Geol. Paläont. Mitt. Innsbruck, ISSN 0378–6870, Band 25, S. 1–242, 2001

SEQUENCE DEVELOPMENT ON A HIGH-MOUNTAINOUS SUBSTRATE: THE HÖTTING BRECCIA (PLEISTOCENE, INNSBRUCK, AUSTRIA)

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Following a Pleistocene glaciation, north of Innsbruck (Austria) a terrestrial clastic sequence sourced by its local, high-mountainous substrate accumulated, and consists of systems tracts each formed in response to changes in depositional system upon onlap onto and burial of high, steep rocky slopes and cliffs.

The sequence formed during the ?last Interglacial, and is underlain and topped by an unconformity each cut, largely, by glacial erosion. In the distal portions, the sequence locally rests on lodgement till topped by a thin loess layer. At most locations, however, including the medial and proximal parts of the succession, the substrate consists of Triassic carbonates and, at intermediate topographic height, of an outcrop belt of Permo-Triassic redbeds. Nowhere else in the area were redbeds exposed below the Hötting Breccia. The stratigraphically lower part of the sequence consists of an alluvial fan succession of debris-flow breccias and, subordinately, of stratified breccias/conglomerates and cross-laminated sandstones deposited from aqueous flows. In the lower part of the sequence, clasts derived from the redbeds are abundant. The fan succession dips a few degrees towards the south, and contains multiple intercalations of light-brown, carbonate-bearing sands and silts, interpreted as loess deposits. Both the loess intercalations and plant fossils (Murr, 1926; Gams, 1936) suggest an overall cool-temperate climate, possibly shortly after the Inn valley became deglaciated. Towards the east, the lower part of the sequence consists largely of conglomerates and conglomeratic breccias deposited from gravelly streams and, subordinately, of debris-flow breccias; debris-flow deposits similar to the western part (i.e. with a red-coloured matrix from erosion of redbeds) are rare, but become more common up-section. The lower part of the sequence constitutes a laterally continuous apron along the base of the former slope. To date, no depositional geometries or deposits suggesting persistent, stable channels, and no soil profiles have been identified.

The presence of conglomerates, breccias and sandstones deposited from aqueous flow, and their vertical association with debris-flow deposits suggests quasi-perennial to ephemeral (seasonal peak?) surface runoff. The lower part of the sequence was sourced by its immediately adjacent rocky slopes and cliffs, and probably consisted of laterally coalescing, small, unvegetated to scarcely vegetated fans with superposed, ephemeral channels.

Up-slope, both above the belt of Permo-Triassic redbeds and the onlapping fan succession, the sequence consists of a rock-fall megabreccia and/or of thick-bedded rudites (breccias to conglomerates) composed of clasts from the local substrate. The rudites are arranged in amalgamated stratal packages that formed from channelized flow within gullies, from sheet flows and, subordinately, from debris flows. This intermediate succession dips between 5-15°, and in its topmost portion interfingers with lithified talus aprons. In the intermediate succession, with the exception of extremely rare clasts of crystalline rocks (remnants of glacial deposits from the preceeding glaciation), all the clasts are derived from the immediately underlying Triassic substrate, including characteristic brown-weathering dolomitized limestones and cellular dolomites (Reichenhall Fm) and red, nodular lime mudstones (Schusterbergkalk Fm) exposed in the local substrate.

Near the contact with the substrate, both in the lower and middle part of the sequence saproliths, colluvium and small talus accumulations are locally present. Within the lower and middle part of the sequence a few, large clasts of lithified carbonate slope breccias suggest that, either, (local) lithification of breccias proceeded rapidly, or that erosional remnants of an older generation of slope breccias existed. At one location in the middle part of the sequence, in a succession at least a few meters thick of fine-grained deposits below the ruditic succession, a fossil flora is preserved. The composition of the flora is similar to mixed Alpine-deciduous floras that today are locally present, at similar altitudes, on hillslopes with southerly exposure. Two elements of the flora, however, may suggest an overall warmer climate than today (MURR, 1926; GAMS, 1936). The deposits with the plant fossils mainly are cream-coloured, chalky lime mudstones to siltstones. This location is now covered by vegetation.

The intermediate succession of mainly conglomerates and breccias deposited from (quasi-) perennial to ephemeral surface runoff suggests a climate of similar to lower or more seasonally distributed precipitation than today. The composition of the succession of clasts derived from the local substrate, and the vertical association of gully deposits, sheet flow deposits and debris-flow deposits, and the 5–15° dip strongly suggest that the succession accumulated in the basal to lower part of talus aprons that were strongly overprinted by channelized and unchannelized surface runoff. The fine-grained deposits with the plant fossils, if penecontemporaneous with the ruditic succession, may have accumulated in a small lake or pond beside the talus. Similar lake-talus facies associations are locally present at high altitudes in the Northern Calcareous Alps today.

The stratigraphically and topographically highest part of the sequence consists of thick, lithified talus aprons that steepen from 10–15° in their lower part to 35° and, locally, 40° at their head. The downslope part of the talus successions is characterized by extremely poor to poor sorting (gravels to boulders), common presence of matrix, variable bed thickness and, locally, poorly defined bedding, variable bed dip/strike, cut-and-fill structures, and by local large-scale foreset-bedding. Upslope, in the steeper-dipping middle part of the talus, bedding becomes regular and planar. The middle and upper portion of the talus succession is characterized by (a) beds of moderately to well-sorted gravels to cobbles with „openwork" fabric, cemented by calcite, and (b) fewer beds, commonly poorly to very poorly sorted, of clast-supported gravels to cobbles, with a matrix of mixed carbonate siltstone to mudstone. Upslope, both the openwork beds and, to a lesser degree, the matrix-rich beds are generally better sorted and grade into moderately to well-sorted, coarse to medium gravels; bedding becomes still more regular and even.

The talus succession probably was fed from a periglacial s.l. environment with seasonal freezing. The openwork beds probably formed by dry grain sliding and particle creeping; at least many of the beds with matrix were deposited from debris flows. The talus breccias locally prograded over the underlying succession. "Grèze litée" suggesting deposition of the talus successions by nivational processes and/or from solifluction lobes was not identified.

Each of the described depositional systems from alluvial fans to talus slopes represents a distinct geomorphic stage with a specific position within the sequence, and with specific depositional geometries, stratal dip, stratal packaging and lithologies related to sequence development and, hence, is regarded as a systems tract. When the rocky slopes were largely exposed, during deposition of the lower systems tract of the sequence, debris-flow dominated deposition and deposition from (ephemeral) gravelly streams prevailed near the toe-of-slope ahead. When the Permo-Triassic redbeds were buried by onlap, deposition in ephemeral gullies and from sheet flows prevailed in the basal and lower part of a developing talus apron. This intermediate systems tract, in turn, provided the foundation for the buildup of the aggradational to progradational talus aprons that constitute the upper systems tract of the sequence.

References

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