Vibroseismic and geodetic investigations of a deep funnel-shaped depression at the tongue of Gepatschferner (Ötztal Alps, Austria)

Martin Stocker-Waldhuber[1,2] Andrea Fischer[2] Michael Kuhn[3], Lorenz Keller[4]
martin.stocker-waldhuber@uibk.ac.at

1. Institute for Geosciences and Geography, Physical Geography, Martin-Luther-University of Halle-Wittenberg, Germany
2. Institute of Interdisciplinary Mountain Research, Austrian Academy of Sciences, Innsbruck, Austria
3. Institute of Meteorology and Geophysics, University of Innsbruck, Austria
4. roXplore gmbh, Amlikon-Bissegg, Switzerland

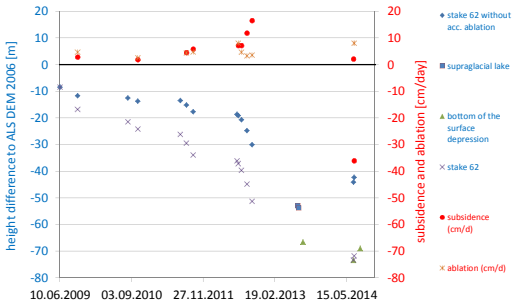
Development of the surface depression at the tongue of Gepatschferner

Funnel shaped surface depressions are widely spread and occur on different types of glaciers. The processes behind those depressions vary as much as their size and temporal development. Beside of the dynamic formation due to ice flow over subglacial barriers, the formation of surface depressions can originate from thermal and mechanical processes due to the subglacial drainage system, the water inflow of the surrounding slopes or even heavy precipitation events and lake outbursts. In the accumulation area, surface depressions can also be formed by wind erosion. Depending on the different processes the sinks occur within weeks, months or years.

At the tongue of Gepatschferner (46°52'30"N, 10°45'25"E) the evolution of a surface depression has been monitored since the beginning of the development. Vibroseismic soundings by using a shear-wave vibrator were carried out in 2012 and 2013 at two profiles on Gepatschferner with a length of 144 m each. During the same period the surface ablation at an ablation stake and its position and motion was measured with DGPS regularly. Two ALS surveys were carried out in 2012 and additionally, former ALS DEMs are available.

The observed subsidence rate was around 30 m per year and increased after a heavy precipitation event in August 2012 to about 15 m per month along with a decreasing surface velocity close to zero. At its maximum, the surface depression had a diameter of around 50 m and a depth of around 15 m at the downhill side.

Fig 1: Rates of elevation change according to the ALS surface of 2006



The formation of the surface depression at the tongue of Gepatschferner is shown in the Figures 1-3. Figure 1 shows the rates of the elevation change since the beginning of the stake measurements in relation to the surface of the ALS DEM in 2006, where the surface depression did not exist. In Figure 2 daily mean volume changes between the available ALS DEMs are shown. Figure 3 gives an overview to the changes along the stake cross-section through the surface depression (Fig. 4).

Fig 2: Calculated daily mean volume changes between the ALS DEMs

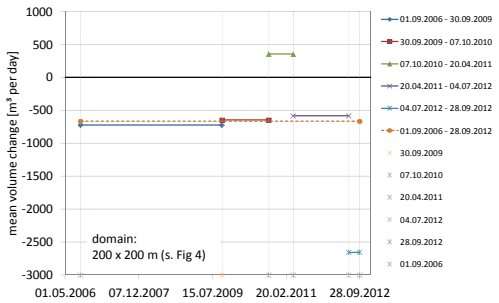


Fig 3: Elevation change at the cross-section and DGPS measurements at stakes

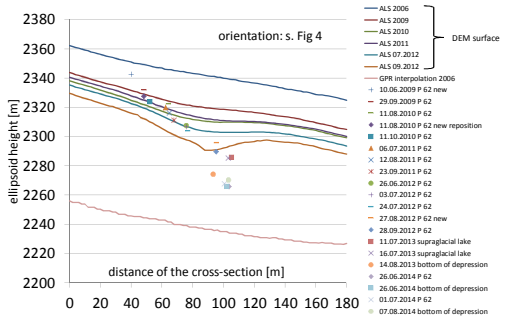
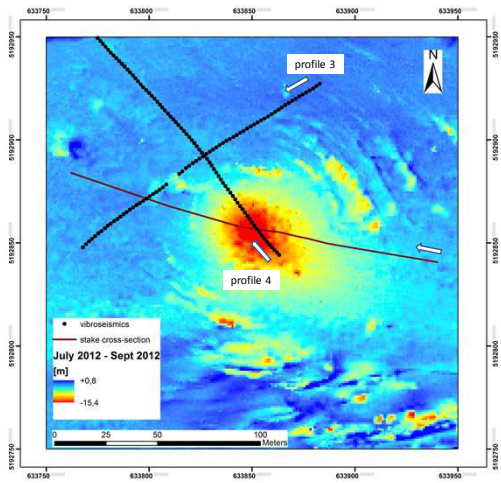


Fig 4: ALS DEM difference July 2012 – Sept 2012 (domain: 200 x 200 m)

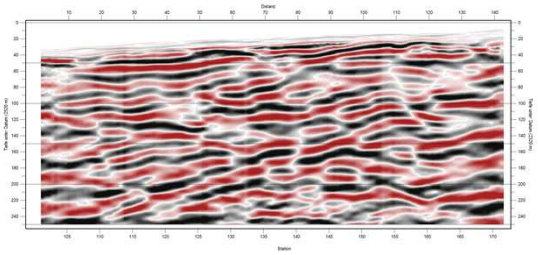


What is the reason for the development of the surface depression?

- Formation due to the dynamics of the tongue?
- Evacuation of subglacial sediments?
- Subglacial lake outburst?
- Existence of a natural sediment trap?

} Combination?

Fig 5: Seismic section of the vibroseismic profile 4 in 2012, incl. topography (orientation s. Fig 4).



Guiding values of the shear-wave velocities on Gepatschferner

Snow:	500 – 800 m/s
Ice:	mean velocity: 1780 m/s
Sediment and loose rock:	1000 – 2000 m/s
Solid rock:	>2000 m/s
Water:	0 m/s

Fig 6 (below): Time-migrated shear wave section of the vibroseismic profile 4 in 2012 with velocities in colors (orientation s. Fig 4).