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Fact sheet for the now-collapsed Birchgletscher, Switzerland

SUMMARY: On Wed 28.05.2025, 15:24 CEST, the glacier known as Birchgletscher (Valais, Switzerland), collapsed under the weight of the rock-debris that had accumulated on its surface due to a series of rock avalanches originating from Kleines Nesthorn, a mountain peak that became unstable in the course of the preceding week. This factsheet provides our present understanding of the situation, including key background information about the glacier, its pre-event behavior, the role of permafrost, possible links to climate change, and information about comparable events involving glaciers in the past.

Key facts about the glacier

Name: Birchgletscher
Swiss Glacier Inventory (SGI) ID: B32-06
Location (Lon/Lat; WGS84 coordinates): 46.402542, 7.838604
Elevation range (as of 2023): from 2563 to 3430 m a.s.l.
Area (as of 2023): ~0.34 km^2 (of which about 0.12 km^2 were impacted)
Ice volume (as of 2023): ~5.5 million m^3 of ice (of which ca. 3 million m^3 were impacted)
Maximum ice thickness (estimated): ca. 50 m
General characteristics: The small glacier consisted of three disconnected parts. Whereas the upper two glacier sections are steep, contain little ice volume and are unrelated to the present instability, the main body of the glacier had smaller surface slopes and was mostly covered by supraglacial debris before its collapse.

Pre-event evolution

Due to two notable snow and ice avalanches in December 1993 and December 1999, which had a partial impact on the local infrastructure, the upper part of Birchgletscher has been under observation over the past decades. Since about 2019, the front of the lower part of the glacier advanced by approximately 50 meters related to an acceleration of ice flow (https://www.planet.com/stories/birchgletscher-_aQhOXzNg). At the same time, ice thickness at the glacier snout increased by up to 15 meters between 2017 and 2023, while the glacier dynamically thinned in the upper reaches. This unusual behavior was possibly due to the accumulation of rock debris that originated from periodic, pre-event rockfalls. While not adding significant mass to the glacier, this debris insulated the glacier ice, thus reducing melting rates. These changes of Birchgletscher, diverging from all other Swiss glaciers, were known to authorities and were thus monitored regularly.

Present understanding of the event on 28.05.2025

While detailed investigations will need to follow, the main drivers of the event on 28.05.2025 appear to be (i) the terrain motion caused by the partial collapse of Kleines Nesthorn, a formerly 3335 m a.s.l. high mountain peak located above the glacier, and (ii) the accumulation of a large quantity of rock debris, originating from a series of medium- to large-sized rock avalanches stemming from Kleines Nesthorn.

The weight of these accumulated materials must have resulted in the following effects on the ice although the relative role in triggering the failure still remain uncertain: (1) A strong increase in pressure on the ice, which – in a temperate glacier – leads to more pressure melting and thus both basal and englacial water production, estimated to be in the order of 10 mm and occurring directly after the deposition of the rock mass. (2) The observed acceleration of ice flow after the deposition of the rock mass (estimated at up to 10 m/day), which resulted in high shear heating and represented an estimated additional water input at the glacier base of ca. 5 mm/day. (3) The onset of snow melting and a minor rainfall immediately before the failure, contributing additional water to the system. (4) A strong increase in basal shear stress due to additional loading of the glacier and approaching the limit which the glacier bed can support. (5) Strongly accelerated motion of the uppermost part of the landslide deposit beneath Kleines Nesthorn in the morning of 28 May is likely to have exerted an additional force on the glacier that finally led to its failure.

Combined, these factors likely resulted in a rapid rise of englacial water pressure and, thus, reduced basal friction, as indicated by the acceleration of the ice flow before the failure. This eventually destabilized the entire lower and thicker part of the glacier and caused a catastrophic rock-ice avalanche burying the village of Blatten. Differencing of digital elevation models indicates a glacier volume of 2.9 million m^3 and a rock/debris volume of 6.4 million m^3 involved in the failure. The fall of these roughly 20 million tons of material over an elevation difference of 1200 meters released a large amount of potential energy theoretically sufficient to melt as much as ~1 million tons of ice. It is estimated that this resulted in the melting of around 27% of the involved ice volume. It took around 40 seconds from the triggering of the rock-ice avalanche to reach the valley floor, equaling an average speed of around 200 km/h. The resulting rock-debris and ice mixture impacted the village of Blatten and led to the damming of the Lonza River, which flows in the valley below the glacier. Two days after the landslide, a stream channel formed in the rock-ice deposit and the level of the newly formed lake stabilized.

The situation of the glacier before and after the collapse is illustrated by Rapid mapping acquired by the Federal Office of Topography swisstopo (https://s.geo.admin.ch/y1o40mtw055l). This indicates that the entire lower section of Birchgletscher has disappeared (0.12 km^2).

Former glacier bed of Birchgletscher (now filled with debris) and marginal ice remaining after the collapse. Photo: 01 June 2025, D. Farinotti

The role of climate change

Globally, human-induced climate change has led to a long-term warming of about 1.2°C since pre-industrial time (1864)[1] A year-long average global warming of 1.5°C was exceeded for the first time in 2024[2]. Regional warming in Switzerland has been about twice as large than the mean observed global warming, reaching a long-term warming of 2.9°C in 2024[3]. It is well established that this warming, mostly caused by the burning of fossil fuels since the middle of the 20th century[4], has led to widespread glacier melting and permafrost thawing in the Swiss Alps, as well as to changes in snow cover, the timing of snowmelt, changes in streamflow, and to an increase of heavy precipitation[5] (CH2018). These trends are projected to continue over the next decades and affect natural hazards in various ways.

Rockfall in mountains are now happening more frequently than in historical times, while trends remain unclear for larger events such as rock avalanches[6]. Human-induced climate change has been identified as a causal factor contributing to this increase in frequency, but robust statements are difficult due to observational bias, i.e. the varying number of observations though time, as observation capabilities increase. Although dedicated analyses will need to be conducted, it is thus likely that climate change in the Swiss Alps has contributed to key elements of the event notably including (1) substantial glacier retreat over the last century and the loss of snow and firn coverage, which permitted more direct interaction between the warming atmosphere and parts of the underlying rock, and (2) degradation of permafrost which facilitated the percolation of water from either melting or rain into deeper rock compartments, eventually reducing shear strength through repeated freeze-thaw cycles and other processes.

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[1] https://www.earth-system-science-data.net/about/news_and_press/2024-06-05_indicators-of-global-climate-change-2023-annual-update-of-large-scale-indicators-of-the-state-of-the-climate-system-and-human-influence.html

[2] https://climate.copernicus.eu/global-climate-highlights-2024

[3] https://www.meteoswiss.admin.ch/climate/climate-change.html

[4] https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf ; https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter05.pdf

[5] https://www.nccs.admin.ch/nccs/en/home/climate-change-and-impacts/swiss-climate-change-scenarios/technical-report.html

[6] https://www.sciencedirect.com/science/article/pii/S0012825224002137

The area of the rock instability at Kleines Nesthorn that initially triggered the Birchgletscher collapse lies within a zone of permafrost, as indicated by the map of potential permafrost distribution (https://s.geo.admin.ch/6nbb4ccmkp08) by the Federal Office for the Environment. Rapid increases in ground temperature have been observed across the Alps[7] and the area was identified as both warm permafrost and as potentially critical because of its vicinity to infrastructure[8].

While long-term geological preconditioning certainly played a role in the failure of Kleines Nesthorn, and while the event was the result of several compound elements that require further analysis, there are several indications suggesting that climate change played a role in the processes that led to the collapse and the subsequent cascading event.

Deposition in the valley floor. Photo: 01 June 2025, D. Farinotti

Comparison to other historical events

At the scale of the Swiss Alps, the recent event is unprecedented. This is true for both the dynamics and the impact of the rock-ice avalanche. However, some parallels exist to other known events in both Switzerland and globally:

- There are some similarities to the 2017 event at Pizzo Cengalo (Grisons, Switzerland), where ~3 million m^3 of rock impacted a small glacier below, partially entraining it and forming a highly mobile debris flow that caused damage in the downstream village of Bondo and claimed eight lives along the way.
- Notable even if different in nature, is the rock-ice collapse on 14 April 2024 at Piz Scerscen (Grisons, Switzerland), which involved an estimated volume of 8-9 million m^3 but did not cause any damage. Here, a glacier sat atop a large rock volume that failed, and the resulting mass-flow ran about 5 km out of the Roseg valley.
- Outside of Switzerland, some similarities can be seen with the much larger Kolka-Karmadon glacier collapse, which happened on 20 September 2002 in the Russian Caucasus Mountains. In that case, heavy rock and ice falls from the northern flank of the Kazbek massif deposited several million m^3 of material on the glacier surface. In response to this, the

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[7] https://doi.org/10.1038/s41467-024-54831-9
[8] https://www.e-periodica.ch/digbib/view?pid=vsp-004:2022:27::195#36

relatively flat glacier accelerated, and thus bulged and crevassed, and eventually detached completely. This caused around 130 million m^3 of ice to rapidly accelerate, travel up to 19 km downstream, and deposit a debris layer of locally over 100 meters in the valley. The ice and debris buried the village of Nizhniy Karmadon, dammed the river flowing into the Genaldon gorge, flooding additional settlements and caused at least 125 casualties.

- On an equally large scale, the detachment of Sedongpu Glacier (southeast Tibet) in October of 2018 removed around 130 million m^3 of ice. This detachment occurred after a rock avalanche of 50 million m^3 that impacted the glacier a year prior. The rock avalanche had no apparent immediate impact on the glacier, but large ponds formed on the glacier and the flow velocities increased from 1-3m per day to 25 m per day during the 9 months before the detachment. This ultimately culminated in the complete failure of the glacier and a damming of the Yarlung Tsangpo river.

A summary of other known events with some similarity (not including the Swiss events at Pizzo Cengalo and Piz Scerscen) can be found in the following publication: https://tc.copernicus.org/articles/15/1751/2021/.

Further information

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Imagery

The link below provides images and videos of Birchgletscher and the deposits at the valley floor, as taken on our field visit of 01 June 2025. Imagery may be reused when stating the source: *"VAW Glaciology - ETH Zurich & WSL Sion"*. The materials are shared with the permission of the Meldungsstab Kippel, whose work is greatly appreciated.

https://polybox.ethz.ch/index.php/s/fMz9LLwop9qiBzr