine was probably formed during the 1920 advance. A blocky latero-frontal moraine of the 1920 advance can be also distinguished in the forefield of the glacial lobe that flowed below the eastern flank of Großer Mörchner massif, in the opposite side of the valley. It reaches an elevation of 2,280 m and is located 240 m NNW of the elevation point 2,386 m.

High and blocky Holocene moraines of small avalanche-supplied glaciers occur also in the cirque east from Mörchenscharte notch and in the southern part of Sonntagsfeld cirque. In both cases, moraines are several tens of metres high and are composed of several close-spaced moraine crests. Additionally, some small debris walls accompany snow and firn patches below the high rock wall in the eastern flank of Kleiner Mörchner mountain.

Valley floor

The valley floor is almost completely covered with large talus, avalanche and debris flow cones, which are supplied from valley-side ravines. There are valley sections where these cones are interlocking making natural valley blockades dissected by Floitenbach stream. Such situation occurs in Tristenbachalm, Franzes Jh. Sulzenalm, near Seinbockhaus and in Baumgartenalm. Wider alluvial valley floor covered with rounded blocks, gravels and sand occurs south of Steinbockhaus.

A heavy rainfall that has occurred in 3–4 August 2011 caused many large debris flows which descended to the valley floor and made considerable destruction on the road which leading trough the valley. The largest debris flow deposits occurs 500 m north of Baumgartenalm. Its thick tongue of debris flow material reached Floitenbach stream channel and forced the stream to flow to the right-hand side of the valley.

Bericht 2012 über geologische Aufnahmen von quartären Sedimenten im Zillergrund, Sundergrund und Bodenbach auf Blatt 2230 Mayrhofen

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During 2012 Quaternary sediments and landforms were mapped over an area of ca. 40 km^2 in the western slope of the Zillergrund valley (in-between Nößlrain and In der Au settlements) in the western slope of the Sundergrund valley and in the area of the Bodenbach stream valley. All of these valleys are typical glacial troughs dissected in the Zentralgneiss crystalline rocks. Quaternary sediments mostly occur there in valley floors and in bottoms of hanging glacial cirques.

Evidence of the maximum ice extent (Last Glacial Maximum, LGM)

In the northern part of the investigated area the highest position of ice-moulded bedrock occurs in the spur descending to the north from the Trenker mountain at a level of 2,240 m. It indicates the ice-surface in the Zillergrund valley around location of the Nößlrain at a level of ca. 2,250 m. Trimmed facet of the spur which steeply running down from Äußere Gefallschneid towards Bodenbach stream valley point out maximum ice erosion in the middle section of this valley up to the level of 2,420 m. In the mouth of this valley, in the ridge which fencing the valley from the east, traces of ice erosion can be seen up to ca. 2,330 m. Two well-developed truncated spurs in the mouth of the Sundergrund valley: Stange and Grünkarlegg, mark trimline at the level of 2,400 and 2,440 m adequately. Further up the Sundergrund valley the former ice-surface has lifted up to 2,560 m in location of the spur which descends from the Vordere Stangenspitze towards the east and up to 2,620 m in the head of the Sundergrund valley in location of Roßkopf truncated spur (outside of reported map area). There are also traces of ice erosion (ice moulded bedrock, partially frost cracked) in the valley-head's watershed ridge around Hörndljoch cool (2,553 m). The ice moulded bedrock can be seen there over a distance of 600 m and up to 2,580 m. Also the north facing slope below this ridge bears traces of ice erosion, what is not common situation on a typical cirque back-wall. It might be considered that during the LGM some portion of ice accumulated in the Sundergrund valley head flowed over the Hörndljoch cool to the south, to the Ahrntal valley system (Italy), but the discharge of ice was there not enough large to effectively erode-down the ridge (ca. 20–30 m of ice thickness on the cool). The Hörndljoch cool in this respect can be considered as transfluence pass, but in the initial stage of development.

Lateglacial

In the study area two groups of Lateglacial moraines are distinguished basing on morphostratigraphic relations. Older moraines were most probably formed during the Eastern Alpine Gschnitz advance and the younger moraines ordered in multi-walled sequence were formed during the Egesen stadial advances.

Gschnitz age moraines occur only in the northern part of investigated area and in a lower altitude, below 1,850 m. The highest Gschnitz moraine wall (ca. 40 m high) occurs in the Hansenegg location, in the mouth of the Stadelbachalm valley, 2 km north of the Trenker mountain. It is a right-hand lateral moraine of glacier which occupied the Stadelbachalm valley. The highest position of this moraine reaches 1,850 m. The glacier, which formed this moraine, probably existed independently of the glacier which occupied the Zillergrund valley. Further up in the Stadelbachalm valley there is also well-developed and multi-walled Egesen moraine sequence (outside of map area). Very interesting moraine wall/terrace occur in the left-hand side of the Zillergrund valley, close to the mouth of the Bodenbach stream valley, 500 m east of Graßegg alp. This is the left-hand lateral moraine of the glacier which occupied the trough of the Zillergrund valley. The moraine extends parallel to the main valley axe on relatively low-sloped area of a glacial shoulder. The ridge of this moraine descends from 1,620 to 1,600 m. It indicates 580 m thick glacier in the Zillergrund valley (valley floor is at a level of 1,040 m in this location). Boulders which built this moraine are composed purely of Tuxer Kern gneiss lithology. A lack of well distinguishable Zillertaler Kern gneiss lithology in composition of this moraine implies relatively short glacial transport route from the tributary Bodenbach stream valley where this parent lithology does not occur in contrary to the upper catchment of the Zillergrund valley system (Zillergründl, Hundskehle and upper Sundergrund valleys). The highest position of moraine associated with the same glacial system can be considered in the mouth of the Bodenbach stream valley, in its right-hand side, 600 m NW of the Bärlahnerkopf mountain. This moraine descends from 1,730 to 1,660 m where it ends at the cliff of the Zillergrund trough edge. Presented moraine configuration indicates a large Gschnitz dendritic glacier system in the Zillergrund valley in which the glacier in the Bodenbach stream valley was the last large tributary affluent of the main trunk glacier.

Well-developed moraine sequences of the Egesen stadial can be observed especially in the Bodenbach stream valley and in the Rachkaralm cirque (the northernmost left-hand tributary cirque of Sundergrund valley). Moraines assigned in this report to the Egesen stadial moraines occur below 2,300–2,400 m. The exception is blocky, south exposed, rock glacier like moraine in the Rachkar cirque which reaches ca. 2,500 m. In the Bodenbach stream valley two morphological fresh, latero-frontal moraine walls stretch subparallel in the mouth of this valley, in its right-hand side, between 1,580 and 1,700 m. They mark positions of Bodenbach glacier tongue probably during the Egesen I and II advance. Several meters high terminal