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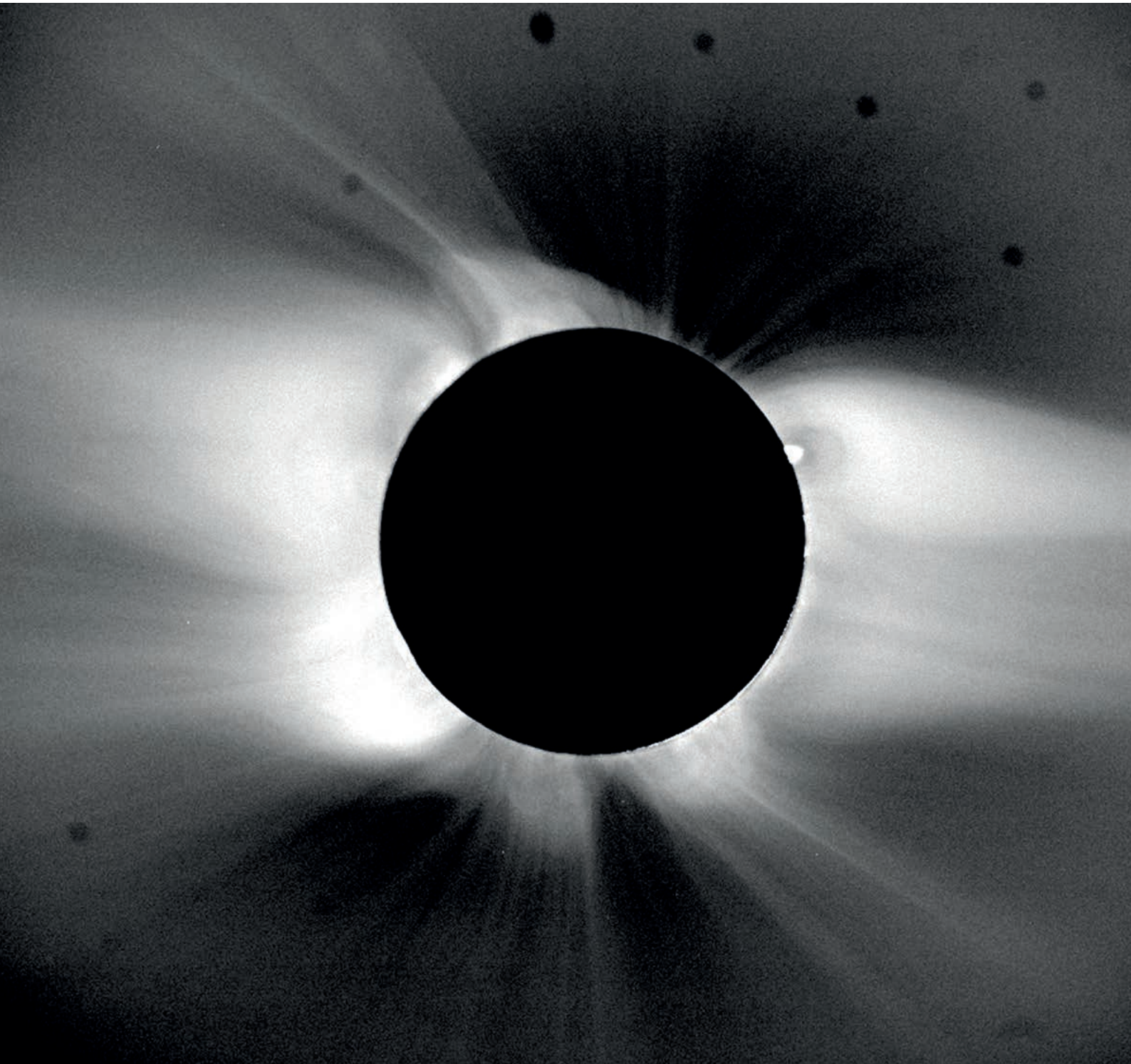

EDITOVANÉ ČÍSLO O FOTOGRAFII A VĚDĚ / SPECIAL ISSUE ON PHOTOGRAPHY IN SCIENCE
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The Camera as a Tool in Geography: Parallels between Friedrich Simony's Pictures of the Dachstein and the Use of Photographic Images in Geography Today

For more than fifty years, Friedrich Simony, an Austrian pioneer of geography and the first professor of this subject at the University of Vienna,[1] explored the Dachstein massif in the Northern Limestone Alps. Not only did he map it and collect stone samples, but he also created, at first, hundreds of drawings and, later, photographs. He composed panoramic views as well as unusually detailed depictions of geomorphological phenomena and captured the movements of the glaciers there in pictures. Geographer Albrecht Penck, who succeeded Simony at the university, paid tribute to this work in a comprehensive biography, mentioning specifically the value of his predecessor's early and continuous monitoring of the glaciers: *'Thanks to this work, the history of the Dachstein glaciers today must count as one of the best-known of all Alpine glaciers, but no other is so excellently captured in pictures.'*[2]

Simony laid down a foundation that allowed a detailed analysis of the changes in the glaciers at Hoher Dachstein from his time up to today. The photographic timeline of the glaciers he created in his lifetime is unique in terms of the information it contains on glacier retreat in the course of anthropogenic climate change. This is vital, since glaciers, as sentinels and icons of climate change,[3] play a significant role in the societal discourse.[4] Simony's crisp and clear pictures present the changes drastically and unambiguously.

Simony's scientific achievements, however, go far beyond documenting regional changes and related geomorphological processes. His way of capturing landscape forms as the result of the processes he had documented was a revolutionary scientific method and just as innovative in the academic discourse as in the dissemination of the results. Friedrich Simony was a pioneer in the use of images to present issues in the geosciences. His images focus the debate, illustrate the results, and guide the attention of the audience. Before Simony, the academic discourse had been dominated by long lectures and treatises. Apart from the odd illustration, scholars had to make do with sketches on a chalkboard or simple black-and-white line diagrams. One reason was that affordable mass reproduction of photographs in journals and books was not available to scientists at the time. Simony was the first to familiarize himself with the creation and reproduction of images to such a degree that he could make full use of the argumentative force of photography.

Friedrich Simony was born in 1813 in the small Bohemian village of Hrochův Týnec/Hrochowteinitz (in today's Czech Republic). In 1835 he moved to Vienna to study natural sciences. In 1840 his interest in mountains took him to the Dachstein massif, located not so far from Vienna, which he began to depict in extraordinarily precise drawings and watercolours. He included measurements in his pictures and used sophisticated tools to draw to scale.[5] Simony worked like a detective in his investigations and documented even the smallest landscape details: *'There is nothing in the landscape that does not take on specific forms of its manifestation under the influence of certain natural conditions and laws.* […] *We are right to say that the ground around us contains its history in its countenance, but it is written in hieroglyphs. However, they can be deciphered by anyone who makes the effort to study them.'*[6] In the face of this comparatively new understanding of landscape as the result of complex processes, Simony's quest for ever more detailed and precise depiction seems logical and eventually led him to photography.

Simony used photographs in teaching at a time when this medium — thanks to technical improvements — began to be taken up by various scientific disciplines.[7] In 1875 the geographer took up the camera himself. Previously, there had been several photographic tours taken in Europe's high mountains, which proved to be very expensive undertakings, sometimes with brilliant results, mainly carried out by professional photographers — for instance in 1862 by the Bisson brothers,[8] or the following year by Vienna-based Gustav Jägermayer[9] — who were not primarily driven by an interest in science.[10] Simony kept a close eye on these developments, theorized about the use of photography in geography, but only took it up when it seemed technically advanced enough and not financially ruinous for him.[11] Unlike professional photographers, he planned not just *one* spectacular, costly tour of the mountains; rather he saw the camera as a permanent companion on his research trips. He put the pictures taken over the years to multiple uses in teaching and in various publications, including his best-known work,

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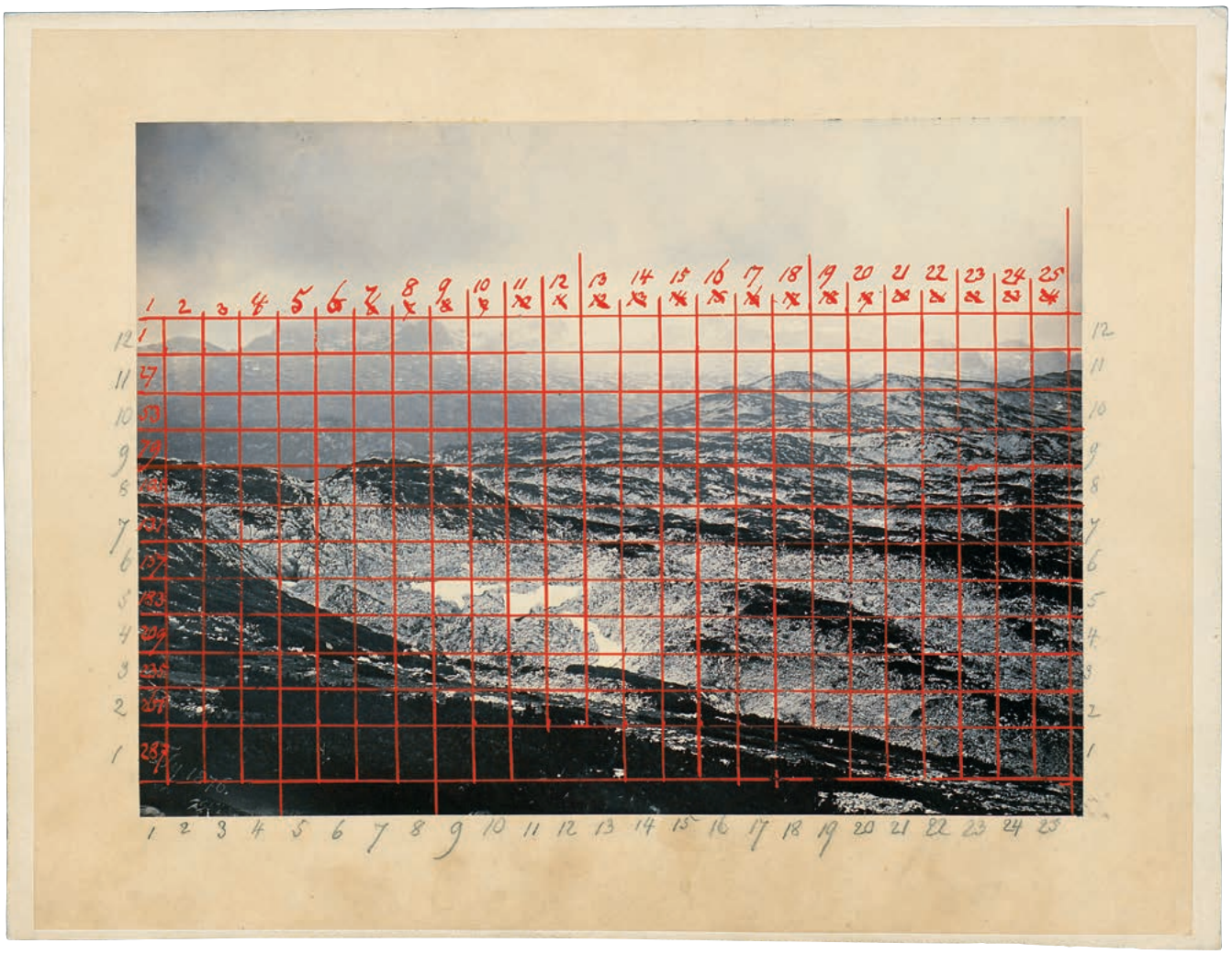

1 / **Friedrich Simony, View from Hirzberg (2044 m) towards the west**, 1876
albumen print with grid lines drawn by hand
University of Vienna, Geography and Regional Research Library (partial estate of Friedrich Simony)
Photo: University of Vienna, Geography and Regional Research Library

Das Dachsteingebiet: Ein geographisches Charakterbild aus den österreichischen Nordalpen, which, after several part by part publications, was finally presented as a whole in 1895, shortly before his death. With 220 plates and illustrations with text it offered an unusually rich pictorial layout. Simony understood the *Dachsteingebiet* as a model case: it was of a manageable size, yet rich in forms and well suited for demonstrating various surface forms and processes '*without having to introduce new morphological terms*'.[12]

Today's physical geography textbooks rely heavily on pictures, with each page containing several figures on average, both photographs and diagrams or illustrations in the style of Simony's large glacier illustration *Gletscherphänomene*, a seven-square-metre wall tableau, which was presented at two world exhibitions, in London in 1862 and in Vienna in 1873. This fictitious landscape, composed with the help of his drawings of real places, served to illustrate the typical geomorphological phenomena of a glacier and its surroundings. This composition of phenomena typical of an 'artificial' landscape was a new didactic technique, complementing the geoscientific concept of 'Typlokalitäten' (type localities), where an existing landform of a 'textbook nature' presents very clear evidence of the process that formed the specific landscape without great disruptions or later reshaping by other processes. The Dachstein area is probably one of the earliest examples of such type locality.

Smaller illustrations also find their way into textbooks, for instance, in the style of the 'Karrenfeld', described below, as an example of a karst form. They present small landscape elements, for example, a soil profile, a moulin, or other structures, that allow assumptions about past processes that created the form in question, and describe their position and function in the greater context of the landscape. In this way the large-scale shaping of a landscape by glaciers, which can be seen

in panorama in round forms and large moraines as well as in valley shape, can be substantiated by details of moulins, the inner structure of moraine deposits, or striae.

It is this virtual excursion, which includes both an overview and details, that unlocks the history of a landscape. The examples below combine this total view, which demands the greatest skill in order to display all sections with sufficient contrast, with pictures of details, which are essential for identifying the structures. The comparison of pictures (repeat imagery) of Karlseisfeld [4] is a tool pioneered by Simony and indispensable to this day for documenting changes. The resulting time series of glacier changes shows very clearly the impact of climate change even for non-scientists. At the same time, these images are precise enough to allow the quantification of the loss in volume. Repeat imagery today is also employed in satellite remote sensing,[13] where it is called *change mapping* or *image correlation*. It allows the delineation of floods, mass movements, clearances, and construction projects, or even the calculation of the speed of glacier flow.

Below are four pictorial examples from Simony's photographic work. Magdalena Vukovic first presents them from a photo-historical perspective, then Andrea Fischer relates them to contemporary methods in glaciology and geography.

1/ View from Hirzberg (2044 m) towards the west, 1876
Albumen print with grid lines drawn by hand [1]

In 1851 Friedrich Simony was appointed the first professor of geography at the University of Vienna. In his application he stressed his '*recognized skill in geophysical representations and in scientific landscape drawing*'.[14] Once appointed, he immediately started to produce teaching materials, especially wall panels or maps, which were scarce at the time.[15] Since his students often became schoolteachers on completing their degree, he wanted them to also acquire this skill in a drawing course that was part of Simony's curriculum from the start. His teaching methods are still visible in the fine grid lines on photographs, drawings, and lithographs. The students drew grid lines on them by hand in order to transfer the illustrations on a different scale. Penck later described the practice in detail: '[Simony] *also had them draw after his own etchings, which he covered with a network of red squares to be able to reduce or enlarge them. Occasionally, he went on excursions to let them draw based on nature; in short, he did everything to impart in his students the fine precision of his eye, which he had acquired through years of observation, and the sureness of drawing lines.*'[16] In this way, Simony's students had to engage with even the smallest detail in a landscape or an image.

Sketching in situ is still part of the basic training of students in physical geography. It compels students to observe precisely and to scale and trains them to recognize landforms and processes. At the same time, the teacher can quickly gauge from a look at the students' sketches which part of the subject matter has been absorbed and where there are gaps in understanding. Using grid lines on a picture serves for correct scaling and at the same time allows for the quick quantification of results, for instance, for estimating the percentage of ground cover by vegetation or the degree of englaciation or of glacier retreat. In principle, grid lines are a precursor of satellite remote sensing methods and geographical information systems (GIS), in which data are available in a grid, that is, in a digital raster format, and can be compared in change mapping by grid points, or in feature tracking by calculating the movement of individual values or patterns in image correlation algorithms[17] via raster cells.

2/ Part of a karst formation near the "im Schnalz" spring (Wiesalpe), 1876
Albumen print [2a, b]

To concentrate on exploring geomorphological phenomena in his depictions of landscape, Simony developed 'contour drawing' (*Contourenzeichnung*[18]). He translated the landscape into a dense weave of lines, ignoring things he deemed irrelevant and emphasizing things relevant to his research, for example, sediment layers or karst structures, or even making them visible in the first place. Penck detailed the method, for instance, in relation to Simony's famous panoramas: *'He strives for a meticulous representation of the individual forms of the mountain range; he draws each gully, each band, and bans anything changeable from the landscape. He omits any effect of light or cloud; everything is clear and certain. These drawings do not just capture a moment, as photographs would, but return the sum of individual observations, with anything morphologically irrelevant suppressed in favour of the morphologically significant.'*[19] Penck went on to differentiate clearly between the modes of drawing and photography: the latter was an automatic picture of a moment, the result of just a few interventions by the human hand, while Simony's panorama drawings processed a multitude of scientific insights. And yet, one should not understand Simony's drawings exclusively as a collage of observations relevant to the discipline. His photographs, too, especially in terms of post-processing, were subject to similar processes.

Simony's partial estate at the University of Vienna includes the picture *Partie eines Karrenfeldes bei der Quelle 'im Schnalz' (Wiesalpe)*. The mounted albumen print was presumably made shortly after Simony's second photo tour of 1876, which he embarked on for the first time without the help of professional photographer Alois Elsenwenger.[20] The rugged rocks emerge brightly in the foreground, and even though the print has not faded and still offers strong contrasts, it is almost impossible to identify details on these white areas. Almost twenty years later, this photograph was included in Simony's *Dachsteingebiete*, albeit as a strongly reworked autotype. Only now can we discern the fine traces of weathering on the rock surfaces as well as the deep furrows, after countless fine lines have been

2a / **Friedrich Simony, Part of a karst formation near a spring 'im Schnalz' (Wiesalpe)**, 1876
albumen print
University of Vienna, Geography and Regional Research Library (partial estate of Friedrich Simony)
Photo: University of Vienna, Geography and Regional Research Library

drawn in by hand and light and shadow greatly enhanced. The autotype skilfully guides the viewer into the centre of the picture, where the spring, called *'im Schnalz'* by Simony in the caption, has 'eaten a rivulet [into the rock] that is clearly marked as spring erosion',[21] whose course is now easily traceable with the naked eye.

Simony may have emphasized photography's fidelity to nature, but an analysis of contemporary prints and negatives proves that hardly any photograph remained free of post-processing or retouching. Penck dedicates a whole page to the topic of 'picture enhancements'.[22] He claims that Simony mitigated defects in the photographs, worked on light and shade (by burning or dodging), and improved fuzzy parts with pen and pencil. Such descriptions imply that Simony might have embellished his pictures, but the example of the karst formation is clear evidence that it often was his reworking of the photographs that made them useful for science in the first place.

Even today, scientific analysis of photographic images often only starts during or after post-processing. As with Simony, the choice of correct setting (snow cover, clouds, position of the sun) and post-production are essential for obtaining a useful image. The high backscatter of fresh snow, which reflects almost 90 percent of sunlight, still makes it difficult to display the contrasts within the much darker layers of firn or to render the structures of glacier ice, which only reflects about 10 percent of sunlight. In high summer, pictures of glaciers are often impaired by cloud shadows from convective clouding; in autumn the hard shadows make parts of a picture disappear in the dark. Glaciers often flow in a northerly direction, a very unfavourable aspect in terms of light. The firn areas are in the shadow of high cirques, where avalanches deposit snow. Early and late in the day, shadows darken the glacier edges; in the midday sun the glacier is backlit. At all times of the day, the firn area and snow areas are oversaturated, with extremely reduced contrast, while lower areas are very dark. Only very rarely can a single shot display the dynamic range of the firn area and the internal structures of the glacier tongue. This means that even today's camera options — for instance, digital layering of images with different exposure times during one shot or the selection of areas within one view to change contrast or brightness — are of limited usefulness. We are still forced to wait for favourable conditions, for instance, high stratiform clouds. Photographing the stratigraphy in ice caves under a glacier is particularly challenging as even additional lighting has little effect due to the low backscatter of the ice. Imaging of inner structures, say, of snow, today is preferably done tomographically in laboratories[23] or in the field using LiDAR.[24] In this method a laser beam scans the ice in a grid. The amplitude of the backscatter reflects the differences in brightness, which can be seen with the naked eye, but are difficult to capture in a photograph. From the runtime of the laser beam between sender and reflective surfaces a digital elevation model (DEM) can be calculated, that is, a digital grid in which each grid point represents the medium elevation of the pixel. This digital afterimage of the Earth's surface can then be used to produce a three-dimensional view of the landscape from

2b / **Friedrich Simony, Karst formation in the Wiesalpe (plate 6 from Dachsteingebiet),** 1876
autotype
Photo: Collection Mila Palm

any viewpoint. The position of the artificial lighting in this shaded relief can be freely selected, even as lighting from the north, which is often favourable for the representation of glaciers. Surface roughness can be enhanced by the hard shadows at low positions of this 'artificial sun' and by selected lighting aspects. This method is used today to map the reach of glaciers[25] and to document their disappearance.[26]

Laser scanning and photography are the major imaging tools used in geography today. Laser scan images represent structures such as furrows much more clearly than photographs could, especially as the Earth's surface can be captured without vegetation in laser scanning. This makes masking surface formations of forest cover redundant. Geomorphological formations are much more clearly visible than in a photograph, where ground cover and the differences in colour and texture deriving from it dominate the viewer's impression.

3/ The bed of the tongue of Gosau Glacier, 1884
Collotype print [3]

After 1877 Simony increasingly dedicated himself to publishing his pictures of the Dachstein massif. At first, he self-published folders of loose photographs with a short text included.[27] He was mainly interested in publishing his material in specialist journals, but for technical reasons these featured few illustrations at the time. Only when printing processes improved markedly from 1883 onwards did more photographs find their way into Simony's publications. From 1885 onwards he used autotypes, then a new method that allowed printing a photograph and a text together in one process. Putting words side by side with pictures made it easier for Simony to underline his arguments. At the same time, technical advances reduced costs and improved image quality to such a degree that the material could be published in high print runs. Simony's photographs subsequently appeared in loose format as teaching material, in magazines, specialist journals, and eventually in his richly illustrated Dachstein monograph.

One of the first photographs in the *Mittheilungen der k. k. Geographischen Gesellschaft in Wien* from 1885 is Simony's and shows the bed of the Gosau Glacier.[28] This detailed view illustrates several scientific insights. The Gosau Glacier reached its maximum in 1848, at the end of the so-called Little Ice Age, which brought cooler periods and a glacial maximum between 1250 and 1870 AD. The glaciers expanded to cover an area exceptional in size in the last 10,000 years of the post-glacial period. Advancing glaciers push sediment ahead, leaving bank-like deposits that, once the glaciers recede, mark their largest expanse. The different grain sizes of the sediment in glacial deposits are unsorted, unlike deposits that result from transport by water. No one had described these facts before Simony, who showed them in this photograph as the basis of a scientific debate. The person in the picture serves to illustrate the scale and is not, as in images of the time, part of the artistic composition.

The moraine on the right is clearly not situated at the edge of the glacier but away from it. Simony thus demonstrates a change in Alpine glaciers, which was called *oscillation* at the time. It had been mentioned in

3 / **Friedrich Simony, The bed of the tongue of Gosau Glacier**, 1884
collotype print
University of Vienna, Geography and Regional Research Library (partial estate of Friedrich Simony)
Photo: University of Vienna, Geography and Regional Research Library

historical reports but not been measured in natural science terms. The justified historical-critical analysis of the reports on glacier changes thus lacked evidence. The picture clearly demonstrates that the area where the person is standing was once englaciated. Thanks to the clear, high-contrast image, the different grain sizes and sharp forms that Simony describes in the related text can be clearly appreciated, as well as the mix of these grain sizes in the glacial deposits. The image supports the line of argument contained in the text and paves the way for mapping the former reach of the glacier.

Simony also passed these findings on to his students as is suggested by the large number of prints of this motif in his estate at the university. The wide acceptance of the genesis of these landscape forms, which we call glacial today, among young scientists made room for a thesis that some opinion leaders of the time, like Humboldt, rejected[29]: the theory of ice ages, that is, fluctuations in the size of glaciers. Simony documented the glacial transport and deposit of erratic rocks, which had been interpreted as the result of deluges just a few years before. His theories, supported by convincing photographs, inspired the next generation to map the size of Ice Age Alpine glaciers[30] and thus prove the existence of ice ages and climate change. It became clear that climate is not a static characteristic of a place but one that can change.

At the beginning of the twentieth century, Tyndall[31] proved that the CO_2 content of the atmosphere influenced the Earth's climate, yet research in the following decades was mainly dedicated to the natural fluctuations of the climate. Glaciologists concentrated on investigating theories of cyclical fluctuations. It was only when direct measurements of CO_2 in the atmosphere started that the anthropogenic rise in temperatures caused by greenhouse gas emissions became accepted. While earlier summaries for policymakers made by the Intergovernmental Panel on Climate Change (IPCC) stated that temperatures were rising, it took the IPCC report of 2007[32] to point out the clearly attributable role of human activities, when the rise in temperatures measured until then lay outside the natural fluctuation range. In all reports, glaciers retain their role as definitive and clearly understandable witnesses of climate change, a role they have had since Simony's days, and the cover of the 2013 IPCC report shows a picture of a glacier in Simony's style.[33] Comparing pictures to demonstrate changes in glaciers is still the method of choice, both in a scientific context and in the societal discourse on climate change, its consequences, and the measures required to deal with it.

4 / **Friedrich Simony, Double page from Schwinden des Karlseisfeldes**, 1891
autotypes
Upper Austrian Provincial Museum, Linz, library
Photo: Upper Austrian Provincial Museum, Linz, library

4/ Double page from Schwinden des Karlseisfeldes, 1891 Autotypes [4]

Among Simony's most impressive photographs are those of the glaciers of the Dachstein massif, especially the largest one, known as Karlseisfeld (Hallstätter Gletscher). Long before he started using photography, Simony had taken measurements to document the advance of the Dachstein glaciers, which after 1856 began to permanently retreat, which is still continuing today. In 1840, on his first visit of the Dachstein, he painted a watercolour of the Karlseisfeld. He chose a position with a good view on the glacier tongue from where he later also took photographs. He recommended a systematic approach to producing scientific images: taking down the exact time and place of capturing an image would facilitate a *'general interest and understanding'* and turn it into a *'historic document'*.[34] To trace periodic changes, especially in the case of glaciers, it was necessary to take up the exact same position regularly and consistently, so that different stages became clearly visible. Penck was quick to acknowledge the significance of this type of documentation: *'The significance of Simony's studies of the Dachstein glaciers today rests mainly on the fact that he himself witnessed the advance of the* [eighteen] *forties and fifties. He saw the Karlseisfeld expand, then collapse at the tongue, split above the Eisjoch pass and shrink to a state that we know from an earlier period only in legend. He has captured all these different phases of the reach of the ice in pictures.'*[35]

Today, comparing pictures to demonstrate changes in glaciers is ubiquitous in science as well as in the public discourse[36] on climate change. In this context, the photographs that Friedrich Simony took of the Dachstein glaciers have gained a second lease on life: a photographic timeline of the development of glaciers is all the more valuable the further back it goes. Across the world there are very few photographic records of alpine glaciers[37] that start so early and continue for decades. Simony recognized the value of his glacier photographs as historical documents. But there cannot be many scientists in the world whose oeuvre has remained topical for such a long time and which has influenced contemporary research so greatly through historical developments.

NOTES

1 Elisabeth Lichtenberger, 'Die Entwicklung der Geographie als Wissenschaft im Spiegel der Institutionspolitik und Biographieforschung. Vom Großstaat der k. u. k. Monarchie zum Kleinstaat der Zweiten Republik', in Robert Musil and Christian Staudacher (eds), *Mensch Raum Umwelt. Entwicklungen und Perspektiven der Geographie in Österreich*, Wien 2009, pp. V13–52.

2 Translator's note: Translations of quotes in this paper are aimed at a contemporary readership and do not always follow closely the diction of the mid-nineteenth-century original. Albrecht Penck and Friedrich Simony, 'Leben und Wirken eines Alpenforschers. Ein Beitrag zur Geschichte der Geographie in Österreich', *Geographische Abhandlungen* VI, 1898, No. 3, p. 42.

3 Wilfried Haeberli, Martin Hoelzle and Frank Paul, 'Integrated Monitoring of Mountain Glaciers as Key Indicators of Global Climate Change: The European Alps', *Annals of Glaciology*, No. 46 (1), 2007, pp. 150–160.

4 Nerilie Abram, Jean-Pierre Gattuso, Anjal Prakash et al., 'Framing and Context of the Report', in Hans Otto Pörtner et al. (eds), *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*, 2019.

5 Ingrid Kretschmer, 'Kartographische Arbeiten Friedrich Simonys', in *Geographischer Jahresbericht aus Österreich* LIII, Wien 1996, pp. 43–61, esp. pp. 45–46 (Friedrich-Simony-Gedenkband).

6 Friedrich Simony, 'Die Landschafts-Photographie in ihrer wissenschaftlichen Verwertung', in *Photographische Correspondenz*, Wien 1876, pp. 105–111, esp. p. 106.

7 Archaeologist Alexander Conze had used photographers since 1873 on his Samothraki expeditions and included many of the resulting pictures in his publications. Magdalena Vuković, 'Der Geograf als Fotograf: Friedrich Simonys Aufnahmen des Dachsteins als Lehr- und Anschauungsmaterial', in eadem (ed), *Von wunderbarer Klarheit: Friedrich Simonys Gletscherfotografien, 1875–1891*, Wien 2019, p. 16.

8 Milan Chlumsky, 'Die Erfindung der Natur: Die Alpenphotographie der Gebrüder Bisson', in Bodo von Dewitz (ed), *Alles Wahrheit! Alles Lüge! Photographie und Wirklichkeit im 19. Jahrhundert*, Köln 1999, pp. 380–399.

9 Monika Faber, 'Gemeinschaftsaktion Großglocknerbild', in eadem (ed), *Inspiration Fotografie: Von Makart bis Klimt*, Wien 2016, pp. 72–73.

10 Vuković (note 7), pp. 14–15.

11 Simony certainly knew the pictures of Mont Blanc by the Bisson brothers, which had been shown in Vienna at the first meeting of the Austrian Alpine Club in November 1862. His first documented comment on the pros and cons of photography as a tool in geography appeared in an essay in 1868: Friedrich Simony, 'Das Landschaftsbild als geographisches Anschauungs-Mittel', in *Mittheilungen der k. k. Geographischen Gesellschaft*, Wien 1868, pp. 252–257. — Vuković (note 7), pp. 19–20.

12 Friedrich Simony, *Das Dachsteingebiet: Ein geographisches Charakterbild aus den österreichischen Nordalpen* II: *Atlas und Text* [sowie Begleitwort], Wien 1893, s.p. [p. 3].

13 Andreas Kääb, Tobias Bolch, Kimberly A. Casey et al., 'Glacier Mapping and Monitoring Using Multispectral Data', in Jeffrey S. Kargel et al. (eds), *Global Land Ice Measurements from Space*, Heidelberg 2014, pp. 75–112.

14 Albrecht Penck, 'Friedrich Simony: Leben und Wirken eines Alpenforschers. Ein Beitrag zur Geschichte der Geographie in Österreich', *Geographische Abhandlungen* VI, 1898, No. 3, p. 11.

15 Ibidem, pp. 58–59.

16 Ibidem, p. 58.

17 Theodore A. Scambos, Melanie J. Dutkiewicz, Jeremy C. Wilson et al., 'Application of Image Cross-Correlation to the Measurement of Glacier Velocity Using Satellite Image Data', *Remote Sensing Environ* XLII, 1992, No. 3, pp. 177–186.

18 *'Die von* [Simony] *erfundene Methode der Contourenzeichnung* […] *mag immerhin vom rein künstlerischen Standpunkte nicht einwandfrei sein, für wissenschaftliche Zwecke lässt sie sich schwerlich durch eine bessere ersetzen.'* Transl.: *'From an artistic point of view, the contour drawing method invented by Simony may not be perfect, but for scientific purposes there is hardly a better*

one available.' See Carl Diener, 'Zur Erinnerung an Friedrich Simony', in *Mittheilungen der kaiserlich-königlichen Geographischen Gesellschaft*, Wien 1896, pp. 761–769, esp. p. 766.

19 Penck (note 14), p. 29.

20 Vuković (note 7), pp. 16.

21 Simony (note 12), panel VI., s.p.

22 Penck (note 14), p. 52.

23 Michael Lombardo, Martin Schneebeli and Henning Löwe, 'A Casting Method Using Contrast-enhanced Diethylphthalate for Micro-computed Tomography of Snow', *Journal of Glaciology* LXVII, 2021, No. 265, pp. 847–861.

24 Michael N. Demuth, 'LIDAR in Glaciology', in Vijay P. Singh, Pratap Singh, and Umesh K. Haritashya (eds), *Encyclopedia of Snow, Ice and Glaciers*, Dordrecht 2011, p. 713–722.

25 Jakob Abermann, Andrea Fischer, Astrid Lambrecht et al., 'On the Potential of Very High-resolution Repeat DEMs in Glacial and Periglacial Environments', *The Cryosphere* IV, 2010, No. 1, pp. 53–65.

26 Andrea Fischer, Gabriele Schwaizer, Bernd Seiser et al., 'High-resolution Inventory to Capture Glacier Disintegration in the Austrian Silvretta', *The Cryosphere* XV, 2021, No. 10, pp. 4637–4654.

27 Vuković (note 7), pp. 16–19.

28 The figure published here is a trial print (see title) from Simony's partial estate. The photograph was published in the *Mittheilungen* as panel III. Friedrich Simony, 'Über die Schwankungen in der räumlichen Ausdehnung der Gletscher des Dachsteingebirges während der Periode 1840–1884', in *Mittheilungen der k. k. Geographischen Gesellschaft*, Wien 1885, pp. 113–135.

29 Hanno Beck, 'Alexander von Humboldt und die Eiszeit', *HiN: Alexander von Humboldt im Netz* XX, No. 38, 2019, pp. 51–67 (Forschungsunternehmen der Humboldt-Gesellschaft I).

30 Albrecht Penck and Eduard Brückner, *Die Alpen im Eiszeitalter*, Leipzig 1909, 3 vols.

31 John Tyndall, *The Glaciers of the Alps*, London 1860.

32 IPCC, *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Geneva 2007.

33 IPCC, *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge and New York 2013.

34 Simony (note 6), pp. 108–109.

35 Penck (note 14), p. 42.

36 Wolfgang Zängl and Sylvia Hamberger, *Gletscher im Treibhaus. Eine fotografische Zeitreise in die alpine Eiswelt*, Steinfurt 2004. — Deborah Roth, 'Galerie: Gletscherschmelze in Europa: Die Vorher-Nachher-Bilder des Klimawandels von 1880 bis heute', *National Geographic*, 2021, 8. 2., https://www.nationalgeographic.de., 23. 12. 2021.

37 Heinz Jürg Zumbühl and Samuel U. Nussbaumer, 'Little Ice Age Glacier History of the Central and Western -Alps from Pictorial Documents', *Cuadernos de Investigación Geográfica* XLIV, 2018, No. 1, pp. 115–136.