Variation of structures in a retreating glacier: Pasterze (Austria) 1887/89 – 1997

P. Herbst, F. Neubauer

Inst. f. Geologie und Paläontologie, Universität Salzburg, Österreich

Surface structures of the ablational part of the Pasterze glacier, Austria, were mapped in detail from aerial photographs and maps covering a period of 130 years. The variation in the distribution of the fractures, shear-zones, thrust faults, normal faults and shear-extensional faults shows a significant connection to the velocity of ice-movement and therefore to the mass-balance of the glacier and climatic factors since the end of the Little Ice Age (data starting with ca. 1870). The formation of shear-extensional fractures shows a strong connection with climatic changes and ice thickness and therefore a change of the velocity of the ice flow. A higher velocity-gradient between central and lateral parts of the glacier results in wider shear-extensional fractures and large angles between fracture and lateral border of the glacier. Thrust faults only developed in a milieu of glacier retreat, the movement of the thrust-faults glacier-upwards seems to be a function of the ice-thickness and the velocity at the terminus. Normal faults always appear on the glacier, mainly on topographical steps, at the retreating terminus andt lateral margins.

An increase of precipitation or decrease of temperature cannot be visible on the glacier at the moment due to the long response-time which was calculated for the Pasterze glacier with 34-50 years for the volume and 70-137 years for the length. Reactions of the structures on the mass-balance are, therefore, never visible at the moment, but always with a major time lag. At the same time the glacier with a negative mass balance suffers from a lack of ice at the terminus and also his back-load decreases steadily which also makes the velocity of the glacier to decrease. The velocity of the glacier was highest during the last 70 years from 1978 to 1982 and in the 1930's which corresponds quite well with the development of the annual precipitation and also the lowest velocities during the 1950's correspond well with a decrease of precipitation in that time. Since 1982 there exists a steady decrease of velocity, by now the velocities have reached the lowest values of the 1930's.

A very sensitive tool for climatic changes and therefore the velocity of the glacier are the shear-extensional fractures at the lateral margins of the glacier. Since they have their origin in the velocity-gradient between lateral and central parts of the glacier, they react on every change in velocity with change of their width and orientation as well as style. Thrust faults develop in theory in two ways (1) by pressure from the back ("bulldozer-model"). In this case the medium develops in connection with a basal plane of low shear-resistance (as the contact glacier–bedrock) thrust faults in the thin, frontal part; and (2) by pressure from the front where the stress is concentrated in the frontal parts of the medium where, presumably a basal plane of low shear resistance, a frontal block remains undeformed and behind that one the thrust faults appear. This could also represent velocity gradients with decreasing velocity from the terminus to the upper portion of the ablational area.

For a glacier with no obstacle in the front the bulldozer-model seems to better fit the data. If the back-load increases, the number of thrust faults should increase. Regarding the Pasterze glacier there are thrust faults visible in 1969, 1978, not in 1983, again visible in 1991 and best developed in 1997. Since the back-load of the glacier was highest in 1983 during that period, there is evidence for a vice-versa connection between mass-balance and appearance of thrust-faults. The motor for the development of thrust-faults at the terminal region of a glacier seems to be that the velocity at the terminus almost reaches zero. If the velocities at the terminus are quite low, the frontal part of the glacier is acting like the frontal block described in (2) and so evoking the thrust faults. Regarding the climatic data there is also evidence for a minimum annual mean temperature to establish thrust faults for a glacier in this area and exposition.

Formation and development of spreading mountain ridges - implications to rock slope hazards and fractured aquifer assessment

S.W. Hermann, L.P. Becker

Institute of Geology and Paleontology, University of Graz, Heinrichstrasse 26, A-8010 Graz

Structures resulting from the mechanics of gravitational spreading are common on high mountain ridges. There, surface characteristics such as twin ridges and slope trenches develop as a consequence of the readjustment of the ridge due to gravitational forces. Kinematic analyses of the faults generated by gravitational spreading point towards an overall internal tension of the ridge. Thereby pre-existing discontinuities have been reactivated to