



Influences of Climate Warming and Facility Management on Continuous Permafrost at Matterhorn Glacier Paradise, Zermatt, Swiss Alps.

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In many parts of the Alps, hazardous bedrock instabilities occur more often during the past 30 years. In many cases, permafrost degradation played a central role for instability (e.g. in 1987 the Val Pola rockslide, Italy). At other events, the role of permafrost degradation is more complex or unpredictable (e.g. in 1991 the Randa rockfall, Wallis, Swiss Alps). However, instabilities in perennially frozen bedrock may also be provoked by human influence. This is exemplarily shown at touristic facilities in the Alps.

Human impact on permafrost is often underestimated, or even carelessly taken into account. The tourist resort Zermatt with more than 1.8 million overnight stays per year is located at 1600 m a.s.l. and is surrounded by high mountain ranges that often reach above 4000 m. The dry and sunny climate results in a high glacier equilibrium line thus leaving space for vast non-glaciated permafrost terrain. Numerous tourist facilities provide excellent logistics and easy access to permafrost sites, and the region is thus especially suitable for permafrost research.

The infrastructure erected on permafrost consists of hotels, restaurants and mountain huts, station buildings of railways, funiculars, ski lifts and installations for artificial snowing the ski-runs. Some problems at these constructions due to permafrost degradation are shown. At the Matterhorn Glacier Paradise station at an altitude of 3820 meters, today's MAAT ranges between -6°C and -8°C . During the construction of a tunnel in 1981 bedrock temperatures were at -12°C . Over the past 30 years, these bedrock temperatures have risen to -3 to -2°C , due to the heat brought into the tunnel by facilities and more than 490,000 visitors per year. In an elevator shaft, the temperature temporarily even rose above freezing point. Several new construction sites in continuous permafrost are described and new research data is presented.

Another interesting site for permafrost and ice studies at Matterhorn Glacier Paradise is the glacier palace. Since summer 2011 this tourist attraction can be accessed via two elevators leading to an ice tunnel about 12 meters below the glacier's surface. Interesting thermal interactions exist between the permafrost bedrock that is in direct contact to the glacier ice. Great care has to be taken that there is no heat transfer from buildings to the glacier ice.

Degradation of permafrost due to climatic change and human interference may become a serious threat to many installations of high mountain tourist centers. These facilities need appropriate management. Permafrost scientists may provide the necessary expertise for a proper hazard management.