High-Altitude Architecture and Landscape: a Survey for the Conservation of Military Works at the Stelvio Pass

Alessio Cardaci, Pietro Azzola, Antonella Versaci

Abstract

The Stelvio pass hosts treasures that tell the story of the Great War. Remains hidden for more than a century in the ice of peaks of more than 3.000 meters altitude and revealed today following the gradual increase in temperatures. Complex of small fortifications, trenches, artillery sites and tunnels for the shelter of troops and vehicles. They testify to the violent clashes between the mountain ranges of Ortles-Cevedale, Tonale and Adamello. An integrated system where the military architecture blends with the landscape and camouflages itself with the materials and colors of the high-altitude environment; the rock is transformed into buildings to accommodate the spaces and functions necessary for the survival of men. A story little told but useful to make known another 'viewpoint' of the conflict to spread and communicate also with the tools of the Science of Drawing. The surveyor thus has the task of rendering, thanks to the graphic representation, the measurement of the territory and the representation of the landscape. The essay presents the results of a historical-architectural and landscape study that included the virtual reconstruction of the fortification of the pass: from the acquisition carried out with UAV systems to the return through 3D modelling. A particular place that the direct investigation and the electronic eye of the sensors, which from the top of the sky can read the particularity hidden among the high peaks, have allowed to perceive and document to preserve its physical substance and memory.

Keywords: Great War, 3D survey, drawing, documentation, valorisation.

Introduction

The Stelvio Pass hosts treasures that document and tell the story of the Great War (1914-1918). They are a complex of vestiges and artefacts preserved for over a century among ice of peaks over 3,000 m high and made visible today by the progressive increase in temperatures. They also comprise small fortifications, trenches, artillery emplacements and tunnels created to shelter soldiers and vehicles. These bear witness to the violent clashes fought on the Ortles-Cevedale Mountain group, whose main ridge just begins from the pass (fig. 1). This integrated system is where extraordinary natural scenarios contrast with tragic events that took place in an extreme context. Here, military architecture blends with the landscape and camouflages itself with the materials and colours of the alpine environment; the rock was transformed into built spaces to accommodate the functions necessary for the survival of men.

The 'White War' fought on the mountains was a conflict that took place between the snow and the stars. It distorted the traditional art of war, posing previously unthinkable tactical and logistical problems. The unexpected combat zone surprised the general staff of both belligerent countries, who showed themselves unprepared in the face of the difficulties imposed by the impervious heights. According to strategists, these territories, which would have remained no man's land, instead became the scene of a clash between explorers' patrols.

What took place in the high mountains was not a mass war, as in the plains, with the attacks of large battalions.

Fig. 1. The Stelvio Pass seen from the Braulio valley: in the center, the valle dei Vitelli, on the left Monte Scorluzzo, on the right the peaks of the Hohe Schneide and of the Geisterspitze. Jered Grube ©.

It was indeed characterised by a series of fights between small units comprised of a few soldiers, with military action transformed into an enterprise aimed at conquering the summit [Thompson 2014; Robbiati, Viazzi 2016]. Resistance at such altitudes under harsh climatic conditions was only possible thanks to structures capable of enabling war operations and guaranteeing human livelihoods. Therefore, it became necessary to build solid and warm shelters and a network of infrastructures to connect with the valley floor, which transformed the mountain into a glowing construction site. Soldier workers dug trenches and tunnels, built villages on the crests, perched on the walls or inside the rock and built mule tracks and numerous cableways for the transport of goods [Ferrario 2016].
Places that remain solitary today are still filled with memories of a tragedy in which an authentic vocation for peace sank; therefore, their knowledge and appreciation are essential. This research is one section of a project financed by the Lombardy Region called *Grande Guerra, valorizzazione delle testimonianze e recupero dei manufatti: strategia area interna Alta Valtellina* [POR-FESR Lombardia 2014/2020, Axis VI]. By examining the aspects related to documentation for knowledge, this project intends to promote interventions for the protection and safeguarding of existing sites.

Fortifications on the Stelvio Pass

The peaks around the Stelvio Pass were the crossroads of connections between the Austro-Hungarian Empire, the Kingdom of Italy, and the neutral Swiss Confederation. Their role was strategic for the Italian army, to prevent the advance of the Habsburg militias in Lombardy and in the Western regions and for the Austrians to curb the entry of Italian troops into South Tyrol. Notably, a long stretch of the border passed through the area between the Stelvio and Lake Garda, which the declaration of war of 24 May 1915 transformed into a warfront [Zaffonato 2017].
The Italian outpost at the famous crossing, which had always been manned by an armed contingent, was conquered at the beginning of June 1915 by a small group of Austrian soldiers who set up a first line of defence in a trench with only rifles and machine guns on these rocks. The attempts made by our troops to reconquer the pass were timid and tardy, allowing the enemy to consolidate

Fig. 2. The Stelvio Pass, from top to bottom: map of Lombardy, military survey (1818-1829); the map of Europe – 19th century cartography; map of the Habsburg Empire, military survey (1869-1887). mapire.eu ©.

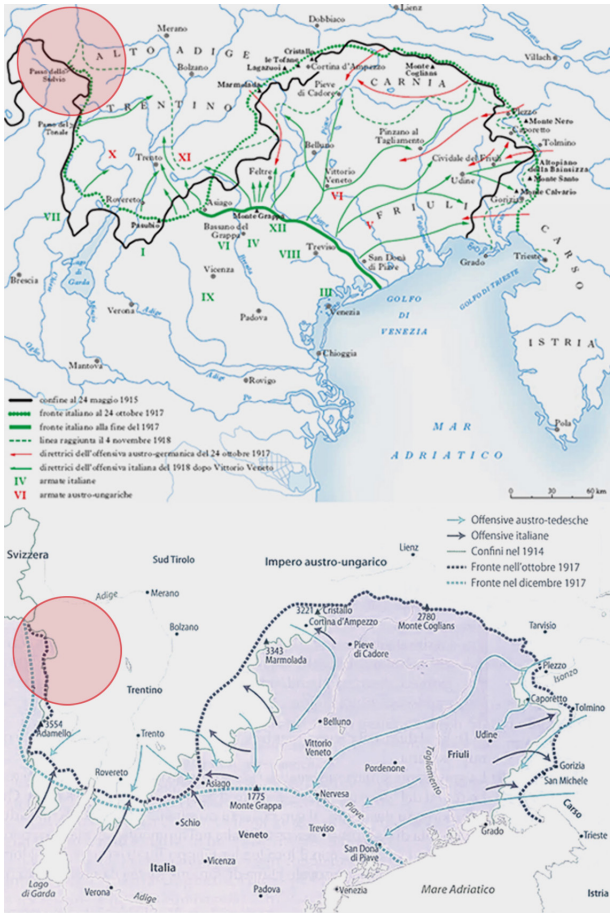


Fig. 3. The border and the war front. S.A.B.E. ©.

their positions, raise stone bulwarks and build wooden barracks. The Italian command, due to a serious and inexplicable tactical error, did not prevent the area from being occupied by the invader and ordered the withdrawal and protection of the Filon del Mot Ridge [Fettarappa Sandri 2020]. Subsequent attacks were deployed from below and in the open field towards the perched and entrenched positions on the ridges but had little success [Von Lempruch, Von Ompteda 2009]. They resulted in a line of separation that remained almost unchanged for the duration of the conflict (figs. 2-3). This withdrawal from the peaks, perhaps avoidable, prevented the Alpine battalions from becoming a threat and compromised all subsequent military actions. The pass, in fact, was the site of a few non-striking offensive actions that attempted to consolidate positions (fig. 4). The main conflicts on the Stelvio stemmed from the struggle against climate, bad weather and avalanches that caused more loss of life than the battles themselves [Viazzi 2012].

Between 1915 and 1916, Stelvio was fortified by both sides. The Austro-Hungarians strengthened the advanced line on the rocky terraces of Scorluzzo and Scorluzzino, building trenches protected by metal cages filled with pebbles and shelters dug into the rock to shelter the troops [Trotti 2011]. The small garrison of the Festungswerk Goldsee was strengthened with the imperial artillery position called *Goldseestellung* to defend the Trafoi valley and with the Lehmbruchlager field to place the long-range cannons of the Sperre Gomagoi fort in Val Venosta. It became the most important Austrian fortress on the Stelvio Pass, equipped with troop quarters, warehouses, kitchens, stables and a field hospital. Supplies were guaranteed by a system of three cableways, which, starting from Tafoi, first reached the Franzenhöhe refuge, then the Festungswerk Goldsee and finally Lehmbruchlager.

On 16 September 1917, the fortress hosted Emperor Charles I of Austria during his visit to the front. The fort stood in a large, nearly flat space near Golden Lake in a protected place sheltered from the blows of the Dosaccio di Oga fort (above Bormio); no projectile would have crossed Swiss airspace, violating its neutrality [Belotti 2009; Papetti 2019].

The Austro-Hungarian defensive structure was strategically composed of a large 'mountain fort', which was sheltered from enemy fire and not far from the front. It was assisted by a network of 'front line' entrenchments that were

Fig. 4. The vestiges of the White War at the Stelvio Pass. S.A.B.E. ©.

Fig. 5a. The survey of the military village of the Filon de Mot. S.A.B.E. ©.

Fig. 5b. The survey of the cave refuge on Monte Scorluzzo. S.A.B.E. ©.

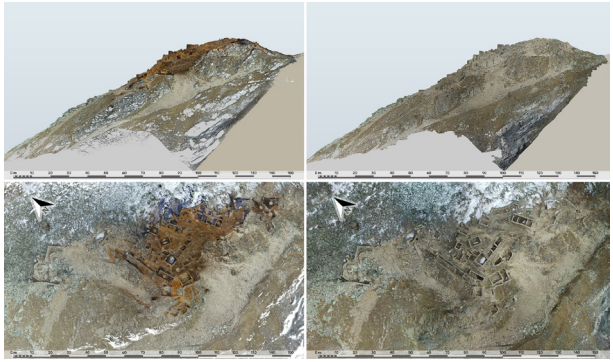
manned day and night; this required the construction of shelters dug into the rock [Bellini, Pizzarotti, Pedemonte2020]. The Trafoi-Tal was, in fact, a wide, open valley that had to be protected with artillery at high altitude because a possible breakthrough by the Italian army would have allowed the aggression of the regions of South Tyrol. By contrast, the director of the Stelvio, connecting the Val Venosta with the Valtellina, followed "an eccentric director leaning against Switzerland of limited logical scope and easily blocked" [Corpo di Stato Maggiore 1927, p. 301]; in particular, the Valle del Braulio (towards Bormio) was a narrow and winding alley that was easily defensible because it was difficult to pass through with many vehicles and men.

The Italian defences were therefore lighter and directly at the front to primarily function as guards. An imposing stronghold was not built (leaving them much more exposed to enemy fire); it was a system of military villages connected with trenches and firing positions to provide shelter for the soldiers and control the enemy 'a few metres away' [Sigurtà 2017; Barco 2021]. The system was comprised of two villages: one located on the ridge of Filon del Mot and the other below in the plain of Buse. Both hosted buildings that were made of weakly reinforced cement mortars, stone walls and mighty but quite different layouts: the first followed a highly irregular layout to adapt to the mountain, while the second was set on a circular geometry.

Fig. 6. 'Bird's eye' perspective of the digital model of the Filon de Mot military village. S.A.B.E. ©.

The village of Filon de Mot and the shelter in the cave of Monte Scorluzzino

The story of the White War at the Stelvio Pass is, unfortunately, little known. Nevertheless, it offers a different perspective on the conflict, which is necessary and indeed perhaps a duty, to disseminate and communicate with the tools of the science of drawing. Thanks to the graphic representation, the surveyor can return the measure of the territory and the representation of the landscape to acquire and provide users with information of a cognitive nature, stimulating their interest and favouring experiential activity and the subjective sensation.
The survey and graphic representation of the mountain landscape are two inseparable processes that are oriented towards the understanding of the natural areas and the man-made environment. They represent an analysis of the impact of cultural and environmental phenomena on a given territory that is aimed at understanding diachronic transformations [Rossi 2004]. It is a complete, complex investigation that combines historical research with the latest multidimensional acquisition and restitution tools and information from documentary, cartographic, iconographic sources with the survey tools for modelling, rendering and virtual landscaping. A logical project that is programmatic and systematic, and organised in flexible stages to allow a critical selection of choices. It is not a *stricto sensu* mathematical–scientific approach, but rather an emotional approach that can restore the essence of a place [Marotta, De Bernardi, Bailo 2008].
The best 'observers' are not always those who evaluate the metric aspects with great accuracy; they are those who recognise the distinctive signs of a territory through the reading of reality and the past, thanks to the testimony of ancient prints, draftsmen's sketches and old photographs. The ability to see is expressed by grasping the elements that characterise the *genius loci*, for which profound sensitivity and perceptive ability are required. The representation of reality is filtered by the personality of the executor and moves through the difficult relationship between architecture and the environment. The restitutions are not only metric images but also virtual representations that respond to the need for the metric survey and the possibility of communicating a space by making its peculiarities, including the aesthetic ones, eloquent.
The virtual reconstruction of both the pass area, which is simultaneously enchanting and inhospitable, and of two



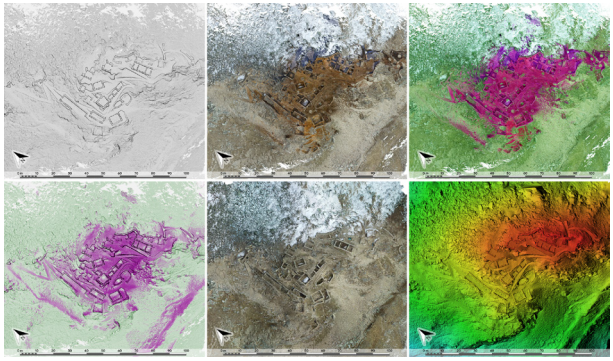


Fig. 7. Representation in double projection of Monge of the Filon de Mot military village: plan and elevation of integrated models. S.A.B.E. ©.

Fig. 8. The digital models of the Filon de Mot military village: on the left, Point Overview LS-Map & F-Map; in the center, Mesh Texture LS-Map & F-Map; on the right, Point Texture LS&F-Map e DEM. S.A.B.E. ©.

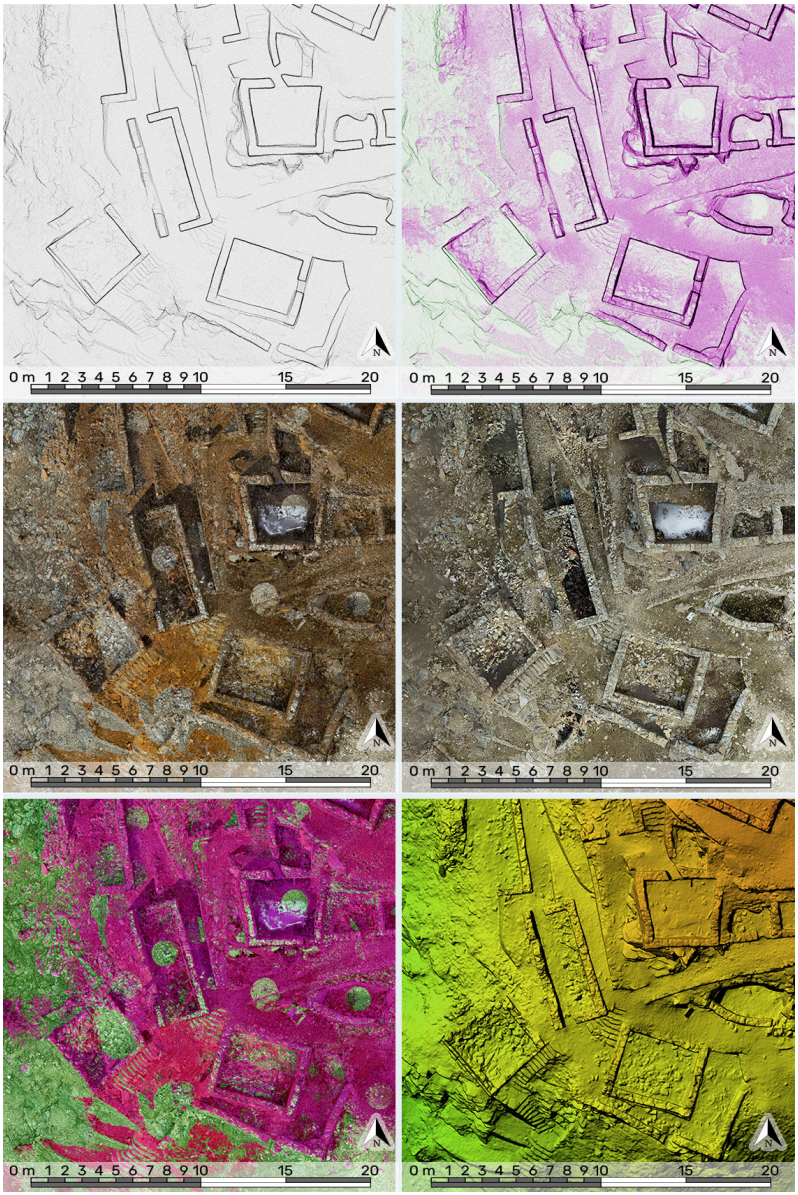
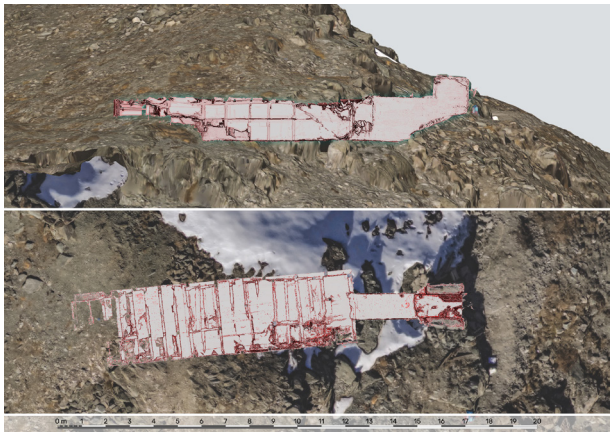


Fig.9. The digital models of the Filon de Mot military village: details of the different representations at 1:50 scale, thickness accuracy ± 1.5 cm and GSD 0.5 mm. S.A.B.E. ©.

Fig. 10. The cave shelter of the Scorluzzino: detail of the entrance, the trenches and the interior, freed from the ice, with the dormitories and the finds. Stelviopark ©.



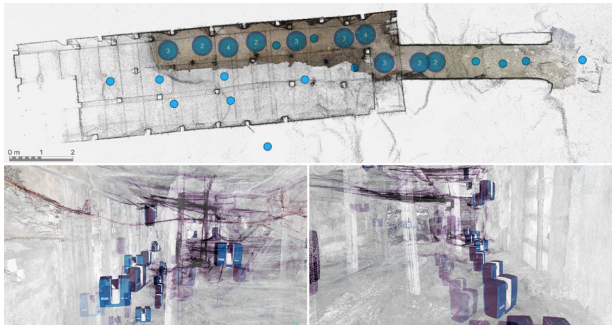


Fig. 11. The cave shelter of the Scorluzzino: plan and elevation. S.A.B.E. ©.

Fig. 12. The cave shelter of the Scorluzzino: plan and interior views of the model. S.A.B.E. ©.

significant episodes of architecture adapted to nature (the Italian village on the crest of the mountain and the Austro-Hungarian refuge dug in its belly) was based on an acquisition process conducted with remotely-piloted aircraft systems followed by 3D modelling. It aimed to reveal the morphology and functional and constructive characteristics of a space that were at the core of border surveillance activity, which remained unchanged during the entire conflict. Rocks, which became 'home' to hundreds of extremely young soldiers, are now considered 'special' for the meanings they embody. They have been documented by both the direct investigation and the electronic eyes of the sensors, which from the top of the mountain sky can read the peculiarities hidden by the high peaks.

The military village of Filon del Mot is an architectural work of great value that faces on three sides and is articulated on several levels linked by stone staircases. It is an extensive set of buildings with various functions, such as dormitories, an armoury, an infirmary, a canteen and a kitchen with an oven and a water tank. The buildings were made of dry masonry, internally covered with wood and with a cavity filled with straw and sawdust to ensure better thermal insulation. Even wooden roofs were coated with tarred cardboard or galvanised steel.

The village was protected on the eastern side by a large wall with loopholes for riflemen. From there, it branched off a dense network of trench walkways to reach the artillery emplacements, the cableway with the village of Buse downstream and the circular lookout fort. Construction of the village on the crest in such an elevated position (which was also uncomfortable, given that the space to move around was very limited), rather than on the plain below, was linked to offensive and defensive factors. From above, it was easier to monitor the movements of the enemy and to pummel a large portion of the territory more easily with artillery because these structures, positioned at a lower altitude, would have been more exposed to enemy fire directed from above.

Scorluzzino's underground shelter is part of the system of defensive fortifications erected by the Austro-Hungarian army. The cave was excavated at right angles to the eastern slope of the mountain and is positioned on the back of a short trench that allows access to a small observatory with loopholes on the roof. Nearby, the trench segments branch off towards the fortified peak of Monte Scorluzzo. The shelter is accessible by a short corridor protected by two reinforced concrete walls with metal beams that

support the tile. The compartment then widens and has a wall on one side covered with sheet metal. The stove and numerous nails used to hang clothes, weapons and equipment were leaned against it, while, on the other wall by the dormitory hung a large wooden shelf. At the back of the cavity, a wooden plank panel isolates a small room used as the commander's quarters, which is equipped with a single cot and a table with a stool. The inside of the military infrastructure was completely lined with wooden arches and had to house a garrison of about twenty men to garnish the neighbouring positions.

Survey of the landscape and the built heritage at 'high altitude'

The survey of sites placed at 'high altitude' requires particular precautions due to the difficult accessibility, the danger involved (for example steep and landslide slopes that can be reached 'on foot' but are often unsafe due to snow and/or permafrost) and the environment, including low temperatures, excessive wind and strong lighting. The planning of the *in situ* acquisition phases is therefore a crucial aspect that must consider both logistical issues and various aspects related to safety risks. For example, equipment transport is difficult and sometimes only possible with helicopters.
The surveys at the Giogo dello Stelvio were carried out between the end of summer and the beginning of autumn 2022 (that is in the final phase of thawing and before winter snowfalls (fig. 5). A rather short period of surveying, which was due to an anticipated disturbance and the consequent snow cover on the peaks, made it impossible to carry out the activities at all the planned sites (the operations were postponed to the following summer).
Integrated survey techniques and instruments were employed –Global Navigation Satellite System (GNSS), 3D laser scanning and terrestrial and aerial digital photogrammetry–, with particular attention to instrument care. Temperatures below zero may degrade instrument and battery electronics and adversely affect targets and sensors. To avoid problems, heat-insulated enclosures were foreseen, and the equipment was used at regular intervals to avoid thermal stress. The photographs also required careful planning to limit the consequences of the great contrasts and large shaded areas typical of the mountain area, as well as the use of neutral density (ND), a polarizing filter (PF) and sky light to increase image sharpness and reduce glare and reflections induced by clear skies and white snow [Re 2016; Bregani 2017]. To adequately carry out the 3D laser scans, the frozen surfaces were 'dirtied' with earth and ash (otherwise, reflective 'mirrors' would have altered the metric accuracy of the data), and special bases were made to place the instrument on the ground and to acquire nooks and crannies.
The conversion of the GNSS geographic coordinates into a Cartesian topographic system, which is indispensable for georeferencing all the models in a single reference, required a complex treatment following the large differences between the WGS84 ellipsoid and the local datum. The decision to carry out multiple elaborations by integrating data with different characteristics allowed the graphic rendering of several images enriched by a considerable amount of important information [Achille et al. 2015; Luhmann 2019; Fiorillo, Limongiello, Bolognesi2021; Pesci et al. 2022]. Specifically, the reconstruction of two large point models was completed using data obtained from both active (range-based) and passive (image-based) sensors. The processing made it possible to obtain the dot representations Overview Map and Texture Map from the former, while the same dot representations plus textured mesh returns and the Digital Elevation Model (DEM) were gotten from the latter. In total, six models, when combined and treated with one another, provided new and singular images capable of highlighting characteristics and particularities that cannot be deduced with traditional data-processing methodologies. The special treatment so called 'tomographic' allows the production of representations in Mongian double projection, which, as a 3D model, highlights the surfaces orthogonal to the painting and hides the parallel ones. An orthogonal projection of the model was placed onto a photographic plate covered by a thin film that darkens according to the states intercepted by the projecting ray: the greater the number of aligned dots, the more intense the grey will be, which, along with it, only intercepts a few white dots. A rendering style, which, if superimposed on a textured image of a planimetry or a section elevation, allows highlighting the deformations of the walls and the out-of-plane elevations, is essential for the design of conservation and consolidation activities (figs. 6-12). As a function of the possible recovery of the structures, a series of 2D graphic drawings were obtained from the integrated model on which the localisation and description of decay and instability phenomena were performed.

Conclusions

The first studies on the Alpine War were based on an analysis of places with photographic images and sketches from life. They were founded on the personal memories of the Italian and Austro–Hungarian officers: fictionalised sources with heroic tones and nationalist accents that were often characterised by a deference to the beauty of the landscape combined with the narration of the drama of a conflict fought in extreme conditions.
Research on the White War received a new impetus following the celebrations of the centenary of the First World War (2014-2018). A series of new infrastructural interventions has therefore been launched for the recovery of these places of memory [Trotti, Milani 2021]. A fertile field of interdisciplinary dialogue has made it possible to abandon the excessive attention to the story of the man with his bare hands against nature to concentrate on a systematic and impartial archival study. This was accomplished through a collaboration between the archaeological investigation and scientific–technological analyses, which aimed at understanding the profound anthropic action that sought to make inaccessible places habitable for humans to live on [Morosini 2022].
Today, the *Giogo dello Stelvio* is not only the ancient theatre of war, but also a representation of the Anthropocene and climate change, which is increasingly extreme, frequent and devastating. The retreat of the glaciers has, in fact, brought out a precious historical archive and exposed the artefacts and relics of the great conflict. This may make a long-hidden heritage accessible, allowing its documentation and possibly its recovery. Conversely, it may become a dangerous and worrying effigy of the transformation, which is perhaps irreversible, of our mountains, of the destabilisation of the slopes and of the risks associated with phenomena of change in the Alpine landscape. It is a complex environmental challenge that calls into question all subjects at the local and global levels.

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