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The Christmas Landslide at Mt. Hundstein (Lungau, Austria) in 1768: myth or historical fact?

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6 Text-Figures, 1 Table

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natural hazard
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"Wer übertreibt, beginnt abzuweichen von der Wahrheit. Das ist der Anfang der Lüge und die Lüge ist das häßlichste Ding auf der Erde. [...]"
"– Oh Sir, ich werde ganz gewiß nie mehr übertreiben."

Dialogue between the teacher Augustus Thurgar and the five year old Eduard Suess in Prague during the year 1836 (Suess, 1916: 16).

Contents

Abstract

The landslide at Mt. Hundstein, which is supposed to have occurred during the Holy Night of 1768, is documented by the Lungau monograph of Ignaz von Kürsinger (1795–1861) which has been published in 1853. The event is generally taken as historical fact, and is taught as such in the elementary schools of Lungau. It is also narrated by a local book of folktales, which has been printed in several editions since 1922. A careful examination of the story reveals some contradictions between the different narrations, as well as between the narrations on the one hand and the local geological situation on the other hand. Most probably, the landslide story underwent a certain mythification during the first decades after the event, and was progressively modified by imaginative additions. Thus, the original testimonies of the witnesses became altered.

Lichenometric and geological investigations on the spot show, that the landslide was much smaller than it is suggested by the ancient reports and tales. The landslide deposits *sensu stricto* occupy only a small area at the bottom of the Ödkar, at an altitude between 2,050 and 2,140 m. Re-deposited boulders of the avalanche-fan at the bottom of the Lignitz valley are mainly elder than the event of 1768 and are not the result of the historical landslide. The statement that a portion of the Hundstein has fallen to the other side of the mountain ridge, i.e. down to the Weisspriach valley, is an outcome of pure imagination or even a lie.

The traditional story of the Christmas Landslide may be considered as a mythified synthesis of true observations, speculations, religious expectations, dishonest exaggerations, and narrative alterations.

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Der Weihnachtsbergsturz am Hundstein (Lungau, Salzburg) im Jahr 1768: Mythos oder historisches Faktum?

Zusammenfassung

Der Bergsturz am Hundstein, der sich in der Christnacht von 1768 ereignet haben soll, ist in der 1853 erschienenen Lungau-Monografie Ignaz von Kürsingers (1795–1861) schriftlich überliefert, gilt als historisches Faktum und wird an den Schulen des Lungaus als solches gelehrt. Das Ereignis fand auch Eingang in ein Lungauer Sagenbuch, das seit 1922 in mehrfacher Auflage erschienen ist. Bei genauerer Betrachtung zeigen sich jedoch Widersprüche zwischen den überlieferten Berichten, sowie solche zwischen den Überlieferungen einerseits und der geologischen Situation vor Ort andererseits. Anscheinend fand schon in den ersten Jahrzehnten nach dem Ereignis eine gewisse Mythenbildung statt, die in weiterer Folge durch lebhafte Schilderungen, Ausschmückungen und Hinzufügungen zu einer zunehmenden Verfälschung der ursprünglichen Zeugenaussagen geführt hat.

Lichenometrische Untersuchungen und eine geologische Bestandsaufnahme vor Ort sprechen für einen Berg- oder Felssturz, der bei weitem nicht so riesige Ausmaße hatte, wie es die überlieferten Berichte vermuten lassen. Die eigentliche Bergsturzablagerung liegt nur im Karboden des Ödkars, in einer Höhe von ca. 2.050 bis 2.140 m. Der umgelagerte Blockschutt auf dem tiefer gelegenen Murenkegel im Talgrund des Lignitztales ist größtenteils älter als das Ereignis von 1768 und daher nicht unmittelbar und schon gar nicht ausschließlich auf den historischen Bergsturz zurückzuführen. Die Behauptung, ein Teil des Berges sei auch auf der anderen Seite des Grates ins Weißpriachtal gestürzt, dürfte überhaupt frei erfunden sein.

Die tradierte Geschichte des sogenannten Weihnachtsbergsturzes ist eine mythifizierte Synthese tatsächlicher Beobachtungen, spekulativer Zeugenaussagen, religiöser Erwartungen, betrügerischer Übertreibungen und diverser Verfälschungen durch spätere Erzähler.

Introduction

Since the early days of geological science, our understanding of landslide mechanisms is based on direct observations and on historical documents of such observations. The landslide of Goldau (Kanton Schwyz, Switzerland), for example, which occurred in 1806, in the afternoon of September 2nd, has been observed by several people, and their testimony has been summarized in a newspaper (“Neue Zürcher Zeitung”) from September 9th. Another example is the Elm landslide (Kanton Glarus, Switzerland), which occurred in 1881, in the afternoon of September 11th (cf. Heim, 1932). In the meantime, many other examples of landslide testimonies were published, and their number still increases (Kariya et al., 2007).

However, it should be borne in mind, that the terms “true” and “historical” are not synonymous. Not every chronological fact is described by historical documents, and not every testimony is necessarily true in the strict sense of the word. The specific circumstances of terrifying events can produce an exceptional psychological situation, including traumatic memory and stimulated imagination.

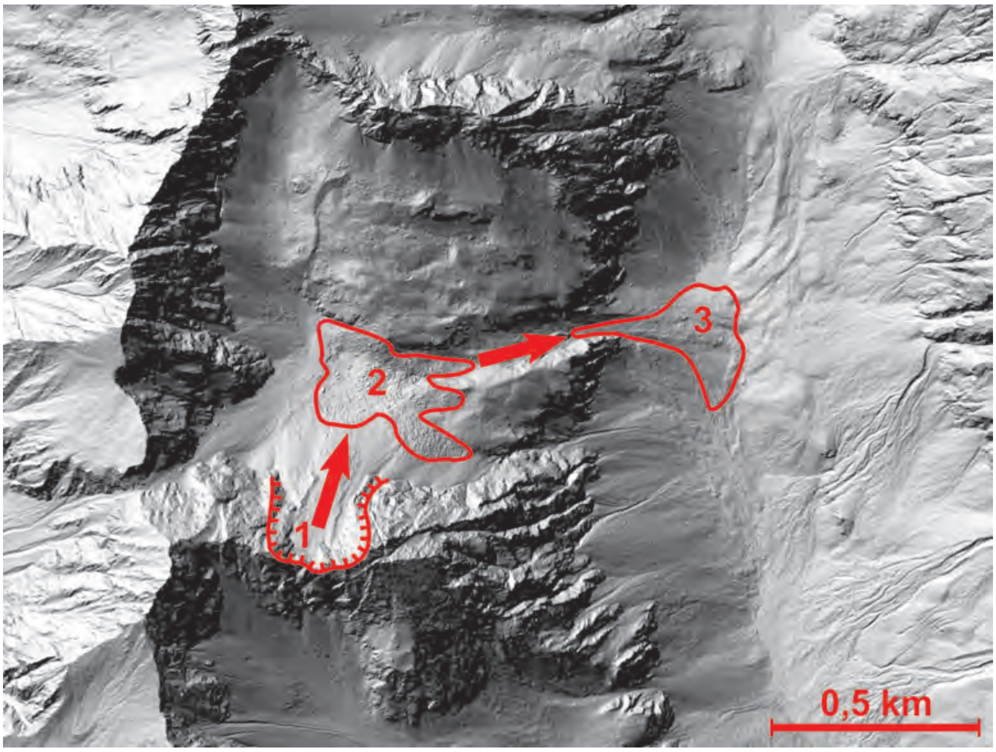
The scientific term of myth geography was introduced by Riedl (2010) for the attempt to clarify mutual relationships between the human perception of landforms and the mythological expectations in a specific sociocultural environment. This concept has been applied to mythological aspects of the Cyclades (Riedl, 2010) and to regional examples from Lower Austria (Riedl, 2016). Mythological research is often concerned with the historical input and age of myths, but also with psychological, linguistic and anthropological questions. In general, myths are traditional stories which are reported over several generations of a society. Their intersubjective acceptance is an important difference to individual dreams that are not dedicated for oral or written re-narration from one generation to the next. Myths do not reflect a primitive state of the human mind, and are not necessarily induced by a semantic misinterpretation of linguistic traditions (cf. Riedl, 2010, and references cited therein).

The Hundstein landslide, which is supposed to have occurred during the Holy Night of 1768 in Lungau, could not be observed directly because of the darkness of the night, but has been perceived by sounds (thunder), optical phenomena (lightning), and by a smell of sulphur in the next morning. These acoustic, optic, and olfactoric perceptions gave rise to some contradictory descriptions, which underwent mythification in course of time. Based on the reported descriptions, on the present-day situation at the landslide location, and on lichenometric data, this article aims at a better understanding of the landslide and its historical context.

Location and topography

The Lungau is identical with the district of Tamsweg, which is one of six administrative districts of the Province of Salzburg. With an area of about 1,000 km^2, the Lungau is mainly situated at altitudes above 1,000 m (965 m in Ramingstein; 3,076 m at the summit of Mt. Hafner), and is drained towards East by the Mur river. Because of the high mountain crests to the West and North, the central basin of Tamsweg is well protected against clouded weather, and receives less rain than the surrounding mountains. The annual mean precipitation around Tamsweg is about 800 mm (station Tamsweg: 742 mm), while the main crests of the Radstadt and Schladming Tauern receive up to more than 1,500 mm precipitation. The mean air temperature at the bottom of the basin varies between + 15° C in July, and – 7° C in January. Tamsweg has about 170 days of frost, and the snow cover lasts for almost four months (i.e. 109 days, as an average value between 1961 and 1990). These and other climatic data are provided by the “Zentralanstalt für Meteorologie und Geodynamik” (1190 Vienna, Hohe Warte 38).

The Lignitz valley extends in N–S direction over a length of 11 km between the Lignitz pass (2,205 m) and the village of Zankwarn (1,157 m). It is drained from North to South by the Lignitz brook, which flows into the Taurach, being a tributary of the river Mur. The bottom of the Lignitz valley is mostly between 1,300 and 1,800 m altitude. Its limitating crests to the West and East have maximum elevations of more than 2,600 m (Hundstein 2,614 m; Steinkarspitze 2,626 m; Hocheck 2,638 m). The valley has an u-shaped glacial morphology, with trough shoulders and glacial cirque bottoms at about 2,000 m altitude.



Text-Fig. 1.
Shaded relief map of the Ödkar, the adjacent crests, and the Lignitz valley. 1 = Break-off niche; 2 = primary landslide deposits; 3 = avalanche fan. Arrows indicate the downfall direction of the landslide.

Geological mapping of the Geological Survey of Austria (cf. Hejl & Slapansky, 2005) has shown that the quoted Christmas Landslide has affected the Ödkar, which is situated to the West of a small lake ("Kleiner See", 1,764 m), and to the Northeast of Mt. Hundstein (2,614 m).

The landslide has broken out from the northern flank of the eastern crest of Mt. Hundstein, where it produced a 200 m broad niche between 2,300 and 2,400 m altitude (Text-Fig. 1). The basal gliding-plane dips towards NNE, with a slope angle of about 35°.

The landslide deposit consists of boulders of up to more than 5 m in size, which occupy the central part of the Ödkar, between 2,050 and 2,140 m altitude (Text-Figs. 1, 2). They cover an area of 40,000 m^2.

Big boulders can be also found in the steep trench, which drains the Ödkar in eastward direction, i.e. down to the bottom of the Lignitz valley. At the lower end of this gorge, the scree passes into an avalanche fan, going down to the southern shore of a little lake (1,764 m). The avalanche fan has more vegetation than the boulder deposits of the Öd-

Text-Fig. 2.
The landslide deposit at the bottom of the Ödkar, at about 2,060 m altitude (view towards west).

kar, but does not have a very old appearance too. With only few bunch of grass between the boulders and almost no trees, it seems to be much younger than adjacent moraines and rock-fall deposits at the same elevation (Text-Fig. 3).

Basement geology

The Lignitz valley is situated in the Schladming Crystalline Complex (SCC), which is a polymetamorphic unit of the Austroalpine. The SCC is composed of pre-alpine, medium- to high-grade metamorphic rocks, and of Variscan metaplutonites. Its pre-alpine metamorphic rocks comprise paragneisses, migmatites, amphibolites, and few garnet-micaschists. The plutonites have mainly granitic and granodioritic compositions, and were transformed into gneisses during an alpine metamorphism under greenschist facies conditions (cf. MATURA, 1980; EXNER, 1989, 1990; HEJL & SLAPANSKY, 2005).

Mt. Hundstein and the outcrops around the Ödkar are mainly composed of monotonous migmatic gneisses, i.e. gneisses rich in biotite and plagioclase, with bright leucosomes of plagioclase and quartz. Muscovite and chlorite occur as minor constituents; the latter is always the result of retrograde metamorphism. The leucosomes are concordant layers and nebulous veins, with thicknesses up to few cm. Such migmatic gneisses are the predominant rock type of the big boulders occurring at the bottom of the Ödkar. SLAPANSKY (1990) has reported, that blocks of serpentinite, of talc schist and of chlorite schist are also conspicuous elements of the landslide deposit. These rocks must have originated from a small ultrabasic body and its marginal facies.

The basal gliding-plane of the landslide is due to the NNE-ward dipping schistosity of the gneisses, layers rich in mica being the planes of preferred rupture.

Quaternary sediments and landscape development

Quaternary sediments being elder than the climax of the Würmian glaciation are mostly not preserved in the Lungau area. Such sediments are only known from the vicinity of Flatschach and Unternberg, i.e. in the Mur valley to the West of Tamsweg. At these places, bedded sands and clays of up to 15 m thickness are buried under Würmian ground moraine (EXNER, 1989, 1994). Also the banded lacustrine clays of a former pit in Flatschach belong to this unit. EXNER (1989) has supposed that they have been deposited in early Würmian times.

During the climax of the Würmian glaciation, about 20,000 years ago, the central Lungau basin was buried under a 1,000 m thick ice cover of the upper Mur glacier (SPREITZER, 1959/1960). In consequence of late Würmian warming, the central Lungau basin became free of ice, and the glaciers retreated back to the tributary valleys of the Tauern ranges, as for example the Weisspriach and Lignitz valleys, and later to the glacial cirques at altitudes above 1,800 m. The precise age of the corresponding moraines is badly known. EXNER (1989, 1990) has suggested, that the end-moraines at the connections of the Tauern valleys and the central basin could have a Gschnitz age (circa 13 ka BP), and those of the cirques above 1,800 m could correspond to the Egesen stage (circa 10 ka BP) – however without proof. During the final stages of glaciation, but still under permafrost, periglacial mass flows as for example tongue-shaped rock glaciers have developed at altitudes above 2,000 m (LIEB, 1983).

The history of latest Würmian and Holocene vegetation, with progressive immigration of trees, is relatively well known by palynological investigations and ^{14}C-dating of peat-bogs (KRISAI et al., 1991). *Pinus* dominates among the tree pollen of the latest Dryas; pollen of contemporaneous herbs support the assumption of a cold steppe, as for example in present-day Central Asia. After 13 ka BP, the Lungau was densely wooded by pines (*Pinus cembra*) up to elevations of about 1,700 m. This situation persisted until the early Holocene (9 ka BP), when spruces (*Picea*) spread very fast up to 1,800 m altitude, and became the predominant trees. During the late Holocene (since circa 5 ka BP), firs (*Abies*) became quite common too, but the spruces (*Picea*) still prevail until present.

When the first Illyrian or Celtic settlers arrived in Lungau, they found a primeval forest of spruces and some firs, which occupied the entire valley bottoms and slopes. Begin of agriculture is documented by the appearance of corn pollen in the pollen profiles of the peat bogs. Especially the early Middle Age was a period of fast growing population and accelerated clearing of the woods. Consequently, the Lungau evolved gradually to the present-day cultivated land.

The bottom of the Lignitz valley is generally covered by Holocene scree, rockfall deposits, and avalanche fans. The moraine adjacent to the little lake (“Kleiner See”, 1,764 m) must have a late Würmian age – may be Gschnitz or Daun. The small moraines of the Ödkar must be a little bit younger – probably Egesen (circa 10 ka BP). The present-day timber-line is at an elevation of approximately 1,800 m, i.e. slightly above the valley bottom (Text-Fig. 3).

Ignaz von Kürsinger jun. – oral traditions and written records of the landslide

This chapter deals with the biography of Kürsinger jun. in order to emphasize his credibility and to facilitate the understanding of historical circumstances. His Lungau monograph (KÜRSINGER, 1853) was indeed the most or even only comprehensive description of the area at this time. Biographic data were summarized according to MARTISCHNIG (1993).

Ignaz von Kürsinger jun. was born in Ried im Innkreis (Upper Austria) as a son of the imperial official Ignaz von Kürsinger sen. (1761–1834), who was director of the court district of Ried. Kürsinger sen. was very popular because of his heroic support of the local population during the Napoleonian wars. Kürsinger jun. attended the secondary school in Linz and Kremsmünster. After his studies of jurisprudence and political sciences at the University of Vienna from 1815 to 1819, he became an official at the regional

Text-Fig. 3.
The little lake (1,764 m) and the avalanche fan viewed from above.

administration in Linz ("Landesregierung"), but was soon transferred to the administrative courts of Obernberg and Braunau (Upper Austria). In 1829 he became official at the court of Mauerkirchen (Upper Austria) and then, in 1833, he was nominated as administrative official ("Pfleger") of Thalgau (Flachgau, Salzburg).

From 1834 onwards, Kürsinger jun. was head of the administrative court ("Pfleggericht") of Mittersill (Oberpinzgau, Salzburg), where he became a regional celebrity with his successful activities concerning the drainage of the Salzach swamps, the amnesty of deserters and welfare programs. In 1841 he organized an expedition to the top of the Grossvenediger (3,667 m) – Salzburg's highest mountain, which had not yet been ascended at this time. During 3rd September 1841, 26 mountaineers of this expedition reached the summit. Besides of a report of the Grossvenediger ascent, Kürsinger also published a monographic description of the Oberpinzgau, dealing with the history, topography, statistics, and the natural history of the region.

In 1842, Kürsinger moved to Schärding (Upper Austria) where he became the head of the administrative court ("Pfleggericht"). Again he initiated welfare programs and started a re-organisation of the financial system, but in consequence of an intrigue of his subordinates, he was impeached of administrative irregularities, and was suspended from his office in 1844. As a private gentleman, he moved to Tamsweg (Lungau, Salzburg), where his younger brother, Karl von Kürsinger, was official at the administrative court. During the next three years, Ignaz von Kürsinger jun. had plenty of time for historical investigations in the official archives of Tamsweg and Moosham, as well as for field excursions in the surroundings. He collected topographic, historic, and ethnographic information, and summarized them in a comprehensive Lungau monograph, which was published in 1853, six years after his return from Tamsweg.

In the meantime, he had moved to the city of Salzburg, and had been rehabilitated by the ministry in July 1848. During the revolution of 1848, the city and the rural districts of Salzburg had nominated him as a Member of the Constituting Parliament ("Konstituierende Nationalversammlung") in Frankfurt am Main (Germany). He sat in the middle-left of the parliament – spatially as well as politically – and voted together with the Grossdeutsch-Austrian Party. Kürsinger jun. died in 1861, in the city of Salzburg.

Kürsinger's Lungau monograph ("Lungau. Historisch, ethnographisch und statistisch aus bisher unbenützten statistischen Quellen") was the most comprehensive description of the region for decades, and even nowadays is still an important source of historical information. It comprises topographic, climatic and hydrographic data, as well as descriptions of important villages, market places and valleys. One of the described excursions deals with the Lignitz valley and the landslide of the Hundstein Mountain.

Kürsinger's walking-tour through the Lignitz valley is not precisely dated, but must have happened during the years from 1844 to 1847. He started in Mariapfarr, and followed an alpine footpath along the villages of Örmoos, Zankwarn, Grabendorf and Kraischaberg. After about one hour and 15 minutes, he arrived at a summer pasture with eleven alpine huts, corresponding to the place of the present-day village of Lignitz. From here he went farther north, along the bottom of the deeply incised Lignitz valley, which appeared to him as horrible gorge, filled with broken pieces of rock, boulders and rubble. As a non-geologist, he was obviously not able to distinguish landslide deposits *sensu stricto* from moraines, avalanche deposits, rockfall and scree. All the boulders in the valley below the Hundstein appeared to him as having resulted from a single but enormous landslide. Modern mapping by the Geological Survey of Austria (cf. HEJL & SLAPANSKY, 2005) has shown, that the landslide deposits of Mt. Hundstein occupy only a rather small area, as has been mentioned in this article. Kürsinger tried to find out when this landslide could have occurred. He searched in the archives of Moosham, but found only some requests for tax abatement from the years 1769 and 1770, because of destroyed oxen pastures in consequence of a landslide in the Lignitz and Weisspriach valleys. Finally, after long interrogations of the native population, Joseph Rainer, a farmer in Lintsching and member of the local board, gave him the following explanation:

"*My father, who died few years ago as an old man, was born in 1761. He was a boy of 7 or 8 years in age, when together with his parents he went to the church of Mariapfarr, in order to participate in a Holy High Mass – because it was the Holy Night, when Christ the Lord was born to Bethlehem.*

When after worship the devout believers left the church in pious atmosphere, they became attentive to a noise like thunder, with lightning that shined between the claps, – the terrible phenomenon came from the direction of the Weisspriach- and Lignitz valleys.

Nobody had an explanation for this frightful phenomenon. It was in 1768 when recently an epidemic disease like pestilence had killed many human beings in Lungau. Therefore, many people were anxious that the day of the Last Judgement could begin to dawn; some others thought that a special kind of cannons were fired off in order to announce the birth of Christ to the wide valley; others thought that it could be a landslide, and one had to wait. In the morning and the next day an annoying smell of sulphur spread out over the valley.

After few days, some courageous men went to the region where the mysterious midnight noise had come from.

And they solved the enigma – the rocks on top of Mount Hundstein had collapsed, and had buried the grassy oxen pastures under huge rock debris, that had fallen over frightful walls down to the Weisspriach and Lignitz valleys. Now, even a goat does not find its scanty food on these former pastures.

This story has been often told by our old father, when we sat around him in the evening.

"This occurrence", he [the father] said, "has been impressed so deeply on my youthful mind, that still today I think to hear the horrible thunder and to see the lightnings; it was a good fortune", the father always emphasized when he told us the event, "that the landslide happened during the Holy Night before Christmas and not in late summer, because otherwise people and cattle could have been killed and buried under the rubble.""

This was the story that the farmer and member of the local board ("Gemeindevorstand") Joseph Rainer has told to Kürsinger during the years 1844 to 1847. The story became part of Kürsinger's Lungau monograph.

Michael Dengg (born in 1879) was a farmer and mason who lived in Mauterndorf (Lungau). Besides his hard professional work, he collected Lungau folktales and published them in 1922 for the first time. Dengg gave full credit to Kürsinger's Lungau monograph from 1853, but also used other sources of information, as for example personal communication of native Lungau inhabitants. Dengg (1922) includes a report of the Hundstein landslide, which coincides roughly with that of Kürsinger (1853), but is different in some details. We tried to translate some important sentences into English, and have underlined the specific differences:

"*When his relatives sat around him during the Holy Night before midnight worship, the old Karl-farmer in Lintsching used to narrate of a terrible phenomenon which had occurred during the Holy Night of 1768. It was the Hundstein landslide. It was his grandfather, who has been witness, and who has told it to him several times. He was a little boy of 8 years in age, when during the Holy night he accompanied his parents to the midnight worship in Mariapfarr. [...] It was a long continuous thunder, which was followed by several powerful earthquakes, as when all the mountains would fall one upon another. Glaring flashes illuminated shortly the terrible spectacle, which happened there, but did not permit to discern what it could be. [...] Only when a lightning was very bright, one could see in the direction where the misfortune occurred, that a huge black cloud towered up.*

[...] Some people claimed that it is an earthquake which is expanding more and more. Others believed that a planet had collided with the Earth and had broken into debris. Others said that a special kind of cannons were fired off from the alps in order to announce the birth of Christ to the wide valley. [...]

[...] Because nobody could give a conclusive explanation for this uncommon event, and because the noise did not diminish but even increase for some time, the excited souls could not be calmed, and always new foolish speculations were discussed.

Only in the morning it became quieter. The terrible thunder and earthquake, that had frightened the people during the night, had ceased. The clouds of smoke and dust, which had accumulated in the valleys began to disperse. But a smell of sulfur spread over the Lungau and lasted for several days.

[...] This has been told by the grandfather of the old Karl-farmer and he closed with the words: "This event has been impressed so deeply on my youthful mind, that still today I think to hear the horrible thunder and to see the green lightning.""

Besides some stylistic details, the following differences between the two descriptions are important:

- Kürsinger (1953) has mentioned no earthquakes but only noise and lightning;
- Dengg (1922) states some additional speculations of the witnesses (earthquake, planet collision);
- Dengg (1922) describes black clouds – visible during the lightning as well as in the next morning.
- Kürsinger (1953) has emphasized a midnight event – in contrast to Dengg (1922), who states that the landslide lasted over hours, until the morning.
- The color of the flashes, which was not specified by Kürsinger (1853), became green in the tale reported by Dengg (1922).

Lichenometric studies in 2006

In course of a field trip on September 14th in 2006, we walked through the upper Lignitz valley and ascended up to the bottom of the Ödkar, where the big boulders of the landslide deposit occur. We tried to elaborate a complete survey of saxicolous lichens on the landslide boulders (see the list below) and to perform representative measurements of thallus diameters of *Rhizocarpon geographicum*, which are supposed to be a function of the time having elapsed since the landslide event.

List of saxicolous lichens of the landslide deposit

Bellemerea alpina (Sommerf.) Clauzade & Cl. Roux
Calvitimela aglaea (Sommerf.) Hafellner
Carbonea supersparsa (Nyl.) Hertel
Carbonea vorticosa (Flörke) Hertel
Lecanora cenisia Ach.
Lecanora intricata (Ach.) Ach.
Lecanora polytropa (Ehrh. ex Hoffm.) Rabenh. var*. polytropa*
Lecidea commaculans Nyl.
Lecidea confluens (Weber) Ach. var. *confluens*
Lecidea lapicida (Ach.) Ach. var. *lapicida*
Lecidea lapicida (Ach.) Ach. var. *pantherina* Ach.
Miriquidica garovaglii (Schaer.) Hertel & Rambold
Porpidia superba (Körb.) Hertel & Knoph
Porpidia tuberculosa (Sm.) Hertel & Knoph
Protoparmelia badia (Hoffm.) Hafellner var. *badia*
Rhizocarpon geographicum (L.) DC.
Rhizocarpon lavatum (Fr.) Hazsl.
Rhizocarpon lecanorinum Anders
Schaereria fuscocinerea (Nyl.) Clauzade & Cl. Roux
Sporastatia polyspora (Nyl.) Grummann
Sporastatia testudinea (Ach.) A. Massal.
Tremolecia atrata (Ach.) Hertel
Umbilicaria cylindrica (L.) Delise ex Duby var. *cylindrica*

This lichen cover of the landslide deposit reflects the acidic conditions on the gneiss surfaces in the subalpine and alpine vegetation belt of the Central Alps. Remarkable is the occurrence of *Lecidea commaculans*, which is extremely rare in the Alps.

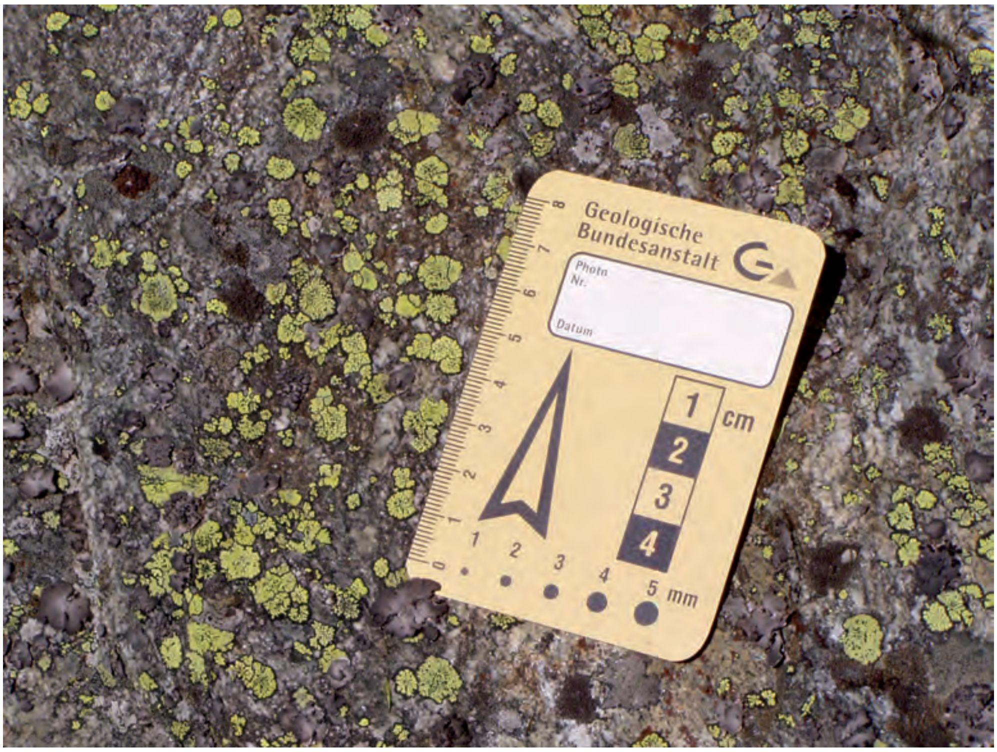
Thallus diameters of *Rhizocarpon geographicum* (L.) DC. were determined according to the recommendations of Beschel (1961). We measured the maximum diameter of thalli with approximately circular shape, we made sure that they did not comprise intergrown individuals, and that they did not touch each other (Text-Figs. 4, 5). Repeated measurements of the same diameter have shown that the reading precision of the flexible scale bar is about 0.5 mm. Consequently, we have rounded the individual values to full millimetres.

The measurements were undertaken at 10 representative boulder surfaces in the central part of the landslide deposit, between 2,060 and 2,075 meters altitude. The chosen surfaces had a minimum size of 0.5 m^2 with a fairly homogeneous orientation, concerning direction of exposition and dip angle. On each of these surfaces, the maximum diameters of the 15 largest thalli were measured. The results of the individual measurements as well as arithmetic means and standard deviations are presented in Table 1. In the case of the blocks 1 and 6, respectively two different exposition surfaces were studied. In the case of block 4, the two tested surfaces represent sharply delimited areas with obviously different thalli sizes in the upper and lower part of the rock (4a and 4b, respectively). We suppose that the larger thalli sizes at the base of block 4 are due to a higher humidity supply, because of a longer lasting or repeated snow cover in course of the year.

	block 1a	block 1b	block 2	block 3	block 4a	block 4b	block 5	block 6a	block 6b	block 7
block size (m)	4	4	2	2	3	3	4	4	4	4
altitude (m)	2,060	2,060	2,060	2,060	2,060	2,060	2,070	2,070	2,070	2,075
exposition	010°/60°	135°/70°	340°/18°	012°/52°	195°/56°	195°/56°	116°/18°	192°/50°	041°/59°	110°/53°
thallus size (mm)	17	28	16	7	22	35	29	7	14	24
	17	25	16	4	18	32	20	7	15	26
	15	30	14	4	16	38	22	9	13	26
	14	33	18	5	15	35	20	10	17	27
	11	25	14	6	15	41	20	10	16	29
	17	34	17	6	14	41	28	10	12	26
	10	33	15	5	21	33	23	9	15	28
	14	37	15	6	14	38	25	11	16	21
	14	21	16	7	14	37	24	10	24	27
	16	26	17	6	21	41	27	10	17	26
	17	33	16	6	16	29	33	10	17	30
	15	28	15	5	21	37	39	10	19	26
	14	22	18	7	18	29	31	12	21	26
	13	23	14	5	23	31	26	9	19	26
	14	30	13	6	15	31	27	11	26	27
arith. mean (mm)	14.5	28.5	15.6	5.7	17.5	35.2	26.3	9.7	17.4	26.3
std. dev. (mm)	2.1	4.8	1.5	1.0	3.2	4.2	5.3	1.3	3.9	2.1

Tab. 1.
Results of the lichenometric measurements at the Ödkar bottom (area 2 of Text-Fig. 1).

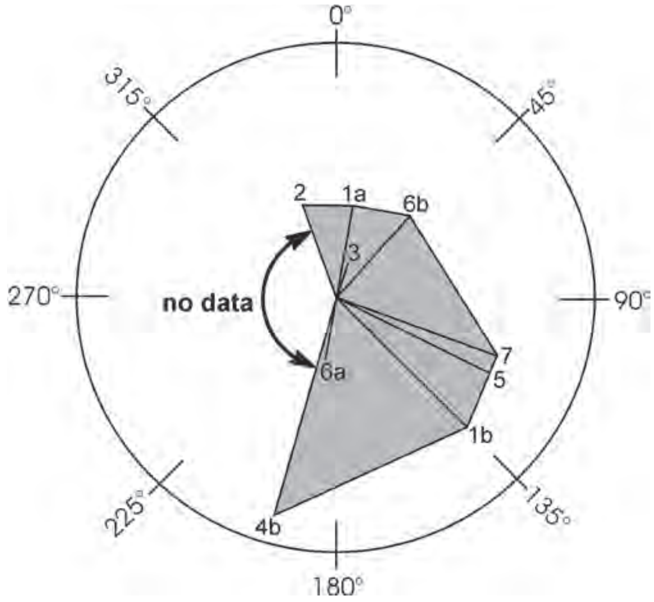
Text-Fig. 4.
Rhizocarpon geographicum (greenish yellow), *Lecidea lapicida* (pale grey to reddish), *Tremolecia atrata* (rusty red) et div. al. spec. on a southward exposed block of the landslide deposit.



Text-Fig. 5.
Rhizocarpon geographicum (greenish yellow) and *Umbilicaria cylindrical* (greyish to brownish black) on block 6a (southward exposure). The maximum diameters of *Rhizocarpon* thalli with circular shape, but without intergrowth with their neighbours were measured (cf. Table 1).

The diameters of *Rhizocarpon geographicum* range between 4 and 41 mm, but within each individual surface the diameters are relatively constant (low std. dev.) and thus indicate that the growth condition were quite similar within each individual area. However, significant differences are observed between the various exposures. Our measurements cover North-, East- and South-exposures. Unfortunately we could not find suitable surfaces with West-exposure (Text-Fig. 6). The thallus sizes on the surrounding boulders and rock surfaces outside of the landslide deposit in the central part of the Ödkar are much larger. We found maximum diameters up to more than 12 cm at *Rhizocarpon geographicum* and more than 20 cm at *Rhizocarpon alpicola*. Such large sizes also occur on the avalanche fan at the ground of the Lignitz-valley to the south of the small lake (Text-Fig. 3).

Text-Figure 6 displays the arithmetic means of thallus diameters as a function of exposure. Apart from block 6a, the maximum diameters of the thalli in South- and South-



Text-Fig. 6.
Maximum thalli diameters as a function of exposition. The largest thalli occur on blocks with southward and southeastward exposure. The exceptional low value of block 6a may be due to a later arrival of diaspores and/or to a longer lasting snow cover close to the base of the block.

east-exposures are significantly larger than those in North-exposures. The reason for these differences is probably the lower supply of light which reduces the photosynthetic activity of the thalli. Another possible reason is the higher amount of melting water running off the surfaces on the South-exposure due to the higher heat up on sunny winter days. This simultaneous action of both sunlight and wetting seems to be very favourable for lichen growth. Wetting experiments of ARMSTRONG (1976) have shown that the growth rate of a given lichen increases with the wetting frequency until an optimum value, and then decreases with further wetting. There is no growth when the thallus is dry, but the initial phase of rewetting always causes a net loss of carbon from the lichen. This initial loss of carbon is due to leakage and starting respiration of the thallus. Only when the thallus is wet sufficiently long and well exposed to the light, the photosynthetic activity can overcome this carbon loss. Thus, long lasting water saturation under sunlight is more favourable for lichen growth than a frequent succession of short wetting periods and intermittent desiccation.

Discussion

Lichenometric data from the landslide deposit can be interpreted in a two-fold manner: first with regard to lichenometric timescale calibration, second with regard to the credibility of the historical landslide reports. Both aspects should be considered in a synoptically way, because they have logical implications on each other. On the one hand, every timescale calibration requires a certain credibility of the reported chronology; on the other hand, the calibration results can provide a better understanding of the real events. In order to avoid a circular argumentation, lichenological findings from other areas must be considered too.

Since the early days of lichenometric dating (BESCHEL, 1957, 1961, 1963), it is well known that lichen growth rates are dependent on humidity, favourable temperature, light and the presence of nutrients. Among these factors, the climatic parameters (humidity, temperature and light) are the most important, because on most rock surfaces the nutrients are present in excess – at least with regard to the slow growth of crustaceous (saxicolous) lichens. Mineral nutrients become available through weathering of the substratum, or may be blown or washed over the exposed surfaces. Bacteria can absorb atmospheric nitrogen and excrete it in form of water-soluble nitrate. Thus, the local supply of nutrients is probably not the limiting factor for lichen growth. BESCHEL (1961) has argued that lichen growth rates are mainly controlled by climatic conditions. He concluded that "*Lichenometry permits relative dating of events which led to the exposure of bare rock surfaces within the age limit of the lichens in similar macroclimates. This can be converted to an absolute scale if one event is dated by other means, e.g. historical information, or if the growth rate is measured directly*" (BESCHEL, 1961: 1044). Depending on the climatic setting, the diametral growth rates of *Rhizocarpon geographicum* are indeed highly variable. They range from < 0.1 mm a^{-1} in Antarctica and on polar islands to almost 1.5 mm a^{-1} under favourable climatic conditions, as for example on gravestones in North Wales (cf. the bibliographic review in BRADWELL & ARMSTRONG, 2007). Diametral growth rates between 0.3 and 0.5 mm a^{-1} are quite common in alpine areas above the timber line. But even under a fairly similar macroclimate, the local microclimatic conditions can cause large deviations from the mean growth rate, as has been demonstrated by the different thallus sizes on rock surfaces with different exposition within a very small area of the Christmas Landslide deposit.

An additional complication arises from the fact that the diametral growth rates of *Rhizocarpon geographicum* are not constant during the whole life of the individual lichen. First, the reproductive bodies (diaspores) of the lichens must arrive on a newly exposed rock surface and be lodged in capillary cracks or small hollows. This first arrival does not necessarily occur in the first year after the exposure, but may happen several years later. Afterwards, the diameter of the thallus increases very slowly, and some additional years may elapse before the lichen becomes visible. BESCHEL (1961) has suggested a hypothetical sigmoidal growth curve (diameter versus time), and explained it in the following way: As long as the organic matter produced by the thallus is distributed over the whole lichen area and shared by all its parts, a constant production rate per area will result in an exponential increase of the diameter. When the radius reaches a critical value where the horizontal transport of organic substances becomes ineffective, the central parts will cease to contribute to the marginal growth. Only an outer rim of constant thickness will produce the organic matter for a further increase in diameter. Consequently, the radial growth rate should become fairly constant.

However, later growth rate studies on *Rhizocarpon geographicum* and other saxicolous lichens have shown that a linear increase of thallus diameters with time is rather the exception than the rule. When the growth velocity is plotted against time, we obtain a growth rate curve, which is the first differentiation of the growth curve. In most cases, such growth-rate curves are bell-shaped, with an initial phase of accelerated growth, a broad peak corresponding to a phase of high growth rates, and a final but long period of decelerated growth. In the case of *Rhizocarpon geographicum*, the phase of declining growth occurs in thalli with diameters being larger than ca. 50 mm (ARMSTRONG, 1983). Consequently, growth rates can be also regarded as a function of the lichen size. The validity of this statement is essentially confirmed by a recent study of BRADWELL & ARMSTRONG (2007) who have measured diametral growth rates of this lichen species on a terminal moraine complex in southern Iceland between May 2001 and September 2005. They found that growth rates increase rapidly in small thalli (< 10 mm), remain high until a size of ca. 50 mm and then decrease gradually. Former lichenometric dating attempts having assumed constant growth rates over several decades are probably unreliable and should be viewed with caution.

With regard to the Christmas Landslide, it is important to notice that the thalli on the big boulders of the Ödkar are mostly smaller than 40 mm. About half of the thalli, especially those from northward exposures are even smaller than 20 mm. Most probably, many of these lichens are still in the phase of accelerated growth, some of them may have reached the phase of maximum growth rates, but certainly not the final phase of decelerated growth. Due to the special circumstances at the bowl-shaped bottom of the Ödkar with its long lasting snow cover, we do not know if the first arrival of diaspores happened soon after the landslide event and if the annual increase in diameter follows a regular trend. Nevertheless, the thalli of *Rhizocarpon geographicum* on the boulders at the bottom of the Ödkar are distinctly smaller than those in the steep trench below, and those on the avalanche fan to the south of the little lake (Kleiner See, 1,764 m), where some thalli of *Rhizocarpon geographicum* have diameters of more than 12 cm. If we assume that the blocks of the avalanche fan were created by the Christmas Landslide and came to rest in 1768, and if we further assume that the lichen diaspores have been lodged on the boulders shortly after the event, such large present-day diameters (> 12 cm) of *Rhizocarpon* thalli would imply a mean diametral growth rate of more than 0.5 mm a^{-1}. In comparison with other alpine locations, such high growth rate is rather improbable. Therefore, we assume that the avalanche fan is mainly elder than the year 1768. It may have been created by repeated rock falls, avalanches and even landslides coming down from Mt. Hundstein and the Ödkar during the Holocene, but the last event in 1768 did probably not contribute very much to the fans growth. However, we cannot exclude that a minor portion of scree from the Christmas Landslide has been transported as far as to the bottom of the Lignitz valley.

The lichenometric investigations strongly suggest that the deposits of the historical landslide from 1768 are mainly restricted to the boulder field at the bottom of the Ödkar (area 2 in Text-Fig. 1) – in contrast to earlier statements, which have argued for a significant extension of the landslide down to the bottom of the Lignitz valley (SLAPANSKY, 1990; HEJL, 2003). In any case, the landslide could not fall to the Weisspriach valley, which is to the west of Mt. Hundstein (2,614 m) and Mitterspitzen (2,607 m), on the other side of the crest. In order to do this, the landslide should have fallen upwards over the crest. Such process is obviously impossible.

The landslide story which has been reported by KÜRSINGER (1853) appears as a strong exaggeration, which does not fit to the geological situation on the spot. We have already mentioned a certain tendency of mythification – for example an earthquake, a planet collision, a long-lasting event over hours until the next morning, and green flashes reported by DENGG (1922) –, but what could have been the reason for the misleading statement, that a portion of the landslide has fallen to the Weisspriach valley, which is on the other side of the crest? This obviously wrong detail has not been added by Dengg, but is part of KÜRSINGER's report from 1853. With regard to this detail, we should remember that Kürsinger has searched in the archives of Moosham and there he found some requests for tax abatement from the years 1769 and 1770 because of destroyed oxen pastures in consequence of a landslide in the Lignitz and Weisspriach valleys. It is only logical that the first request is from the year 1769, because it would have been impossible to evaluate the amount of destruction during the few winter days between Christmas 1768 and New Year 1769. A first survey of the destructions could have been made in spring 1769 and been used as argument for tax abatement. But why a second request for tax abatement in 1770? Could it be that the first request was successful and that some clever farmers have tried to enlarge the affected area as much as possible, in order to obtain tax abatement too? We are not able to find out if this was the case. But the example shows, that even a documented historical fact may be obscured by individual interests. In any case, special attention should be paid to the credibility of the witnesses (cf. SUESS, 1916: 16).

With regard to its mythogeographical significance, it can be stated that the story of the Christmas Landslide has indeed emerged from a historical event, and that it was not the outcome of pure imagination or of a certain state of consciousness. On the other hand, the written records demonstrate that some speculative elements of the story (Last Judgement, cannons) were introduced immediately by the persons who became witnesses of the landslide in 1768. These speculative elements of the story can be explained by the emotional state and religious expectations in the context of the Holy Night.

Conclusion

Because of the specific microclimatic conditions at the bottom of the Ödkar, the boulder deposits of the historical landslide from Christmas 1768 are only of limited value for the regional calibration of a lichenometric timescale. The long lasting snow cover in the hollows between the boulders, and variable microclimatic conditions depending on the exposition are responsible for a complicated pattern of local diametral growth rates of *Rhizocarpon geographicum*. Any extrapolation to other areas of bare rock surfaces should be considered with great care. However, the lichenometric investigations show that the emplacement of the boulders in the Ödkar is younger than the major part of the avalanche fan, down the slope at the bottom of the Lignitz valley. Consequently, only a minor part of this avalanche fan should originate from the Christmas Landslide of 1768.

The synopsis of historical information, lichenometry, and the local geological situation shows that the tales of the Christmas Landslide are strongly exaggerated with regard to the size and chronology of the event. These alterations of the true story may be partly due to later mythification but also to lies of original witnesses. Some of these witnesses could have been motivated by personal economic interests, i.e. by the possibility to get tax reductions by the administrative authorities.

Thus, the story of the Christmas Landslide is a mythological synthesis of a natural event (landslide), religious expectations (Last Judgement), speculations of the witnesses (planet collision, earthquake), economically motivated exaggerations (with regard to tax reduction) and narrative alterations (green lightning) in course of time.

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