Ice-Contact Sediments and Landforms and Multi-Phase Deglaciation in the Area of the Confluence of the Sill and Inn Glaciers

J. Magiera & J. Zasadni
AGH-University of Science and Technology, Pl 31-059 Krakow

Contents

The area where the Sill and Inn valleys join, S of Innsbruck reveals unusual abundance of ice-contact and extraglacial landforms and sediments: kames, kame terraces, fluvioglacial fans, infills of the ice-dammed lakes. The area is located mostly on a "rock terrace" or a "valley shoulder" (Inntalterrasse) and its slopes and stretches along the Inn River valley as well as along lower parts of the Sill River and Stubai valleys (Fig. 10). The landforms and sediments are the surface remnants of the glaciers of the last (Würm) glaciation climax. Boulder clay (of Würm age too) is a substratum of the surface sediments and also covers a remarkable part of the area (cf. KERNER v. MARILAUN, 1890; HEISEL, 1932; PATZELT et al., 1996). Further down, the buried parts of the valleys have a very complex structure. They are generally filled with glacial and fluvial sediments of the pre-Würm age, in places of remarkable thickness of up to 700 m (GRUBER & WEBER, 2003).

Sediments and Landforms

The parallel trains of steps formed by the kame terraces along the Sill River valley (or Wipptal) are the most impressive ones (Figs. 1 and 2). Kame terraces continue further ESE and WNW along the Inn valley.

Kame hills occur usually on vaster flat areas, as, e.g., between Patsch and lake Lanser See. They were formed in front of the kame terrace of the same age and are commonly surrounded by sediments of the subsequent kame terrace. Some kames were built over bedrock hills, on their lee-sides (Fig. 3).

Outcrops of the kame sediments are scarce. Fine to middle grained and poorly to moderate-rounded gravel with sandy-silty matrix can be seen in the scarps below the edges of the terraces and in the soil on their surfaces. Disordered texture prevails, cross and horizontal bedding is rare. All this indicates a rather low energy water sedimentary environment in the gaps between the glacier and the hill slope and in the thaw holes. Longer axes of the kame hills are oriented generally along the valleys, with a small clockwise rotation, i.e. towards the S–N direction. The kames apparently formed in the thaw holes developed along the diagonal and longitudinal shear cracks and crevasses.

Fig. 1: Trains of kame terraces on the E side of the Sill River valley (Wipptal), as seen from Mutters (Nockhof).

Fig. 2: The kame terrace (level 8) in Raitis.

Fig. 3: Kame built on the lee-side of the bedrock hill which forms a slope and small mounds on the left. Level 6, N of Patsch. Flat area below is the top of the kame terrace of level 7. Stubai valley is in the right, in the background.

The topmost parts of some kame and kame terrace consist of very fine, usually homogenous, white sand (Mehlsand). Sometimes the sand reveals horizontal bedding and/or contains dropstones (Fig. 4). The sand points to a very calm, stagnant water environment, developed towards the end of the formation of the ice-margin sediments.

Fig. 4: Mehlsand: bedded (left) and homogenous with a dropstone (right). Top of the Kame of level 7, S of Patsch (Gansbichl).

Silt and silty clay, with intercalations of sand, in most cases bedded (varvites) were found in four places: in the Mühlbach valley (1260 m a.s.l. and 1070–1120 m a.s.l., Fig. 5), in Schönberg (1005 m a.s.l.) and in Mieders (Mühltal, 900–920 m a.s.l.). They apparently are indicators of four ice- or moraine-dammed lakes, located on different heights and, thus, of different age.

Fig. 5: Silty clay (varvite) with sand. Mühlbach, ca. 1085 m a.s.l.

Levels

Strikingly well pronounced arrangement of the kame terrace and kame trains on the sides of the valleys encouraged their correlation into local levels. The main direction of the dip of the terraces and the height above the valley floor were the essential basis for the correlation. The heights of terrace edges and flat tops of the kames were measured. Generally, such geometric correlation can be misleading. However, in the present case the kames and terraces could be easily traced, both in the field and on the Digital Elevation Model (DEM) and such danger was substantially reduced.

The highest ice-margin sediments were found on the N slopes of Patscherkofel at 1100–1200 m a.s.l. and on E slopes of Saile (above Kreith, 1100–1180 m a.s.l., level "0"). However, they do not form significant landforms and cannot be used for level estimation. Some even higher placed patches of gravel and sand (up to nearly 1300 m a.s.l. above Kreith) are probably fluvioglacial fans of the Sagbach River. The remaining kame terraces and kames were grouped into 19 levels (Figs. 6, 7, 9, 10). They were numbered from 1 (the highest) to 19 (the lowest).

Levels 1–4

The four highest are represented by several small fragments of the kame terraces preserved on slopes of Tulferberg, above Tulfes. The approximate height of level 1 is 380–410 m above the Inn river valley floor (a.r.l.) or 950–980 m above the sea level (a.s.l.), level 2: 360–400 m a.r.l. (930–960 m a.s.l.), level 3: 360–380 m (925–950 m) and level 4: 350–360 m (900–925 m).

Level 5

Fragments of level 5 are much more widespread. A large terrace forms a well-pronounced slope step between Tulfes and Rinn, three smaller terraces occur around Asten and Wiesenhöfe. The height of level 5 is 340–360 m (890–920 m) around Tulfes and 330 m (880–900 m) in the vicinity of Aspen. The level obviously rises slightly towards ENE, i.e. downstream the Inn valley.

Level 6

is marked by few isolated landforms stretching from the lower part of the Stubai valley to Volderwald (Bramor) in the Inntal. Its height is 350 m (1020 m) in Mieders, 330 m (1040 m) in Schönberg, 310 m (980 m) N of Patsch (Fig. 3) and 310 m (890 m) in Bramor. This level is the highest preserved in the Wipptal and Stubaital.

Level 7

today has a slightly smaller extent: from Schönberg to Rans. Its height varies from 300 m (1010 m) in Schönberg and Gansbichl to 285–290 m (960 m) by Goldbichl, to 310–320 m (880–890 m) around Sistrans and 300 m (860 m) NE of Judenstein. Varvites in Schönberg (1005 m a.s.l.) are associated with this level.

Level 8

Terraces and kames that mark level 8 stretch from St. Peter in Wipptal and Mieders in the Stubai valley to Mutters and Volderwald. The level is well pronounced particularly in the Stubai valley and in the Wipptal. The edge of this level is located at a rather stable height of 260 m a.r.l. along the Stubai valley and Wipptal, except for Schönberg where it is slightly higher (270 m). Similar to level 7, the height of level 8 is remarkably greater in the Inn valley just below the Wipptal mouth (320 m), but reduces to 220 m further ENE. Level 8 is the highest of the levels which, consequently, lower along the Inn valley towards ENE (Fig. 6).

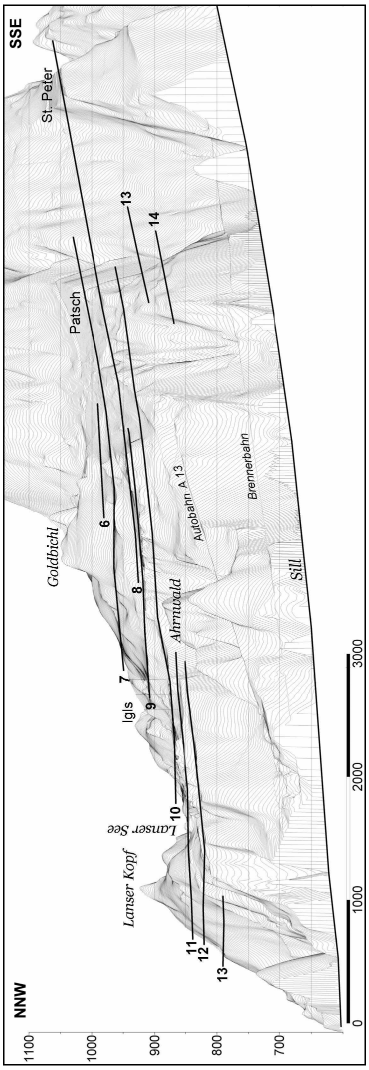

Fig. 6: Correlation of the kame terraces and kames on the ENE side of the Sill valley (Wipptal). Exaggerated 5x.

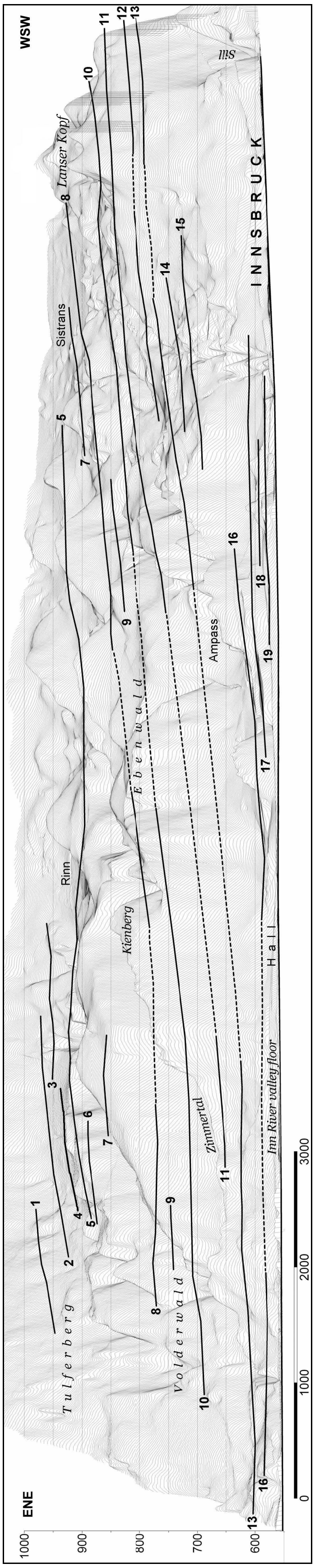

Fig. 7: Correlation of the kame terraces and kames on the SSE side of the Inn valley. Exaggerated 5x.

Level 9
is the next consecutive level of ice-margin sediments and landforms that is clearly seen over almost the whole the study area. In the lower part of the Stubai valley level 9 follows the edge of a "shoulder" at a rather stable height a.s.l. of 930–940 m but at a rapidly growing height above the valley floor, from 90 m at the Mühltal mouth to 200 m N of Mieders and to 250 m by Patsch. Further N in the Wipptal the height grows only to 260 m (by Igls) and does not change in the Inn valley until it reaches Ebenwald where it decreases to 190 m in Volderwald (Gasteig). Varvites in Mühltal (900–920 m a.s.l.) are related to this level.

Level 10
The remnants of level 10 are preserved northward of Patsch (Gänsbichl) and continue to Gasteig. In Wipptal the level height is 230–240 m. It grows to 260 m around Igls and then consequently reduces to 170 m in Gasteig. This is the highest level, which appears in the close vicinity of the lakes N of Igls and Lans.

Level 12
The lowest parts of the Wipptal shoulder W and NW of Igls and in Mutters mark level 12. Its height is 200 m above the Sill River. It follows higher levels and disappears around Aldrans.
The remaining levels form a series of shelves along the S slope of the Inn River valley, dipping consequently downstream.

Levels 13, 14 and 15
can be traced only in the vicinity of Natters and E of the Sill mouth. Their heights are 160–140 m above the Sill River in Natters and 170–130 m above the Inn SW of Aldrans. Further downstream only level 13 can be traced at the height of 130 m in Ampass and 60 m at the Zimmertal outlet.

Levels 16, 17, 18 and 19
Small fragments of kame terraces and small kame hills represent levels 16, 17, 18 and 19 (Fig. 8). They stretch along the rim of the Inn River valley floor from the vicinity of Ampass to the mouth of the Voldertal River. Their heights do not exceed 15 m above the valley floor.

Fig. 8: Kame terraces of level 16 (on the right) and 17 (in the front). Alluvial Inn River valley floor below, on the left. Ampass.

Phases of deglaciation

The origin of the kame terraces and kames is directly connected to the phases of glacier melting (e.g.: EHLERS, 1996). They form in periods of glacier level stagnation (which does not necessarily mean that the glacier is immobile or inactive). When glaciers thaw and "retreat" quicker, the ice-margin sediments disperse over the slopes and do not form terrace steps nor mounds. Therefore, the kame terrace and kame levels mark glacial phases while the gaps among them mark the period of intense ice thawing. All of them refer to the climax of the glacial period. The phases and their numeration suggested in the present study are informal (Figs. 9 and 10).

The highest recognizable levels (1–4) mark the glacial phases in which the glacier surface stretched as far as the upper edge of "rock terrace", just at the foothill of the steep slopes of Glungezer. The line of the glacier extent stretched probably further WSW and into the Wipptal and Stubaital, but there are no preserved traces of it in both valleys.

During younger phases, corresponding to levels 5–12, a typical areal deglaciation probably took place on the flat parts of the "rock terrace". The lines of the glacier extents are very lobate. The highest hills and ridges (Lanser Kopf, Kienberg, Ebenwald, Rinner Bichl) on the terrace were probably nunataks during some phases.

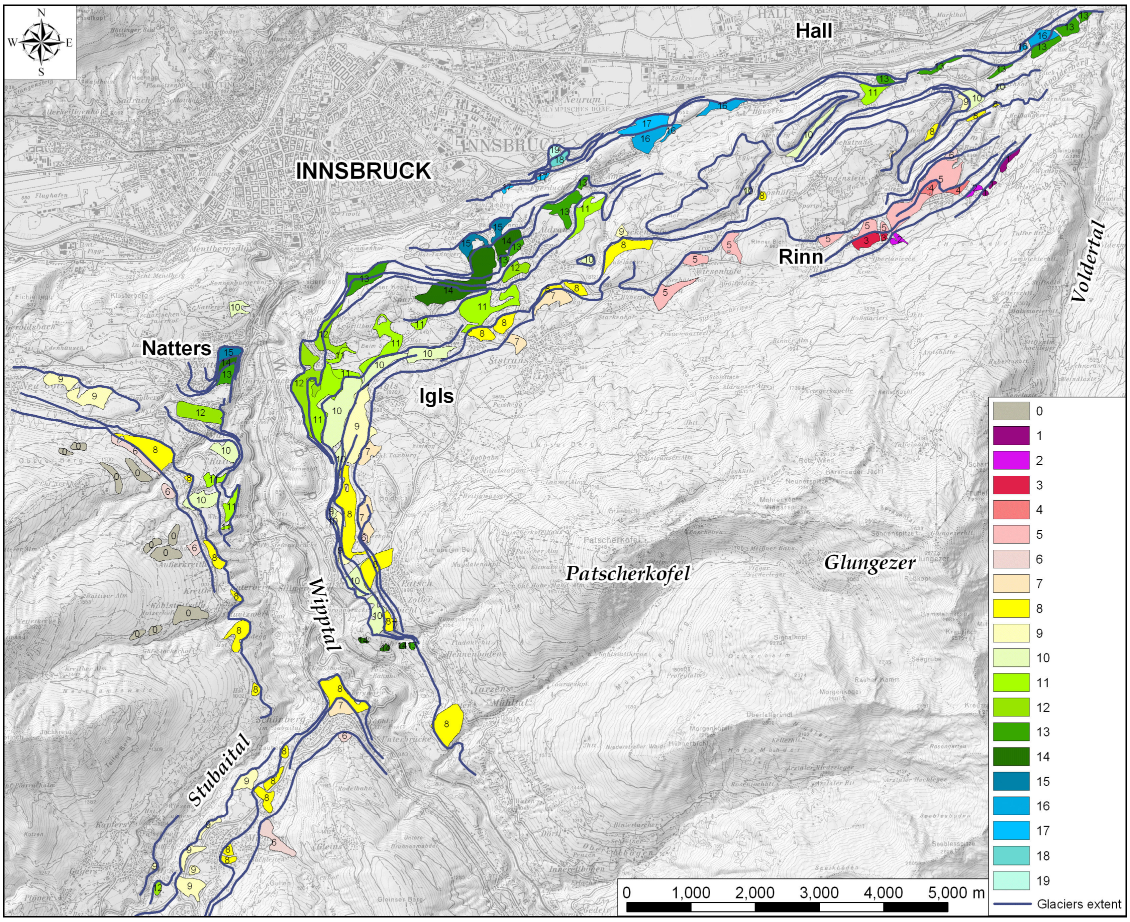

Fig. 9: Levels of the kame terraces and kames and interpreted glacier extents in the Sill and Inn glaciers confluence area.

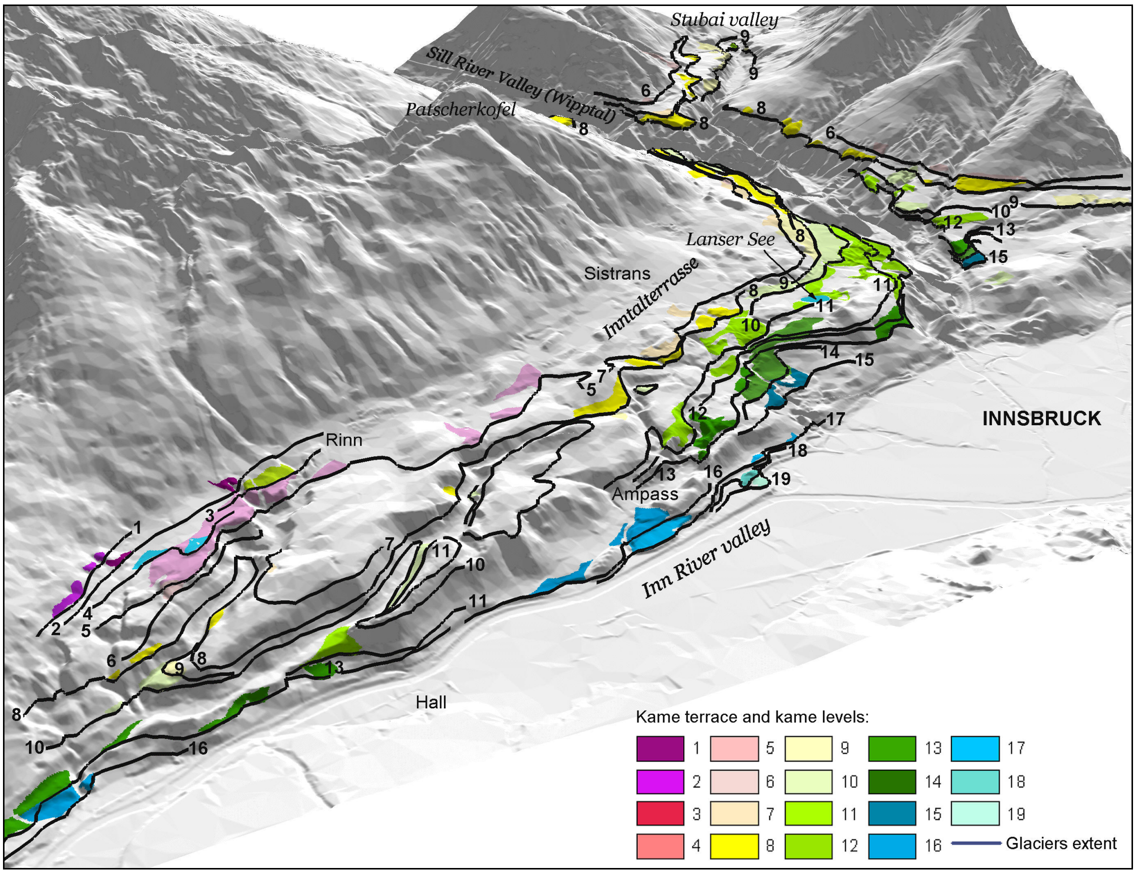

Fig. 10: Levels of the kame terraces and kames and interpreted glacier extents in the Sill and Inn glaciers confluence area. Perspective projection, view from NE.

Phase 8 was probably the last one, during which the glacier in the Wipptal was supplied by the Stubai glacier. During phases 9–12 the lowest part of the Stubai valley, i.e. the deep furrow below Telfs, was filled with long inactive ice tong.

Phases 10 and 11 seem crucial for dating deglaciation phenomena at least in the study area. It applies particularly to the area of the "Lake District", among Igls, Lans and Lanser Kopf, where two lakes (i.a. Lanser See) and swampy depressions occur (ca. 830–850 m a.s.l.). The glacier of phase 10 reached there the height of ca. 860–880 m a.s.l. Melting, it left dead-ice blocks and fields which preserved depressions in the bedrock eroded earlier by the glacier from being buried under the melt water sediments of the subsequent glacial phase 11. The glacier of phase 11 probably did not enter the area of the "Lake District" but reached the height of ca 830–860 m a.s.l. on E slopes of the Wipptal as well as on NW and N slopes of Lanser Kopf. The area behind Lanser Kopf was a place of intensive deposition of melt water sediments. These sediments now form kame terrace and kames of level 11. One of these kames, forming a very impressive winding hill E of Vill, hosts an archaeological site on top (Fig. 11).

The disappearing of the dead-ice blocks of phase 10, which at the earliest probably took place at the end of phase 11, created the lakes and gave way to the lacustrine sedimentation. The ^{14}C dating of the peat bog E of the lake Lanser See (PATZELT, 2003) gave the date ca. 14 ka BP (the Oldest Dryas) of the bottom of the sediment. Since then the area of the "rock terrace" has been ice-free.

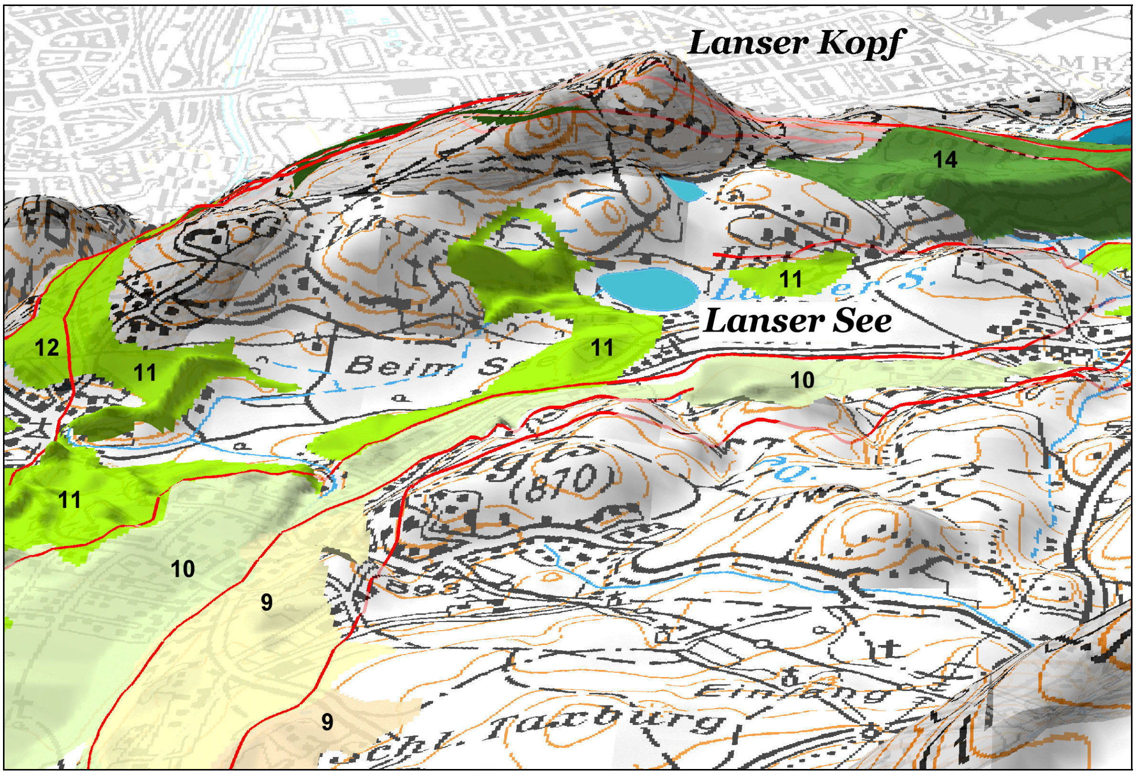

Fig. 11: The lake Lanser See and surroundings: kame terraces and kames of levels 9–14 (numbered) and respective, interpreted extents of the glaciers (red). Innsbruck is in the background. Perspective projection, view from S.

The third lake present in the "Lake District" (Mühlsee, 808 m a.s.l.) is younger and originated probably from the melted dead-ice of phase 11, during phase 12 or 13.

The connection between the Inn glacier and the glaciers in the upper part of the Wipptal was probably broken in phase 10. In younger phases the lowest and the deepest part of the valley was filled with inactive ice.

Finally, levels 15–19 mark terminal phases of Würm, with the Inn valley being filled with dead, dwindling ice-fields.

Except for the data from the Lanser See peat bog there are no more hints for dating the multi-phase deglaciation of the Wipptal forefield. The date of ca. 20,000 years BP (the maximum of the last glaciation) and the ice surface at ca. 2300 m a.s.l. (van HUSEN, 1987) point that the disappearing of the 1450 m thick ice layer lasted ca. 6,000 years. The melting down of the next 300 m of the ice in 10 phases took roughly 2,500–3,000 years.

The surfaces of the glaciers of phases 5–7 and probably earlier phases run horizontally in the Inn valley or even raised up downstream. They were, on one hand, apparently well fed by the Wipptal glacier and, on the other, "pushed off" by it towards the opposite side of the valley. This could have created depressions in the ice E (bigger) and W (smaller) of the confluence. The Inn glacier of phase 8 lost the connection with the Stubai glacier and later, during phase 10, with the Wipptal glacier. The Inn glacier, which no longer was "pushed" towards N, filled the depressions and freely spread over the whole valley. But, getting no more supply from the Wipptal, reduced quickly his thickness downstream. We can easily observe that the kame terraces of levels 8–16 lower in this direction (Fig. 10).

It seems apparent that a dramatic change in the extent of the glaciers and their alimentation areas occurred in the time spanning phases 8 and 10.

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