



# GEOTOURISTIC ATTRACTIVENESS OF BRIKSDALEN VALLEY AGAINST THE BACKGROUND OF CHANGES IN THE EXTENT OF BRIKSDALSMBREEN GLACIER (SOUTHERN NORWAY)

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**Abstract.** The aim of the study is to present the geotouristic attractions of Briksdalen valley (south-western Norway), with particular consideration of changes in the maximum extent of the Briksdalsbreen glacier from the 18th century to the 2020s. The article describes landforms resulting from glacial morphogenetic activity, such as terminal moraine ridges, glacial grooves and striations, potholes and crescentic gouges, which are treated here as discrete (point) geomorphological sites. It also traces changes in the extent of the glacier tongue, focusing especially on the period 1997–2024, when the glacier underwent rapid retreat, with rates periodically exceeding 100 m per year. The article further addresses the issue of protecting the postglacial landforms, that attest to the glacier’s rapid disappearance. It is found that the moraine ridges marking the glacier’s last maximum extent (1996/97) have received no protection whatsoever from trampling by tourists. The article also seeks to promote the region among a wider audience and to encourage geotouristic visits

**Key words:** geotourism, geosites, geoheritage, Briksdalsbreen glacier, Jostedalbreen National Park

## Introduction

Geotourism is loosely understood to be the visiting of geological and geomorphological sites (Słomka, Mayer 2011). The widely applied concept of geotourism was introduced into the literature in 1995 by Thomas A. Hose. He defined it as: “The provision of interpretive and service facilities to enable tourists to acquire knowledge and understanding of the geology and geomorphology of a site (including its contribution to the development of the Earth sciences) beyond the level of mere aesthetic appreciation” (Hose 1995). This definition can be extended to include other strictly geomorphological features, such as natural terrain features, including glacial, slope and morphological features (land slope, landform shape, exposure, etc.), as well as the products of natural processes

such as erosion or mass movements (Miśkiewicz *et al.* 2007).

Geotourism clearly goes hand in hand with geological heritage (geoheritage). According to Urban *et al.* (2020) (after Urban *et al.* 2021), geoheritage focuses on abiotic elements of nature – fragments of the Earth's crust, relief, and processes shaping the Earth – that enable the scientific reconstruction of the history of the Earth and of life on it and develop our understanding of the processes shaping it, as well as elements of importance to the cultural and intellectual life of humankind. It should be noted that geological heritage plays an increasing role at various levels of education (see Migoń 2012; Górską-Zabielska 2015; Górską-Zabielska *et al.* 2022).

Given the article’s focus, we should also address “geomorphosites”. These are natural land-

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forms (as well as those modified or created by human activity) that have scientific, cultural or socio-economic value, due either to human perception or to how they are exploited (Reynard 2005, 2009). Geomorphosites are also mentioned by, among others, Wimbledon *et al.* (1999), Migoń (2012) and Górska-Zabielska *et al.* (2024). Geosites range from single outcrops to extensive, complex features such as the unique Dunajec Gorge in the Pieniny Mountains (Górska-Zabielska *et al.* 2024). Fuertes-Gutiérrez and Fernández-Martínez (2010) classify geosites into five typological categories: point, section, area, complex area, and viewpoint. Point geosites can be relatively small, such as erratic boulders, which can be <30 cm along their shortest axis (Górska-Zabielska *et al.* 2022). Geosites can be local, regional, national or global, depending on their scientific significance (Zorina, Silantiev 2014).

In line with the aforementioned view of geotourism and the “promotion” of relief in popularising geomorphology, this study focuses on post-glacial landforms in the Briksdalen valley. The importance of landforms in geomorphological research, overlooked in recent years or even decades, was aptly described by Goudie (2002), thus:

Aesthetics and relevance are essential for making geomorphology a discipline that appeals to the general public and to potential students. A concentration on process studies has led to a relative neglect of landforms, yet, it is landforms that have often stimulated geomorphologists themselves to become geomorphologists. The study and explanation of visually attractive landscapes, the demonstration of the relevance of the discipline to society's needs and, following on from that, a concern with global change, are three areas that need to be developed by geomorphologists.

The documented changes in the Briksdalsbreen glacier head form part of the broader evidence of contemporary climate change. Such visible glacier retreat can raise ecological awareness and support pro-environmental education among visitors (cf. Górska-Zabielska 2024).

## Research objective and scope

The aim of this study is to provide a detailed description of the geotouristic values of the Briksdalen valley (south-western Norway), with particular emphasis on glacial landforms and terrain features regarded as geomorphological geosites. These

features are examined in the context of changes in the extent of the Briksdalsbreen glacier terminus from the onset of the Little Ice Age (LIA) to the present, paying special attention to the period 1997–2024. This sub-period was selected because it has been characterised by dynamic changes in both the glacier's extent and in the landscape of the valley's lower reach. The article also discusses the protection of glacial landforms in the study area.

The valley was selected because the combination of point-type geomorphological geosites, rapid changes in extent of the glacier terminus, the valley's easy accessibility and its considerable tourist traffic make it an outstanding example of the touristic value of glacial heritage.

The research objectives were addressed primarily through analysis of articles by Norwegian researchers, cartographic materials of the Geological Survey of Norway (Norges geologiske undersøkelse) available at <https://www.ngu.no/> and <https://hoydedata.no/LaserInnsyn2/>. From the latter portal, a digital terrain model was downloaded. These secondary data were supplemented by the author's own field observations conducted during six visits to the Briksdalen valley between 1997 and 2024. The locations of the terminal moraines shown on the geomorphological sketch (Fig. 4) mark the maximum extents of the glacier tongue and were identified using field GPS measurements taken at the information boards installed at each moraine (see Photo 5). The positions of the tongue in 1997, 2008 and 2024 were plotted on the geomorphological sketch on the basis of direct field observations.

## Study area location and general morphological characteristics

The study area lies in the north of the Vestland district of Norway (Fig. 1), at the latitude of the upper section of the Nordfjord in the south-western Scandinavian Mountains.

The area of detailed study, namely the Briksdalen valley (Briksdalsbreen glacial valley), is a hanging valley that joins the upper section of the Oldedalen valley (Fig. 2). The Oldedalen valley is ~20 km long, running meridionally to its final connection to the Nordfjord.

The Briksdalen valley trends east–west and is 2.6 km long. The floor of the upper valley section lies at ~350 m a.s.l., while the mouth into the Oldedalen valley is at 140 m a.s.l. (Fig. 2 and Fig. 3a).

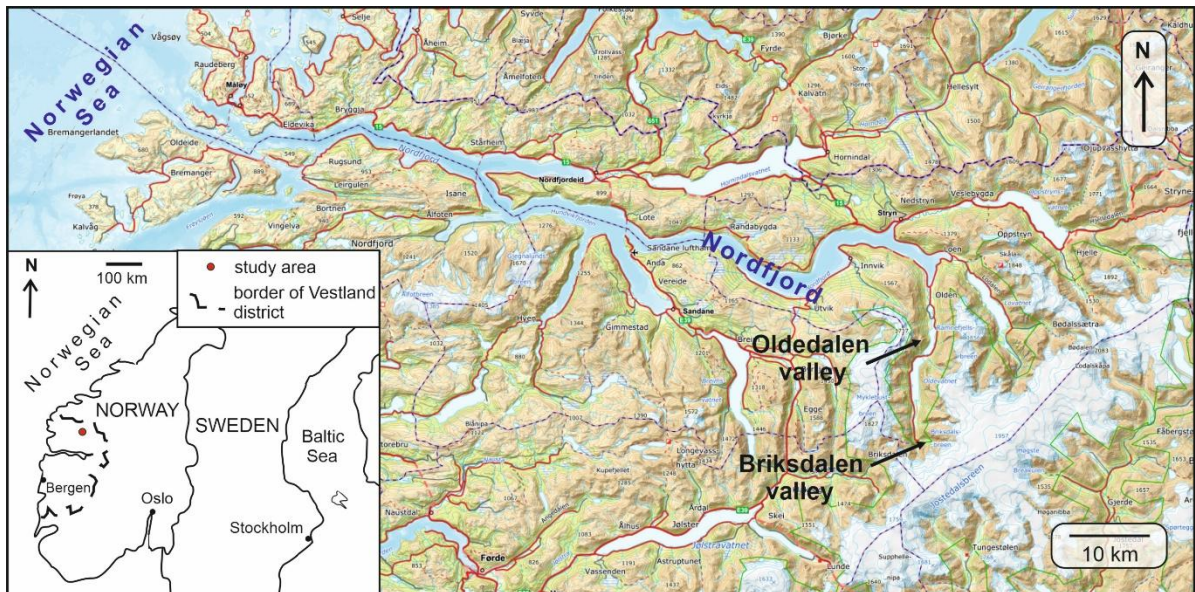


Fig. 1. Study area location

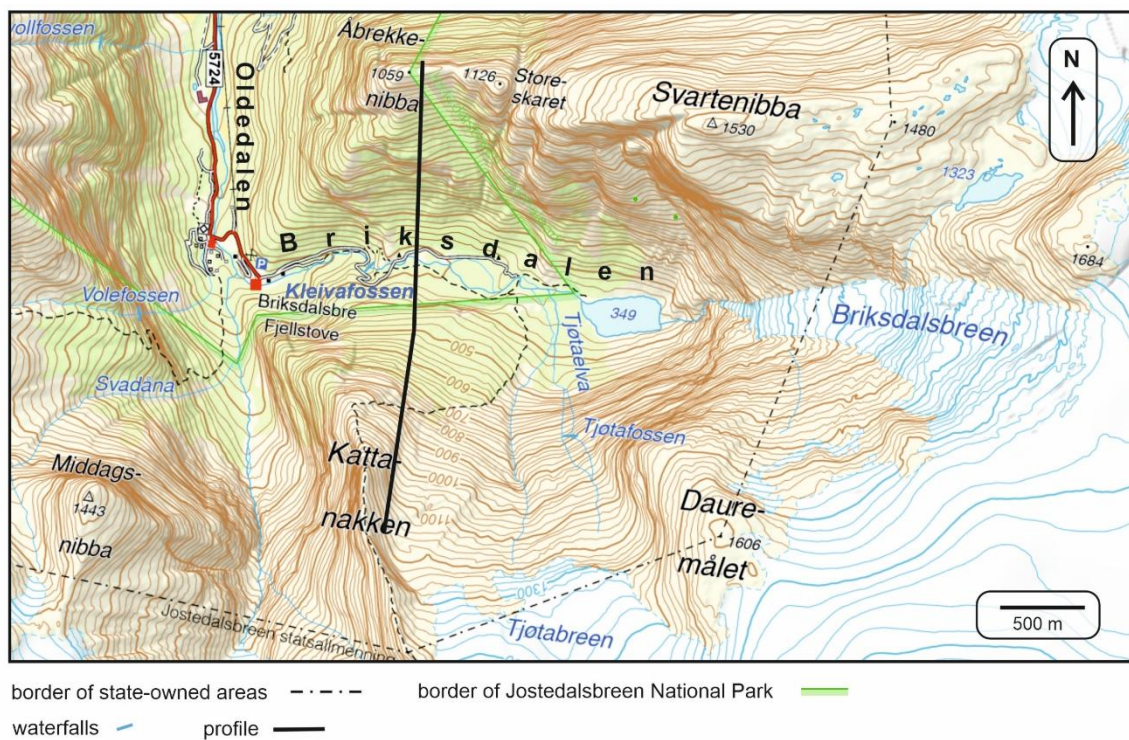


Fig. 2. Topographic map of the study area (based on GeoNgu 2025a, slightly modified)

A prominent knickpoint occurs in the valley floor – the site of the 35-metre-high Kleivafossen waterfall (Photo 1).

In the upper valley, at 350 m a.s.l., lies the Briksdalsbrevatnet lake (Photo 2), which covers an area of 8.5 ha. Above the lake, on the slope enclosing the valley and connecting its floor to the

plateau above, stretches the tongue of Briksdalsbreen. In 2024, the glacier terminus was situated at ~550 m a.s.l. (Fig. 2, Fig. 3a). This glacier forms part of Jostedalbreen – continental Europe’s largest glacier. Briksdalsbreen itself covers ~10 km<sup>2</sup> and extends ~6 km from elevations above 1,900 m a.s.l. (Nesje, Matthews 2012).



Photo 1. Kleivafossen waterfall (*photo by M. Majewski 2024*)



Photo 2. Briksdalsbrevatnet lake and the tongue of Briksdalsbreen (*photo by M. Majewski 2024*)

The valley exhibits a typical U-shaped cross-section (Fig. 3b), and the concave bottom just above the Kleivafossen waterfall is ~250 m wide. Along the valley, from the Briksdalsbrevatnet lake to the Oldedalen valley, flows the Briksdalselva stream, whose channel bed features numerous small steps and erratic boulders. In several places, the channel branches into several smaller streams

and includes surfaces composed of fluvioglacial deposits (see Fig. 4). The hills flanking the valley to the north and south rise to 1050–1600 m a.s.l.

The bedrock of the Briksdalen valley and the entire upper Oldedalen valley consists predominantly of Neoproterozoic monzonites. The area was uplifted during the Caledonian orogeny (Norges geologiske undersøkelse, GeoNgu 2025b).

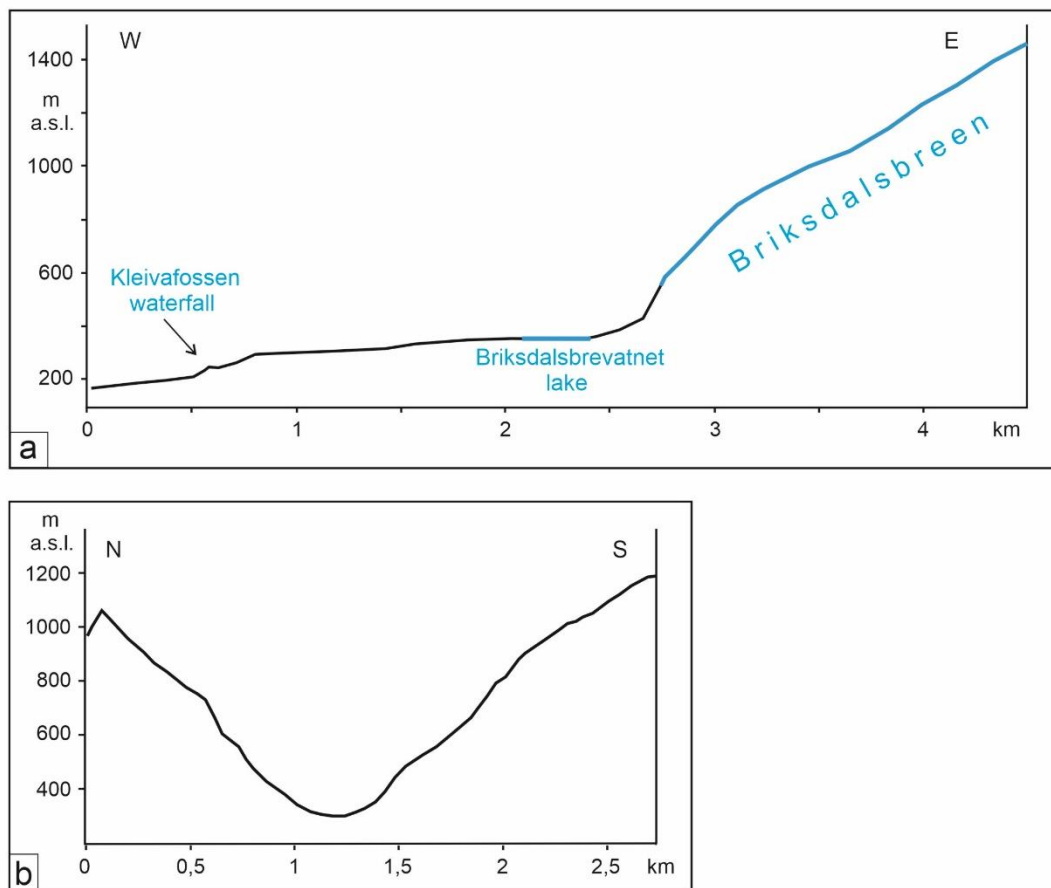


Fig. 3. Briksdalen valley  
 a – longitudinal profile  
 b – cross-sectional profile above the waterfall

The upper Briksdalen valley (roughly to the western shore of the lake) and the entire Briksdalsbreen glacier lie within the Jostedal National Park (Jostedal nasjonalpark). The entire valley and western part of the glacier are designated as the Briksdalen geosite and have been protected since 1991 (GeoNngu 2025).

A hiking trail (described later herein) runs along the valley floor. Its difficulty level is rated as easy or very easy. The route starts at the Briksdalsbre Fjellstove car park ( $\varphi = 61^{\circ}39'49''\text{N}$ ,  $\lambda = 6^{\circ}49'27''\text{E}$ ) and ends at the north-western shore of the Briksdalsbrevatnet lake ( $\varphi = 61^{\circ}39'51''\text{N}$ ,  $\lambda = 6^{\circ}51'33''\text{E}$ ) (see Fig. 2). The trail is 2.4 km long and can be hiked in ~40–50 minutes. Alternatively, one can take a shuttle ride in an electric utility vehicle. Notably, however, the route taken by these vehicles bypasses most of the marked geosites.

### Movements of the Briksdalsbreen glacier head from Little Ice Age to present

Briksdalsbreen has long been a major tourist attraction and an important scientific research subject, especially for geologists, geomorphologists and climatologists. As early as around 1900, Johan Rekstad of the Bergen Museum began annual measurements of the glacier front (Winkler *et al.* 2009). Scientific interest in the glacier itself stems partly from the excellent record of frontal oscillations in the terrain and from the exceptionally short response time of its mass budget to climate changes – only 3–5 years (e.g., Nesje *et al.* 1995; Laumann, Nesje 2009). These climatic changes are expressed primarily in variations in summer temperatures and winter precipitation.

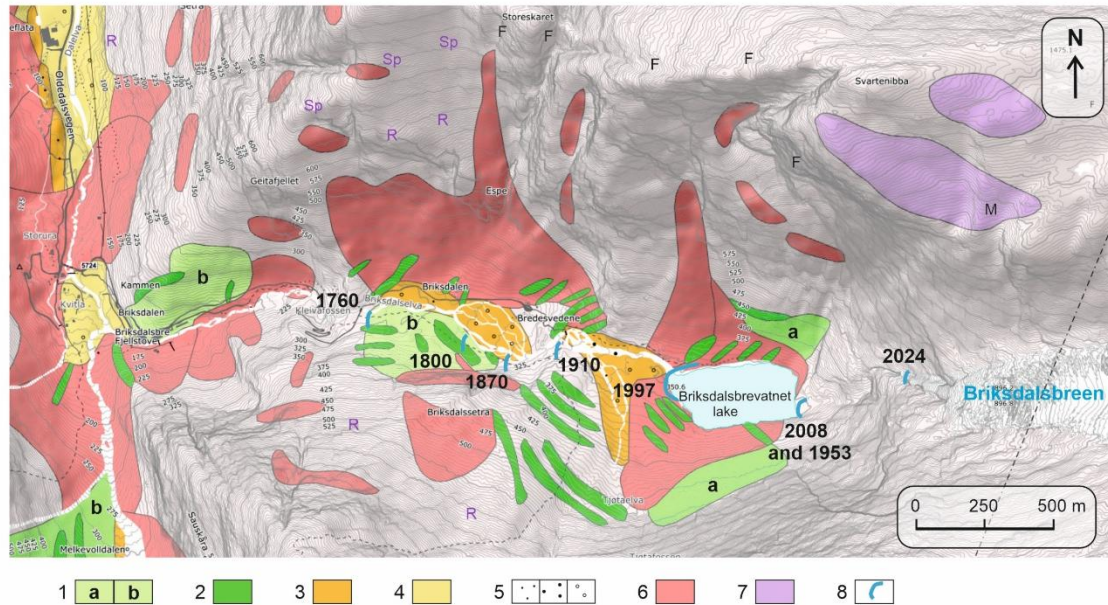


Fig. 4. Geomorphological situation and changes in the extent of Brikdalsbreen (based on GeoNgu 2025c, with additions)

1 – moraine material: a) continuous, locally very thick cover, b) discontinuous/thin cover; 2 – terminal and lateral moraines; 3 – glacialfluvial deposits; 4 – fluvial deposits; 5 – sands, gravels and cobbles; 6 – landslide material; 7 – weathering cover; 8 – terminus position by year; F – weathering cover; M – moraine material; R – slope deposits of varying thickness; Sp – rock (debris) glaciers

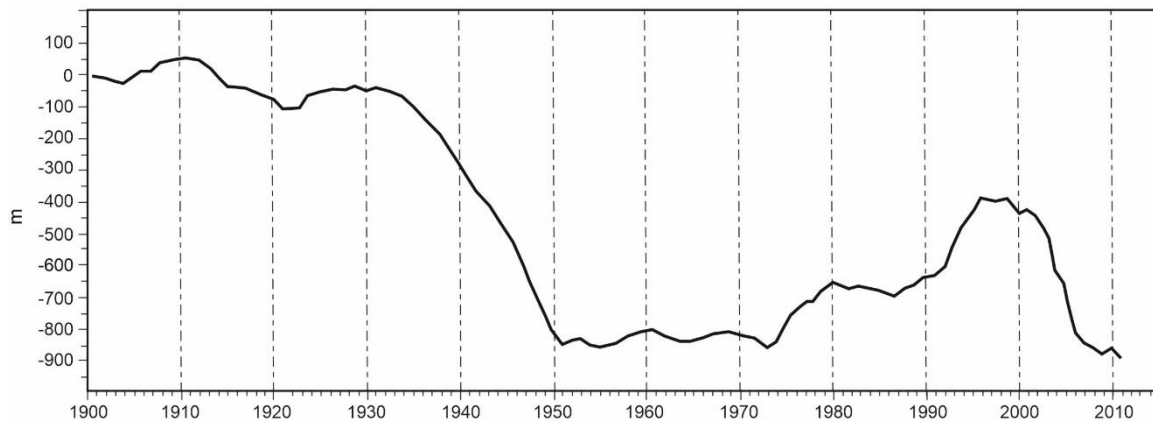


Fig. 5. Changes in extent of Brikdalsbreen, 1900–2011 (after Nesje 2014, slightly modified)

During the Little Ice Age (LIA), Brikdalsbreen reached its maximum extent around 1760–65 (Nesje 2014, after Pedersen 1976). It was also in the LIA that the entire Jostedalsglacier attained its greatest Neoglacial dimensions (Carrivick et al. 2022). The Brikdalsbreen tongue advanced almost to the lip of the present-day Kleivafossen waterfall, covering ~1,600 m of the valley floor (Fig. 4). After this period, the glacier head began to retreat. By 1800, its terminus had receded by ~360 m (Fig. 4), corresponding to an average rate of 9–10 m/year.

The next well-documented terminus position dates to 1870 and indicates a retreat of ~180 m in 70 years (average 2.6 m/year). The terminal moraines associated with the 1870 and 1910 glacier fronts lie ~190 m apart. However, this period saw both glacier regression (until around 1903) and a subsequent advance thereafter (Fig. 5). Then, in 1910–12, Brikdalsbreen reached its greatest extent of the 20th century and the first decades of the 21st, a position it is not expected to regain in the coming decades (see Laumann, Nesje 2009).

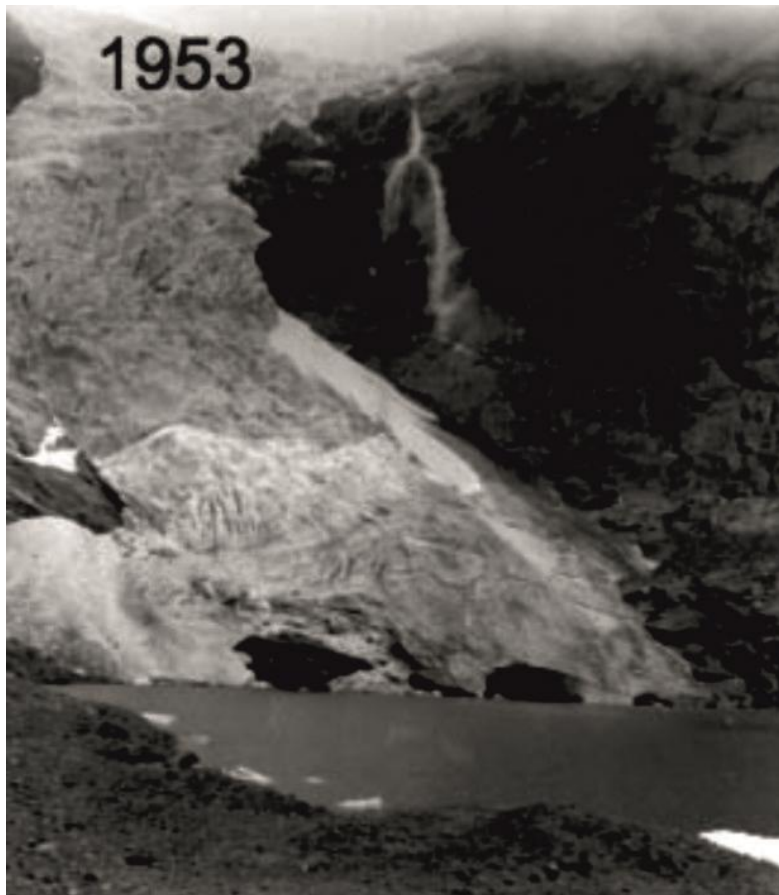


Photo. 3. Extent of the Briksdalsbreen tongue in the early 1950s (after Nesje 2014)

The glacier front remained relatively stable until the mid-1930s, with a slight tendency towards retreat, but the recession rate then increased considerably up to 79 m in 1948 alone (Nesje 2014). By the turn of the 1950s, the Briksdalsbrevatnet lake was entirely exposed (see Photo 3).

From the mid-1970s to 1996, the glacier front advanced almost continuously (with only a minor retreat in the first half of the 1980s). Between 1987 and 1997, it advanced by 441 m. By the end of this period, the glacier had reached the distal part of the proglacial lake Briksdalsbrevatnet (see Fig. 4) and was advancing into the unfrozen, fine-grained, water-saturated glaciolimnic lakebed sediments, creating terminal moraines (Winkler, Nesje 1999). In just four years (1993–1996) Briksdalsbreen advanced an impressive 278 m (Nesje 2005). The glacier front reached its maximum extent in 1996 and remained there until 1997, with the glacial tongue covering the entire lake (Photo 4).

The period 1997–2024 was one of frontal retreat. According to Nesje and Matthews (2012),

Briksdalsbreen retreated by 486 m between 1996/97 and 2009, peaking at 145 m/year in 2005/06 – the maximum annual retreat recorded since measurements began in 1900.

According to Hart *et al.* (2011), the average retreat rate between 2000 and 2007 was a dramatic 70 m/year. This recession resulted from a combination of higher summer temperatures, reduced precipitation (linked to the negative phase of the North Atlantic Oscillation), and increased fracturing of the tongue. The progressive exposure of the proglacial lake further accelerated retreat by enabling calving, and it promoted crevasse formation and fluctuations in water content at the glacier margin.

By 2008, the lake surface was fully exposed again (photo 4) and the terminus had receded to 350 m a.s.l. In 2011, the lower part of the glacier “split in two” (Nesje 2014). By 2024, the tongue had receded to an elevation of ~550 m a.s.l., and its disconnected lower part had ceased to exist.



Photo 4. Changes in extent of Briksdalsbreen, 1997–2024 (photo by M. Majewski)

### Glacial landforms and changes in glacier extent as a geotourism attraction in Briksdalen

The most characteristic and abundant glacial landforms in the Briksdalen valley (other than the tunnel valley itself) are moraine ridges (mainly terminal moraines) that record changes in the glacier extent from the mid-18th century to the end of the 20th century (see Fig. 4). Notably, at Briksdalen's outlet into the Oldedalen valley, terminal moraines dating to the Pleistocene–Holocene transition are also present (Nesje 1996).

The Little Ice Age maximum extent of the glacier is recorded by moraine ridges accompanied by an information board stating that it marks the glacier front position around 1760. Unfortunately, these moraines are poorly discernible in the field in summer due to the relatively dense vegetation (Photo 5).

Far more visible are the terminal moraines dated to 1800 (Photo 6), 1870 and 1910. These provide tourists with clear visual impression of how rapidly the glacier has retreated over recent centuries.

Regrettably, no information boards mark younger moraines that record the extent of the glacier front's recent high activity. Most striking is the absence of any information board at the very prominent terminal moraine from 1996/97 (Fig. 6), which represents the glacier's furthest extent since the mid-1940s.

Other glacial formations, such as ice-polished bedrock, glacial grooves and striations, and potholes, are also marked along the trail through the valley (Photo 7). The name given to each landform is accompanied by a Norwegian and English description of its origins.

In addition to the landforms accompanied by information boards, other geomorphological geotourist attractions include unambiguous glacial striations and glacial gouges, as well as a small pothole. The striations and the pothole occur along the path (Photo 8) but are not accompanied by information boards. Crescentic gouges (Klimaszewski 1978) are preserved, including on rock surfaces between the lake and the glacier tongue.



Photo 5. Terminal moraine from around 1760 (*photo by M. Majewski 2024*)



Photo 6. Terminal moraine from around 1800 (*photo by M. Majewski 2024*)



Photo 7. Postglacial landforms marked along the trail

a – ice-polished bedrock

b – glacial grooves or striations (ambiguous size classification)

c – large pothole (*photo by M. Majewski 2024*)



Photo 8. a – Glacial striations

b – small glacial pothole

c – crescentic gouges (*photo by M. Majewski 2008*)

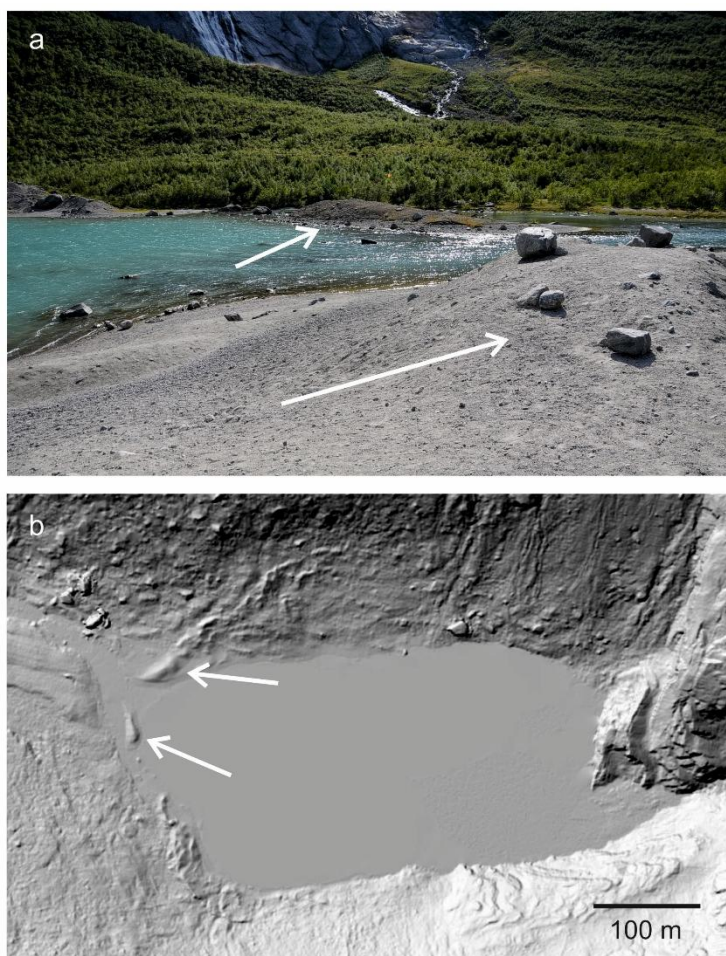


Fig. 6. Fragments of the terminal moraine ridges related to the glacier extent in 1997  
a – image from 2008 (photo by M. Majewski 2008)  
b – image derived from the digital terrain model (Hoydedata 2025)

## Discussion and conclusions

Any discussion of the geotouristic aspects of the study requires a determination of the intended visitor audience. According to Migoń (2012), geotourists fit into three groups according to their level of preparation and receptivity to informational content:

- professionals with specialist training, familiar with specialist terminology and the basics of Earth sciences (geologists, geographers, geoarchaeologists);
- enthusiasts of educational tourism without formal specialist training;
- casual visitors to geotourism sites with no particular prior motivation or knowledge, often visiting incidentally.

From a geotourism perspective, the study area potentially appeals to all three target groups.

Earth-science professionals will find their interest increased by the wealth of the scientific literature on Briksdalsbreen's fluctuations. This group obviously constitutes the smallest among visitors to the valley. For enthusiasts of educational tourism, the site is particularly compelling, especially when guided interpretations (e.g., by a geomorphologist) accompany the trail's boards and descriptions accompanying each terrain feature along the trail. During my own visits to Briksdalen, I have personally guided more than 25 visitors, stimulating their interest in climate change and the origins of the visible landforms. My subjective observations suggest that a significant proportion of visitors to the valley come here incidentally, typically on coach excursions from large cruise ships docking at the port of Olden at the mouth of the Oldedalen valley. These tourists rarely stop at the information boards.

### A subjective assessment of the geotourism potential of the Briksdalen valley

The valley exhibits a high degree of geotourism potential. Firstly, the landscape exhibits minimal human interference: the trail lacks catering facilities, accommodation, observation towers or such. Indeed, other than a few wooden benches and tables installed in recent years, nothing significantly intrudes upon the landscape. Second, the valley offers substantial educational value through its numerous well-described post-glacial forms. Additional strengths include the area's outstanding natural beauty, easy accessibility and the opportunity to see things "up close". Each year, the area

attracts ~300,000 tourists from all over the world (VISITNORWAY 2025) indicating an educational reach far beyond Norway.

The glacier remains the overwhelming central attraction. The 2007 report *Tourism in Sogn og Fjordane ...* (Brandshaug *et al.* 2007) treats the Briksdalsbreen glacier as a tourist attraction in its own right. In the 1990s and early 21st century, one particular attraction was walking on the glacier surface. As retreat exposed the entire lake, what remained of the tongue was too steep to climb, so a new attraction was introduced: pontoon trips to the front, where tourists could go ashore and, for example, interact with ice blocks that had fallen from the upper tongue (Photo 9).



Photo 9. Tourists *en route* to and at the Briksdalsbreen glacier front (*photo by M. Majewski 2008*)

## The valley's geotourism future

Seeing the glacier from just a few hundred – or even tens – of metres can be a deeply emotional experience. The vivid blue of the glacial ice, the deep crevasses, and the roar of falling ice blocks can create impressions that are difficult to articulate in words. If the glacier tongue disappears, the valley will lose much of its geotouristic and broader touristic appeal, and tourism will likely suffer. It is hard to imagine that the glacial landforms and proglacial lake alone would attract tourists in the same numbers as were seen early in the

21st century, when the glacier tongue was visible. Without its hanging glacier, the valley will become one of many similar U-shaped valleys, losing much of its uniqueness.

Detailed forecasts for the future of Briksdalsbreen are anchored in the model by Laumann and Nesje (2009) (Fig. 7), which predicts that the retreat of the steep frontal section above the eastern lakeshore will total 2.5–5.0 km by 2085. This would likely eliminate the spectacular icefall, one of the main tourist attractions in western Norway, transforming Briksdalsbreen into a plateau-type glacier that will gradually melt.

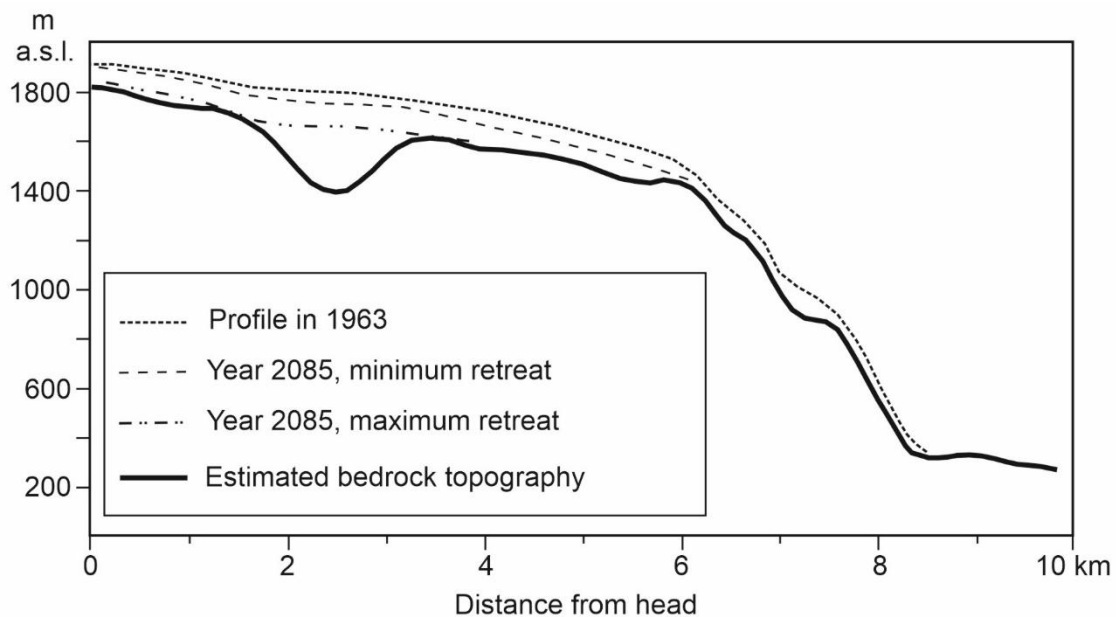


Fig. 7. Projected changes in the extent of Briksdalsbreen tongue (after Laumann, Nesje 2009, slightly modified)

## Protection of glacial forms in the valley

A particularly controversial issue remains the absence of protection of post-glacial forms, especially of the moraines marking the maximum extents of the glacier in the last 80 years, i.e. since around 1945. As mentioned earlier, these moraines are very close to the lake's western shore and have thus been heavily trampled by visitors (see Photo 10).

Unfortunately, the clearly defined hiking trail ends a few tens of metres short of the lakeshore, such that tourists disperse freely in various directions, often walking several times along the moraine ridges. The absence of vegetation in this zone offers no resistance to foot traffic. The lack

of protection of landforms is especially surprising given that the area belongs to a national park and the moraines are an important record of the glacier's recent history – a significance recognised not only by the author, but also, for example, by Norwegian sources (see GeoNgu 2025a). This situation thus leaves room for action by, for example, geomorphologists to protect landforms as items of natural heritage (see Migoń 2008). Given the obvious respect for untamed nature demonstrated by the abundance of tourists visiting Norway, some protection could certainly be afforded by, for example, installing information boards explaining the origins and ages of moraine ridges and in-



Photo 10. Long-term trampling (in Jostedalbreen National Park) of the 1996–1997 moraines recording the glacier's late-20th-century maximum extent (*photo by M. Majewski*)

cluding a request not to climb or walk on them. Many tourists are probably not even aware that they are contributing to erasing significant evidence of rapid environmental change.

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