NOTES AND RECORDS

THE CENTENNIAL EDITION OF THE 1908 ALPENVEREIN MAP OF THE BRENTA MASSIF, ITALY

(Map Supplement: Gruppo di Brenta 1:15 000
Special Edition on the Occasion of the 100th Anniversary of the First Edition)

Manfred F. Buchroithner and Thomas Himpel

Summary: The synergetic use of different traditional and, above all, modern techniques and technologies permitted the time-efficient production of a Centennial Edition of the world-famous high-mountain map of the Brenta Massif, first published in 1908. During the updating field survey in this extreme alpine terrain, classical cartographic field-sketching, terrestrial laser scanning, and geotagged landscape (stereo) photographing, together with measurements by geodetic and handheld GPS, were applied. Satellite imagery and digital image processing supported the digital cartographic work. However, glacier retreat areas had to be complemented by classical manual rock and scree drawing in the unique style of Aegerter-Rohn in order to maintain a homogeneous appearance of the re-used terrain depiction of the first edition.

Zusammenfassung: Durch den synergetischen Einsatz verschiedener traditioneller und vor allem moderner Techniken und Technologien konnte mit hoher Zeiteffizienz eine aktualisierte Jubiläumsausgabe der weltberühmten Hochgebirgskarte der Brenta-Gruppe anlässlich des Erscheinens von deren erster Ausgabe im Jahre 1908 hergestellt werden. Klassisches Krokieren, terrestrisches Laserscanning und „geotagged" (Stereo-) Geländefotografie wurden unter Verwendung von geodätischem und hand-held GPS in extremem alpinen Gelände appliziert. Satellitenfernerkundungsdaten und digitale Bildverarbeitung unterstützten die digitalkartographischen Arbeiten. Gletscherrückzugsgebiete mussten allerdings mit klassischer händischer Fels- und Gerölldarstellung im einmaligen Stil von Aegerter-Rohn ergänzt werden, um den homogenen Eindruck der wieder verwendeten Geländedarstellung der ersten Ausgabe zu erhalten.

Keywords: Brenta, glacier mapping, mountain cartography, rock drawing, scree drawing, terrestrial laser scanning (TLS), digital image processing, GPS

1 Geographical setting

Located in Northern Italy, west of Trento and north of Lake Garda, the Brenta Group certainly represents the second famous calcareous mountain massif in the Southern Alps besides the Dolomites (Fig.1). It covers an area of roughly 300 km² with the highest peaks reaching above 3000 meters (Cima Tosa, 3146 m; Cima Brenta, 3151 m). The maximum altitude differences amount to approx. 2850 meter.

The high relief intensity and the multitude of mighty dolomite faces and spires make Brenta's landscape very unique and have for long been attracting tourists. This is also the reason why the Deutscher und Österreichischer Alpenverein (German and Austrian Alpine Club) published a high-mountain map of the group at a scale of 1:25 000 already in 1908.

2 Motivation – the Brenta Map of 1908

Credits have to go to the late Professor Gustav Neugebauer, Munich, for having given appropriate appraisal to the unique and at the time of its publication, already highly acclaimed Alpenverein Map of the Gruppo di Brenta. It was published in 1987 at the scale of 1:25 000 and there was a special 187-page volume dedicated to the map called

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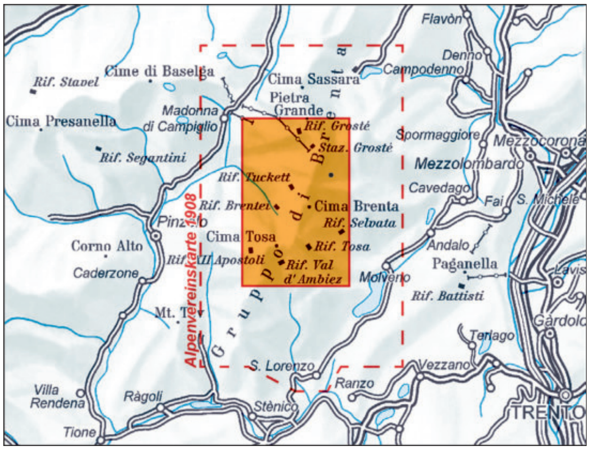


Fig. 1: Location map of the Brenta Group with indication of the map outline of the 1st edition from 1908 (broken-line frame). The orange field indicates the extension of the present 2009 edition. Taken from the cover of this edition

the "Brenta Monographie" (Neugebauer 1987). Since the production of maps for the Deutscher Alpenverein (DAV, German Alpine Club) is one of the activities of the TU Dresden Institute for Cartography, the authors were well aware about the upcoming centenary of the publication of the first edition of the Brenta Map. It was in discussions with the head of the Cartography Unit of the DAV, Johannes Fischer that the plan arose to produce a "Centennial Edition" of this unique map.

Regarding an objective scientific assessment of this famous map, the reader is kindly referred to the aforementioned Brenta Monograph. The congenial team of Leo Aegerter and Hans Rohn, responsible for the first map edition, generated a whole series of brilliant high-mountain maps within the period from about 1900 to approx. 1935. Leo Aegerter, a Swiss citizen, born 6 February 1875 in Paris and deceased 30 May 1953 in Zirl near Innsbruck, was an engineer-topographer and employed by the Deutscher und Österreichischer Alpenverein (Neugebauer 1987). Hans Rohn, an Austrian citizen, born 25 February 1868 in Vienna and deceased 23 December 1955 in Vienna, was an academic painter ("Akademischer Maler") and employed as a carto-lithographer at the famous Viennese map publishing house Freytag-Berndt & Artaria (Fischer 2009). They were active during a time when elevation contours and rock-drawing were still considered independent, and even mutually exclusive, map elements. Further information about this period of the high-mountain cartography, the so-called period of "classical Alpenverein (Alpine Club) cartography", can be retrieved from Erik Arnberger's comprehensive volume "Die Kartographie im Alpenverein" (Arnberger 1970). In insider circles, the Alpenverein maps are referred to as AV maps.

To update the last, 5th edition of this map – in particular with respect to the glacier states – and to compensate for some of the mistakes made within the cartographic work from the previous editions was a great challenge for the team mentioned in the next section.

3 Updating the 5th edition of 2005

3.1 Field campaign

Starting on 10 August 2008, a team of three cartographers from the Institute for Cartography of the Dresden University of Technology, namely Manfred Buchroithner, Klaus Habermann and Thomas Himpel, set off from the Rifugio Vallesinella (1513 m) for a strenuous two-week field campaign. A Riegl LPM-321 terrestrial laser scanner with a synchronous Canon EOS 350D, a car battery, a Trimble 4000SSI geodetic GPS, a laptop, alpine gear for the climbing of viae ferratae (fixed-rope routes), nutrition and clothing resulted in backpacks of close to and for one team member even more than 50 kg. The route accomplished within this comparatively short period of time is shown in figure 3.

From discussions with the DAV, in particular with the cartographer Johannes Fischer, it was known that the glacier updating had been culpably neglected in the previous editions, and that some glaciers were supposed to have lost more than 20 meters in thickness or even vanished completely. Hence, the major task of the field survey was to accomplish a complete updating of the glaciers on the whole map sheet. That – quasi en passant – also all other relevant features, in the first instance the tourist infrastructure, had to be checked and updated, goes without saying. Due to the comparatively recent edition of 2005, these updates turned out to be not overly comprehensive.

A major job, however, was the mapping of the scree and rock areas where the glaciers had vanished. For this task two methods were applied. First, a cost-intensive high-precision survey by means of terrestrial laser scanning (TLS), and second, a less expensive approach using field-sketches and directed geotagged (stereo) photography for subsequent stereo-plotting and stereo interpretation.

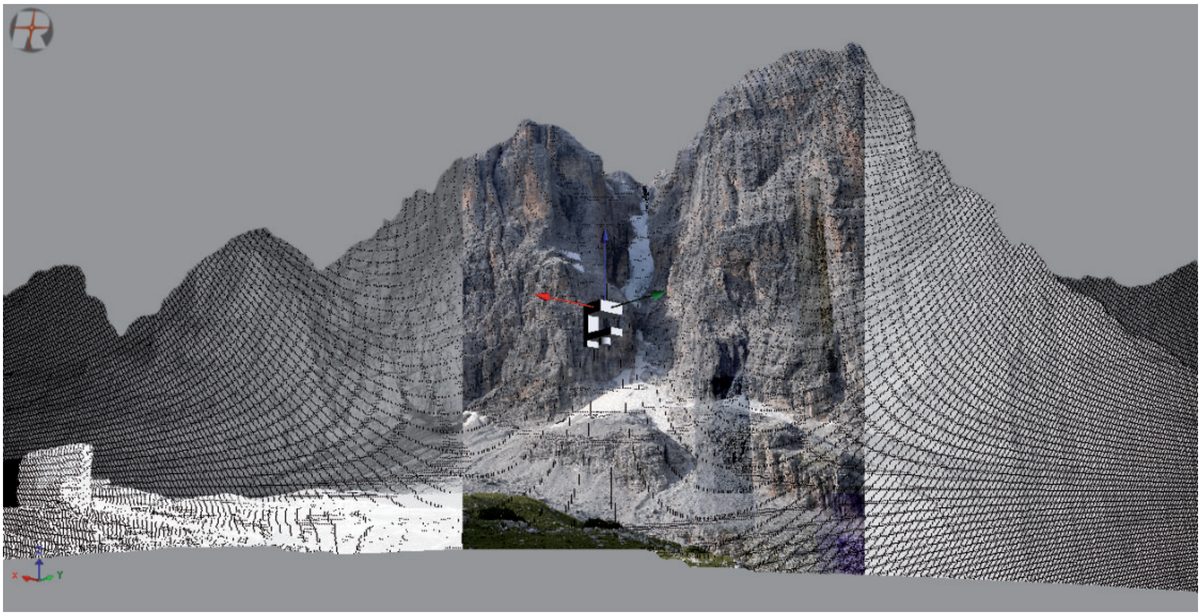


Fig. 2: Visualisation of the raster-converted point cloud partly of the north-side of Cima Tosa (3146 m) overlaid with image texture using RiProfile® Software. To the right of the coordinate system there is the recent disruption spot of the previously continuous famous ice couloir

3.1.1 Terrestrial laser scanning

Based on previous experiences of the team with glacier surveying in the Austrian Großvenediger Group with the same device, the glacier measurements with the Riegl LPM-321 terrestrial laser scanner went rather smoothly. Due to well selected surveying points, a satisfying coverage was achieved. However, the limits of terrestrial glacier laser scanning also had to be discovered: Too acute incidence angles of the laser beams on the ice or snow resulted in scrambled data.

The extreme alpine nature of the terrain and in particular the necessity to use viae ferratae (fixed-rope routes) as well as the very heavy gear (cf. Photo 1) including the laser scanner with some 20 kg and the car battery with more than 25 kg prevented checking all glaciers during the field campaign. The major "points of interest" for the TLS application were the Vedretta di Brenta inferiore, reaching up to the Bocca del Tuckett (2649 m), scanned from a rather exposed surveying point near the Refugio Tuckett e Sella (2272 m; cf. Photo 1 and Fig. 3. L1: 2414 m, and L2: 2274 m, Photo 2), and the Cima Tosa Ice Couloir, reaching up to the summit of Cima Tosa (3146 m), scanned from the chapel (2195 m) near the Refugio Brentèi (2182 m, Photo 3).

In order to exploit the performance limits of the LPM 321, the Vedretta di Camosci, reaching up to close to the Bocca di Camosci (2784 m), was scanned from a location near the Refugio Casinei (1835 m). Albeit, despite night-survey attempts between 2:30 and approx. 5 a.m., subject to the horizontal distance of 5200 m to the upper glacier boundary, a vertical difference of more than 900 m and the resulting acute incidence angle of the laser beam onto the glacier surface this scanning did not result in usable measurements. (The surrounding rock faces gave excellent results, though.) All other glaciers

Photo 1: Negotiating a rope-belayed passage of an exposed narrow mountain trail in the valley of the Vedretta di Brenta inferiore carrying the LPM-321 terrestrial laser scanner and tripod. Mounted on the carrying frame to the left is the 26.5 kg car battery. In the background, the Bocca de Tuckett (2649 m) where the Vedretta di Brenta inferiore originates. To the right, the northface of Cima Brenta (3151 m). Cf. Photo 2, figures 3–4 and enclosed map supplement

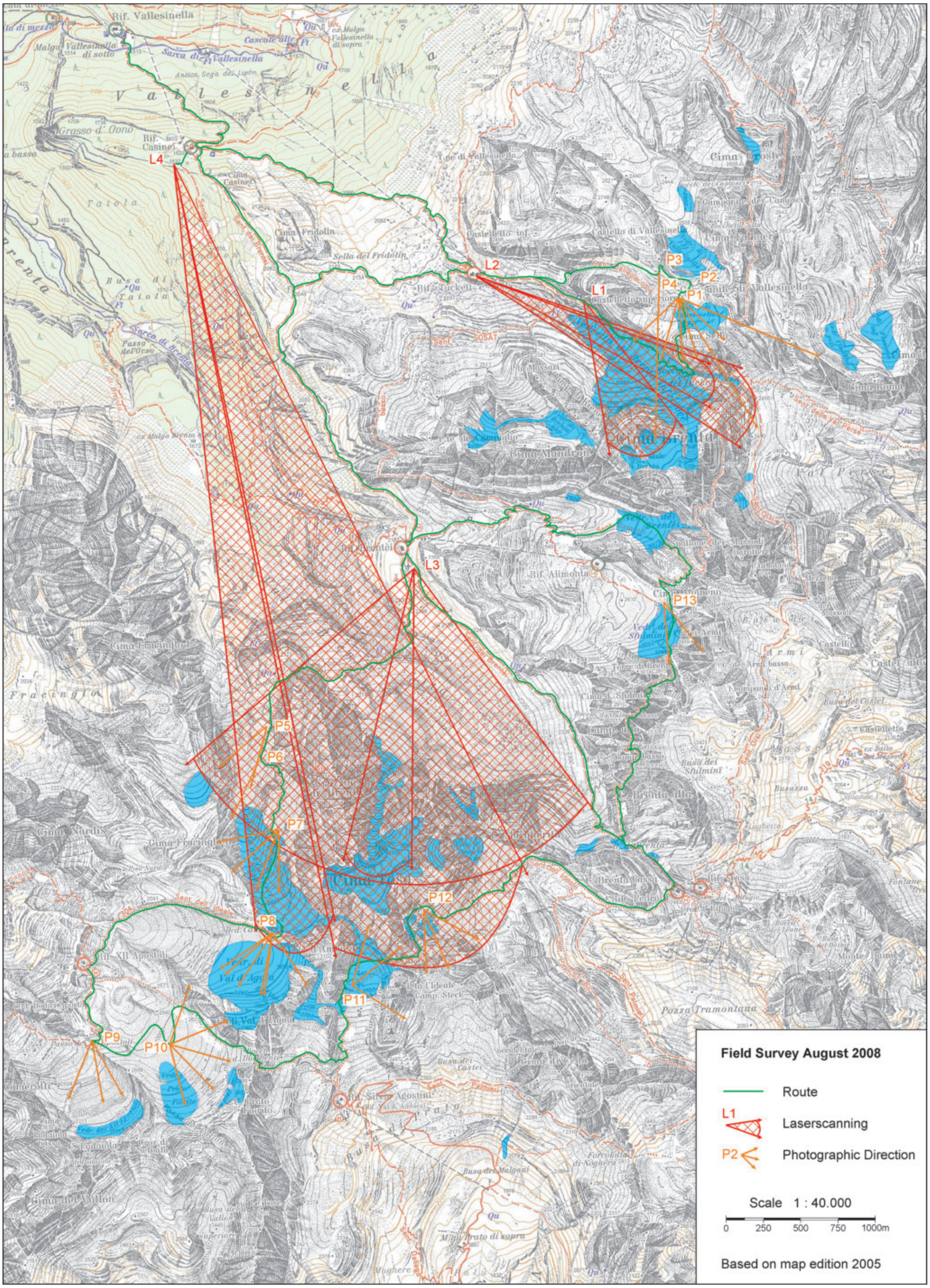


Fig. 3: Centennial edition of the Brenta Map showing the route of the summer 2008 field campaign with indication of the photographic and TLS survey

Photo 2: Eastern part of Cima Brenta (3151 m) North Face (cf. figures 3 and 4). From this very location both TLS and geotagged photographic surveys were carried out

were mapped using the second method. This was in part caused by the fact that the field team tried to avoid climbing the very exposed passages of the viae ferratae along the previously optimised route with the heavy TLS equipment, which was stored at the Rifugio Brentèi (2182 m) when not used.

Various screen-shots of the scene visualisations generated by the RiProfile® Software were then used for later interpretation, resp. integration (Fig. 2).

It goes without saying that for the whole route, continuous GPS measurements were recorded that were then later used to verify and, where necessary, update the exact up-to-date trail locations. Regarding the recent height of Cima Tosa, i.e. its summit ice cap, GPS recordings of befriended alpinists were used to average the up-to-date elevation (cf. caption of figure 5).

3.1.2 Directed geotagged field photography

As already indicated, most of the glaciers were updated using conventional field-sketching (croquis) and directed geotagged photography. The acquired digital photographs, which were taken by a high-quality digital reflex camera Canon EOS 400D, were then used back in the office in verifying and fine-tuning the field sketches. Those that were taken with a defined overlap were also used for subsequent stereo-plotting (using e.g. the ERDAS LPS Software) and, predominantly, mono-plotting. The majority of the pictures was, however, simply interpreted using a normal mirror stereoscope. The long-standing experience of one of the authors allowed the quick and accurate mapping of the summer 2008 boundaries of the glaciers. However, it should be mentioned that the outlining of the actual ice extent was not always easy, even in the field: in many instances, a scree cover hid the true glacier extension and it required extensive field experience and a sharp eye to determine the actual origins (e.g. Bocca Camosci) and termini of the glacier ice.

It was within the course of the field campaign during many discussions with active map-using alpinists in which the critique frequently came up: that the existing editions of the Brenta AV Map do not allow one to really exploit and hence appreciate the excellent quality of the Aegerter-Rohn rock drawing due to the too small map scale and, hence, the too high line density, which at places even results in almost completely black bands. Consequently, we came up with the plan to gener-

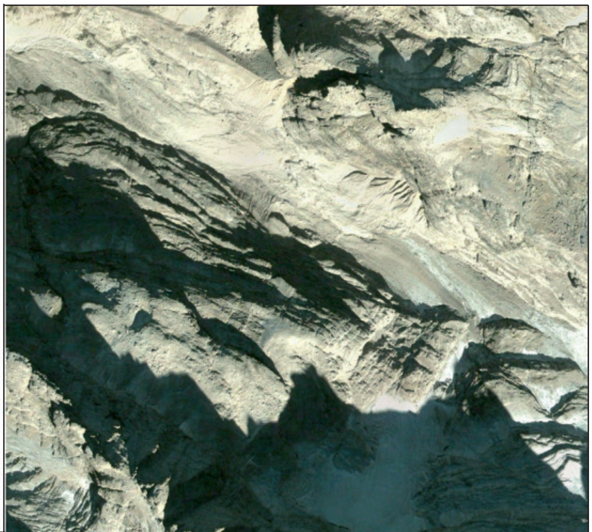
Photo 3: The Riegl LPM-321 terrestrial laser scanner stationed in front of Refugio Brentei (2182 m) while scanning the famous Cima Tosa (3146 m) Ice Couloir

ate a magnified version that provides appropriate credit to the beauty and richness of the rock and scree depiction. This, however, again implied the reduction of the map field in order to not obtain a sheet size which is difficult to handle. In any case, the "heart" of the range with its famous via ferrata, the Bocchette Trail, had to be depicted. Subsequent considerations finally resulted in the decision for a scale of 1:15 000 and a map-field size of 48 cm x 66 cm.

3.2 Cartographic work

The integration of the updated glacier boundaries, which were gained from the field sketches, the photo restitution and the analysed TLS measurements, into the original printing films of the 2005 Edition of the Brenta AV Map was done in several steps. (The data files of the digitised printing films were kindly provided by the DAV.) Due to the missing geocoding of these original films (onto the precise recent map projection) and in order to reduce the quality loss coercively caused by such a georeferencing and the related transformation procedure, a geometric correction was not carried out.

For raster data processing, Adobe Photoshop CS2 software was used. First, the eight colour separations of the 1:25000 map, supplied with a resolution of 1200 ppi as individual special colours, were imported into one joint Photoshop file. Then the



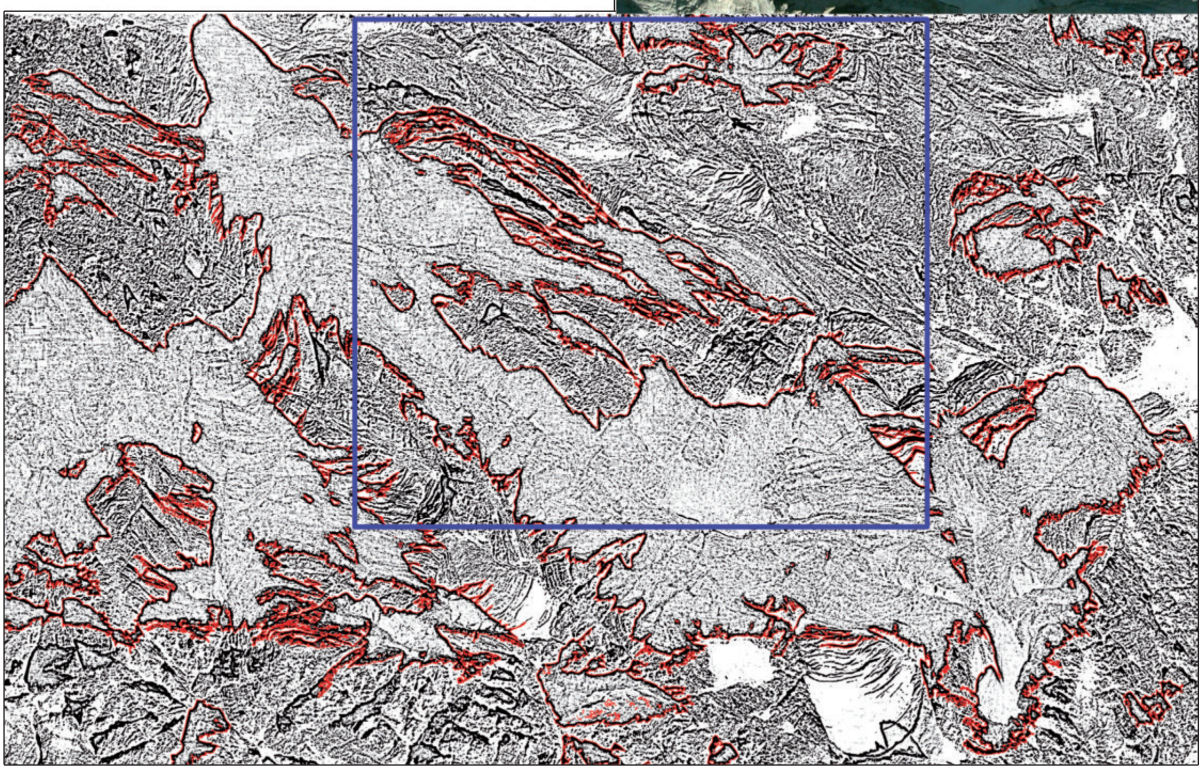


Fig. 4: Original (top) and edge/contrast-filtered subscene (bottom) of ultra-high resolution QuickBird satellite imagery of 2008/07 showing the northface of Cima di Brenta (3151 m). The typical layered rock structure becomes clearly visible (cf. Photo 2 and the enclosed map supplement). Red lines mark light/shadow boundaries. The original image (top) represents the central portion of the lower binary picture (cf. blue frame)

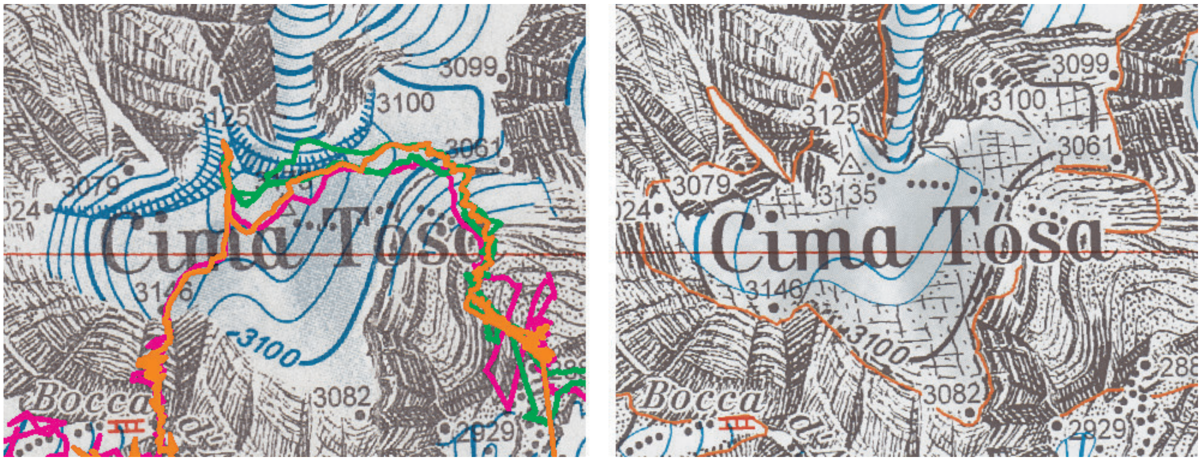


Fig. 5: Summit ice cap of Cima Tosa (3146 m). Left side: Alpenverein map edition 2005. Indicated are GPS tracks from summer 2008 and 2009 (purple: 26-07-2008, orange: 24-08-2008 green: 23-07-2009) Right side: The present map clearly shows the shrinkage of the ice cap both in thickness and extension. The rock-drawing reveals the nearly orthogonal fracturing of the horizontally layered dolomite rocks that now crop out

map field corresponding to the envisaged new map was defined and transformed onto a resolution of 716 ppi, which corresponds to the scale of 1:15 000. In a second step, the new glacier outlines and elevations contours of the glacier retreat areas derived from both TLS and photo stereo-plotting and interpretation were inserted into the file's special colour channels Blue and Black. Prior to that, however, the old glacier extensions and contour lines had to be deleted using the rubber stamp function. Subsequently the two colour channels were combined into one plot, which served as a basis for manual completion of the missing scree and rock drawings.

On the basis of ultra-high resolution QuickBird satellite imagery (Fig. 4, on top) and an image product resulting from the application of edge-filtering (Roberts, Kirsch; cf. Fig. 4, bottom) the missing scree and rock depiction was manually completed. This was done on hardcopies magnified by a factor of 2 in order to allow imitating the drawing style of Aegerter-Rohn in the best way possible. However, after filtering, the shadow areas were marked with red contours in order to avoid an erroneous drawing of shadow "contours" (i.e. boundaries) as rock bankings. The results of the rock and scree drawings were then copied into the special colour channel Black. The fact that all colour separations were available and also processed as binary data, allowed performing the afore mentioned work step without considering the brightness differences that actually resulted between the "old" rock drawing being initially generated as a grey-level image and the scanned lines of the new manual rock drawing. The merging of the old and the new rock drawing was done with sub-pixel accuracy.

The hill-shading layer was not provided by DAV in digital form. Thus, the respective printing film was scanned at the Saxon State and University Library (SLUB) with their large-format CRUSE Scanner CS 220 SL 450.

The further cartographic work concerning layout, map frame and margin as well as the integration of the glacier boundaries of 1908 (which were considered to be of interest for the map-users in comparison to those of 2008) was done using Swiss OCAD software. All 9 colour separations were loaded into OCAD which was then also used to complete the file to the final product. Consequently all colour separations were exported as binary images in TIF format.

This data format could be easily handled by the printing house of the c-macs. However, the presence of the authors during the printing process allowed performing additional final colour fine-tuning, mainly of the forest areas and the hill-shading in relation to the rock-drawing. The aim was to obtain a most delicate lining of the rock drawing in order to come close to its original appearance in the 1908 edition.

4 Conclusions and outlook

Despite the very short handling time available and an extremely difficult alpine terrain, the synergetic use of various field surveying and cartographic technologies and techniques allowed generating an up-to-date large-scale high-mountain map of the Brenta Group. Remarkable is the combined application of TLS and directed geotagged terrestrial photography as well as the combination of ultra-high resolution satellite imagery, digital image processing and classical manual scree and rock drawing. The optimised application of these approaches resulted in a map product, which not only documents the glacier state of 2008 (in comparison to the also indicated situation in 1908), but also puts the value of the outstanding original rock drawing by Aegerter-Rohn into the right light.

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