



UNIVERSITÀ  
DEGLI STUDI  
DI PADOVA

Sede Amministrativa: Università degli Studi di Padova

Dipartimento di Scienze Storiche, Geografiche e dell'Antichità

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SCUOLA DI DOTTORATO DI RICERCA IN: Studi storici geografici e antropologici

INDIRIZZO: Geografia umana e fisica

CICLO: XXVII

**MILITARY GEOGRAPHY AND GEOLOGY STUDY OF THE FIRST WORLD WAR SITES IN THE  
PROVINCE OF BELLUNO**

*(Studio geografico e geologico militare dei luoghi della Grande Guerra in Provincia di Belluno)*

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*“Da lo mesmo hacer un sueño  
que vivirlo en esta vida”*

(‘Tata Nica’ by Alberto Merlo)

## Abstract

The conducted research was linked to the theme 'Military Geography and Geology Study of the First World War Sites in the Province of Belluno' and emerged from the Ph.D. scholarship awarded by the Foundation for University and High Culture in the Province of Belluno.

The Province of Belluno, located in the southern eastern Alps, is an Italian administrative division. Its territory, which is almost entirely mountainous, was the site of many battles between the Austro-Hungarian Empire and the Kingdom of Italy during the First World War. Despite the enormous historiography on the First World War's Italian front, few studies have examined how the geography of the Alps influenced the War.

This thesis studied the influence of geography on the Eastern Tyrol front in the First World War, particularly the geography of the Dolomites front (which in part corresponds to the territory of the Province of Belluno). To reach this aim, the research produced four papers. The first paper was a bibliographical review of the Cadore offensive's failure and provided a synthesis of opinions surrounding the involved factors and origins, which in turn led to the other three papers.

Following the bibliographical review, the second paper focused on General Cadorna's military assessments for the Cadore offensive's geography. In accordance with some authors (i.e., Botti, 1991; Isnenghi and Rochat, 2008), the results suggest that possibly Cadorna did not fully consider the difficulties connected to the geography.

The third and fourth papers, on the base of the perspective traced by the first paper, aimed to provide a better characterization of the military value of terrain, producing an empirical qualitative and quantitative analysis of physical geography and its influence on military operations.

The third paper studied the influence of geomorphology on the Cadore offensive. To reach this purpose, a geomorphological and a military history map were made for four of the most important areas in the Dolomites front. In particular, the steep and high valleys' sides, part of the unique geomorphology of the Dolomites, determined unassailable positions from where the defenders, with protected and sometime relatively accessible rear lines, precluded the use of the valley, due to the visual control and the use of crossfire. From that point of view, topography, as the result of the particular morphogenetic processes which took place in the region, can be considered as one of the main geographical aspects that controlled the development and the outcomes of battles in the Dolomites front.

The fourth paper used a cost distance analysis, a Geographic Information System (GIS) tool, in order to assess the obstacle to trafficability in Eastern Tyrol. The obstacle to trafficability can be considered one of the most important properties through which terrain influences war in mountainous countries (Clausewitz, 1832). The results demonstrated that the decision to defend the Tyrol Defence Line (TDL; i.e., the line chosen for the defence of the Tyrol region by Austria-Hungary) instead of the former political border did not reduced the perimeter to be defended. Thus, from this perspective, the shorter length of the TDL cannot be considered a military advantage, as other authors have inferred (e.g., Lichem, 1995).

## Riassunto

La presente ricerca è stata condotta nell'ambito del progetto intitolato "Studio geografico e geologico militare dei siti della Grande Guerra nella Provincia di Belluno", finanziato attraverso una borsa di Dottorato da parte della Fondazione per l'Università e l'Alta Cultura in Provincia di Belluno.

La Provincia di Belluno si trova nelle Alpi sud-orientali ed il suo territorio, quasi interamente montuoso, è stato teatro di azioni belliche e di importanti battaglie tra l'Impero Austro-Ungarico ed il Regno d'Italia nel corso della Prima Guerra Mondiale. Nonostante quasi ogni opera dell'estesa storiografia riguardante la Prima Guerra Mondiale sul fronte italiano sottolinei l'importanza della geografia, gli studi specifici e sistematici riguardanti l'influenza dei fattori geografici sulle vicende belliche nelle Alpi sono un numero limitato.

Lo scopo della presente tesi è quello di analizzare l'influenza delle condizioni geografiche sulle attività militari condotte sul fronte delle Dolomiti, in parte corrispondente al territorio della Provincia di Belluno, durante il primo conflitto mondiale. Questo obiettivo è stato raggiunto attraverso la stesura di quattro articoli scientifici. Il primo ha riguardato una revisione bibliografica delle motivazioni che hanno portato al fallimento dell'offensiva italiana del Cadore. Questo lavoro fornisce una sintesi completa delle opinioni relative alle cause che hanno portato al sopraddetto fallimento.

Sulla base delle considerazioni emerse attraverso l'approfondita ricerca bibliografica, il secondo articolo è focalizzato sulle valutazioni militari del Generale Cadorna relative agli aspetti geografici correlati all'offensiva nel Cadore. In accordo con quanto riportato da altri autori (Botti, 1991; Isnenghi and Rochat, 2008), i risultati della presente ricerca suggeriscono che probabilmente il Cadorna non considerò appieno le difficoltà dovute alle condizioni del terreno di azione.

Il terzo ed il quarto articolo, muovendo a partire dalla prospettiva di indagine tracciata nel primo articolo, hanno lo scopo di caratterizzare in maniera approfondita il valore militare del terreno attraverso analisi qualitative e quantitative di particolari caratteristiche geografiche e della loro influenza sulle operazioni militari.

Il terzo articolo riguarda l'influenza che ha avuto la geomorfologia nel fronte delle Dolomiti. In particolare sono state realizzate una carta geomorfologica ed una carta con informazione militare storica per quattro settori puntuali del fronte di guerra, in corrispondenza di potenziali linee di facilitazione e ove gli austriaci posizionarono le loro difese. Lo studio integrato dei dati storici e geografici ha dimostrato in quale modo la particolare geomorfologia delle Dolomiti ha avuto un peso determinante sulle azioni di guerra e, in ultima istanza, sugli esiti delle battaglie.

Il quarto articolo fornisce una caratterizzazione dell'ostacolo alla percorribilità nel Tirolo orientale attraverso l'uso di una "analisi costo-distanza", strumento disponibile in ambiente GIS. L'ostacolo alla percorribilità può essere considerato come uno dei principali elementi attraverso cui la conformazione fisica del terreno influenza l'attività bellica nei territori montani (Clausewitz, 1832). I risultati relativi a questo articolo dimostrano che la decisione di difendere la "Linea di Difesa del Tirolo", ovvero la linea scelta per la difesa della regione

del Tirolo da parte dell'Impero Austro-Ungarico, al posto del confine politico, non ha corrisposto ad una reale diminuzione del perimetro che doveva essere difeso. Secondo questa punto di vista, la minore lunghezza della "Linea di Difesa del Tirolo" non può essere considerata come un vantaggio militare, come sostenuto da altri autori (Lichem, 1995).

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# INTRODUCTION

## 1. Historical events and area of study

The conducted research was linked to the theme 'Military Geography and Geology Study of the First World War Sites in the Province of Belluno' and emerged from the Ph.D. scholarship awarded by the Foundation for University and High Culture in the Province of Belluno.

The Province of Belluno, located in the southern eastern Alps, is an Italian administrative division. Its territory, which is almost entirely mountainous, was part of the theatre of war between the Kingdom of Italy and the Austro-Hungarian Empire during the First World War, and thus was the site of many battles.

The role that the territory of the Province of Belluno played during the First World War stemmed largely from its particular geographical location, which was defined by the Treaty of Vienna signed by Italy and Austria-Hungary on 3 October 1866, thereby ending the Third Italian War of Independence. Indeed, that treaty defined the political border between the two countries, which corresponded to that of the former Kingdom of Lombardy-Venetia. Thus, the territory of the Province of Belluno, which until the treaty was entirely part of Austria-Hungary, was divided and most of it became part of Italy. Furthermore, most of the northern and eastern boundaries of the Italian part of the territory represented the political border between the two states until the outbreak of the hostilities between them in the First World War (Fig. 1).

More specifically, the political border stemmed from the Treaty of Vienna extended from the Swiss border to the Adriatic Sea for nearly 600 km. Its particular shape, which resembled an 'S', presented the following two salients: a western Austro-Hungarian salient into the Italian territory, called 'the Trentino salient' or 'the Tyrol salient', and an eastern Italian salient into the Austro-Hungarian territory. In this context, the Province of Belluno represented a large part of the common side between the two salients and the apex of the Italian salient into the Austro-Hungarian territory (Fig. 1).

The political border ran mainly through mountainous terrain of the Southern Eastern Alps. In fact, just 40 km of the total 600 km were below 100 m.a.s.l., and only 60 were below 600 m.a.s.l. Also the political border ran along mountainous regions in the part which corresponded to the territory of the Province of Belluno,.

In particular, the part of the Province of Belluno which the border passed corresponded to the Dolomites, which can be considered among the harshest mountains of Europe. The harshness of these famous mountains stems not only from their altitude, but also from their lithology, tectonics and climate. These factors have facilitated the creation of a unique landscape, where 'the mountains rise as peaks with intervening ravines, in some places standing isolated but in others forming sweeping panoramas. Some of the rock cliffs here rise more than 1.500 m and are among the highest limestone walls found anywhere in the world'. Furthermore, there are 'spectacular vertical forms such as pinnacles, spires and towers, with contrasting horizontal surfaces including ledges, crags and plateaux, all of which rise abruptly above extensive talus deposits and more gentle foothills' (World Heritage Committee, 2009).

It is possible to distinguish three key moments for the territory of the Province of Belluno in the First World War: 1) from the beginning of the war to the autumn of 1915; 2) from the autumn of 1915 to the Battle of Caporetto and 3) from the Battle of Caporetto to the end of the conflict between Italy and Austria-Hungary.

### Spring–Summer 1915

The events which occurred in the territory of the Province of Belluno at the beginning of the conflict, from 23 May 1915, when Italy entered the First World War against Austria-Hungary, to the autumn of 1915, derived mainly from the Italian operational planning and its failure.

The Italian operational design had to be offensive, due to Italy's military alliance, while also taking into account political, economic and irredentist national interests. The operational design that Cadorna, Chief of Staff of the Royal Italian Army, formulated in the autumn of 1914 for the war identified the country's key strategic objectives beyond the Julian Alps and the 'Carso' (the 'Classic Karst' area at the Italian border with modern-day Slovenia). Therefore, the bulk of Italian forces were deployed in those directions. However, as the strategic and organizational situation of the two armies changed during the period of Italian neutrality<sup>1</sup> in the operation plan issued on 1 April 1915 just before the Italian declaration of war<sup>2</sup>, the Julian and Carso strategy was momentarily abandoned. Indeed, from the declaration of war until the end of the Italian Army's mobilization, Cadorna established a strategic defensive stance for the whole army. The only exception concerned the 4<sup>th</sup> Army, which was the unit deployed in the Province of Belluno.

The 4<sup>th</sup> Army had to mount a strategic offensive from the region of Cadore<sup>3</sup>, which would lead to its first objective: to reach the Puster Valley. The 4<sup>th</sup> Army thus became the only unit that from the beginning of the war had an offensive task beyond the political border of strategic, and not just tactical, importance. More important, such an attack from the territory of the Province of Belluno towards the Puster Valley represented, if considered the former operation plans, the first time in history that the Royal Italian Army intended, from the start of operations, to cross the political border and to take possession of an important objective beyond this border (Di Martino and Cappellano, 2007).

The first step for Nava, the commander of the 4<sup>th</sup> Army, was to overcome the Austro-Hungarian defence line, i.e., 'the Tyrol Defence Line', which blocked the routes to the Puster Valley. However, as weeks passed since the declaration of war with the Italians unable to launch an attack, the Austro-Hungarian defences grew even stronger. During the summer of 1915, the 4<sup>th</sup> Army launched the main offences against the enemy's defences, however, without obtain the desired results.

By the beginning of the autumn of 1915, Cadorna realized that the offensive from Cadore had failed and that the Dolomites front had bogged down into attrition warfare. This dashed his hopes of reaching the Puster Valley and induced him to redirect the 4<sup>th</sup> Army to a mainly

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<sup>1</sup> Italy declared war with Austria-Hungary about 10 months after the outbreak of the First World War in Europe; during this period it remained neutral.

<sup>2</sup> Document *Variations to the directives of 1<sup>st</sup> September* (IOH, 1927–88, vol. 2 bis).

<sup>3</sup> Cadore is a historical Italian region located in the northern part of the Province of Belluno.

defensive strategy. As a result, the strategic offensive action was designated exclusively for the great mass of men concentrated in the direction of the Julian Alps and the Carso.

#### Autumn 1915–October 1917

From the autumn of 1915, the front of war in the Province of Belluno remained in a stalemate, with almost no shift in its location. As supplies continued flowing to this front, the field fortification multiplied, extending the defensive lines from the valleys to the mountainsides, glaciers and peak summits.

However, battles never stopped, even during the very cold winters of 1915–1916 and 1916–1917. Under such terrible conditions, the attrition warfare in the Dolomites presented some unique aspects, characterized, for example, by the use of alpinism techniques, by the use of mining and even by the construction of military recoveries inside glaciers. It was thus one of the most spectacular instances of mountain warfare in military history.

These conditions prevailed until October 1917, when the Austro-Hungarians, no longer engaging the Russians, spread with German help from the Julian Alps onto the Venetian Plain. This forced the withdrawal of the majority of the Italian units, including the 4<sup>th</sup> Army, from the territory of the Province of Belluno.

#### October 1917–November 1918

The Central Powers' advance onto the Venetian Plain finished at the Italian line of defence of the Piave River. Hence, the territory of the Province of Belluno passed to Austro-Hungarian hands and primarily constituted the rear of the Austro-Hungarian deployment in the front of war that was created between the Grappa Mount and the Piave River. This condition lasted until the Battle of Vittorio Veneto, whose Italian victory led to the end of the war between the two countries.



**Figure 1** - Location of the Province of Belluno in the theatre of war between Austria-Hungary and Italy before the First World War.

## 2. Fields of study: brief literature review

### *2.1 The applied and the historical approach of military geography*

The central theme defined by the scholarship is clearly interdisciplinary; it concerns military history and military geography. The later can be considered as a sub-discipline of geography that studies the influence of geographical elements on war (Porro, 1898). With respect to military geography, it is worth mentioning that it presents two main areas of interest. Indeed, “in one respect [military geography] is of an applied nature, employing the knowledge, methods, techniques, and concepts of the discipline [geography] to military affairs, places, and regions. In another sense, military geography can be approached from a historical perspective” (Palka and Galgano, 2005).

The applied nature of military geography, which represents the most recent branch, shows the biggest advances in the field today. The applied nature of military geography first emerged in Europe in the second half of the nineteenth century (Porro, 1898), by focusing mainly on geology and its influence on military operations. Among the forerunners of this new military applied study, Von Sonklar (1873a, 1873b) stood out in Austria, while Fervel (1873, 1875), Clerc (1876, 1880a, 1880b, 1883, 1888), Niox (1880) and Marga (1885) distinguished themselves in France.

The application of geology to the solution of military problems was definitely strengthened and tested during the Second World War when many geologists were employed in national armies. During this conflict, the responsibilities of geologists were predominately in the areas of water supply, military mining, dugout construction, locating construction material and terrain classification for troops’ and vehicles’ mobility (Kiersh and Underwood, 1998). For instance, geologists made significant contributions to the Allied armies, particularly in the UK (Brooks, 1920; Rose and Rosenbaum, 1998), the US (Brooks, 1920; Pittman, 1998) and France (Brooks, 1920). The armies of the Central Powers also paid significant attention to military geology. Indeed, by 1918, some 100 German geologists were contributing to the solution of military problems on the Western Front (Brooks, 1920).

After the First World War, the interest in geology continued to increase in the armies, and “the advent of the Second World War brought about the proliferation of applied geology on a scale hitherto unimagined” (Kiersh and Underwood, 1998). This was particularly true in Germany (Häusler and Willig, 2000), the UK (Rose and Rosenbaum, 1998) and the US (Terman, 1998).

During the Cold War, the synergy between geology and military continued to grow under the guidance of technology and quantitative analysis (Barner, 2008). The application of geology to military operations, as developed in the European and Pacific regions, was the most important advancement in engineering geology during the 1940s and 1950s (Kiersch, 1955). Furthermore, many important textbooks and publications that advanced the principles of engineering geology practice and military geology were released after the Second World War, including those by Trefethen (1949), Paige (1950), Eckel (1951), Keil (1954), Kiersch (1955), Schultz and Cleaves (1955).

In the present day, applied military geography is developed within military environments, such as national and international defence organizations, and is linked to various activities, such as cartographic production or searching for underground water resources. However,

this approach also attracts the interest of academic scholars, as evidenced by studies regarding some of the most recent wars, such as those in Kosovo, Afghanistan and Iraq (e.g., Beck, 2003; Palka and Galgano, 2005; Palka et al., 2005; Palka, 2008; Willig, 2012).

The other major area of interest for military geography, which concerns historical studies, has a longer tradition than applied military geography. In fact, Porro (1898) stated that “military geography was the branch of geography that for longer and more tightly was related to the history, because represented an essential complement for the knowledge of the theatres of war”.

Over time, the relationship between military geography and military history has developed in two main directions. One way (the most recent) in which military geography and military history are connected is by considering the impact of past war events on geography, particularly on natural environments. In this way, the majority of those interested in studies which relate military geography and military history are geographers. Some recent examples of this approach include Hupy (2006), Hupy and Schaetzl (2008) and Hupy and Koehler (2012).

The other way, the classical one, considers military geography as a key aspect of understanding past military events and views geography as a main factor constraining military operations and the outcomes of battles, campaigns or wars. The results obtained by this approach represent an interest for historiography.

However, nowadays, the main interest of military historians has been directed towards other factors which influence, or are influenced by, war (e.g., cultural, social and economic), and thus less attention is being directed towards military geography. Only a few scholars nowadays, the majority of which are Anglophones, are interested in considering the influence of geography on warfare. Some of these scholars are represented by the International Association of Military Geosciences, which holds the International Conference of Military Geosciences every two years and publishes the proceedings of each conference. In this context, military geographic analysis of past events is carried out mainly by geographers and geologists, who apply tools, methodologies and materials typical of their disciplines. Studies supported by digital technologies, such as Geographical Information System (GIS) and remote sensing, have thus been published in recent years. GIS, in particular, produces results suitable for the integrated analysis of spatial and historical data (e.g., Bondesan et al., 2013; Guth, 2011).

Particularly with respect to the First World War, the majority of the studies which concerned military geography followed the classical approach, which considers military geography as a key aspect of understanding past military events. These kinds of studies were developed even from the first moments of the war (e.g., Leaf, 1916; Bryan, 1920; Brooks, 1920; de Martonne, 1925). Among the studies regarding the Italian front, Johnson's (1917, 1921) books, which focus mainly on strategic aspects, stand out.

Examples of scholars recently interested in the geologic influence on the military events which occurred in the Western Front include Doyle et al. (2000) and Willig (2011). Barrett (2011) has published research on the Transylvanian Front, while Schramm (2011) considered the Alpine Front.

## ***2.2 Military historiography on the First World War in the Italian front and in the Province of Belluno***

The military history literature focused on the Italian front and concerning the battles and events which occurred during the First World War in Belluno Province is sizeable. Obviously, the majority of this literature is written in German and in Italian; English-language military history works on the Italian front are still rare. Among the more recent studies, Thompson (2008) provides a general overview of the whole Italian/Austro-Hungarian conflict, dealing with social, political and cultural issues, all chronologically underpinned by the military events which occurred. Schindler (2001) provides a general historical framework, focusing mainly on the Isonzo front.

Aiming to broadly contextualize the First World War in the Province of Belluno, a good starting point can be represented by studies such as Pieri (1998), Isnenghi and Rochat (2004) and Lichem (1995). Among other themes, these volumes deal with the strategic value of the front, its role inside the operation plans and the characteristics of the conflicting armies. Some specific works on the Alpine or Dolomites front include the following: Di Martino and Cappellano (2007), Vianelli and Cenacchi (2006), Lichem (1995), Striffler (2006), Shaumann (1984) and Langes (1981). They provide overall summaries of the most salient features and events of the war in the Dolomites. Moreover, a complete listing of the war events in the Dolomites is provided by the Italian official history (IOH, 1927–88) and by Mariotti (1964), which aimed to reproduce official sources.

In order to conduct an in-depth examination of the knowledge of local or singular episodes, further information about military events is given by historical narration texts. They give accurate descriptions, which often stem from direct experience. For instance, Berti's (1985 and 1989) books provide information about the following areas: Montecroce Comelico Pass, Sentinella Pass and Som Pauses. Regarding the area of Valparola Pass, one can consult the works of Pieri (1996) and Viazzi and Mattioli (1997). Another useful monograph regarding the military events that took place in the Sentinella Pass area is that of Zandonella Callegher (2008).

With respect to the bibliography specifically interested in the influence of geography on past military events in the Dolomites front, despite almost every author that considered the military events in that front highlighted the importance of geography, it can be considered sparse. Beyond the texts which were published during or just after the war, the only bibliography found which applies a military geography reading to events which occurred in the territory of the Province of Belluno is part of the proceedings of the VIII International Conference of Military Geosciences (Vienna, 2009), which focused on mountain warfare.

### **3. Introduction to the specific objectives, materials and methods of the research**

According to the area of study, the historical event and the fields of study defined by the central theme of the scholarship, the research was structured in four main moments which correspond to four papers. Each of the four papers was an independent study with an abstract, introduction, specific analysis (where material, methods and results were identified), conclusion, bibliography and acknowledgments. They also mainly concerned the Italian offensive that took place on the Dolomites front in the First World War. Thus, with



respect to the three moments of the First World War in the Province of Belluno that were identified in the previous section, these four papers focused on the first and the second moment. In addition to the territory of the Province of Belluno, the papers also examined the current territories of the Italian provinces of Trentino and Alto Adige and of the Austrian State of Tyrol.

Beyond this similarity, the four papers were very different with regard to specific objectives, material and methods. The first paper concerned a bibliographical review which regarded the failure of the Cadore offensive. The main aim of this paper was to identify the state of the Italian historiographic discussion around this military failure. The material used included monographs of Italian military history. The methodology adopted for the analysis of the sources was developed *ad hoc*; in particular, a classification was conducted which allowed for a synthesis of the opinions of the different authors about the factors which determined the failure and the origins of these factors.

From the perspective of the main theme of the research, the results of the bibliography review allowed us to understand the importance that the study of the influence of geographical elements would have for 1) a better comprehension of the failure of the Cadore offensive and 2) to identify some particular aspects concerning this topic that would be interesting to develop.

From this point of view, the second, third and fourth paper developed three specific themes concerning the role of geography in the Cadore offensive. By developing different approaches, the three studies provided a broad overview of the role of geography in the Cadore offensive. Indeed, this theme was analysed both from a theoretical point of view and from an empirical point of view, both from the tactical point of view and from the strategic point of view, on both a local geographical scale and a regional geographical scale.

The second paper concerned the theoretical military value of the Cadore offensive's geography. The material used concerned military history bibliography, including Cadorna's writings. The methodology conducted was a comparative analysis between Cadorna's theoretical assessment and some theoretical military geography considerations based on the theories of this period.

The third paper aimed to study the influence of geomorphology on the Cadore offensive. This study focused on specific areas of tactical importance regarding where the Italians launched their attacks against the Austro-Hungarian defences: Montecroce Comelico Pass, Som Pauses, Valparola Pass and Sentinella Pass. Among the material used, besides military history bibliography and geologic-geomorphologic cartography, Digital Elevation Models (DEM) and satellite images played a significant role. GIS was the main instrument used due to its capacity to combine spatial and historical data. The methodology consisted of the following major steps: 1) collection, digitization and interpretation of historical and cartographic data obtained from literature; 2) collecting and digitization of previous geological and geomorphological information and cartography from literature; 3) collection and interpretation of data obtained by remote sensing; 4) realization of a geomorphological map and a military history map for every area of study and 5) integrated analysis of historical and geomorphological data.

The fourth paper was aimed at the study of the trafficability of the terrain in Eastern Tyrol, where the Italian attack should have been launched. To this end, different Austro-Hungarian lines of defence and different Italian lines of attack in the sector of the front between the

Valsugana and the Cresta Carnica were considered. The main material used was historical cartography and a DEM. The principal survey methodology chosen was that of spatial analysis by using GIS. In particular, a cost distance analysis was conducted based on slopes and distances.



# CHAPTER 1

## The Failure of the Cadore Offensive: Factors and Origins in the Italian Historiography on the First World War

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### Abstract

The Cadore offensive in the First World War and the discussion that has taken place around its failure occupied an important place in the literature of Italian military history. The aim of this paper is to conduct a historiographical review of this military failure. By proposing a specific methodology for the analysis of the bibliography, we focused on the opinions regarding the factors that determined the failure and on the opinions regarding the origins of the factors that determined the failure. At the end of the analysis, we presented what we consider to be the main features of the bibliography consulted. We concluded that, since many elements of military influence were not considered in depth and the author's points of view about them have varied, further studies regarding the value of those elements would be worthwhile in order to better understand the reasons for the failure.

Keywords: First World War, Italian Front, Dolomites Front, Mountain Warfare, Cadore Offensive, Historiographical Review,

### 1. Introduction

The Kingdom of Italy joined the Allied Forces and declared war against the Austro-Hungarian Empire on 23 May 1915, just about one year after the assassination of Archduke Franz Ferdinand of Austria. The theatre of war between Italy and Austria-Hungary was determined by the political border that had existed between the two countries since the Treaty of Vienna in 1866. When offences began, a large part of the political border became the front of war. It mainly extended through the Eastern Alps, from the Swiss border to the Adriatic Sea, and was around 600 km long. Barely, 40 km were below 100 m.a.s.l. and 60 were below 600 m.a.s.l.

From the beginning of the war in Europe, in August 1914, Austria-Hungary was heavily engaged in the Russian and Serbian fronts; thus, its first operation plan against Italy had to be strictly defensive. Italy, instead, when declared war to Austria-Hungary, on 23 May 1915,

due to its military alliance, as well as political, economic, and irredentist national interests, was forced to take an offensive stance.

The operational design of Luigi Cadorna, Chief of Staff of the Italian Army, identified the country's key strategic objectives beyond the Julian Alps and the Carso (the 'Classic Karst' area at the Italian border with modern-day Slovenia). Thus, the bulk of Italian forces would have been deployed in those directions. Nevertheless, that offensive represented a great challenge to Italy, considering that its enemy was already mobilized. Therefore, during its neutrality, the Italian High Command developed a new mobilization plan for the Italian Army, called 'red', which would have allowed deployment with concealment of an aliquot of the troops from the beginning of the conflict; hence allowing them to conduct a limited but sudden attack.

After a careful reassessment of the strategic and organizational situation of the two armies, just before the entrance into the war, on 1 April 1915, Cadorna issued the document, *Variations to the Directives of 1 September* (IOH, 1927-88, 2bis), whose instructions were those implemented at the beginning of the war; therefore, it can be considered the Italian operation plan. This document established a strategic defensive stance for the entire front during the army's mobilization. The only exception concerned the 4<sup>th</sup> Army, deployed in the central sector of the political border, which had to lead an attack towards a strategic objective in the Habsburg territory. Therefore, the 4<sup>th</sup> Army became the only unit that, from the beginning of the war, had a task beyond the political border of strategic, and not just tactical, importance.

Considering the shape of the political border between Austria-Hungary and Italy, the central sector, where was deployed the 4<sup>th</sup> Army, represented an Italian salient into the Austro-Hungarian territory. In the northernmost part of this salient, laid the historical region of Cadore (Italian, Eastern Alps), which can be considered among the harshest mountain regions of Europe. Cadore, as the apex of the Italian salient, was near an important Austro-Hungarian Alpine valley, the Puster Valley, whose railway represented an important line of communication parallel to the political border. From the Italian territory three north-south valleys connected to the Puster Valley: the Badia, Landro, and Sesto Valleys.

Even if the Puster Valley was just 12 km from the Italian territory in its nearest part, it represented a very difficult objective due to the permanent fortifications built after the Napoleonic wars, which prevented the Italian transit through the main roads and, due to the field fortifications, built during the period of the Italian neutrality.

In *Variations to the Directives of 1 September*, Cadorna assigned what would have been the first objective of the 4<sup>th</sup> Army: with its right part seizing Dobbiaco, in the Puster Valley, and its left part seizing the heights surrounding the Sella Mountains.

Sardagna (1924) divided the mission of the 4<sup>th</sup> Army into three moments, or phases:

1. Operations to be done during the period of the mobilization of the Italian Army, which basically correspond to the defeat of the enemy defences that prevented the Italian use of the main roads that led to the Puster Valley;
2. Achievement of the first objective, which basically correspond to the seizure of Dobbiaco, in the Puster Valley, and the seizure of the heights surrounding the Sella Mountains;

3. Further operations to be done after the achievement of the first objective, depending on the situation, which basically correspond to movement from Dobbiaco along the Puster Valley eastward towards Fortezza, or westward towards Lienz and the Gail Valley.

When the war started, the 4<sup>th</sup> Army advanced but could not defeat the Austro-Hungarian defences. As time passed, the Austro-Hungarians had time to reinforce their defence positions and move more troops to this front. The supplies continued flowing through the summer of 1915, and the battles become bloodier. By the beginning of the autumn of 1915, Cadorna realized that the offensive from Cadore had failed, and, with no hopes of reaching the Puster Valley, re-directed the 4<sup>th</sup> Army strategic role to a mainly defensive one, while the offensive action was designated exclusively to the great mass of troops concentrated in the Julian Alps and the Carso. The front in Cadore remained almost unaltered until October 1917, when the Austro-Hungarians, no longer engaged against the Russians, spread out with German help from the Julian Alps onto the Venetian Plain. This forced a quick and total withdrawal of the majority of the Italian units, including the 4<sup>th</sup> Army from Cadore.

The Cadore offensive can be considered a unique event for military history due to its particular characteristics—a combination of the mountainous environment and the particularities of the attrition of warfare. Furthermore, considering First World War military history, the failure of the Cadore offensive is an important event because it is inevitably associated with the failure of the irruption into the Austro-Hungarian territory that Italy expected to achieve at its entrance into war. In this regard, the Austrian official history specifies that the failure of the Italian irruption was one of the greatest mysteries of the First World War (AOH, 1930–39, 2). Inside Italian military history, its importance goes beyond that specific for the First World War, because the Cadore offensive, considering the Italian military operational planning, represents “the first time that the Italian Army from the beginning of the operations intended to conquer an important objective beyond the border” (Di Martino and Cappellano, 2007).

For this and other reasons, Italian military historians have become interested in and have considered this event from different points of view. Opinions regarding the reasons for the failure of the Cadore offensive have been numerous, and the debate continues. One of the most recent studies about this offensive, which analyses it from different aspects, is that of Di Martino and Cappellano (2007). In this study, the authors also included a historiographical review of the reasons for the failure of the offensive.

The aim of our paper is to continue the historiographical review of Di Martino and Cappellano (2007) by consulting further sources and by proposing a specific methodology for the order of the historiographical information gathered. In particular, we attempt to differentiate between opinions about the factors that determined the failure and opinions about the origins of these factors.

## **2. The literature regarding the Cadore offensive and the survey methodology adopted by this study**

The consulted literature included monographs of Italian military history that contained information and opinions about the failure of the Cadore offensive. This topic, inside the

monographs, has been treated variously by different authors. In some cases, it has received primary attention (e.g., Liuzzi, 1922; Nava, 1922), while for the largest part, it has represented parts of the monographs on the Italian First World War (e.g., Alberti, 1924; Capello, 1919; Sardagna, 1924) or of monographs on the war in general (e.g., Gatti, 1929). The information and opinions that we considered for our paper concerned parts of the general analysis and synthesis on the failure of the Cadore offensive in its entirety, in none case we considered the parts of analysis or synthesis on specific moments or events of the offensive.

In our opinion, the interest in the failure of the Cadore offensive inside historiography can be traced to two main issues: one has concerned the inadequacy of the means available to the 4<sup>th</sup> Army in relation to the difficulties imposed by the objectives assigned, and the other has concerned the modalities for implementing the commands of Cadorna by Luigi Nava<sup>1</sup>. In almost all the monographs consulted, even if they carried very different weights, both of these arguments were addressed.

With regard to the interest of historiography in the modalities for implementing the commands by Nava, it has developed, on the trace of Cadorna's analysis of Nava's actions (Cadorna, 1950)<sup>2</sup>, essentially as a chronological summary of the directives and communication that existed between the High Command and the army command and between the army command and the subordinate commands. Moreover, this chronological summary has been correlated with other information such as the changes in the number of Austro-Hungarian forces available to defend the border in the same period (e.g, Di Martino and Cappellano, 2007; Papafava dei Carraresi, 1967).

Regarding this historiographical interest, we believed that the opinion that the defeats and the arrest suffered by the 4<sup>th</sup> Army can be justified just partially by reasons which concerns means and difficulties (such as "the harshness of the places which favoured the defensive action", "the lack of knowledge of the terrain" or "the lack of means"), because in a big part they depended by the actions of Nava (Capello, 1919; Di Martino and Cappellano, 2007), has been based on the assumption that different modalities for implementing the commands of Cadorna by Nava would have allowed the 4<sup>th</sup> Army to reach their objectives.

Although, we learned from the literature consulted that many authors have believed that the inadequacy of the means in relation to the difficulties imposed impossible, or almost impossible, conditions to the 4<sup>th</sup> Army to reach their objectives, thus we thought that the study of this topic had precedence over those that focused on how the commands were implemented, or could have been implemented. This opinion has also been adopted by Sardagna (1924, 147).

This precedence of the interest for the analysis of the imbalance between means and difficulties over that for the analysis of the actions of Nava in the study of the failure of the Cadore offensive, in our view, has already appeared as part of one of the first and most important debates relating to this failure, that between Cadorna and Nava. Indeed, Nava

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<sup>1</sup> The character Nava and his ability to command may have been considered among the characteristics of the means available to the 4<sup>th</sup> Army. However, in literature, the two topics were principally considered distinctly and we preferred to follow this form.

<sup>2</sup> For further information, see the chapter in which Cadorna responded to Nava's accusations and in particular the excerpts from the document *Report on the actions of the Commander of the 4<sup>th</sup> Army*.

(1922), judged for his actions by Cadorna (Cadorna, 1921, 1950), attempted to prove that, because the Austro-Hungarian defence positions were well set up and garrisoned by sufficient forces, a surprise attack was impossible (Cadorna, 1950). Cadorna's (1950) answer to the imbalance between means and difficulties raised by Nava focused on what were the Austro-Hungarian means at the front over time, which were the interpretations about these means by Nava and the feasibility of the target.<sup>3</sup>

Even if the debate between Cadorna and Nava presented many very interesting insights about the unfeasibility of the offensive and is full of information about the concept of the imbalance between means and difficulties, in our analysis of literature, we preferred to omit their writings. This choice was based on our difficulties to discern where their evaluations and judgments have been more targeted to the validation of their personal action and plans, rather than to an objective historical analysis.<sup>4</sup>

In literature, several authors, in addition to Nava and Cadorna, have given great importance to the imbalance between means and difficulties that characterized the failure of the Cadore offensive. The concept of the imbalance was expressed in different terms and each author made reference to different elements that influenced the military events and the failure of the offence.

In our survey we attempted to include those different elements of military influence mentioned by these authors, into those elements, which according to Cadorna, are the key to determining an operation plan: the own forces and those of the enemy, the strategic objectives, the terrain, and the logistics infrastructure (Cadorna, 1921, 23-24). Hence, with the term 'means', we considered the logistics infrastructure and the forces made available to the 4<sup>th</sup> Army, in the broadest sense, thus including men, weapons, and all the other kinds of materials. With the term 'difficulties', we considered the enemy forces and the terrain. Within the element terrain, in addition to physical geographic features, we included anthropogeographic elements, such as the Austro-Hungarian defence structures.

However, the discussion of the imbalance between means and difficulties has not limited to the conditions of the elements of military influence, deeming them as factors that determined the failure of the offensive, but authors have also considered the origins of those factors.

In order to consider separately the opinions about the factors and origins of the failure of the offensive in literature, in our paper, within the opinions about the factors, we included the opinions regarding the conditions of the elements of military influence that have been considered regarding the failure of the offensive. Among the opinions about the origins, we included the opinions regarding the causes that led to the determination of the conditions of the elements of military influence.

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<sup>3</sup> It should be recalled that in his later writings (1950), the same Cadorna recognized the high difficulty that the offensive met and the limited resources with which it had to be conducted.

<sup>4</sup> Some appreciation regarding the aim to validate the personal actions and plans in the writings of Cadorna have been considered by Sardagna (1924), and Bencivenga (2014, 171-172). Regarding Nava, for example, before the start of hostilities, he was favourable to an offensive from Cadore, contradictory to what he attempted to demonstrate in his later writings.



According to the distinction between those factors and origins that we considered to have been more regarded and those factors and origins that we considered to have been less regarded in literature, we structured the paper in the following way:

- in Part One, we grouped the opinions about the factors that determined the failure of the first phase of the offensive<sup>5</sup> and the opinions about the origins that have mainly regarded the operation plan of Cadorna;
- in Part Two, we focused mainly on the opinions about the factors and origins that have been considered by Liuzzi (1922) and Bencivenga (2014, 2015).

### 3. Part One

#### *3.1 The factors that prevailed in literature*

The majority of the scholars who have been interested in the failure of the Cadore offensive have focused their attention on the conditions that were presented for the 4<sup>th</sup> Army to deal with the first phase of the offensive, namely the breaking of the Austro-Hungarian defensive system.

Certainly, in the evaluation of those conditions, the terrain has been considered as one of the primary difficulties. Concerning this element the Austro-Hungarian defence system was considered by most authors as a major factor in determining the unfeasibility of the offensive. In particular, the imbalance that was presented between artillery of siege available to the 4<sup>th</sup> Army and the Austro-Hungarian permanent fortifications has been widely mentioned. This point seems to have been focused on mainly by Pieri (1998), who supported Murari-Brà's (1923) opinion.

In addition to the permanent fortifications, another difficulty of the terrain element, which has been widely discussed in literature, has been the field fortifications (e.g., Pieropan, 1988; Sardagna, 1924). Some authors, like Segato (1927) and Valori (1925, 100), seem to have focused their attention on these rather than on the permanent fortifications. However, it is worth mentioning that, according to some other authors, the preparation of these field fortifications when the conflict began were not yet completed, and thus, did not represented a difficulty in determining the unfeasibility of the offensive (e.g., Segato, 1927).

The last aspect to consider regarding the terrain element are the physical geographic features (e.g., hydrography, roughness, slope of the reliefs, etc.), which, as the Austro-Hungarian defence system, have been considered of primary importance. In fact, especially with regard to the field fortifications, both those difficulties have been often mentioned together, as if they represented a whole. However, differently as many authors did for the permanent fortifications, by signalling the lack of artillery of siege, for the physical geographic features were not explicitly identified the means which would have allowed to overcome them.

For those reasons and because in many of the consulted texts the physical geographic features were only named (e.g., Pieri, 1998, 64; Pieropan, 1988, 66–68; Sardagna, 1924,

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<sup>5</sup> Regarding the phases that Sardagna (1924) identified for the mission of the 4<sup>th</sup> Army, see the Introduction of this paper.

137–138), despite they were always considered crucial, it is very difficult to recognize what was their 'real' weight in determining the unfeasibility of the offensive.

The physical geographic features have been often mentioned in specific parts of the texts that concern the Cadore offensive as well as in almost all the parts regarding the military geography framework of the Alpine theatre of war. However, their treatment has been limited to the description of the main physical geographic features or, at least, to a surface characterization of the military importance of this difficulty. How much the characterization and the assessment of physical geographic features have been trivialized and to what extent resulted difficult can be highlighted by comparing some texts: for Valori (1925, 41), the value of the difficulty represented by the terrain doubled that represented by the enemy forces, while for Sardagna (1924, 145), that of the enemy forces was quadrupled by the value of the terrain.

Segato (1927), who was commander of the 1<sup>st</sup> Army Corps, was a great connoisseur of the difficulties that the Cadore offensive had to face, and he was one of the few to explain, in general terms, the influence of physical geographic features on military operations. In particular, according to Segato, physical geographic features impacted the movement of the attacker and forced him to advance slowly, through narrow places, which exposed him to the enemy.

As for the difficulty represented by the enemy forces, it seems that the more common view has been that these did not represent the main reason for the unfeasibility of the offensive, especially when they were considered according to the conditions at the beginning of the conflict (e.g., Capello, 1919; Papafava dei Carraresi, 1967; Segato, 1927; Viazzi, 1976). Many authors came to this appreciation by comparing the number of men the two contenders moved towards the front over time.

Among the reasons for the imbalance between means and difficulties, there were also deficiencies or inadequacies in the means provided to the 4<sup>th</sup> Army. The conditions of the means have been treated in literature as mainly operational aspects; logistics were barely mentioned. The main of these deficiencies or inadequacies, as we have already reported when discussing the value of the Austro-Hungarian defence system, was inherent to artillery, which was considered from the perspective of its quality, but above all in its quantity (e.g., Capello, 1919; Pieri, 1998; Segato, 1927). Other considerations about specific materials and weapons that failed or were inadequate were explosives, wire cutters to open barbed wire gates, and an airplane to complete the work of the artillery observers (Pieri, 1998).

With respect to the troops, some authors focused on the scant number (e.g., Pieri, 1998; Sardagna, 1924). But where there has been a greater consensus has been on the inadequacies of the troops in terms of the type and quality. In this regard, several authors reported a lack of battalions of 'Alpini' and oriented and specialized troops for mountain warfare (e.g., Papafava dei Carraresi, 1967; Pieri, 1998; Sardagna, 1924; Segato, 1927). Pieri (1998) also reported the presence of brigades filled with workmen who were not always adequately committed.

The inadequacies in terms of quality also included the commands. Sardagna (1924) explained the impact of some subordinate commanders' poor knowledge of the mission and

of the terrain. Also, Pieropan (1976) and Valori (1925) indicated that there were inadequacies among the senior officers.<sup>6</sup>

Sardagna (1924), in reference to the forces of the 4<sup>th</sup> Army, clarified that it was not only the amount and type of troops and materials available, but also the great disorganization that followed the 'red' mobilization, which made the available means initially unusable.

### ***3.2 The origins that prevailed in literature***

In our opinion, the origins of the imbalance between means and difficulties that have interested large part of the historians have been those concerning the operation plan of Cadorna. Indeed, a common opinion has been that the Cadore offensive would have been feasible (e.g., Corselli, 1942; Mandel, 1935; Papafava dei Carraresi, 1967), or, even more, would have represented one of the best strategic choices for its usefulness and necessity (e.g., Capello, 1919; Mandel, 1935; Sardagna, 1924; Segato, 1927; Valori, 1925), if not for certain errors in the formulation of the operation plan.

Within this group of historians, certain points of view have been more or less shared with respect to: the conditions when Italy entered the war of the different elements influencing the operation plan, the errors in Cadorna's strategy, and the alternative proposal to Cadorna's strategy that would have better fit the conditions of the different elements influencing the operation plan.

#### The conditions of the different elements influencing the operation plan

Some of the elements considered within this group of authors, with regard to the moment when Italy entered the war, have been the strategic objectives near Cadore, the Italian forces, the enemy forces and the terrain.

Regarding the strategic objectives near Cadore, it has been rather shared the high value they had. One of the main assessments that identified a high value to the strategic objectives near Cadore was based on the mean that would have the occupation of Dobbiaco, or of a part of the Puster Valley, which interruption of the rail and road communications would have been essential to reduce, if not eliminate, the threat that represented the Tyrol salient (Sardagna, 1924, 107–109). For others, the important strategic objective in the Puster Valley was represented by Fortezza, the possession of which would have interrupted the Austro-Hungarian line of communications of the Brenner and, therefore, eliminated the threat of the Tyrol salient (e.g., Corselli, 1942; Segato, 1927; Valori, 1925). Finally, some authors assigned an important strategic value to the Puster Valley due to the opportunity that would have given to the 4<sup>th</sup> Army to march east along the valley in order to collaborate with the operations that would have been taken on the front of the Julian Alps (Mandel, 1935, 296).

Another evaluation that has been more or less shared has been about the condition of the Italian forces. The evaluation of this element was treated within the great chapter of Italian military history of the First World War regarding the status of the preparation of the Italian Army when it went to war and has, in a nutshell, "not been very optimistic" (Pieri, 1998). The

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<sup>6</sup> We have already reported in the note 1 that the character and ability of commanders can be considered among the characteristics of the means. In this regard, Clausewitz (1982) indicated that mountainous terrain, which imposes a high fragmentation of units, requires certain specific command skills.

more common view has been that the value of the Italian forces, in terms of quantity and quality, was not proportionate to the objectives of the operation plan of Cadorna (e.g., Capello, 1919; Sardagna, 1924). This was the result of a lack of preparation with remote origins, from the campaign of Libya (e.g., Capello, 1919; Murari-Brà, 1923), to which were added those problems and lack of preparation that occurred during the year of neutrality (e.g., Corselli, 1942, 77).

The conditions of the elements related to logistics have been included within this general lack of preparation, in our opinion, without arousing special attention and without being treated with particular depth. For example, Sardagna (1924) in his evaluation of the logistical aspects of a hypothetical offensive against the Tyrol salient, has based his analysis on too general theoretical concepts rather than on detailed data and analysis.

Finally, considerations have been similar also with regard to the elements representing the difficulties: the terrain and the enemy forces. The terrain, as we have said, has been treated as part of military geography descriptions of Cadore and has been considered highly important. As for the enemy forces, the most widespread opinion has been that when Italy declared war, there were not enough troops to protect the border. However, its value has been considered very high because, due to the fact that Austria-Hungary was already mobilized and in possession of valid railway lines, the mass of the enemy forces which could have been concentrated in Tyrol or in the Carso at the beginning of war would have been greater than the Italian ones (e.g., Capello, 1919, 113).

#### The errors in Cadorna's strategy

Based on these conditions when Italy entered the war of the different elements influencing the operation plan, the authors focused their attention on the errors of Cadorna's strategy. There were essentially two errors of strategic choice that have been reported and both focused mainly on the lack of preparation of the Italian forces and on the possibility of the enemy to concentrate a greater mass of troops in different parts of the front at the beginning of war.

The first has concerned the need to concentrate more troops on certain points of the front of war. In fact, according to many authors, the deployment of the Italian Army was too diluted (e.g., Capello, 1919; Sardagna, 1924; Segato, 1927). The second has concerned the need to choose strategic objectives that were commensurate with the conditions that presented the Italian forces. Indeed, according to many authors, the strategic objectives in the Carso direction, on which Cardona concentrated the main Italian effort, were too ambitious. This consideration has stemmed from the conditions of the Italian forces available (e.g., Capello, 1919; Corselli, 1942; Mandel, 1935; Sardagna, 1924) and from the reflection that their achievement would have been too dangerous, considering the looming threat from the Tyrol salient (e.g., Corselli, 1942; Valori, 1925).

#### The alternative proposal to Cadorna's strategy

From these differences with Cadorna's strategy, many authors agreed on an alternative proposal, namely, concentrate the Italian forces for a main attack led from Cadore towards its near strategic objectives.

In our opinion, the statement of this proposal had to involve at least one assumption—that the offensive from Cadore would have been possible if more Italian forces had been allocated. However, the considerations in literature about this assumption have not always appeared explicitly, and in many cases, have not been very well founded. It seemed to us that the proposal of a main attack from Cadore in just a few cases has been stated through a complete reasoning that evaluated the operation in all its aspects. Of this idea was also Alberti (1924, 51) about the Capello's proposal (1919) to carry out the main attack against the bases of the Tyrol salient, considering that Capello did not make the slightest mention of the possibility of implementing such operations.

In our opinion, the more detailed statements of this proposal, which, however, treated more the operational aspects than the logistics ones, were those of Sardagna (1924) and Segato (1927). In particular, Segato identified exactly the means of addressing the difficulties of the area of Cadore and presented the order of priorities and actions that the operations should have followed.

Furthermore, in some other cases, considerations regarding this proposal have been associated with contradictory arguments, such as we found in Corselli (1942): page 53 said that in order to fulfil strategic functions, such as to constitute a base for an offensive towards the Puster Valley, Cadore would have needed a greater development of its logistics infrastructure, while page 78 said that the aim to reach Fortezza in the first months of the Cadore offensive would not have been an aspiration disproportionate to the means that Italy could have disposed.

## 4. Part Two

### *4.1 Factors and origins in Liuzzi*

The second and third phases<sup>7</sup> were never faced by the 4<sup>th</sup> Army, and the interest for them inside the bibliography has been less than that for the first time. In the studies where these phases have been addressed, such as in Bencivenga (2014), this was done mostly from the point of view of strategic and tactical operations. In particular, the studies of these two phases have formulated conjectures about the possible outcomes that could have occurred once the first phase had passed and have also made judgments on their unfeasibility.

However, there have also been some studies that have dealt with the second and third phases, based on aspects related to logistics. Studies concerning logistics history are based on more concrete and verifiable considerations (Botti, 1991) than those considerations based on conjectures regarding the operational aspects of the second and the third phase. Therefore, these studies about logistics acquire particular historical interest.

In this sense, the study of Liuzzi (1922), who was the Logistics Staff Officer of the 4<sup>th</sup> Army during the period of the Italian neutrality and during the first months of the war, provided results essential for its level of detail. This study included a very clear judgment about the unfeasibility of the third phase. This was manifested in June 1915 when Liuzzi was asked by the Logistics High Command if he had already considered how the logistics of the 4<sup>th</sup> Army

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<sup>7</sup> Idem, 5.

would have operated when, in August or September at latest, the 4<sup>th</sup> Army would have reached Dobbiaco. Liuzzi was forced to respond that if the 4<sup>th</sup> Army, reached Dobbiaco in September, had to operate to the east or the west of the Puster Valley with the logistic problems which were present in Cadore, by late autumn, and perhaps before, it would have been fatally separated from its supply base and its command, who would innocently have to declare its failure<sup>8</sup> (Liuzzi, 1922).

As for the opinions about the imbalance between means and difficulties, the opinions of Liuzzi (1922) were based on the observation of certain problems that concerned specific aspects of the logistics means provided to the 4<sup>th</sup> Army in relation to the logistics difficulties in Cadore. Exposing these problems, in many cases Liuzzi (1922) analyses their origins, but unlike the authors who focused their attention on the operation plan of Cadorna, his attention was focused on other different aspects.

Even Liuzzi agreed that behind the imbalance between means and difficulties was the general lack of preparation with which the Italian Army faced the First World War. Like other authors, Liuzzi observed that this lack of preparation had a remote origin to which were added the problems and lack of preparation that appeared during the period of neutrality. Particularly to the period of neutrality, the lack of preparation which stemmed from it was a consequence of the hasty formulation and implementation of the new mobilization plan 'red', from which, according to Liuzzi, derived a preparation that, with respect to the logistics services, had to be "rushed and necessarily insufficient" (Liuzzi, 1922).

However, with regard to the lack of preparation, Liuzzi did not limit his commentary to the quality and quantity of Italian forces available; he also emphasized the lack of preparation of the Italian Army in terms of concepts and planning with regard to the administrative responsibilities of the logistics staff of the army, the inadequacy of the locations assigned for warehouses, the dislocation between the command for operations and the command for logistics, and the allocation of logistic means to armies based on the number of army corps that they had rather than on the difficulties imposed by the terrain where they were deployed.

Another aspect that, in our opinion, has distinguished Liuzzi, was the identification of causes completely unpredictable regarding the lack of preparation of the Italian Army. In fact, the lack of preparation was also the result of some completely unpredictable transformation in the way of making war that became apparent only with the outbreak of the war. Thus, part of the pre-war studies, plans, and concepts that had been established during the period of peace were outdated and, in some cases, even harmful.

Other negative opinions about the feasibility regarding the second and the third phases of the Cadore offensive based on logistics were found in the studies of Alberti (1924) and Gatti (1929), where, even if the topic was faced marginally, showed some data and verifiable calculations, such as distances and the efficiency of railway lines.

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<sup>8</sup> According to Liuzzi, this negative opinion on the feasibility of the hypothetical case when it was expressed was based too little on the experience of war. But it was a statement that he confirmed later when the first winter of war arrived (Liuzzi, 1922).

## ***4.2 Factors and origins in Bencivenga***

Also Bencivenga (2014, 2015) traced the factors of the imbalance between means and difficulties with regard to the unfeasibility of the Cadore offensive. In our opinion, the first characteristic that has distinguished his analysis was the assignment of a very high value to the difficulties that the 4<sup>th</sup> Army faced. These difficulties concerned the terrain (i.e., the valuable Austro-Hungarian defence system prepared during the period of neutrality) (Bencivenga, 2015, 93–95) and the enemy forces, considered by the author "sufficient to repel any Italian attack" (Bencivenga, 2015, 103).

Regarding the means available to the 4<sup>th</sup> Army, the considerations of Bencivenga (2015) were similar to those of other authors and focused on the limited amount of artillery, 'Alpini' troops, and units with the necessary mobility (Bencivenga, 2015).

About the origins of this failure, we saw in Bencivenga (2014, 2015) the most original considerations. One of the main origins would have been the incorrect assessment of the difficulties that the Cadore offensive involved. This incorrect assessment of the difficulties stemmed from the increasing military importance over time that certain elements presented. In short, for Bencivenga, two elements acquired high importance and should have represent a greater difficulty in the evaluations: the terrain (by the new use of field fortifications, which, especially in mountainous regions, should have been considered unassailable) and the enemy forces (by the fact that should have been considered easy for the defender to saturate the entire front) (Bencivenga, 2014, 161).<sup>9</sup>

Considering these elements, Bencivenga believed that until 1 September 1914, when the first operation plan was issued, an offensive from Cadore should not yet seem an impossible task, but rather highly advisable (Bencivenga, 2014, 159). However, as time passed and the above mentioned elements acquired an increasingly dominant character in the war that it was being fought in Europe, the prospects of the possibility of an offensive, especially if carried out in the mountains, were highly decreased.

Despite this escalation of the value of the difficulties, Bencivenga thought that even until 1 April, when the last operation plan was issued, an attack from Cadore maybe could have been feasible (Bencivenga, 2014). But, from the beginning of May 1915, when there was a further escalation in the value of the difficulties, the Cadore offensive, became an almost impossible mission to accomplish. In fact, according to the author, because of the denouncement of the Treaty of London, the improvement of the military situation of Austria-Hungary on the Russian front and the problems that the 4<sup>th</sup> Army had to keep its mobilization hidden from the eyes of the enemy, it was impossible to expect to find the border of Cadore unguarded (Bencivenga, 2014, 172).

The reasons, according to Bencivenga, for the oversight of the increasing importance of the terrain and of the enemy forces in the assessment of the difficulties that would have faced the 4<sup>th</sup> Army were essentially two. The first corresponded to the outdated nature of the studies on which were based the assessments of the difficulties. In particular, Bencivenga believed that at the outbreak of the First World War, the offensive against the Tyrol salient, especially that against Dobbiaco departing from Cadore, was a widespread idea in the Italian military schools. But, having been conceived on the basis of studies realized 40 years before,

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<sup>9</sup> On the possibility that modern war gave to the defender to garrison every mountain pass having military value agrees also Alberti (1924, 52).

this idea did not correspond to the reality of the war in 1914 (Bencivenga, 2014, 161–162). Instead, the second reason concerned the ignorance that existed until the outbreak of war by the High Command, and also by the command of the army, about the status and the characteristics of the Austro-Hungarian defence system at the border (Bencivenga, 2015, 95).

Given this incorrect assessment of the difficulties concerning the Cadore offensive, Bencivenga concluded, "At the outbreak of the war it was seen that the difficulties that were present in this front were much greater than it was previously thought [...]" (Bencivenga, 2014, 180).

Another interesting aspect of the origins of the failure of the Cadore offensive identified by Bencivenga regards the means. Indeed, he believed that the first cause at the origin of the inadequacy in terms of means that the 4<sup>th</sup> Army faced occurred at a general level. In particular, he considered that the means that the technique provided to an attacker in 1915 were themselves inadequate in front of the value of the difficulties that the Cadore offensive presented (Bencivenga, 2015, 95).

Moreover, as we saw for other authors, Bencivenga was interested in the origin regarding the inadequacy in terms of means, which stemmed from the Italian Army's lack of preparation at the start of the war. However, the author has stood out due to his opinions about the remote origins of that lack of preparation. Indeed, he believed that at the outbreak of the European war in 1914, even if the Italian Army could not be considered fully efficient, especially with regard to technical means, it was not more unprepared than were the other armies, in particular the Austro-Hungarian.

Therefore, Bencivenga preferred to focus his attention on the recent origins of the lack of preparation that occurred during the period of neutrality.<sup>10</sup> According to his thoughts, the serious deficiency in terms of means affecting the 4<sup>th</sup> Army originated from the failure of the new mobilization plan 'red'. In particular, the assumptions on which the operation plan of 1 April was based, were completely missing from early May. Indeed, by that time, it was possible to recognize the deficiencies that would have been presented, mainly in regard to the mobilization and then to the artillery of siege with which the 4<sup>th</sup> Army should have launched the attack as soon as possible. According to Bencivenga, the commands "were able to assess with full accuracy" the causes of such deficiencies (Bencivenga, 2014, 173–174).

Due to these origins, which affected the value of the means, Bencivenga concluded that the 4<sup>th</sup> Army found itself facing an almost impossible mission considering the means provided to an attacker in 1915 and completely impossible considering the way the 4<sup>th</sup> Army was actually equipped (Bencivenga, 2015, 95).

Some of the aspects highlighted by Bencivenga have been mentioned by other authors. For example, Rochat (Isnenghi and Rochat, 2008, 163), who considered the Cadore offensive doomed to a bloody failure, affirmed that the fact that Cadorna assigned it "shows that he had not yet realized how difficult it was to conduct an offensive, especially in mountainous terrain". In addition to the difficulty of assessing the difficulties, the author referred to the difficulty of assessing the value of the means. In particular, Rochat stated that there was "a difficulty of the Italian High Command to understand the special needs for mountain

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<sup>10</sup> For more information on Bencivenga's thoughts about the lack of preparation of the Italian Army that stemmed from the period of neutrality, consult Pieri (1998).



warfare, which must take account of the terrain [...] and rely on accurate preparation" (Isnenghi and Rochat, 2008, 163).

Gatti (1929, 125–126), shared with Bencivenga the opinion on the increasing value of the difficulties concerning the terrain and the enemy forces. According to both authors, the values of these elements were delineated gradually over time, according to the appearance of certain causes, partly predictable and partly not. It is worth mentioning that until the outbreak of hostilities, at least in part, the characteristics of these elements were unpredictable, and therefore, also were their 'real' value; e.g., that of the enemy forces, which stemmed in part from the Austro-Hungarian operation plan for the Italian front and could not be known until the beginning of the conflict (Gatti, 1928, 126).

Regarding the inadequacy of technical means in 1915 for attackers and the unpredictability of certain facts that changed the values of the difficulties, the Italian official history, about the Italian offensives of 1915, concludes that "different difficulties in largely unforeseen and unpredictable, and against which the means and methods of fighting showed themselves inadequate, frustrated many of our efforts" (IOH, 1927-88).

Finally, we noted that the negative opinion of Bencivenga about the possibility of including in the operation plan the attack from Cadore was associated with a negative assessment of the strategic objectives near Cadore. Indeed, Bencivenga shared with Alberti (1924, 48) not only the opinion on the high value of the difficulties and the inadequate logistics infrastructure conditions that Cadore region had, but also the opinion that the attainment of the Puster Valley would not have been enough to thwart the danger of an attack from the Tyrol salient (Bencivenga, 2014, 162; Alberti, 1924, 50).

## **5. Final considerations**

We consider an important feature of the consulted historiography the little detailed characterization of the terrain military value and the lack of concern about the logistics aspects that we highlighted for the main part of the authors who took in consideration the failure of the Cadore offensive. This feature we noted with regard to the majority of the opinions about the factors that determined the failure of the offensive, as well for the alternative proposal to the operation plan of Cadorna, according to which a main offensive from Cadore would have been possible if there had been more concentrated means.

Another feature that seems to emerge from the results of our historiographical review is the diversity that have existed among the different authors about the values assigned to the various elements of military influence. This seems to appear with regard to elements related to the difficulties, which seem to have reached the highest value in Bencivenga, and with regard to the strategic objectives near Cadore, which seem to have reached the highest value in the authors who have supported the alternative proposal to the operation plan of Cadorna.

These features led us to think that, regarding the opinions about the factors and origins of the failure of the Cadore offensive, some elements of military influence were not considered fully or in-depth. We were also driven to consider with great interest the hypothesis that Bencivenga formulated about the difficulties in the evaluation of the different elements that, ultimately, led to misjudgement.

The assessment of the elements of military influence corresponds to a previous instance to the assessment of the hypothetical strategic choices. In that order, we believe that it should attract the interest of historiography, especially if it is taken into account that, particularly, terrain and logistical infrastructure were elements of fundamental importance, which, for instance, in the formulation of an operation plan can be considered constant to any strategic hypothesis (Cadorna, 1921).

This theoretical observation on the precedence that studies concerning the evaluation of the elements, particularly concerning terrain and logistical infrastructure, must have on those concerning the evaluation of the operation plan seems to be confirmed also by the analysis conducted in this paper. In fact, we highlighted different origins about the imbalance between means and difficulties that were unforeseen and unpredictable. These origins, which appeared between the time of the formulation of the operation plan and the outbreak of war, changed the values of the elements.

It is noteworthy that if these unforeseen and unpredictable origins weighed heavily on the chances of success for the operation plan of Cadorna, it would also have weighed, for example, on the chances of success for a possible operation plan that would have concentrated the main attack from Cadore. Of particular interest in this regard are many of the unforeseen origins noted by Liuzzi, which concerning the planning and concepts that were present in the Italian Army before the conflict, would not be remedied by almost no other type of alternative operation plan. The same consideration can be made from several of the origins that Bencivenga discussed. For example, with regard to the ignorance that existed until the outbreak of war by the commands about the status and the characteristics of the enemy defences. Or with regard to the inadequacy of artillery available to the 4<sup>th</sup> Army at the beginning of the operations, which was largely due to the delay with which the artillery arrived to the front. Indeed, the delay with which the artillery arrived to the front was caused by a number of unforeseen events that appeared gradually over the period of neutrality and would have appeared also in the case of any other strategic choice.

From this perspective, in order to better understand the factors and origins of the failure of the Cadore offensive, it seems that research on the value of the elements of military influence has to develop further. It may concern the assessments of Cadorna, of other authors, and those that were in vogue before the conflict started. This could be complemented by studies focused on the evolution of those values and on the causes, predictable and unpredictable, expected and unforeseen, that led to a particular value. Lastly, analysis aimed at a better characterization of the 'real' weight and role that every difficulty played during the first battles and at better comprehension of which particular means would have corresponded to which particular difficulty, certainly would help in understanding which were the 'real' value of every element on the outbreak of war.

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## CHAPTER 2

# The Cadore Offensive: Theoretical Military Geography Considerations

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### Abstract

The failure of the attack on the Puster Valley at the beginning of Italian hostilities, known as the Cadore offensive, has been of great interest in the Italian debates over the First World War. Despite the widely cited disadvantage of the Alpine front geography for the Italian offensive, specific and systematic studies of this aspect are lacking. In this paper we study the military value of the Cadore offensive's geography from a theoretical perspective. The analysis is based on Gen. Cadorna's theoretical assessment and some theoretical military geography considerations based, in part, on the theory of the decades leading up to the First World War, in particular, those of Gen. Porro.

**Keywords:** First World War, Italian Front, Dolomites, Military Geography, Military Theory, Mountain Warfare.

### 1. Introduction

Italy declared war against Austro-Hungary on 23 May 1915, just about one year after the assassination of Archduke Franz Ferdinand of Austria, joining the Allied forces. The theatre of war between the Italian Kingdom and the Austro-Hungarian Empire extended mainly through the Eastern Alps, from the Swiss border to the Adriatic Sea (Figure 1). By the end of the war, on this front, Italian casualties numbered 651,000 deaths and 953,000 wounded, and Austro-Hungary's numbered 404,000 deaths and 1,207,000 wounded.

Due to Italy's military alliance, as well as political, economic, and irredentist national interests, the Italian military was forced to take an offensive stance. The operational design of Gen. Cadorna, Chief of Staff of the Royal Italian Army, identified the country's key strategic objectives beyond the Julian Alps and the 'Carso' (the 'Classic Karst' area at the Italian border with modern-day Slovenia). The bulk of Italian forces was therefore deployed in those directions. This operational design determined Gen. Cadorna's planning from the summer of 1914 until the autumn of 1917, when Austro-Hungarian forces swept into the plains of northern Italy.

Just before the Italian declaration of war, the Julian and Carso strategy was momentarily abandoned mainly because, after a careful reassessment of the strategic and organizational situation of the two armies, Gen. Cadorna realized that the Austro-Hungarians would have deployed faster than the Italian troops along that front. In his *Variations to the directives of 1<sup>st</sup> September*, issued on 1 April 1915, whose instructions were implemented at the beginning of war, Gen. Cadorna established a strategic defensive stance that would have lasted from the declaration of war until the end of the Italian Army's mobilization. The only exception concerned the 4<sup>th</sup> Army, deployed in the mountainous region of Cadore, to which he assigned what would have been the first objective of the Cadore offensive<sup>1</sup>: to reach the Puster Valley. This way, the 4<sup>th</sup> Army became the only unit that from the beginning of the war had a task beyond the state border of strategic, and not just tactical, importance. More important, such an attack towards the Puster Valley was the first time in history that the Royal Italian Army intended, from the start of operations, to cross the political border and to take possession of an important objective beyond it (Di Martino and Cappellano, 2007).

The first step for the 4<sup>th</sup> Army's commander Gen. Nava was to overcome the Austro-Hungarian 'sbarramenti'<sup>2</sup> that blocked the routes to the Puster Valley (Figure 2). However, as weeks passed since the declaration of war with the Italians unable to launch an attack, the Austro-Hungarian defenses grew even stronger. During the summer of 1915, the 4<sup>th</sup> Army launched the biggest offence against the 'sbarramenti' without any positive result. As supplies continued flowing to this front, the battles grew bloodier, extending all over the state border, from the valleys to the mountainsides, glaciers, and the peak summits. Thus, providing one of the most important instances of mountain warfare in military history.

By beginning of the autumn of 1915 Gen. Cadorna realized that attrition warfare had been established even in the area assigned to the 4<sup>th</sup> Army. This dashed his hopes of reaching the Puster Valley, which would have been a line of penetration into Austro-Hungarian territory. This induced him to re-direct the 4<sup>th</sup> Army to a mainly defensive strategy, while the offensive action was designated exclusively to the great mass of men concentrated in the direction of the Julian Alps and the Carso. This condition prevailed until October 1917, when the Austro-Hungarians, no longer engaging the Russians, spread with German help from the Julian Alps onto the Venetian Plain. This forced the withdrawal of the majority of the Italian units, including the 4<sup>th</sup> Army from Cadore.

The failure of the attack on the Puster Valley at the beginning of Italian hostilities occupied an important place in the debates over the Royal Italian Army's operations in what many considered the 4<sup>th</sup> Italian War of Independence. Discussions included Gen. Cadorna's operation plan, Gen. Nava's long and excessively methodical preparation for attack, the size and growth of Austro-Hungarian forces occupying the state border since the early days of the conflict, the Serbian-Russian attack that should have been launched in the moment that

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<sup>1</sup> Cadore is a historical Italian region presently located in the northern part of the Province of Belluno, in the Veneto Region.

<sup>2</sup> The term "sbarramento" in the Italian literature has been used to identify the Austro-Hungarian blockade of mountain passes and valleys. Usually they correspond to forts that had been built before the war and, as war with the Italian Kingdom became more probable, were reinforced by numerous field fortifications. The word has French origin (see, D'Ayala, 1841).

Italy joined the war and did not happen, the 4<sup>th</sup> Army's lack of technical siege equipment, and the confusing nature of Gen. Cadorna's orders and directives.<sup>3</sup>

Although almost all authors who analysed the Italian operations agree on the immense obstacles the geography presented for the offence, not only for the Cadore offensive but for the entire Alpine front, there has yet to be any specific or systematic studies of the subject.

To contribute further to the study of the failure of the Cadore offensive, this paper focuses on the geography of the area, considering its military values from a theoretical point of view. We direct our attention solely to the offensive values, because the operation plan which the Royal Italian Army followed when joining the war privileged offensive strategy for Cadore. Our methodology is based on a comparative analysis between the offensive values which Gen. Cadorna identified for Cadore at the base of his plan of operation and some theoretical military geography considerations. These considerations are based, in part, on the theory of the decades leading up to the First World War, in particular, those of Gen. Porro.

## **2. Cadorna's military values for the central zone of operation**

Studying the historical events that led up to and surrounded a military campaign is essential to understanding the planning framework in which the campaign was developed. The operation plan which shaped how the Royal Italian Army participated in the First World War was the sole creation of Gen. Cadorna (Cadorna, 1950).

At the base of any military operation plan, which is defined prior to the entrance of war and, therefore, must be adapted to any contingencies developed up to this time, there must be a military geography assessment. Regarding this point, Gen. Cadorna (Cadorna, 1921, I, 23–4) stated as follows:

The operation plan must be developed before coming to war and is determined by: one's own available forces, those of one's enemy, and one's strategic goals. However, there is an element of paramount importance in determining the operation plan that is constant in any case, that is the terrain, which determines the extent of the obstacle in the case of an offensive war, and the viability that establishes the logistical possibility to overcome this obstacle with a given force.

Gen. Porro (1854–1939), considered one of the greatest scholars of military geography in Italy, defines military geography assessment as the determination of the value and influence of geography on the application of military power (Porro, 1898).

According to Gen. Porro, military geography assessment can be done theoretically within certain limits. Such an approach concerns those "few principles regarding the generic functions of different geographic elements in war operations". Gen. Porro includes the following characteristics that should be considered in theoretical analysis of geographic elements: intrinsic conditions, lying posture in the battlefield, relations with other geographical features and orientation related to military action. Besides the theoretical analysis, the field of applied military geography provides further practical specifications of

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<sup>3</sup> For a discussion on these topics, please consult, Berti, 1982; Cadorna, 1921; Cadorna, 1950; Di Martino and Cappellano, 2007; Nava, 1922; Pieri, 1998; Romolotti, 1978.

these functions. This applied analysis, through evaluating different hypotheses of war, introduces the appreciation of positive data, such as the intensity of the forces in action.<sup>4</sup>

Gen. Cadorna's 1921 book, *The War at the Italian Front*, specifically Chapter III, 'The Operational Design', describes the concepts that were foundational to Italian operational planning. In the first part of this chapter, from p. 85 to p. 87,<sup>5</sup> Gen. Cadorna briefly mentioned the defensive and offensive value that he discerned for each of the three zones of operation, in which he divided the theatre of war with Austria-Hungary. We identify this part of Gen. Cadorna's text as a synthesis of his theoretical military geography assessment of this theatre of war.

In describing the central zone of operation, which included the territory relevant to the Cadore offensive, Gen. Cadorna highlighted that it formed a salient inside the enemy territory, whose apex was close to an important Austro-Hungarian interior-lateral line<sup>6</sup>, the Puster Valley. These particular features led Gen. Cadorna to infer the zone's main offensive value: from the apex of that salient in Cadore region, the Italian Army could cut off the Austro-Hungarians' communications in the Puster Valley. Gen. Cadorna also noted another important value of this zone for the Italian offensive: once the Italian Army reached the Puster Valley, it was possible to contribute to offensives against the Trentino, moving towards west, and against the Julian front, moving towards east.

In addition to the offensives values, Gen. Cadorna also highlighted the zone's defensive assets, i.e., to protect the Veneto Plain from attacks that could come from all the roads entering the basins of the Piave and Tagliamento rivers.

### 3. Theoretical military geography analysis

#### 3.1 Geographical framework

Any description of the area relevant to the planned Italian attack on the Puster Valley must start from the valley itself, because it dominates the physiognomy of the Eastern Alps where it lies. The Puster Valley is approximately 90 km long and runs in roughly west to east, parallel to the mountain range. The saddle of Dobbiaco, topographically almost imperceptible, splits the valley in two parts, and is the starting point of the rivers Rienza, which runs west, and the Drava, which runs east. The saddle forms a watershed between the catchment areas of the Adige River to the west and the Danube River to the east. Very near to the saddle, eastward from it, is drawn the current political border between Italy and

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<sup>4</sup> For a deeper explanation in this regard, please see the 'eclectic approach' in, Porro, 1898.

<sup>5</sup> Later on in this chapter, an evaluation of different hypothetical situations of war is also included. Those regarding the Cadore are on p. 90. On p. 91, one can find a summary of the operational design he finally adopted, which could be considered as the result of the application of Gen. Cadorna's strategic concepts and his appreciation of the forces' intensity to the military values derived from the military theoretical analysis.

<sup>6</sup> In this text the term 'interior-lateral line' is used for the translation of the Italian term 'linea di arroccamento', which refers to a communication line (or communication sheaf) with the peculiar feature that it develops more or less strictly parallel to a strategic front. Thus, it allows big, fast and secure shifts of forces from one line of operation to another or from one point of the strategic front to another. Such communication lines are of great value where there is a lack of transversal communications among lines of operation, such as in mountainous theatres of war. See A. Gandin, 'Arroccamento', *Enciclopedia Italiana* (Roma, 1929).

Austria, which cross the valley transversally. The main towns in the valley are: Chienes, Brunico, Monguelfo, Dobbiaco, San Candido, Sillian, Heinfels, Mittewald and Lienz (Figure 2).

The physical origin of the valley can be attributed mainly to the presence of two tectonic faults that join roughly in correspondence of the current political border. In its western region, the valley follows a major tectonic line, the Insubric lineament, which eastward from the state border corresponds with the Gaithal Valley (Janoschek and Matura, 1980). The Insubric lineament, which belongs to the Periadriatic system, plays a fundamental role in the structural framework of the Alps, separating Alpine orogeny into two belts of different geological characteristics to the north and south of the fault: the Europe-vergent belt and the Southern Alps.

The Europe-vergent belt can be subdivided into three main tectonic domains. The Austroalpine domain comes in contact with the Southern Alps along the western part of the valley and is present on both sides of the valley's eastern regions (Dal Piaz et al., 2003). Moving no more than 30 km northward from the Puster Valley, the elevation increases, leading into another tectonic domain, the Penninic, which forms the wide and high east-west relief of the Tauern Alps.

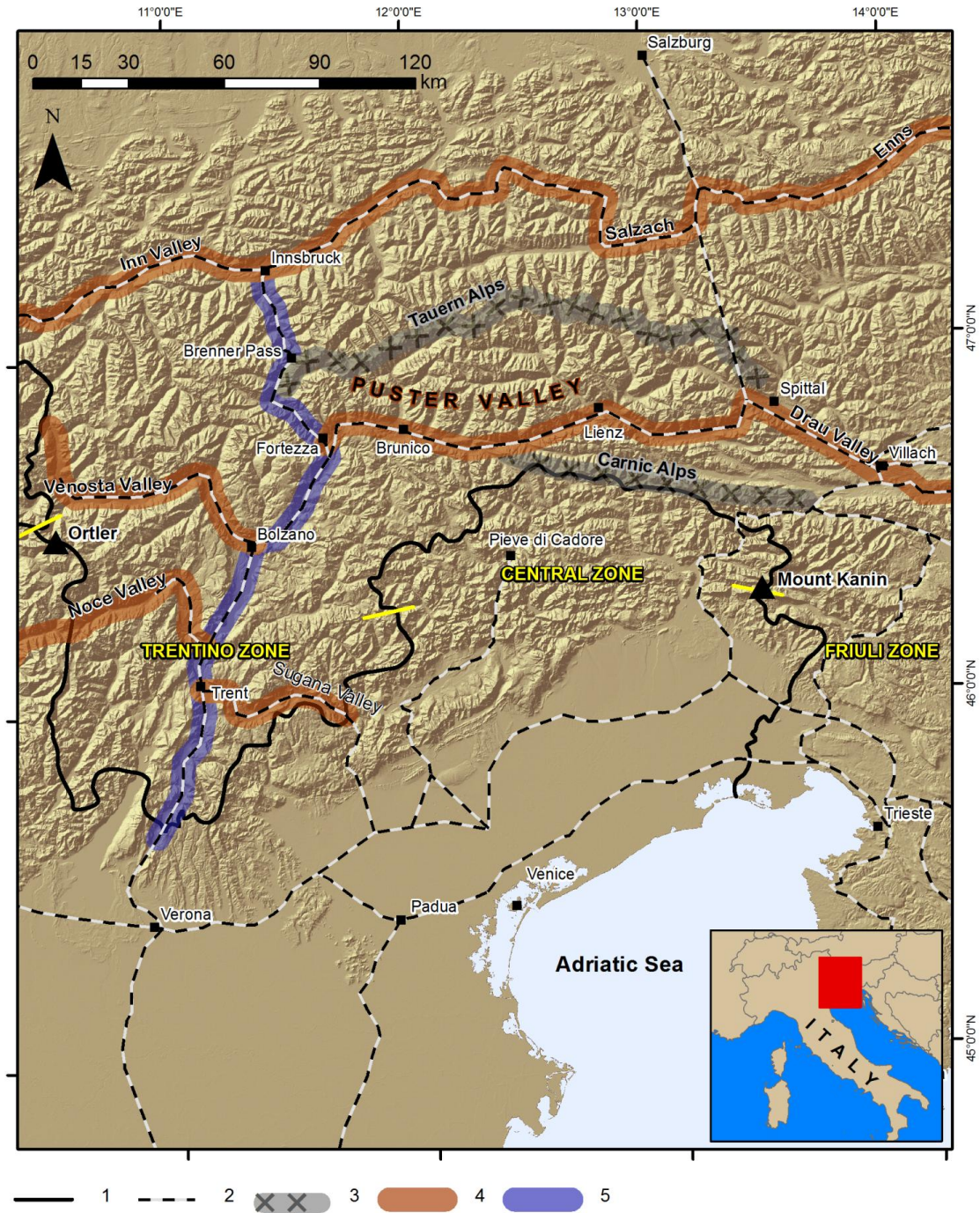
The Southern Alps run along the southern side of the Gaithal Valley and south of the western Puster Valley. In its northern part, the crystalline basement is exposed (Provincia Autonoma di Bolzano, 2004); in the southern side of the Gaithal Valley it forms a long ridge called the Carnic Crest, where the state borders between Italy and Austria have lain since 1866. South of this continental basement are the famous groups of mountains called the Dolomites, formed by the late Carboniferous to Tertiary cover succession. These mountains are characterized by groups of high peaks with steep cliffs separated by deep and narrow valleys joined by saddles. Following those valleys southward will eventually lead, by a labyrinthine path, to the Veneto Plain.

From the perspective of political geography point of view, the western part of the valley is currently in Italy, while the eastern part is in Austria, but until the end of the First World War the entire Puster Valley was the territory of the Habsburg Empire. The border which existed before the First World War was established in 1866, after the 3<sup>rd</sup> War of Italian Independence. The border bulged into Italian territory on its western part, called the 'Trentino salient'. On the eastern base of this salient, the border passed through the northern part of the Dolomites, at one point only 13 km in a straight line from the Puster Valley. The many peaks and deep valleys of the Dolomites determined abrupt differences in altitude along this part of the border. Eastward, the border reached the Carnic Ridge where it ran for about 100 km with minor differences in altitude (Figure 1).

Considering transportation infrastructure at the time of the First World War, the Puster Valley had a railway line that was part of the extended Austro-Hungarian railway system. The western station in the valley was Fortezza, from which it was possible to travel south towards Bolzano or to turn north through the Brenner Pass, eventually reaching the Inn Valley and Germany. From Bolzano, it was possible to continue southwards, connecting to Trent through the Adige Valley. Bolzano also offered a westward train route, going south of the Sarentini Alps to Malles in the Venosta Valley, near the Swiss border (Figure 1). Beyond Lienz, to the east, the railway follows the Drava River up to Marburg, through the cities of Spittal, Villach, and Klagenfurt. Observation states, the Puster Valley was part of a very important east-west communication line covering nearly 500 km, from the Swiss border to



Marburg. Furthermore, from Spittal, the Tauern line had a direct train that connected Trieste to Salzburg in just 9.5 hours, and there were connections from Villach to Vienna in the north and Ljubljana in the southeast.



**Figure 1** - Location of the Val Pusteria inside the theatre of war between the Austro-Hungarian Empire and the Italian Kingdom. Geographical features of strategic interest inside the Eastern Alps. 1: State border 1866 - 24 May 1915 (yellow bar: boundary of Gen. Cadorna's areas of operation); 2: Main railways before 24 May 1915; 3: Topographic barrier; 4: Lateral corridor; 5: Trent-Innsbruck line.

The situation of railway transportation in the Italian-controlled areas of this territory was not nearly so dense. The closest train station to the Puster Valley on the Italian side of the border was the Pieve di Cadore terminal station. The Italian line ran along the Piave Valley until reaching its only connection, with the Veneto Plain railway system at its far southern end. This rail line was more than 100 km long itself and had a low capacity compared to the Austro-Hungarian rail line of the Puster Valley.

Regarding the roadway infrastructure in Cadore, the situation was not better for the Italians. The journeys from Pieve di Cadore to the Puster Valley required roads that often took hairpin turns, included major fluctuations in altitude, and ran through tortuous valleys that also included mountain saddles. Even though the linear distance between the two places is around 30 km, the journeys had to take a long and demanding route that covered at least twice the distance (Table 1).

Itineraries from Pieve di Cadore finished on one of either the Sesto Valley, Landro Valley, or Badia Valley, each of which led into the Puster Valley. To defend the passage through all these valleys, Austro-Hungary built a series of forts after the 3<sup>rd</sup> Italian Independence War (1866), human structures that were immensely important for the region's military geography. Further defensive structures were built in these valleys on the eve of the Italian declaration of war. In Italy these Austro-Hungarian blockades were called 'sbarramenti'.<sup>7</sup>

Roadway itineraries from Pieve di Cadore (878 m.a.s.l.) to the Puster Valley	Distance to the Austro-Hungarian 'sbarramento'	Distance to the Puster Valley
Santo Stefano di Cadore (908 m.a.s.l.) in the <i>Piave Valley</i> – Montecroce di Comelico Pass (1636 m.a.s.l.) in the top of the <i>Padola Valley</i> – Sesto Valley - San Candido (1175 m.a.s.l.) in the <i>Puster Valley</i> .	49 km	65 km
Auronzo di Cadore (866 m.a.s.l.) and Misurina (1752 m.a.s.l.) in the <i>Ansiei Valley</i> - Carbonin (1440 m.a.s.l.) – Lago di Landro (1406 m.a.s.l.) in the <i>Landro Valley</i> – Dobbiaco (1256 m.a.s.l.) in the <i>Puster Valley</i> .	49 km	64 km
Cortina d'Ampezzo (1211 m.a.s.l.) in the <i>Boite Valley</i> – Tre Croci Pass (1805 m.a.s.l.) - Misurina (1752 m.a.s.l.) in the <i>Ansiei Valley</i> - Carbonin (1440 m.a.s.l.) – Lago di Landro (1406 m.a.s.l.) in the <i>Landro Valley</i> – Dobbiaco (1256 m.a.s.l.) in the <i>Puster Valley</i> .	52 km	66 km
Cortina d'Ampezzo (1211 m.a.s.l.) and Fimes (1293 m.a.s.l.) in the <i>Boite Valley</i> – Cimabanche Pass (1529 m.a.s.l.) - Lago di Landro (1406 m.a.s.l.) in the <i>Landro Valley</i> – Dobbiaco (1256 m.a.s.l.) in the <i>Puster Valley</i> .	50 km	63 km
Cortina d'Ampezzo (1211 m.a.s.l.) in the <i>Boite Valley</i> – Falzarego Pass (2117 m.a.s.l.) in the Costeana Valley, – Val Parola Pass (2192 m.a.s.l.) – Badia (1330 m.a.s.l.) in the Badia Valley – Brunico (838 m.a.s.l.) in the <i>Puster Valley</i> .	50 km	94 km

**Tabel 1** - Roadway itineraries from Pieve di Cadore to the Puster Valley finished on one of either the Sesto Valley, Landro Valley, or Badia Valley. Each of these penetration lines was controlled by an Austro-Hungarian 'sbarramento'. Even though the linear distance between Pieve di Cadore to the Puster Valley is around 30 km, the journeys covered at least twice the distance and included major fluctuations in altitude.

<sup>7</sup> See footnote No. 2

### ***3.2 Theoretical military geography assessment***

Studying the area of the Cadore offensive from a military geography point of view requires an approach that tries to consider the military geography theory of the decades leading up to the First World War. The main reference for our analysis is the 'Study Guide for Military Geography' written by Gen. Porro and published in 1898. This work is a summary of the lessons in military geography that Gen. Porro taught at the School of War of the Royal Italian Army, and even today remains the foundation of the study of military geography in Italy.

Gen. Porro's first consideration that is important to highlight regards the mountainous terrain. This kind of terrain, considered in a general sense, is the least suitable to carry out any quick and decisive operations using large numbers of men. This is a fundamental principle of conventional warfare. The reasons for this unsuitability are the harshness of the terrain, their complex climatic conditions and the lack of communication facilities, built-up areas and resources (Porro, 1898).

However, it can be assumed that in most cases of war in mountainous terrain, from the military point of view, valleys represent the geographic elements that have the greatest strategic, logistical and tactical importance (Porro, 1898). In Gen. Porro's theoretical study of the military functions of mountain valleys, special consideration must be given to their shape and size and to the mountain range in which they are located (for example, direction of the valley within the mountain range and spatial relations of the valley with other geographical features) (Porro, 1898).

#### Small scale

D.W. Johnson's 1921 book, *Battlefields of the World War*, provides a clear overview of the major geographical features of the Eastern Alps and their topologic relations from strategic and logistical perspectives.<sup>8</sup> Through this maze of rugged mountains, Johnson revealed that the Puster Valley is part of a series of parallel glacial-tectonic trenches of the greatest strategic importance in warfare. These are, from north to south, the Inn corridor, the Venosta Valley-Puster Valley corridor, the Noce corridor and the Valsugana corridor (Figure 1).

These corridors are both strategically and logistically important; running along an east-west direction, they control all longitudinal movements inside the Alpine range. Their importance is also due to the extremely high mountain crests as they separate the corridors among themselves and between them and the plains, granting safety to communications present inside each corridor.

The tenuous connections among the corridors and between them and the plains are constituted via deep and narrow north-south valleys and, in some cases, only by barely accessible mountain passes. The most noteworthy of these north-south connections is a

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<sup>8</sup> D.W. Johnson was professor of physiography at Columbia University, and had long been interested in the military aspects of this science. He published two books which also analyse the operations of the Italian-Austrian theatre of war in terms of land forms: D.W. Johnson, *Topography and Strategy in War* (New York, 1917) and D.W. Johnson, *Battlefields of the World War* (New York, 1921). He was well qualified for this undertaking, having been a commissioned major in the US Army in 1918 assigned to military intelligence duty. He continued his military service until 1919, visiting all parts of the European theatre of operations, joining Gen. Bliss in Paris after the armistice to work on the definition of the new borders of European states.

continuous north-south corridor formed by the valleys of the Sill River flowing north and the Eisack River flowing south from the Brenner Pass. This Sill-Eisack corridor was not only morphologically important for military activity, but was also already densely packed with transportation infrastructure: it is a crucial communication path, the rail and road connection of Italy and Germany that also crosses and connects all of the east-west lateral corridors Johnson identified (Johnson, 1921) (Figure 1).

Another factor that increases the Puster Valley corridor's value as a line of communication is that it runs practically parallel to the political border of Italy and Austria-Hungary. Thus, it runs perpendicular to the direction of the two countries' military advances towards each other. For the Habsburgs, the Puster Valley constituted an interior-lateral line through which troops and supplies would have been rapidly and safely shifted from one point to another along the battle line once fighting began.

### Medial scale

At a regional scale, however, one can perceive the vulnerability of the Puster Valley. The wide and high Western Tauern Mountain Chain completely cuts the Puster off from communication with the northern Inn corridor. This prevents any tactical support for the Austro-Hungarian defence of the valley from the north. Furthermore, if the Italian Army had reached the valley, they would have split the Austro-Hungarian forces, enlarged the defensive front and, most importantly, considerably lengthened the communication lines between the South Tyrol and the Carnic fronts of war. One can easily conclude that this would strongly impact not only the Italian front, but the entire Austro-Hungarian theatre of war, as a successful Italian assault on the Puster Valley would have overloaded the rest of the Austro-Hungarian railway system.

South, from where the Italian attack had to take place, the Puster Valley presented two different tactical situations. East of the Dobbiaco Saddle, the Puster Valley could be considered naturally well defended: mountain masses sit between the Puster Valley and the smaller but parallel Gaithal Valley. Another chain of mountains south of the Gaithal Valley, the Carnic Ridge, constitutes a further topographical barrier (Figure 2). West of the Dobbiaco Saddle, the Puster Valley joins the three small and narrow north-south corridors, the Sesto, Landro and Badia Valleys, which led into roadways that reach the most upstream area of the Piave Valley. Despite the fact that this upstream region of the Piave Valley was the most important Italian interior-lateral line inside the central operational zone, its strategic and logistical importance was rather limited compared with that of the Puster Valley. The Piave Valley was narrow, its direction ran from southwest to northeast and there was very little infrastructure. These problems detracted from its potential as a communication corridor and a gathering place for soldiers.

### Large scale

The itineraries which, beginning from Pieve di Cadore, led to the Austro-Hungarian 'sbarramenti' and then to the Puster Valley represented a major logistical challenge. Furthermore, from the tactical point of view, they were very unfavourable for any Italian attack to be conducted through them. First, this was due to the morphology of these valleys, which in some parts were incredibly narrow, making any numerical superiority of an

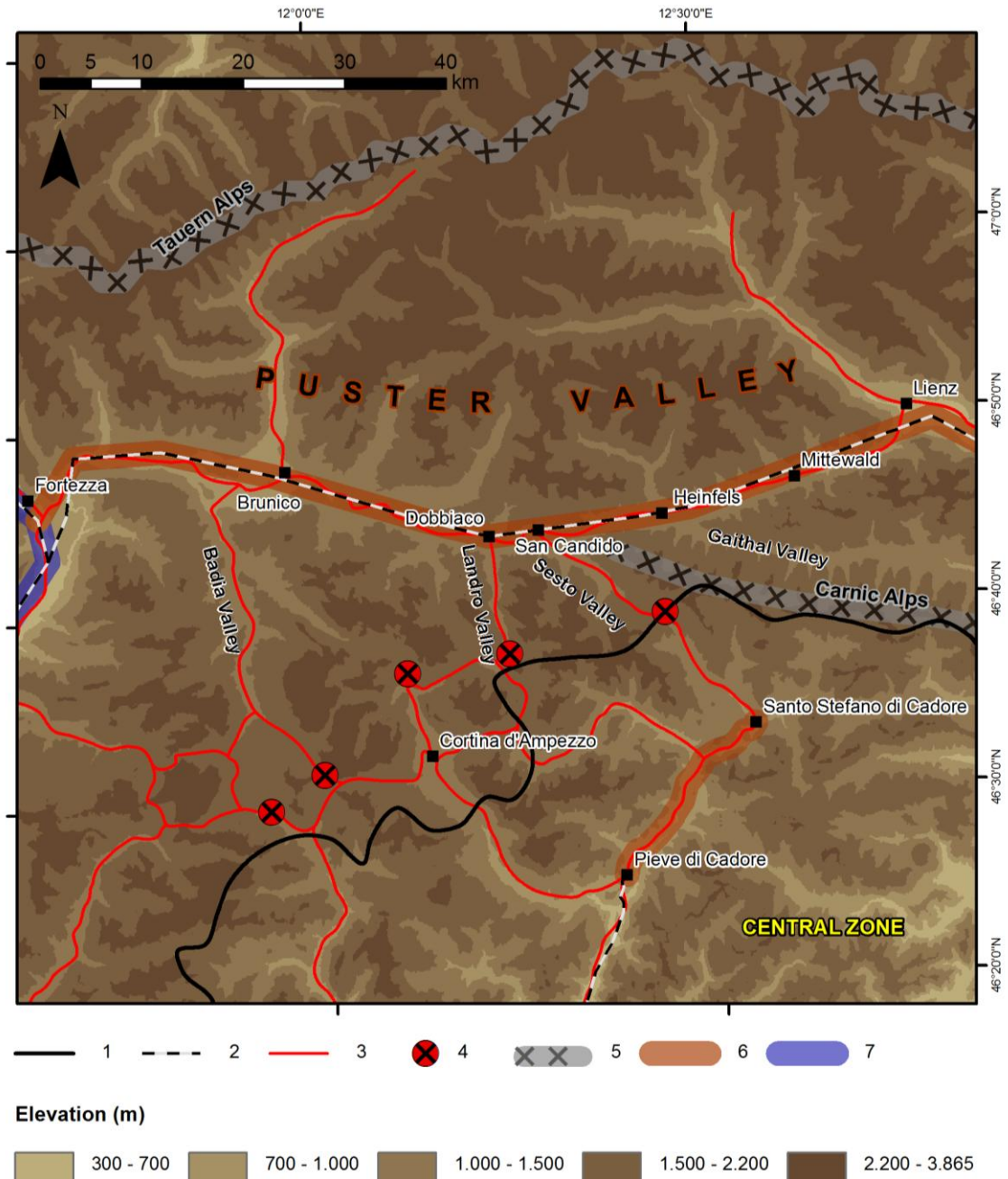
attacking army utterly worthless (Cadorna, 1950). Second, this was due to the presence of the Austro-Hungarian fortification. Last but certainly not least, it can be assumed that the planimetric configuration of these lines of penetration, separated by mountain masses, would prevent any significant tactical cooperation. For instance, a column operating against the Montecroce di Comelico 'sbarramento' would have been completely separated from those attacking the 'sbarramenti' of the Landro and Badia Valleys. Moreover, those attacking the 'sbarramenti' of the Landro and Badia Valleys would have operated with only a slimmest possibility of communication between them (Figure 2).

As for the defenders, each entrance to the Puster Valley was less than 40 km apart, which is the maximum distance along the Puster Valley between the western entrance, Sesto Valley, and the eastern entrance, Badia Valley. Combined with the Puster Valley's solid transport infrastructure, Austro-Hungarian troops would have been able to travel quickly, providing a flexible defence at all the various entrances to the Puster Valley.

However, the Italian Army would have some advantages if it would have reached the Puster Valley. Even though long valleys offered to protract defence at different steps (Porro, 1898), the Puster Valley's general wide cross-section with low sloping sides (Tolomei, 1910) would have afforded the Italian troops an offensive advantage in terms of deployment from a tactical point of view.<sup>9</sup>

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<sup>9</sup> The Puster Valley becomes narrow at just a few points, near its ends at Rio di Pusteria and the narrowing approaching Lienz (Oro, 1911).



**Figure 2** - Topographical map of the northern region of the central front. 1: State border 1866 - 24 May 1915; 2: Main railways before the 24 May 1915; 3: Main roads before the 24 May 1915; 4: Main Austro-Hungarian defences to Val Pusteria; 5: Topographic barrier; 6: Lateral corridor; 7: Trent-Innsbruck line.

#### 4. Logistical considerations of the Cadore offensive

Senior Italian officers during the First World War offered their own judgments about the logistic feasibility of the Cadore offensive, both during and after the war. Gen. Gatti argued that the Austro-Hungarians had far more logistical capabilities for defending Cadore than the Italians had for their attack, implying that Gen. Cadorna’s operational plans overestimated the logistical capacities of the Italian Army. Gen. Gatti’s opinion was based on the fact that

the Italian railway line's transport capacity was such that it would take an entire month to gather the necessary troops for an Army Corp at the Pieve di Cadore terminal station. This was compounded by the length and difficulty of the roads from Pieve di Cadore to the Austro-Hungarian territory (Gatti, 1929).

Gen. Liuzzi, the Logistical Staff Officer of the 4<sup>th</sup> Army, gave a particularly clear assessment of the Italian transportation problem (Liuzzi, 1922, 51), writing in June 1915 that,

If the 4th Army reached Innichen (San Candido) in September, should it operate towards the east or west while continuing to rely upon the railroad of the Piave Valley, with its terminal station in Calalzo (Pieve di Cadore Station), and on the ordinary streets of M. Croce Comelico and Schulerbach for its supplies and evacuations, by late autumn, and perhaps before, it will be inevitably separated from its base and from its Logistical Command that, innocent and pure, will have to declare collapse.

## 5. Results

Our theoretical military geography considerations allow a comparison with the offensive military values that Gen. Cadorna identified for the central zone:

- The Puster Valley had the characteristics to be an important Austro-Hungarian interior-lateral line because of how closely and how long it parallels the state border, its important towns and infrastructure, but most of all, because of its importance for Austro-Hungarian communications. From a local perspective, the Puster Valley guaranteed the flexibility of troop movements along the border. At the level of the theatre of war, it linked South Tyrol, connected with Innsbruck and Germany, with the Julian and the Isonzo fronts, connected with the Serbian theatre of war, and with the heart of the Austrian monarchy;
- this paper's military geography analysis and logistical considerations suggest a significant decrease of the offensive value that Gen. Cadorna ascribed to the central zone of conducting an attack towards the Puster Valley. Despite the proximity to the Puster Valley which Gen. Cadorna highlighted, this offensive value decreased because there was no reliable interior-lateral line inside Italian territory, given the low communication and infrastructure development of the inner Piave Valley. The morphological and planimetric characteristics along the Italian lines of penetration from the Piave to the Puster Valley offered further tactical difficulties;
- with regard to the offensive value of the Puster Valley as a potential line of penetration into Austro-Hungarian territory, the results of our theoretical considerations comply, in part, with Gen. Cadorna's consideration. In particular, the presence of the Tauern in the north would have ensured the flank of the advancing Italian column, and the width of the valley would have allowed possibilities for deployment and manoeuvrability of forces hardly possible in other valleys of the Eastern Alps. However, the considerations examined regarding the logistic aspect considered such a movement westward and eastward along the Puster Valley as inadequate and probably doomed to failure.

## 6. Discussion

Although almost all the authors who wrote about the Italian military operations during the First World War noticed the unfavourable geography where the offensive action occurred, it does not seem that anyone has yet explored this topic in-depth via a systematic study of military geography. Furthermore, many authors analysed and criticized Gen. Cadorna's planning (e.g., operation plan and operational design) without considering his assessment of the different elements at the base (e.g., terrain and logistic infrastructure). From this perspective, we believe this study of theoretical military geography represents an original approach and one of the best departure points to proceed in the study of operational planning, which in turn leads to a better understanding of the historic warfare events in a given territory.

Of course it is important to consider the intrinsic characteristics of any theoretical analysis. Which in the case of military geography, despite limited, because it should just consider those "few principles regarding the generic functions of different geographic elements in war operations" (Porro, 1989), in turn should allow to obtain results with minimum influence from other elements with military influence.

Despite this theoretical advantage, we have to note a difficulty to carry out the methodology proposed, which stemmed from the fact that Gen. Cadorna (Cadorna, 1921) only devoted a "brief mention" to the defensive and offensive values in the text that we identified as his theoretical military geography assessment. Indeed, although Gen. Cadorna very clearly disclosed the main military values that he identified for the zones of operation, an extended presentation of his theoretical military geography assessment would allow a deeper comparison and further conclusions.<sup>10</sup>

Regarding the logistics judgments gathered, we believe that they constitute a great complement to this work's military geographic analysis, helping to clarify the extent of the geographical obstacles and the possibilities to overcome them. This was because logistics history relies on concrete and verifiable foundations, allowing for objective judgments on the feasibility of hypothetical or actual operation plans (Botti, 1991).

## 7. Conclusions

The results of the studies carried out in this paper regarding the offensive values that emerge from Gen. Cadorna's theoretical military geography assessment can be summarized as follows: 1) our theoretical military geography considerations coincide with Gen. Cadorna's belief in the importance of the Puster Valley as an Austro-Hungarian interior-lateral line; and 2) the aptitude of the central zone to conduct an offence aimed to reach the Puster Valley and the potential of the Puster Valley as a line of penetration into the Austro-Hungarian

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<sup>10</sup> Additional geographic considerations from Gen. Cadorna could be gathered from the operation plan and from the assessments that he made for different hypotheses of war, which include numerous considerations on tactics and logistics. However, as previously mentioned, this paper did not consider references beyond those identified as the theoretical assessment.



territory which Gen. Cadorna identified are significantly diminished when compared with our theoretical military geography considerations and with the collected judgements on logistics. Considering these latest differences, we hypothesize that it is possibly that the military geography values that we identified in Cadorna's chapter 'The Operational Design' as being theoretical could have been highly influenced by considerations which do not concern theoretical military geography. For example, they could have been influenced by the strategic issues related to different hypotheses of war, which Cadorna developed in the second part of the chapter (e.g., the impossibility to conduct an offensive stance by the beginning of the war in the Isonzo front).

In addition, the lack of any reference to tactical or logistical issues in this part of the text, where the main military values of the zones of operation were identified, suggest that possibly Gen. Cadorna underestimated the tactical and logistical problems that an offensive from Cadore would have to face.<sup>11</sup> According with this, Rochat (Isnenghi and Rochat, 2008) considered that Cadorna did not fully considered the obstacles determined by geography. Regarding to the Cadore offensive, Rochat (Isnenghi and Rochat, 2008), affirmed that the fact that Cadorna assigned it "shows that he had not yet realized how difficult it was to conduct an offensive, especially in mountainous terrain". And particularly to the logistics difficulties, Gen. Botti stated that logistics is "perhaps the weakest and less realistic side of Cadorna's operational design, hitherto strangely ignored by historical critique" (Botti, 1991).

Overall, the military-geographic approach has allowed us to focus only on analysing physical geographical features, which are often overlooked in military historiographical analysis in favour of other aspects, such as geopolitical, organizational, economic or social issues. The consideration of the physical geography of the study area as a different interpretative key enabled us to achieve valuable and objective considerations regarding Gen. Cadorna's theoretical choices.

## 8. Acknowledgements

This work was funded by the Foundation for University and High Culture in the Province of Belluno and the MIUR ex60% funds (A. Bondesan). The authors thank Margarita Petit for the language revision.

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<sup>11</sup> Is worth to highlight that this lack of any reference to tactical or logistical issues that we mentioned correspond to the part that we identified as the theoretical military geography assessment. But elsewhere (in Cadorna, 1921), Cadorna gives a wholesale theoretical assessment of the tactical conditions of the entire Italian front, and, in other parts, he assesses the logistical and tactical impediments of a hypothetical mass attack on the Trentino salient and of the entrenched camp of Trento.

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## CHAPTER 3

# The Geomorphological Constraints of the Italian/Austro-Hungarian Front in the Dolomites during the First World War

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### Abstract

Despite, almost every text, within the enormous historiography on the First World War in the Italian front, highlighted the importance of geography, specific and systematic studies of the influence of geography on war in the Alps are few. This paper studied the influence of geomorphology on the Cadore offensive. To reach this purpose, a geomorphological and a military history map were made for four of the most important areas in the Dolomites front. In particular, the steep and high valleys' sides, part of the unique geomorphology of the Dolomites, determined unassailable positions from where the defenders, with protected and sometime relatively accessible rear lines, precluded the use of the valley, due to the visual control and the use of crossfire. From that point of view, topography, as the result of the particular morphogenetic processes which took place in the region, can be considered as one of the main geographical aspects that controlled the development and the outcomes of battles in the Dolomites front.

**Keywords:** Military Geosciences, Mountain Warfare, Alpine geomorphology, Dolomites, First World War.

### 1. Introduction

The celebration of the centenary of the First World War (WWI) represents an opportunity for reinterpretation of the military events (Pozzato, 2015), also through interdisciplinary investigations. In this sense the study of the theatre of war, not only through the examination of documentary sources, but also through direct geographical-physical surveys with the use of new technologies, is proving to be an useful and innovative approach for the reconstruction and understanding of the events.

According with General Dellmensingen (Langes, 1981), commander of the Deutsches Alpenkorps until 28 February 1917, mountainous terrains in the wars of the past had represented just areas of passage. The battles in mountainous terrains took place on the

roads that led to the passes and on the peaks which were in the sides of the roads. Only exceptionally military actions in high mountain terrains occurred.

This condition radically changed with the WWI. In particular, with the war fought between Italy and Austria-Hungary from 24 May 1915 to 4 November 1918. At the front of war between those two countries, the two armies clashed along a stalled front that extended in the Eastern Alps from the Swiss border to the Adriatic Sea. It was around 600 km long; just 40 km where below 100 m a.s.l. and 60 where below 600 m a.s.l. Battles occurred along the entire front, from the valley floors and the side of the mountains to the peaks and the glaciers, even over 3000 m a.s.l.

Military geography, as the science that studies the influence of geographical elements on military operations (Porro, 1898), represents a valuable approach to study past military events. Indeed, among the different factors affecting the course of military operations (e.g., logistics, forces, equipment, etc.), the physical environment is of primary importance. On the value of the terrain configuration for an operational plan, General Cadorna (1921) said: "There is an element of paramount importance in determining the operation plan that is constant in any case, which is the terrain, which determines the extent of the obstacle in the case of an offensive war". Among the many physical aspects (e.g., hydrography, meteorology, forestry, etc.) the geomorphological setting can influence the military action from different points of view (e.g., field works, movement of troops and vehicles, defences, deployment, etc.).

Different geomorphological contexts provide different challenges for military activities. From a military perspective, a main morphologic distinction of terrains divides plain from mountains, basing on a fundamental principle of warfare in force during the WWI time: the mass action. The main characteristics that mountain terrain presents are high absolute elevation and high difference of elevation among their different parts. From these attributes stem, in part, another very important factor, that is the harshness that the mountainous terrain forms (Porro, 1898).

The harshness of forms varies widely between different mountainous terrains, and we can confidently affirm that the Dolomites are among the most harshness mountains of Europe. Located in the Italian Eastern Alps and in the central part of the front, the harshness of this famous mountain stems not only by their altitude, but also by the lithology, tectonic and climate. These factors have facilitated the creation of a unique landscape, where "the mountains rise as peaks with intervening ravines, in some places standing isolated but in others forming sweeping panoramas. Some of the rock cliffs here rise more than 1.500 m and are among the highest limestone walls found anywhere in the world". And even more "spectacular vertical forms such as pinnacles, spires and towers, with contrasting horizontal surfaces including ledges, crags and plateaux, all of which rise abruptly above extensive talus deposits and more gentle foothills" (World Heritage Committee, 2009).

Regarding the Italian side, in the Dolomites, was deployed the Italian 4<sup>th</sup> Army, where it had to mount attacks against the Austro-Hungarian defences that would enable it to reach the Puster Valley. The main attacks were launched in the valleys and mountain passes, where it was allowed to concentrate bigger masses of troops.

Therefore, we focussed on four cases of study regarding valleys and mountain passes, with different characteristics in terms of altitude (2,717 m a.s.l.), morphology and Austro-

Hungarian defensive system. Nevertheless, being the studied stretch of the front about 50 km long, we have concentrated our attention on tactics, and not on strategy.

The approach regards an integrated study of military geosciences which consider both the morphologic characteristics and the historical analysis, through the scrutiny of historiographical sources and the integrated analysis by GIS of military historical and geologic-geomorphologic cartography, with particular geographical information processing conducted *ad hoc*.

## **2. Geomorphological settings of the Dolomites**

The Dolomites are a set of mountain ranges in the Eastern Italian Alps. They form a part of the Southern Limestone Alps and extend from the Adige River in the west to the Piave Valley to the east. They belong to the Southern Alps which are one of the most important structural units in the Alpine chain, composed by a complex type of south-vergent fold-thrust belt, bounded on the north by a segment of the Insubric line, known as Puster Line, and to the south by the Neogenic and south-vergent thrust of the Valsugana.

The limestone formations are often detached along the plastic Triassic levels and overthrust with remarkable translations. This allowed the Permian and Triassic sedimentary formations to be exposed by erosion. As regards the tectonics, the direction of the major valleys is determined by the main dislocation lines and cataclastic bands, more sensitive to the erosion processes.

The raising of the Dolomite began during the Eocene, but the real deformation started in the last 15-20 Ma, while the current geomorphology, so extraordinary and typical, famous around the world, is due to the erosion occurred during the last 2 Ma.

On a regional scale and in relation to the morphostructural landforms, the Dolomites have a high degree of geomorphodiversity when compared with other alpine mountains, also according to the morphoclimatic viewpoint (Panizza, 2009).

The history of the Dolomites is a history of changing landscapes that from the Paleozoic volcanoes leads to the tropical Triassic atolls, particularly rich in marine invertebrates, surviving to the present day in the form of fossils. The repeated oscillations of the sea level caused the overlap of processes that were realized both in a submarine and sub-aerial environment; lava flowing from of Ladinian volcanoes have covered vast areas, penetrating from the deep crust or from the mantle through fractures and faults, filling depressions and valleys. Finally, the opposing forces of the Adriatic plate and the Eurasian plate, with deformations, faults, lifts and folds, shaped the high peaks and set the traces of valley furrows, creating a unique landscapes of extraordinary interest, recently also recognized by UNESCO. The rock formations formed in an extremely long period stretching from the Permian to the Ladinian.

The spectacular mountain scenery is the result of the overlapping of several geomorphological processes that over time have shaped the high peaks and the wide valleys. The still active phenomena have changed over time the old scenarios, dismantling the old forms or covering them with new debris formed by the degradation of the slopes.

In the Dolomites the role of the geological structure is particularly effective in the morphogenetic processes that gave rise to the relief. The geological structure includes the tectonics, namely the processes of deformation and fracturing the earth's crust, such as folds and faults, and the lithology, in terms of arrangement of the layers, of fragility of the rocks and of geolithological composition.

The resistance to exogenous agents, responsible for the erosion of the relief, also strongly depends on the composition of the outcropping rocks: dolomites and limestones are more resistant and compact, while conglomerates, sandstones, marl and volcanic rocks has mostly a weakness character. Erosion is thus selectively expressed on the softer rocks. The first group give rough and steep slopes, while the second one tend to form gentler hills.

The differential erosion is also visible on smaller forms, such as for example on the volcanic dikes in the Ladinian limestones of Costabella, responsible for the formation of some forks and saddles that cut the crest.

In the moment of maximum glacier expansion during the last ice age, about 18 ka BP, all the valleys were filled with ice and only the highest peaks emerged from the great ice sheet forming isolated nunatack. The different glacial flows were in connection with each other and flowed over the current main Alpine passes. The subsequent degradation processes obliterated in time the typical glacial morphologies, such as the typical 'U' valleys. The fluvial and slope processes profoundly altered the original morphology, mainly through accumulations of sediment. The glacial deposits along the valley slope, which, albeit discontinuously, are often present on the sides of the great Alpine valleys, marking the position reached by the glaciers, were never deposited since the glacier surface was above the snow limit and consequently inside the accumulation areas.

About 15 ka BP the great retreat of alpine glaciers began, marked by stops and small advancing postglacial stages. Few traces of oldest fluctuation remains, while more frequent are those related to the most recent episodes. In particular, glacial deposits have been preserved at the head of the valleys, cirques and leveled summits.

While the glaciers gradually retreated, running water, supplied by glacial melting, vigorously modeled the valley furrows within they flowed. Sediments heaped the valley floors, flattening valleys sections now crossed by streams fed by meltwater streams, while the rocky steps were carved, forming ravines and narrow gorges. In some places, alluvial fans resting on one of the valley slopes could occupy the entire hollow reaching main places in the opposite side. Alluvial fans generated by affluent valleys were the sites of early human habitation, safely preserved in an elevated position, away from the danger of flooding in the early stages of full river. As was the case elsewhere, fans have also offered little inclined surface, easy to work for agricultural use, being made of loose materials such as gravels, sands and silts. Most of the towns are situated on alluvial fans.

The slope processes are another great post-glacial morphogenetic agent. This term means different phenomena as the run-off, the action of frost and thaw, avalanches and landslides. These processes are responsible for the formation of the fans and scree deposits that extensively cover the foot of the slopes, often with the contribution of recurring collapses and landslides.

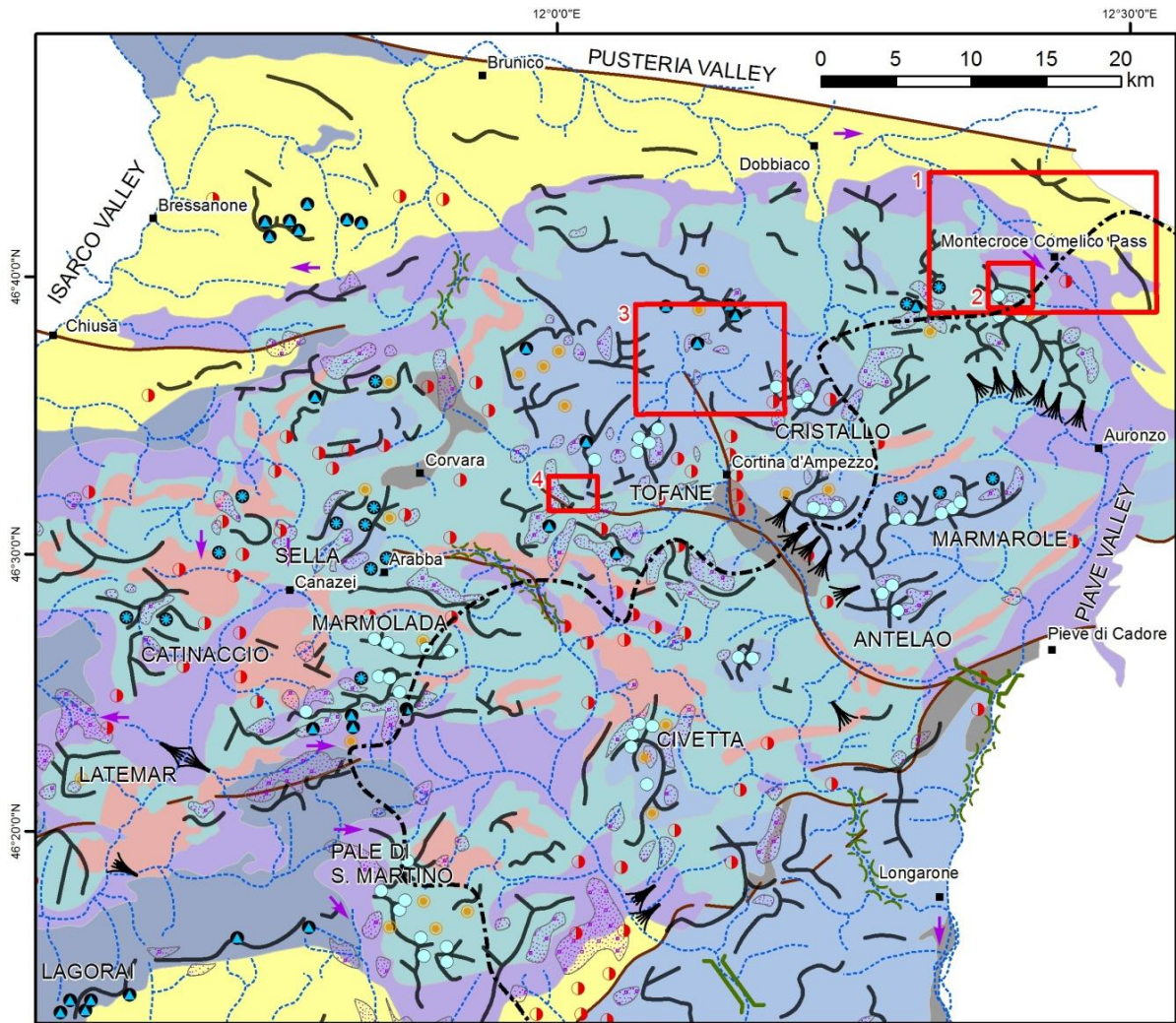
Today the processes of slope degradation are mainly governed by water, frost weathering and the action of gravity that are primarily responsible for shaping the landscape, while the

glaciers have become by now a very rare morphological element with a very limited morphogenetic capacity. The most striking aspects of the recent activities of small glaciers, relegated in higher cirques, materializes in the still well-preserved moraines of the Little Ice Age, a brief phase of climatic cooling that brought advanced of glacial bodies between the beginning of the sixteenth and the mid-nineteenth century.

Until a few years ago many cirque glaciers occupied the higher elevations, less exposed to sunlight and fed by recurring avalanches. Today the conditions for the preservation of glaciers are lacking, being the limit of the permanent snow at higher elevations than the tops of the peaks of the Dolomites. As a result, the glaciers show a marked reduction in volume and appear almost completely covered by a continuous layer of debris. Just the local topographic effects that offers shelter to glacierets, yet allow an ephemeral existence.

Finally, while exerting less of an impact, the karst process deserves to be mentioned, acting on carbonate rocks, dolomite and evaporites (the chalk of the Bellerophon Formation). The karst processes are mostly superficial and occurs in karst canyons, in small sinkholes and karren, that pit the rock surfaces freed from Pleistocene glaciers.





### Legend

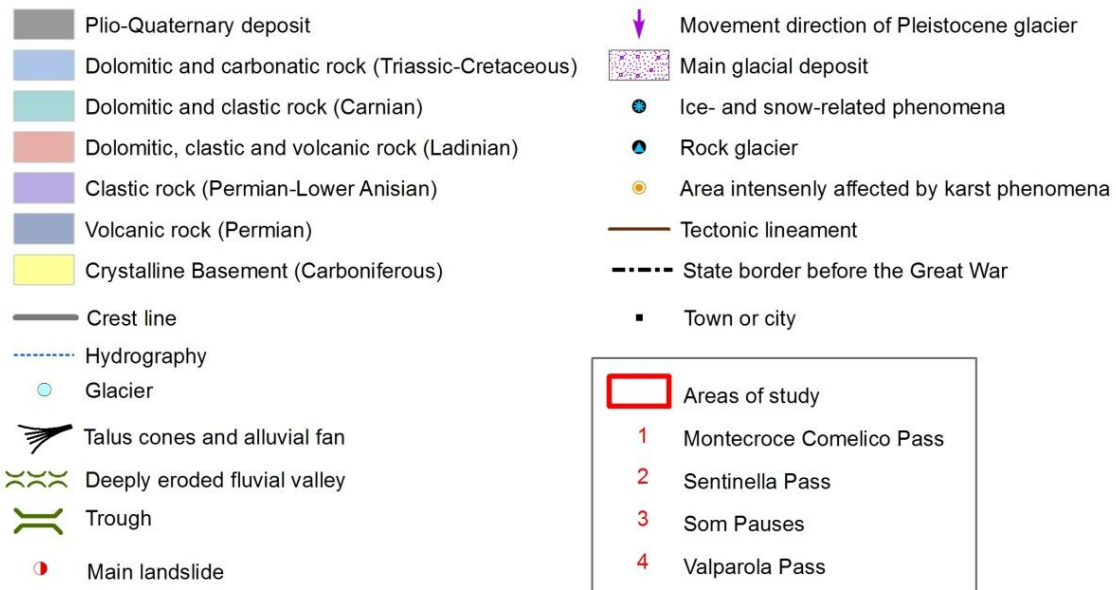


Figure 1 - Geomorphologic schematic map of the Dolomites.

### 3. Historical settings

Italy declared war against Austria-Hungary on 23 May 1915, just about one year after the assassination of Archduke Franz Ferdinand of Austria, joining the Allied forces. The theatre of war between the Italian Kingdom and the Austro-Hungarian Empire was determined by the state border that existed between the two countries since the Treaty of Vienna in 1866. When offences began, large part of the state border became the war front. It mainly extended through the Eastern Alps, from the Swiss border to the Adriatic Sea (fig. 2). The Dolomites were in the central part of that front.

Due to Italy's military alliance, as well as political, economic, and irredentist national interests, the Italian military was forced to take an offensive stance. The operational design of General Cadorna, Chief of Staff of the Royal Italian Army, identified the country's key strategic objectives beyond the Julian Alps and the 'Carso' (the 'Classic Karst' area at the Italian border with modern-day Slovenia). The bulk of Italian forces was therefore deployed in those directions.

Despite this fundamental operational design, on the eve of the entrance to war, after a careful reassessment of the strategic and organizational situation of the two armies, General Cadorna established a defensive stance for the entire front during the army's mobilization. The only exception concerned the Italian 4<sup>th</sup> Army, deployed in the central sector of the war front which includes the Dolomites region. In the document *Variations to the directives of 1<sup>st</sup> September* (IOH, 1927-88, vol. 2 bis) issued on 1<sup>st</sup> April 1915, whose instructions were implemented at the beginning of the war, General Cadorna assigned what would have been the first objective of the 4<sup>th</sup> Army: to reach the Puster Valley. Therefore, the 4<sup>th</sup> Army became the only unit that, from the beginning of the war, had a task beyond the state border of strategic, and not just tactical, importance.

The Austro-Hungarian first operational plans against Italy had to be strictly defensive. From August 1914 the Empire was heavily engaged in the Russian and Serbian fronts. In fact, when Italy declared war, Austria-Hungary was forced to rely for the new Alpine war front mainly upon local militia until other forces could be moved from the other fronts (Lichem, 1995, vol. 3).

In spite of the difficulties faced in the Carpathian and Balkan fronts, from the autumn of 1914, the Austro-Hungarian General Staff carefully started preparations in case of an Italian war front. At the beginning of March 1915 at Bolzano the Command of the 'Pustertal' Division was established. This division, basically composed by two brigades, was deployed from the Passo Pordoi to the zone of Peralba Mount (n. 1 and n. 5 in fig. 2) and was appointed to the defence of the Puster Valley. The *Alpenkorps* contingent, a valuable reinforce to the Austro-Hungarians forces in the Dolomites, arrived from the German Empire two days after the hostilities with Italy started (Berti, 1985).

The Puster Valley represented for the Imperial Army an important interior-lateral line. It was linked in its southern part with three north-south valleys: Badia, Landro and Sesto Valleys (n. 2, n. 3 and 4 in fig.2) in which the Italian invasion, decided by General Cadorna, was forced to pass through. Moreover to the tactical and logistical difficulties that topography and communication infrastructures would represent for the Italian attack, the access to the three north-south valleys was prevented by Austro-Hungarian defence infrastructures. After the Napoleonic wars, many forts were built in several valleys of the Eastern Alps in order to

prevent the transit of armies (Ruffo, 1998). During the WWI, many of the Austro-Hungarian forts inside the main valleys, were further reinforced with field fortifications, garrisoned the first defence line. In the Italian literature the Austro-Hungarian blockade of mountain passes and valleys has been identified with the term 'sbarramento' (pl. 'sbarramenti'. The word has French origin, see D'Ayala, 1841).

Against these 'sbarramenti' the Italian attacks crashed. Three of the fourth case studies in this paper are focused on some of them: the 'Sbarramento' of Montecroce Comelico Pass, that prevented the access to the Sesto Valley, the 'Sbarramento' of Som Pauses, that prevented one of the access to the Landro Valley, and the 'Sbarramento' of Valparola Pass, that prevented one of the access to the Badia Valley.

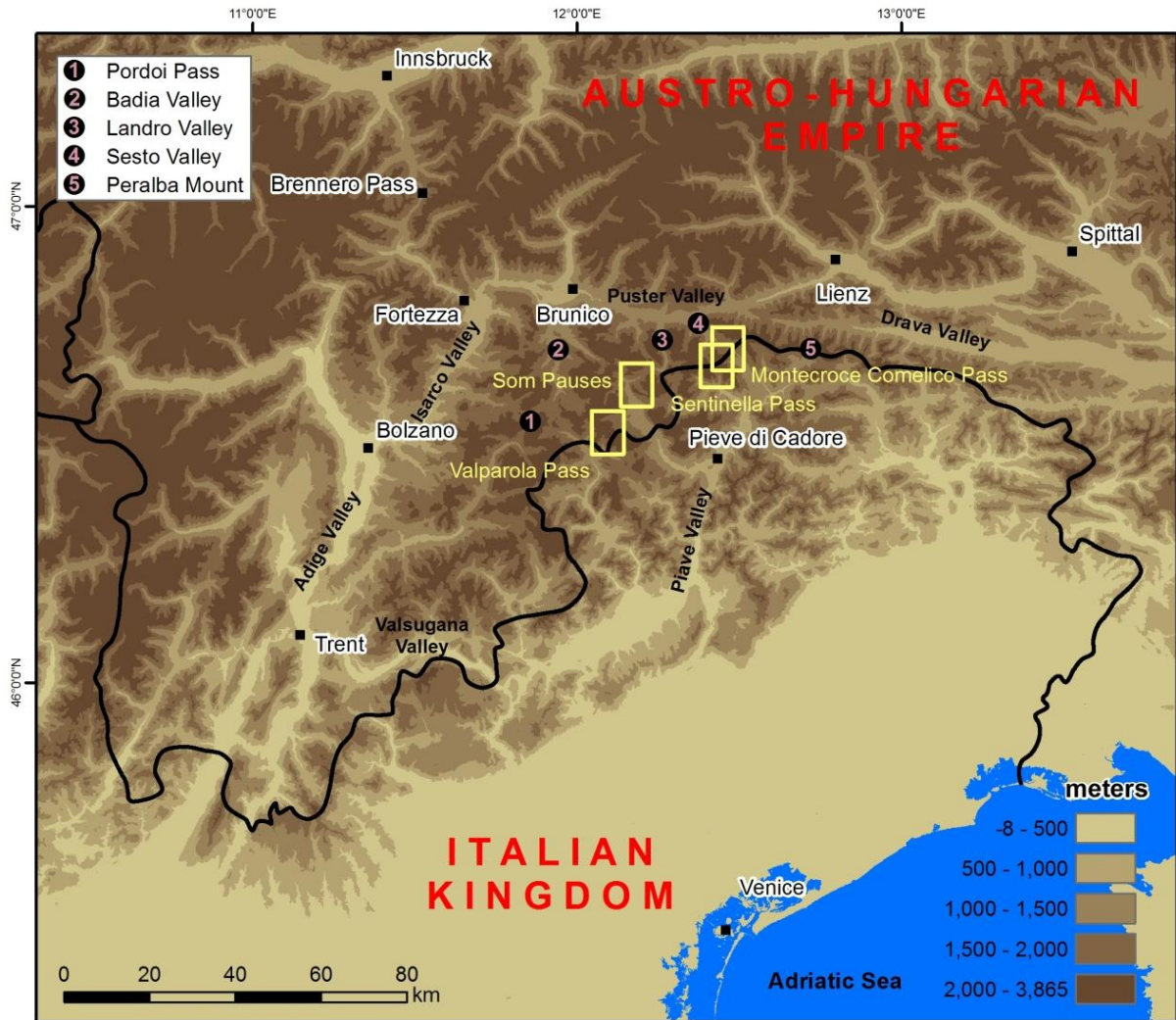
Despite General Cadorna's disposition to reach the Puster Valley in terms of mobilization, once declared war the 4<sup>th</sup> Army was not able to launch important attacks in the Dolomites, thus giving further time to Austro-Hungarians to reinforce their defence positions and move their troops. The first important Italian attack in the Dolomites, aiming to overcome the Austro-Hungarian 'sbarramenti', took place from the second week of June. In some areas, as in the Montecroce Comelico Pass, attacks did not occurred before the first week of August.

As supplies continued flowing to this front, along the summer of 1915, battles grew bloodier. The aim to outflank the 'sbarramenti' bypassing the crests and the necessity of better observation posts to enhance the artillery precision drove war from the valleys to the mountainsides, cliffs, glaciers, and peak summits. Therefore, the Dolomites front became one of the most important instances of mountain warfare in military history. The fourth study case, that regards the Sentinella Pass, concerned this kind of war.

By the beginning of the autumn of 1915, General Cadorna realized that attrition warfare had been clearly established even in the area assigned to the 4<sup>th</sup> Army and no breakthrough was possible in this front. This dashed his hopes of reaching the Puster Valley and induced him to re-direct the 4<sup>th</sup> Army to a mainly defensive strategy, while the offensive action was designated exclusively to the great mass of troops concentrated in the Julian Alps and the Carso.

Notwithstanding both the armies had decided a strategical defence for the Dolomites front, military activities never stopped, even during the extremely cold and snowy winters of 1915-1916 and 1916-1917. Main military actions were however limited to the summer season and usually the main aim was to divert from a main attack somewhere else, in order to fix enemies troops to this secondary front (IOH, 1927-88).

No important changes occurred in the front line of the Dolomites. It remained almost unaltered until October 1917, when the Austro-Hungarians, no longer engaged against the Russians, spread out with German help from the Julian Alps onto the Venetian Plain. This forced a quick and total withdrawal of the majority of the Italian units, including the 4<sup>th</sup> Army from Cadore. The new Italian defence line was placed on the Piave River, thus the Central Empires' forces were no more far than 35 km from Venice. The Piave River front lasted until October 1918 when the last Italian offence started, ending on the 4 November 1918, with the Armistice between Italy and Austria-Hungary.



**Figure 2** - The theatre of war between Italy and Austro-Hungary. The yellow squares indicate the areas of study and the numbers inside the black circles the valleys cited into the main text. The black continuous line indicates the state border before the WWI.

#### 4. Materials and Methods

The research was developed through three main steps: geomorphological study, military history study and military geography study. The main final result was a geomorphologic map and a military history map for every area of study. The scale of the maps for the study of the interest areas fall within the scale of the sketches of military history available in military literature and within the usual scale used for studies of military operations at a tactical level of warfare, from 1:5,000 to 1:100,000 (La Roque, 1953). These scales are suitable to obtain quite detailed geomorphological maps representing the main military features and events.

Some of the studied areas belong to the Alto-Adige, which is an Italian autonomous and bilingual province, and to Austria. For reasons of simplicity, the toponyms in the text and in the maps have, when available, only the Italian name.

#### 4.1 Geomorphologic study

The geomorphologic study was devoted to the analysis of former topographic, geologic and geomorphologic maps (table 1), the interpretation of orthophotos and satellites images and field survey. A GIS project collected all the georeferenced data and different DEMs, processing geographical information and producing different outputs.

<b>Topographic maps</b>			
<b>Name</b>	<b>Scale</b>	<b>Institution</b>	
Carta Topografica d'Italia	1:25,000	Istituto Geografico Militare	
Carta Tecnica regionale	1:10,000	Regione Veneto	
Carta Tecnica regionale	1:10,000	Provincia Autonoma di Bolzano-Alto Adige	
<b>Geologic maps</b>			
<b>Name</b>	<b>Scale</b>	<b>Institution/Author</b>	<b>Year</b>
Carta Geologica d'Italia	1:100,000	Servizio Geologico d'Italia	
Carta Geologica d'Italia	1:50,000	Servizio Geologico d'Italia	
Piano di Assetto del Territorio. Carta litologica	1:10,000	Comune di Cortina d'Ampezzo	
Carta geologico-escursionistica. Parco Naturale Dolomiti di Sesto	1:25,000	Provincia Autonoma di Bolzano-Alto Adige	2004
Carta geologica della Valle del F. Ansiei e dei Gruppi M. Popera-Tre Cime di Lavaredo (Dolomiti orientali)	1:25,000	Università degli Studi di Milano and CNR	1982
Carta geologica. Dolomiti occidentali	1:25,000	Provincia Autonoma di Bolzano-Alto Adige	2007
Geological Schematic Map of the Dolomites. In: Geomorphological features of the Dolomites (Italy)	= =	A. Carton and M. Soldati	1993
<b>Geomorphologic maps</b>			
<b>Name</b>	<b>Scale</b>	<b>Institution/Author</b>	<b>Year</b>
Carta geomorfologica. Piano di Assetto del Territorio	1:10,000	Comune di Cortina d'Ampezzo	
Geomorphological Map of the Surroundings of Cortina d'Ampezzo (Dolomites, Italy)	1:20,000	Università di Modena e Reggio Emilia and CNR	2005
Geomorphological Map of the Alta Badia Valley (Dolomites, Italy)	1:20,000	CE, MIUR, CARG Bolzano, CNR	2009
Saggio di carta geomorfologica dell'Italia nord-orientale	1:1,000,000	CNR – G.B. Castiglioni	1969
Carte geomorfologiche delle fronti dei ghiacciai appartenenti ai gruppi montuosi: Antelao, Civetta, Cristallo, Croda Rossa, Marmarole, Pale di S. Martino, Pelmo, Popera, Sorapiss, Tofane	Different scales	Università di Padova - Thesis' degree of Luigi Cristiana	1990 - 1991
Carta delle morene stadiali della regione dolomitica	1:125,000	Università di Padova and CNR – G.B. Castiglioni	1964
Geomorphological Schematic Map of the Dolomites. In: Geomorphological features of the Dolomites (Italy)	= =	A. Carton and M. Soldati	1993

**Table 1** - Main topographic, geologic and geomorphologic base maps consulted for this study.

As some of the parts of the study areas were not covered by former maps, or the scale of the maps were too small for this study, remote sensing interpretation and field validation has been conducted. The used images includes orthophotos and Google Earth™ imagery. The

used orthophotos have been provided by the Provincia Autonoma di Bolzano-Alto Adige (2011, colour, ground sample distance: 0.5 m) and by the Regione Veneto (2006-2007, colour, ground sample distance: 0.5 m).

A DTM, with cell size of 5 m was used for geomorphological interpretation. It was obtained by rasterisation through kriging of the numeric files provided by the Provincia Autonoma di Bolzano-Alto Adige and the Regione Veneto. Further steps to complete the DTM were: re-sampling, transformation of the geographic coordinate system and merging of the rasters.

The visualization of all the material previously mentioned and the creation of the geomorphologic maps has been performed by ArcGis™ 10.1. The software allowed some spatial elaboration based on the DTM aimed to a better comprehension of the territories' morphology (e.g., hillshade, slope calculation, etc.).

The geomorphologic map of every area of study was developed on the base of a common legend. This legend was structured according to the geomorphologic processes that contain the main geomorphologic forms and deposits present in the Dolomites and bedrock distinguished on a lithological base. Further information regards: main hydrography, settlements and driveways. The base maps were derived from official national and regional cartography (table 1), and from DTMs.



Figure 3 - Legend for the geomorphologic map.

## 4.2 Military History Study

The Military History study regarded the research of military history literature and the creation of a GIS. The main military history literature consulted regarded narration texts which focused on local events. Some of them give accurate descriptions that mainly come from direct experience. For instance, the books of Berti (1985 and 1989) were essential in

this paper for the study of the areas of Montecroce Comelico Pass, Sentinella Pass and Som Pausas. Regarding to the area of Valparola Pass, the main consulted works are those of Pieri (1996) and Viazzi and Mattioli (1997). Another useful monograph that regards the military events that took place in the Sentinella Pass area is that of Zandonella Callegher (2008).

Inside these sources, the original sketches of the military events happened inside the different areas of study were of particularly importance. However, the accuracy of military geographical information, as the direction of the attacks lines or the position of emplacements, was quite variable, depending of the author, the original scale, the symbology, the quality of the base maps used and the purpose of the document.

All military historic information was implemented into a GIS project. On the base of the topographic maps enlisted in table 1, the original sketches of military history were geolocalized. The information of the sketches were digitalized into a vector format, stored into a geodatabase and portrayed in a final map for every area. In order to control and improve the precision of the information of the sketches in historiographic sources, toponyms and geographical reference features extracted from texts were compared and eventually introduced into the final maps. Furthermore, in the case of the defensive lines, their position, when still preserved today, were controlled by the interpretation of the orthophotos and Google Earth™ imagery.

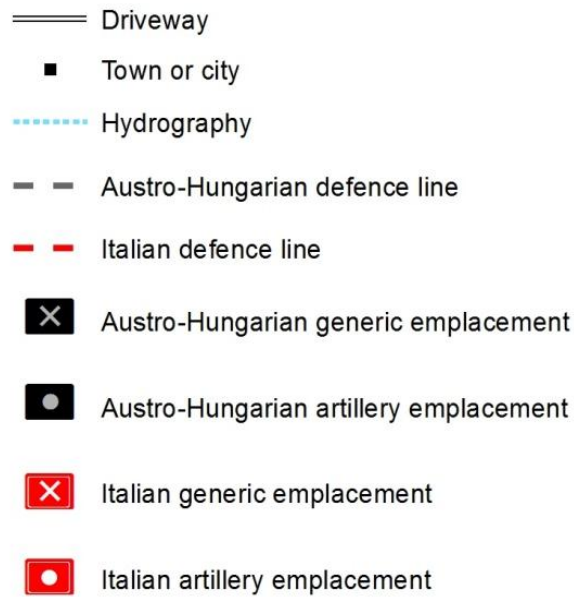
Further integrated analysis between historic and geographical data were supported by specific GIS tools for Spatial Analysis on the DTM, as Viewshed Analysis and topographic profile tracing. The GIS also allowed the creation of a geodatabase with military history information. The database contains for every feature the following records:

- area of study which the feature concerns;
- localization: toponyms or topographical information found inside the literature that are related to the feature;
- exact position: if the localization of the feature has been validated with the remote sensing sources or not;
- information: detailed information of the feature (i.e. units involved, temporal information, military and historic importance and type of emplacement);
- bibliographical source: where the information about the feature has been found.

The final military history maps show the main positions of the units in the field and the main military events. The maps contain a simplified topography, consisting in: contour maps from DTM processing, main river course, roads and main toponyms.

A common legend for all the military history maps was developed. This legend contains simplified information regarding the above mentioned geodatabase. In particular, the feature 'defence line' represents the outer line of defence positions (which corresponds to the 'line of contact' for an attacking enemy). Thus, it refers to field works as trenches, lines of barbed wire, Chevaux-de-Frise, etc. While the term 'general emplacement' includes: observatories, fire emplacements, recovery emplacements, shelter emplacements and huts in the rear lines. Furthermore, every single map contains specific symbols which are indicated inside each map-frame (e.g., lines of attack that correspond to the main fights).





**Figure 4** - Legend for the military history map.

## 5. The Italian/Austro-Hungarian front

### 5.1 Montecroce Comelico Pass

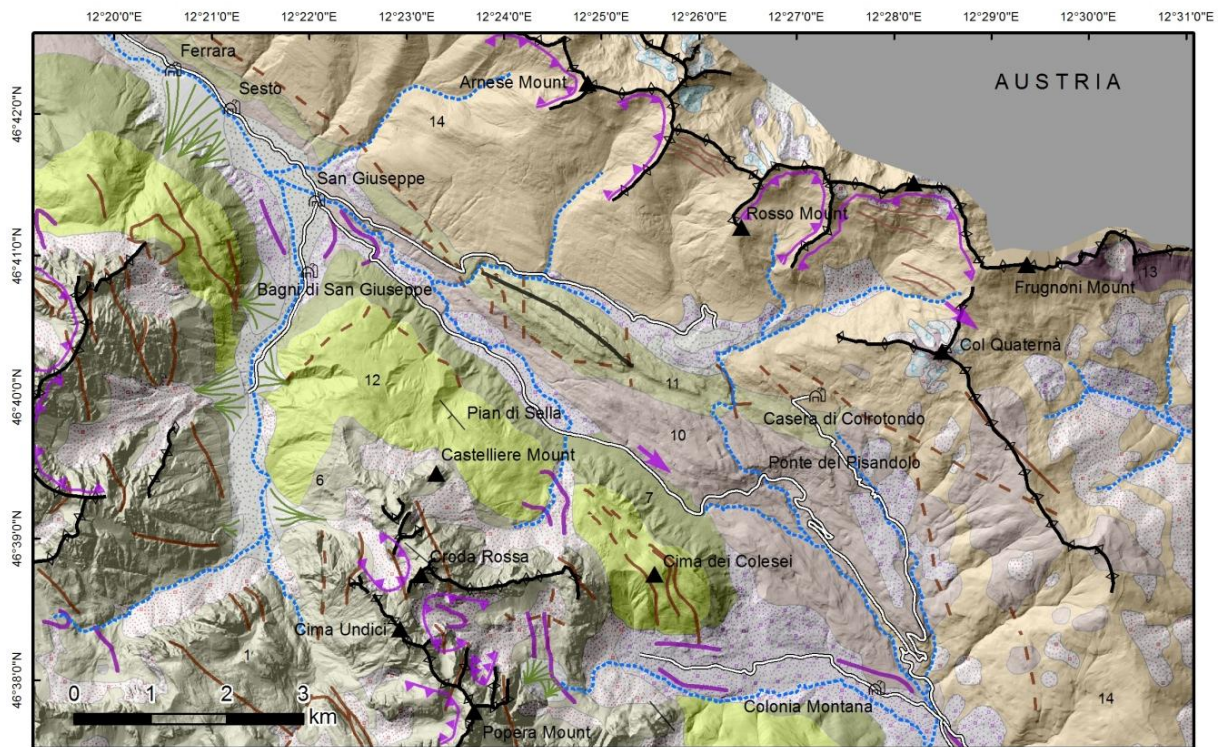
#### 5.1.1 Geomorphologic description

The Montecroce Comelico Pass is one of the probably the wider passes of the Dolomites, where two wide glacial valley encounter. The valley slopes are asymmetric with a well-defined metamorphic ridge on the eastern sectors, along the current border with Austria. Deeply carved glacial cirques formed on the eastern valley side generating spurs, perpendicularly oriented to the Sesto Valley. A central ridge, Mount Covolo, has been shaped by glacial erosion and allows to dominate, albeit not having an high elevation, the surrounding terrain.

The dolomitic and limestone summits, outcropping on the western side, form jagged slopes and peaks: the main heights are Popera Mount, Cima Undici and Croda Rossa, where the glacial erosion formed coalescent wide cirques. The buttresses of Cima Colesei and Castelliere Mount form the lower ramparts facing to the Sesto Valley thalweg.

Extensive glacial deposits are located on the Popera Valley. On the eastern side, some rock glaciers are the clearest testimony of a periglacial environment. The main watershed divide separates in two the head of the Sesto and Padola Valleys with the formation of an embryonic dendritic drainage network.

The evolution of the main valleys is due to erosive processes controlled by a coincident tectonic line.



**Figure 5** - Montecroce Comelico Pass geomorphologic map.

### 5.1.2 Military events

Among the possible ways to reach Puster Valley, the Montecroce Comelico Pass represented one of the best ones, because of its proximity to the Puster Valley itself, and mainly because of its width. When Italy declared war to the Empire, this latter decided to defend the pass standing almost on the old state boundary. This defence line was called in the Italian literature the Sesto 'sbarramento'.

During the firsts months of war the Italian 10<sup>th</sup> Division, which was deployed in this area, did not conducted important attacks, thus permitted the Imperial 56<sup>th</sup> Mountain Brigade not only to reinforce their defence position but also to conquest, at the beginnings of June, all the Carnic Crest in this sector. The Austro-Hungarian defence line remained until the end as follows: Castelliere Mount, Piano Sella, road at Montecroce Comelico Pass, Covolo Mount, Pullbach, Rosso Mount, Demut, Schöntalhöhe, Ferro Mount and Frugnoni.

Two major attacks were made in this zone by the Italians. The first one, on 4 August 1915, was preceded by four days of bombardment. The main targets were the Castelliere Mount, the Covolo Mount and the Rosso Mount, but in the meantime three diversionary attacks were conducted: against the Ferro Mount, from the Col Quaternà against the Frugnoni and in Val Fiscalina (out of this study area). This blooded effort permitted the Italians to draw forward their first defence line, in particular to the south side of the Covolo Mount and to the north of the Rio Bianco, at east of the Castelliere Mount.

The second attack was conducted by 33 Italian companies against 19 Austro-Hungarian and Bavarian companies on the 6 September. The attacks were developed mainly against the

Castelliere Mount-Covolo Mount sector and from the Valorea Crest to the Rosso Mount-Vanscuro sector. During the attacks, in some parts, the Italians could conquest some positions but they could not hold for long time, in others parts they neither could break the barbed wire. The slope was a slaughter factor for the Italian infantry, that counted over 600 death. Austro-Hungarians counted only six death. After these attacks there were no other relevant military actions in this sector, until Caporetto withdrawal.

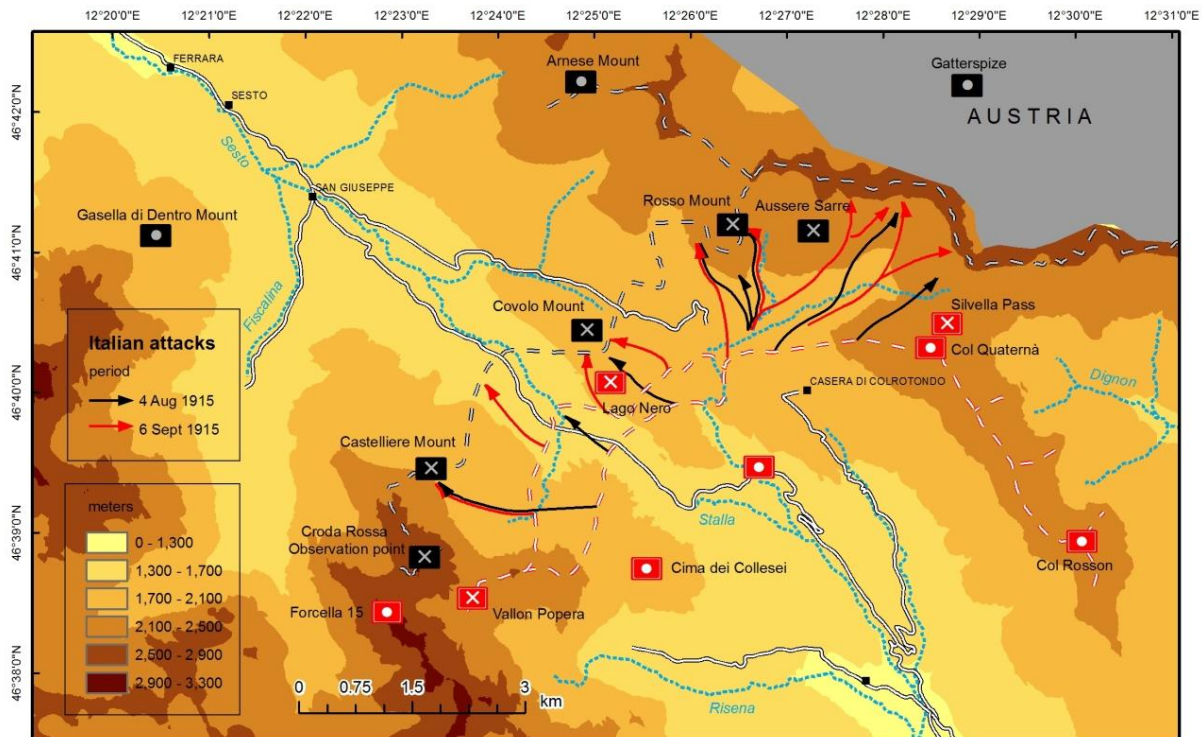


Figure 6 - Montecroce Comelico Pass military history map.

### 5.1.3 Comments about the relation between geomorphology and military events

At the beginning of the war the front stabilized along the administrative border, which was following the watershed line. The two belligerents deployed along the crests on the valley sides and over the spurs transversal to the main valley slopes.

The troops dug trenches on the ridge lines, served by connecting trails on the back, partially protected by the shooting of the Italians.

On the valley floor the Italian line of defence developed from Vallon Popera to Col Quaternà and Col Rosson, occupying the top of ridges whenever possible.

The Austrian line was organized on the ridges of the eastern foothills over two crossing spurs overlooking the Rio Cor and the Klammbach. The line crossed to the Covolo Mount gaining a dominant position on which both the Italian attacks were concentrated, while on the western side it joined the Castelliere Mount.

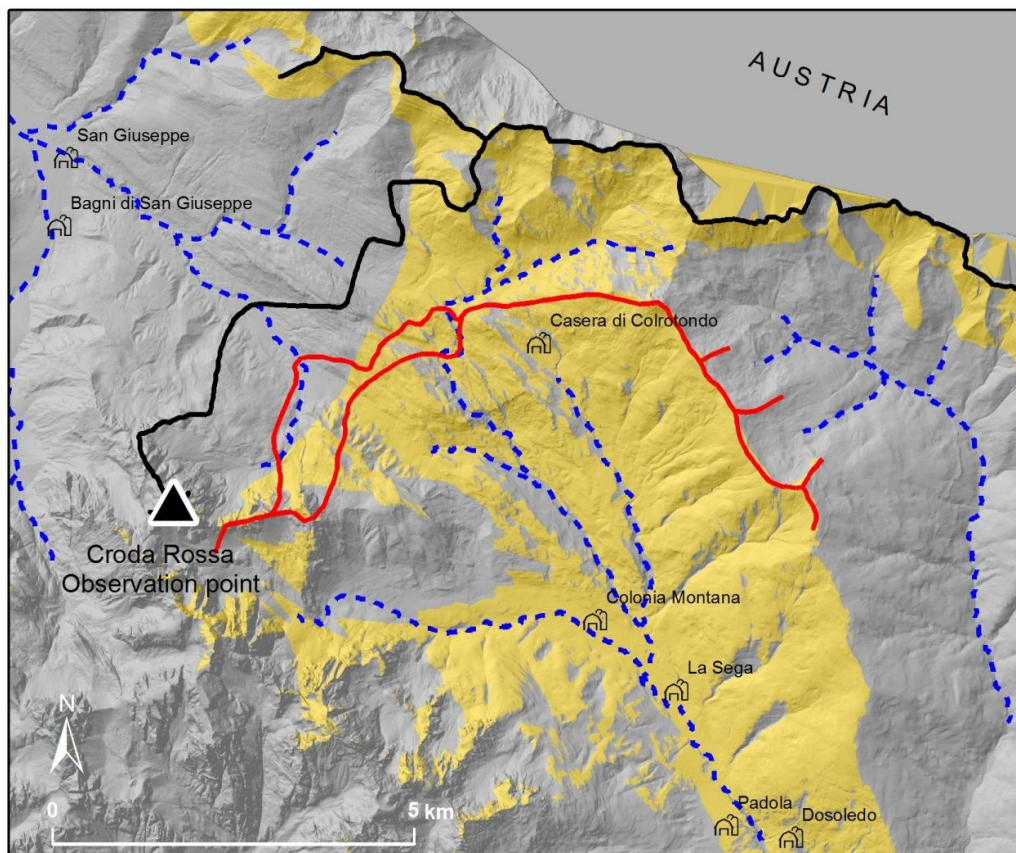
Holding the summit points were particularly important, since they were used by both contenders as observatories of fundamental tactical employment. The Italians took possession of Forcella 15, which ensured the direction of artillery up in the Puster Valley, 12 km far from the front. The Austrians occupied the crest of the Croda Rossa and established there an observatory overlooking a large part of the Italian front, including the rear-lines of the upper Padola Valley (Fig. 7).

The differences of the lithological nature of the two valley flanks allowed easier movements in the eastern sector where metamorphic rocks outcrops, while the indented morphology of the dolomitic summits of Croda Rossa - Popera Mount made the movements of troops more difficult. The domain of the main summits by both armies allowed an easy defence against enemy attacks under conditions of clear visibility, mainly uphill, and in the open field (only a few small hollows allowed Italians to have a temporary shelter during attacks).

Italian attacks were concentrated in the dominant points (Rosso Mount, Covolo Mount and Castelliere Mount), where the approach and the deployment of forces on a broader front was easier.

In particular, as it is apparent from fig. 7, in which the viewshed from the Observation Point is represented, the dominance of Croda Rossa by Austrian was particularly important because it allowed almost the complete control of the Italian lines.

It can therefore be concluded that the dominance of summits and valley sides have been the key to success for the Austrian defence.



**Figure 7** - Viewshed from the Observation point at Croda Rossa.

## 5.2 Sentinella Pass

### 5.2.1 Geomorphologic description

It is a typical dolomitic formation with steep sides and mountain peaks bordered at the base by slope and glacial deposits. The genesis of the forms is strongly related to tectonic and glacial action with the formation of a set of coalescing cirques that isolate horn and arête. The two main cirques form two elongated valleys: the Vallone della Sentinella in Austro-Hungarian territory and the Vallone Popera in Italian territory.

The tectonic lines are mainly oriented in NNW-SSE direction, controlling the formation of the main valley gorges, cliffs and orographic depressions. The ridge lines are strongly displaced by fractures that, together with the periglacial phenomena, generate an uneven morphology with forks and saddles (especially in Zsigmondy Crest).

Some glaciers facing north and west are still active, although strong withdrawal, and generate well formed morainic arcs.

At the lowest points, at the Montecroce Comelico Pass, some small alluvial fans are present, collecting water from the largest streamcuttings.

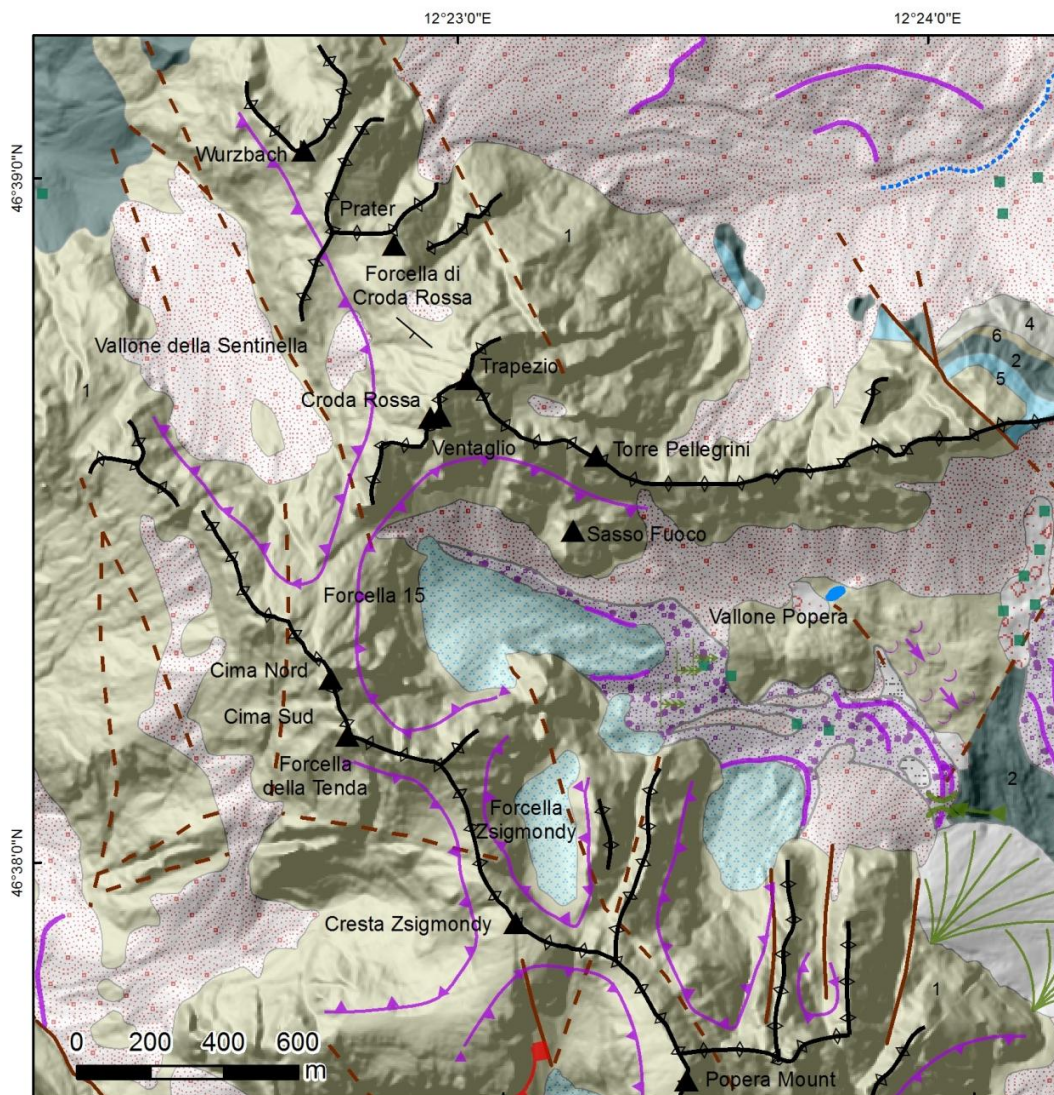


Figure 8 - Sentinella Pass geomorphologic map.

### 5.2.2 *Military events*

Before the war started the boundary between the two countries was along the ridge of Croda Sora i Colesei and southern to Croda Rossa, then it turned southward along the Sentinella Pass and continued along the crest line of Cima Undici - Zsigmondy Crest - Popera Mount- Giralba Mount. From Giralba Mount the boundary turned westward along the Forcella Giralba.

During the first month of war the Austro-Hungarian 56<sup>th</sup> Mountain Brigade occupied the Croda Rossa and the Sentinella Pass. The Italian 10<sup>th</sup> Division took possession of the Popera Mount and the Zsigmondy Crest. On the Popera Mount the Italians raised two 65 mm gun, one of them was settled at 3000 m elevation high (known as “the cannon that shoots from the stars”) that was directed against the Austro-Hungarian observation point in Croda Rossa.

The importance of the Sentinella Pass is well evidenced by Antonio Berti (1985) who declared that it “is a window that watch, by one side to half of Padola Valley, and by the other side almost half part of the Sesto Valley”.

The first relevant military event in this sector is the Italian attack against the pass on the 7 August 1915. Italians mounted a frontal attack coming from Vallone Popera, preceded by and artillery bombardment (mainly by the three cannons on the Creston Popera). The frontal attack was to be supported by a contemporary encirclement through the right side of the pass, from the Pianoro del Dito, and through the left side from Cima Undici. Due to the bad organization and the lack in communication, the surrounding by the left side failed.

During the attack some platoons took possession of Sasso Fuoco, which resulted important because it allowed to shoot from distance, and of some small saddles in Croda Sora i Colesei, in order to protect the main attacking column that was climbing up. When the column arrived around 150 m from the pass they hid behind the rocks of Il Dito, while some of them climbed the Pianoro del Dito. From Pianoro del Dito it was possible only to shoot the Austro-Hungarian reinforcements that was coming from Alpe Anderta, but not to descend to the pass as they had planned due to the steep cliffs. The main column attack was then cancelled due to the presence of two Austro-Hungarian machine guns placed at the Sentinella Pass, which prevented the advance.

On 14 August 1915 and 2 September 1915 the Italians accomplished two similar actions, that were aborted again in the final part of the Italian advance.

The third Italian attack started on 14 April 1916, and followed the same plan of attack, with two important differences from the former ones, that permitted to conquer the pass. The first difference was the surprise factor: an attack on April could not be suspected by the defenders and due to the amount of snow and ice covering Vallon Popera the column going up could not be heard by the defenders (as it had happened before). The second was the occupation of several positions on the Cima Undici massif, which allowed to keep under fire the defenders entrenched on the pass and the descent of some Italians, which were able to take some defensive position on the pass by the back.

The occupation of the positions on Cima Undici was possible by a difficult movement of supplies and troops, hidden from the enemy, along the crests from Zsigmondy Crest during the winter of 1916.

After the conquest of the pass, the Italians failed several attacks against the Austro-Hungarian positions on Croda Rossa, mounted from the south side of the massif.

The Italian occupation of the pass obligated the Austro-Hungarians to change the transport route to the positions on Croda Rossa.

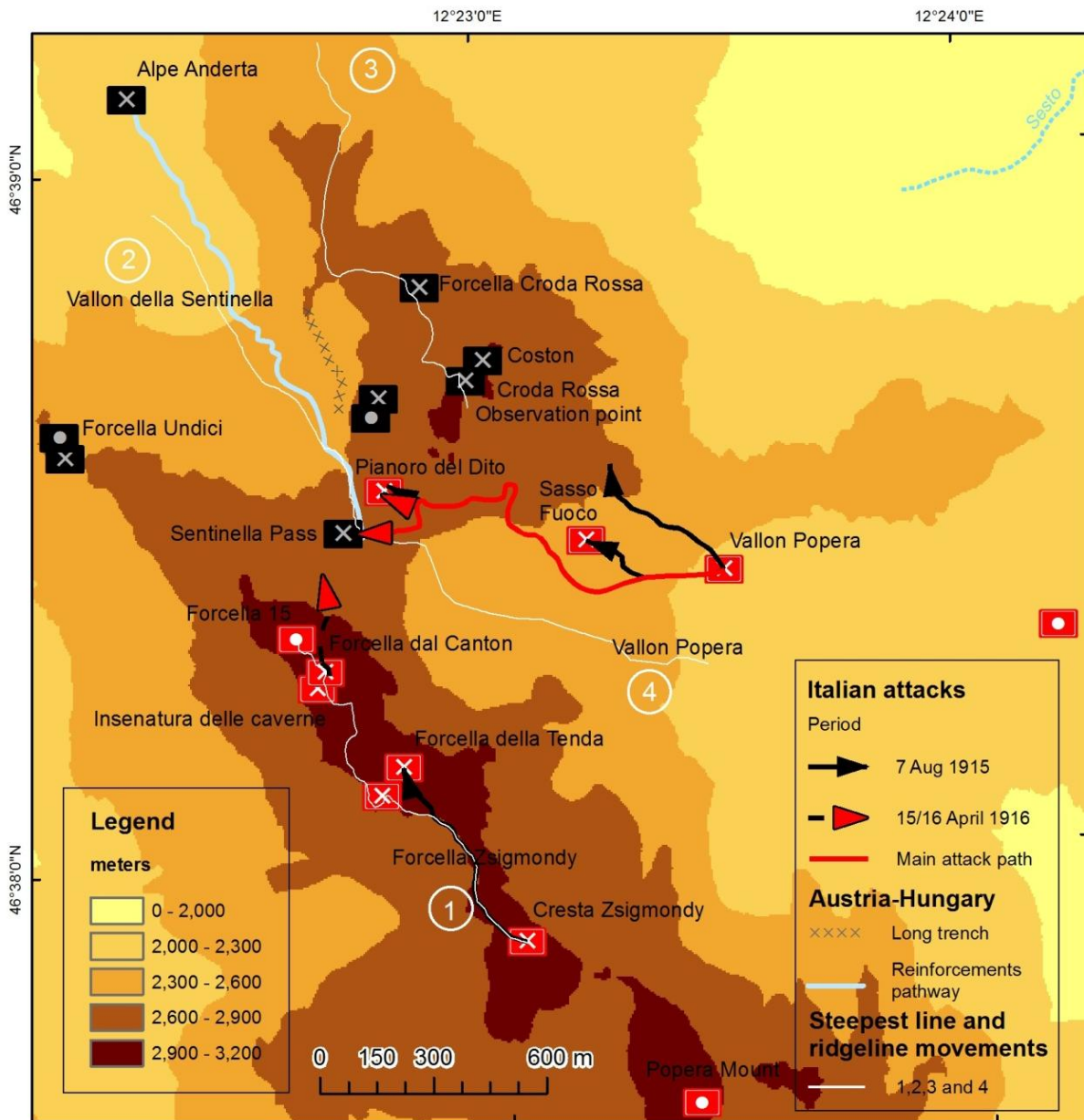


Figure 9 - Sentinella Pass military history map.

### 5.2.3 Comments about the relation between geomorphology and military events

The conquest of the group Croda Rossa - Cima Undici - Popera Mount is fundamental to dominate the Montecroce Comelico Pass and to have the possibility to bypass the pass to the north, towards the Val Fiscalina. The pass, between Cima Undici and Croda Rossa, is the hinge point of the Italian/Austro-Hungarian front. Both sides, for this reason, tried to conquer the pass and the ridges nearby.

The movement for the troops is protected along the summits, which were quickly occupied from the beginning of the war. The valley floor are trafficable only if the enemy does not occupy a dominant position, which is why the Italians did not transit through the valley bottom of the Popera Mount (the Austro-Hungarians were occupying the Sentinella Pass), while Austro-Hungarian troops used to climb the northern part of the Vallon della Sentinella, hidden from the Italian observation.

The next attack in April 1916 developed along the crest of Cresta Zgimondy – Cima Undici, from which, once obtained the dominant position on the pass, the Italians defended the main attack that took place on the left side of the Vallon Popera, unseen from the Sentinella Pass. The conquest of the Sentinella Pass by the Italians determined the dominance on Austrian supply lines, no more sheltered, who had to move on the ridge to the east. Supplies thus become more difficult for the Austro-Hungarian. During the attack, the Italian troops quickly climb to altitude, and then they move approximately horizontally at the same height of the Sentinella Pass (fig. 10).

The different attacks later carried out by the Italians on the Croda Rossa failed because of the steep slopes, the cragged morphology and the presence of highly precipitous narrow ravines in the rock, hardly passable and easily defended by the Austrians.

The front will remain stable in these positions for the rest of the war, until the withdrawal of Caporetto.

The attack of the Italians to the summit was conducted moving on the upper part of the talus slope, where the transit was easier for the finer particle size of deposits and thanks to the defiladed position out of the Austrian view (Fig. 10). The following table compares the average slopes of the paths to reach the highest summits:

Italian mains attacks pathway	32%
Austro-Hungarian reinforcement pathway	42%
Steepest line in Vallon della Sentinella	58%
Steepest line in Vallon Popera	44%

**Table 2** - Mean slopes.



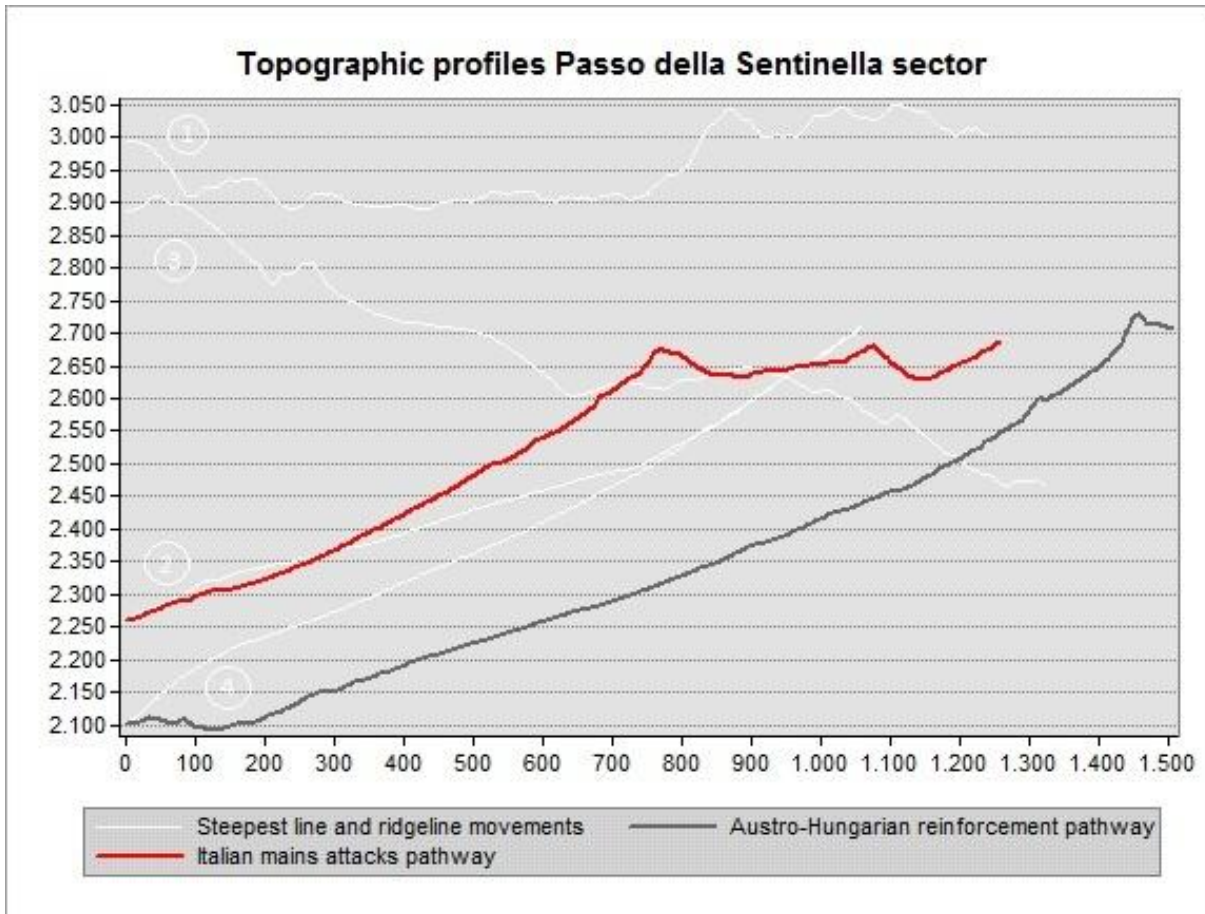


Figure 10 - Topographic profiles for the Sentinella Pass area.

### 5.3 Som Pauses

#### 5.3.1 Geomorphologic description

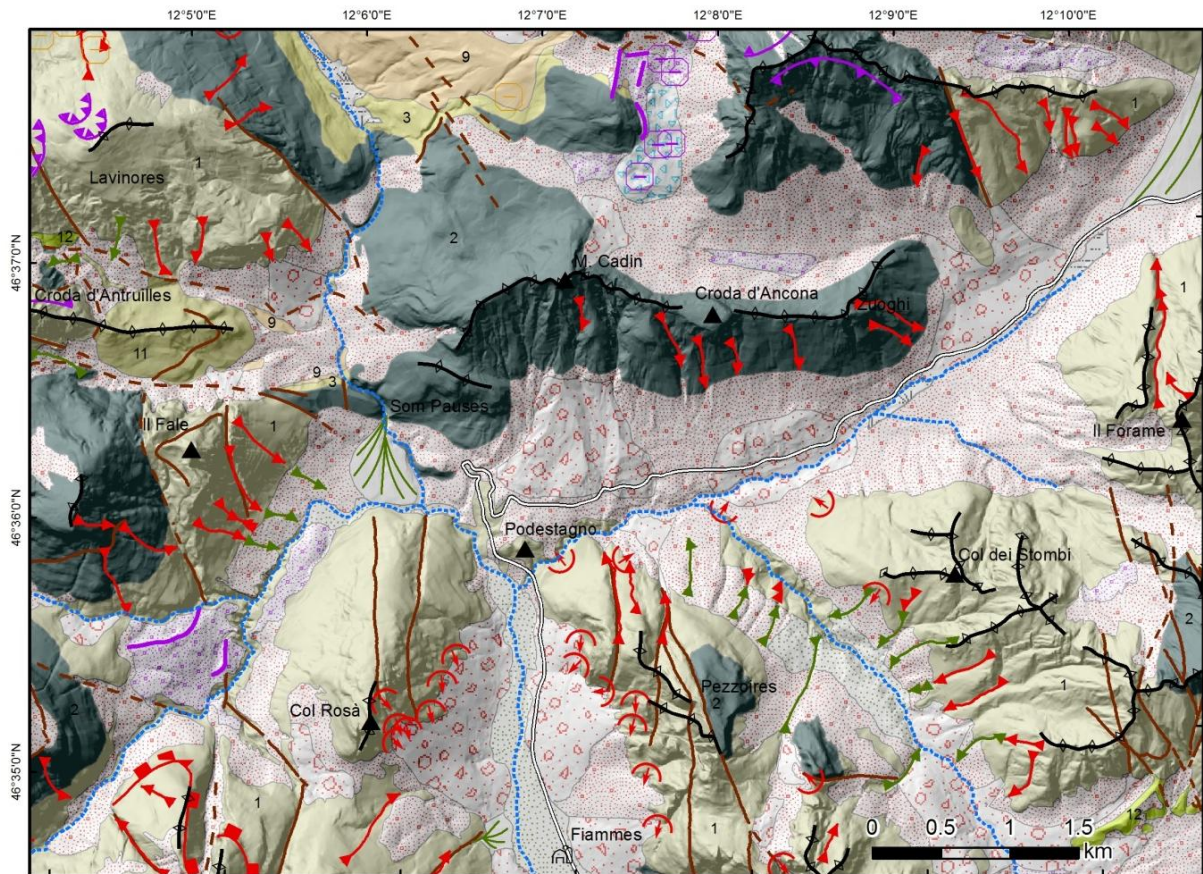
The main crest lines of the southern quadrants converge on the area of Podestagno - Pian di Loa, while in the northern quadrant a preferential alignment of rocky ridges in east-west direction is observed. In the southerly direction of the ridges, as well as the valley furrows, they are closely controlled by the tectonic whose preferential directions are NS and NNW-SSE.

The valleys follow the crest lines directions and converge towards the star node of Podestagno – Pian di Loa from which branches off the Boite Valley that comes out from the node with a meridian direction. The valleys are mostly narrow, with bedrock outcropping at their floor, except for the Boite Valley which has a wider bottom filled with abundant alluvial deposits.

The vergence of the layer is to the north, forming a typical monocline. The layers inclination is about 10-20 degrees with a structural control on the Col Rosà, on the Tofane (outside the study area) and in small Pomagagnon areas. The structure is part of the great syncline of Altopiani Ampezzani which has its core just north of the study area.

The rock slopes are mostly steep and strongly dissected depending on the lithologies that constitute the bedrock, mainly dolomites and limestones belonging to of the Upper Triassic and the Early Jurassic. When covered by slope debris, the morphologies are more regular, with typical angles of the most abundant size classes. The foot of the summits are covered with slope deposits that reach the valley floor, often with considerable thickness. The debris is predominantly gravitational, forming talus and landslide bodies, and only in limited areas morainic (stadial deposits of the Val Travenanzes and small morainic ridges at the foot of the Croda Rossa d'Ampezzo).

Morphogenesis occurs through the denudation of the slopes (both gravitational phenomena and stream incision) and the fluvial erosion of valley floors. Downstream of the hydraulic junction of Podestagno a number of active debris flow are active both in the right and in the left slope, determining the etching of deep canyons at higher elevation and associated accumulations that often reach the valley floor.



**Figure 11** - Som Pauses geomorphologic map.

### 5.3.2 Military events

On 20 May 1915 the Imperial forces left Cortina d'Ampezzo and organized their defensive line in Som Pauses. This barrage, mainly, prevented the Italian use of the road connecting Cortina d'Ampezzo to Carbonin, and was garrisoned by the 51<sup>st</sup> Mountain Brigade. Cortina d'Ampezzo was occupied by the Italian forces nine days after the Austro-Hungarian retreat.

From 7 to 15 August took place the first Italian attack mounted by the 2<sup>nd</sup> Division: 3 columns, supported mainly by the bombardment of the artilleries placed north of Cortina d'Ampezzo.

The left column occupied Ponte Alto, interrupting the direct connection between the Austro-Hungarians positions in Fanes Valley and those at Som Pausas. The center column took the Austro-Hungarian position of Podestagno but then was stopped by the defence position of Som Pausas, leaving many deaths on the field. The right column was directed against Forcella Lerosa, in order to encircle the positions of Som Pausas, but it was also stopped by the enemy entrenchments placed on the highest parts of the valley.

The failure of this operation was a consequence of: an insufficient artillery support, indispensable to break the excellent Austro-Hungarian defence system, the insufficient amount of troops, and the extremely unfavourable topography. Nevertheless, these attacks allowed the Italians to move forward their first defence line, thus consolidating their presence in Cortina d'Ampezzo.

During the autumn of 1916 there were other military actions in this sector, mainly under the Italian initiative, which increase the number of death without giving any relevant result.

The second important event in this sector is the Italian attack between 7 and 27 June, to which four infantry regiments and two battalions of 'Alpini' (Italian alpine units) participated. One column marched along the Felizon Valley, while the other climbed up the slopes of the Croda dell'Ancona and attacked the positions of Selletta di Som Pausas, I Ciadis, Croda dell'Ancona and the Zuoghe. Even if during the attacks, the Italians obtained some temporary successes, on the 10<sup>th</sup> day of the battle they had to withdraw to the former positions with the toll of 324 death, 2826 injured and 85 missing. No other relevant military event was registered in this sector until the Italian withdrawal after the Caporetto defeat.

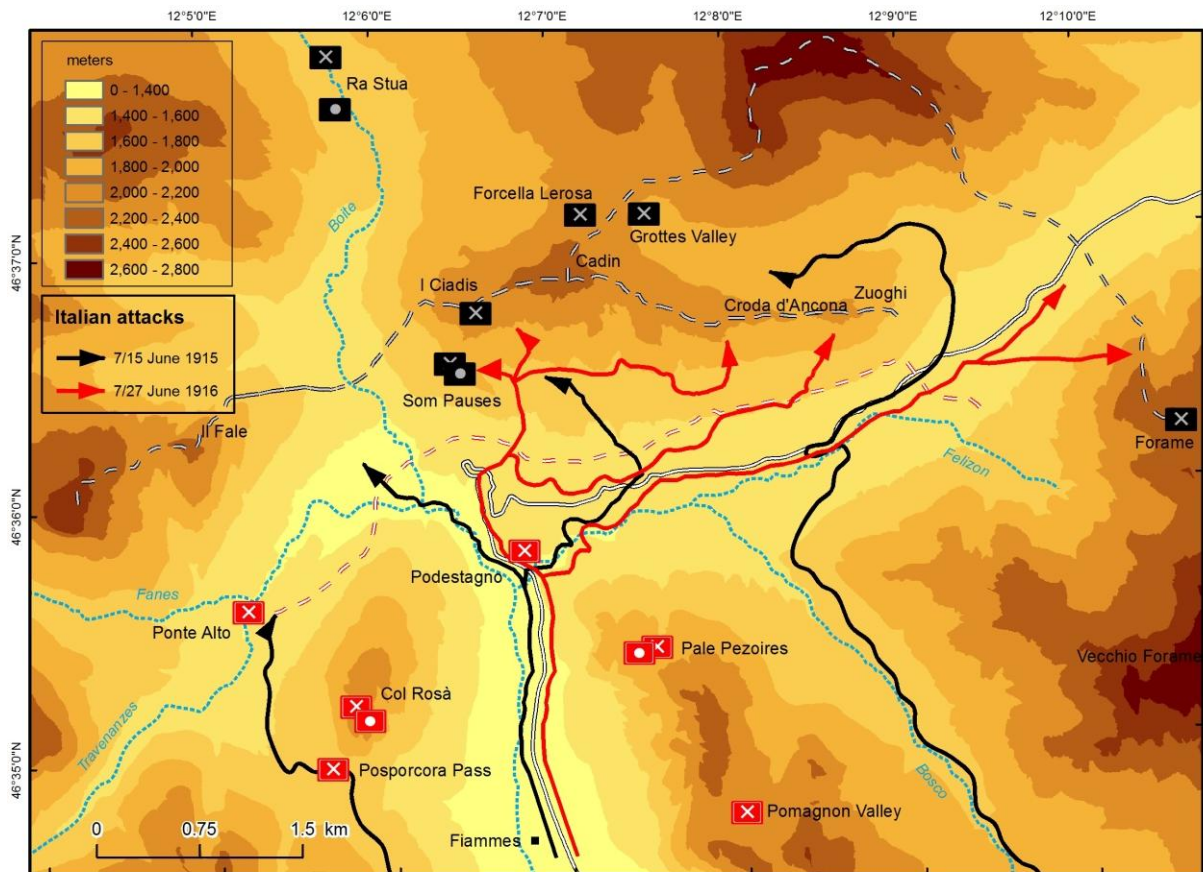


Figure 12 - Som Pauses military history map.

### 5.3.3 Comments about the relation between geomorphology and military events

The morphology of this area seriously affected the tactics of the Austro-Hungarian army, They tried to take advantage of summits and narrow valleys, occupying the Val Travenanzes - Som Pauses - Croda dell'Ancona

The ridge of Som Pauses is probably a tectonic-gravitational lowered block and forms a rampart from which the underlying narrow valley is easily controlled (even with individual weapons) blocking the access to the area of Ra Stua and the upper Valley of Rio Felizon .

Croda dell'Ancona, adjacent to Som Pauses, albeit less incumbent on the valley floor, forms a very elongated defensive barrier that follow the crests of Taè and Taburlo Mounts to the west. The gradient of the slopes is such that a frontal attack was hardly successful. Indeed, the Italians failed both in 1915 and in 1916; the Austro-Hungarian, garrisoning the mountain summits, prevented the circumvention attempted to Forcella Lerosa in 1916.

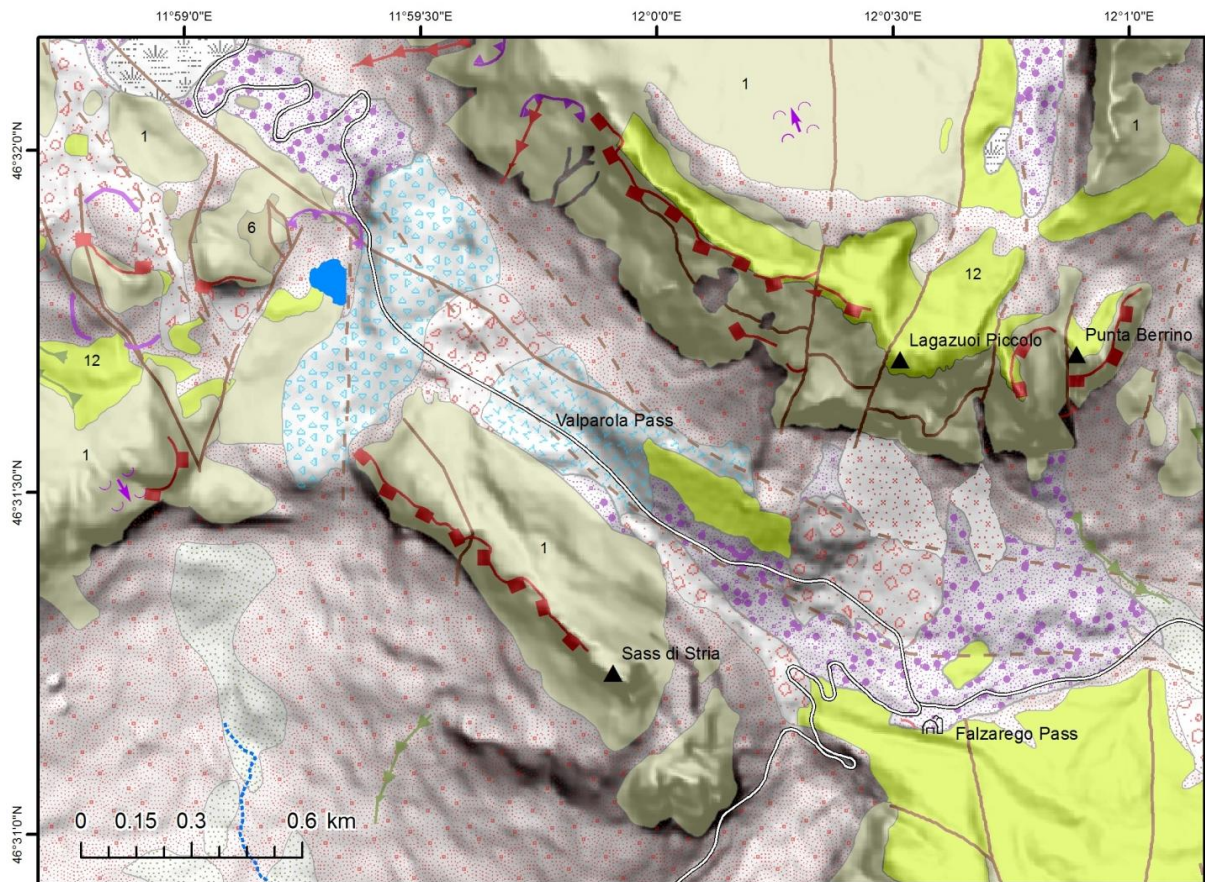
The Forcella Lerosa constitutes a cul-de-sac that allowed shooting the attacking Italian troops through a crossfire from the northern face of Croda dell'Ancona and the southern slope of Croda Rossa d'Ampezzo.

## **5.4 Valparola Pass**

### *5.4.1 Geomorphologic description*

The investigated area lays between the two passes of Falzarego, in lower topographical position, and Valparola. The main objective of study was the corridor stretched in a north-west south-east direction between the Sass di Stria and the Lagazuoi (known as 'Ntra I Sass). The geomorphological setting is typical of the Dolomites. The main lithology are genetically related to carbonate platforms and depositional basins of the Middle and Upper Triassic position, lifted and tilted by thrust systems vergent to the north. There are significant summits (Sass di Stria and Lagazuoi) and the two passes themselves were generated by the great line of the 'Falzarego Thrust'. The thrust forms two main hogbacks (Sass di Stria and, more elevated, Lagazuoi) with impressive vertical walls facing south, forming steep rocky gullies, pinnacles and spiers; the entire area is also crossed by a sub-vertical fault system. Tectonic structural elements form ledges and escarpments. In particular, the ledge called Cengia Martini played a key role in the battle. It extends along a plane of thrust in correspondence of a cataclastic band where the Italian 'Alpini' could more smoothly dig tunnel and shelters. The Cengia Martini constitutes a secondary structure associated to the Falzarego Thrust.

Talus deposits form at the foot of the rocky walls. On the valley floor the landslide and glacial deposits (mainly on the western side, belonging to the Last Glacial Maximum) show the action of periglacial process, the most important being some large rock glaciers. The distinction between glacial and gravitational deposits is not easy, being probably generated by ice-rock avalanches deposits. The glacial morphogenesis is widespread over the entire area of Falzarego-Valparola; some glacial cirques are present on the southern slope of Lagazuoi. Karstic forms are also present on limestones and dolomite formations.



**Figure 13** - Valparola Pass geomorphologic map.

#### 5.4.2 Military events

The Valparola Pass represented one of the two main access from south to the Badia Valley, the other is the Campolongo Pass. None important attacks were carried out by the Italians during the first month of war against the defences of the Austro-Hungarian 51<sup>st</sup> Mountain Brigade. The Italian 17<sup>th</sup> Division, moved forward from the 3 June along the road of Andraz and occupied the areas which the Austro-Hungarians voluntarily had abandoned.

The most remarkable action accomplished by the Italians during this time was the conquest of the Goiginger position on the 15 June, an important observatory on the saddle of the Sass di Stria, that however was quickly recouped by the Imperial forces.

The Italian offensive became more determined from the 5 July when the artillery display was enhanced. The Fort Tre Sassi on the Valparola Pass was heavily bombarded. On the 9 July, simultaneously with other operations that stemmed in the conquest of Cima Falzarego and Col dei Bos, both east next to the Lagazuoi Piccolo, two Italian columns moved forward from their departure lines. One (A in fig. 14) came out from the forests, which were southern to the Sass di Stria, towards the Vonbank position, but it was quickly stopped by the fire of the defenders which were distributed in the side of the two rocky reliefs, Sass di Stria and Lagazuoi. The other column (B in fig. 14), on the day after, could surprise again the Imperial forces on the saddle of Sass di Stria, but this occupation again was brief and the Italians were driven out.

After these failures the Italians started a systematic bombardment of all the Imperial positions, and just small blitz were conducted until the second half of July, when the Italians started offences against the near reliefs (Col di Lana and Tofane). The attack against the Valparola 'sbarramento' was not conducted as it depended on the result of the attack to those reliefs, which failed.

On the 16 October General Etna (commander of the 17th Division), in order to avoid the movement of the Imperial troops from this front to the Isonzo front, where it had started the third battle, ordered to attack the Valparola Pass and the Imperial defensive works between the Settsass and the Sief Mount (on the west side of the the Rio Valparola). He planned to attack with four columns, three of which regard our area of study:

1° column (1 in fig. 14): through the Cima Falzarego and Forcella Travenanzes towards the Lagazuoi Piccolo;

2° column (2 in fig. 14): from the head of the Costeana Valley towards the Valparola Pass;

3° column (3 in fig. 14): up to the Rio Valparola, from the forest, it would have to steer towards the north-east side of the Castello Mount and the western heights of the Valparola Lake.

These attacks were preceded by another blitz against the Sass di Stria ('a' in fig. 14), this time the Italians were able to take the peak, but just for few time. On 18 October a big artillery bombardment started and in the afternoon the four columns moved forward. The first one was able to take possess of the Punta Berrino and the Cengia Martini. From the Cengia Martini the Italians controlled the left part of the Vonbank position and the paths that connected the Sass di Stria emplacements from north (Mariotti, 1964).

The second column was stopped in front of the barbed wire by the crossfire from the Sass di Stria and the Vonbank position. Also the third column was stopped in front of the barbed wire. Both resumed the offensive actions until the end of the month but none progress was made.

Two other Italian attacks were made in the sector of Sass di Stria-Valparola in the evenings of 8 and 9 November, but without any significant results. After these last attacks the Italians did not tried again to breaktrough the Valparola 'sbarramento'. The condition of stalemate that stemmed gave origin to the 'mines warfare', in which both the parts tried to reach by tunnels the enemies positions and blow them up. On the end of October 1917, as in the other parts of the Dolomites front, the Austro-Hungarians advanced with little resistance up to the new Italian line of defence on the Fiume Piave, determining the abandon of the dolomitic front.

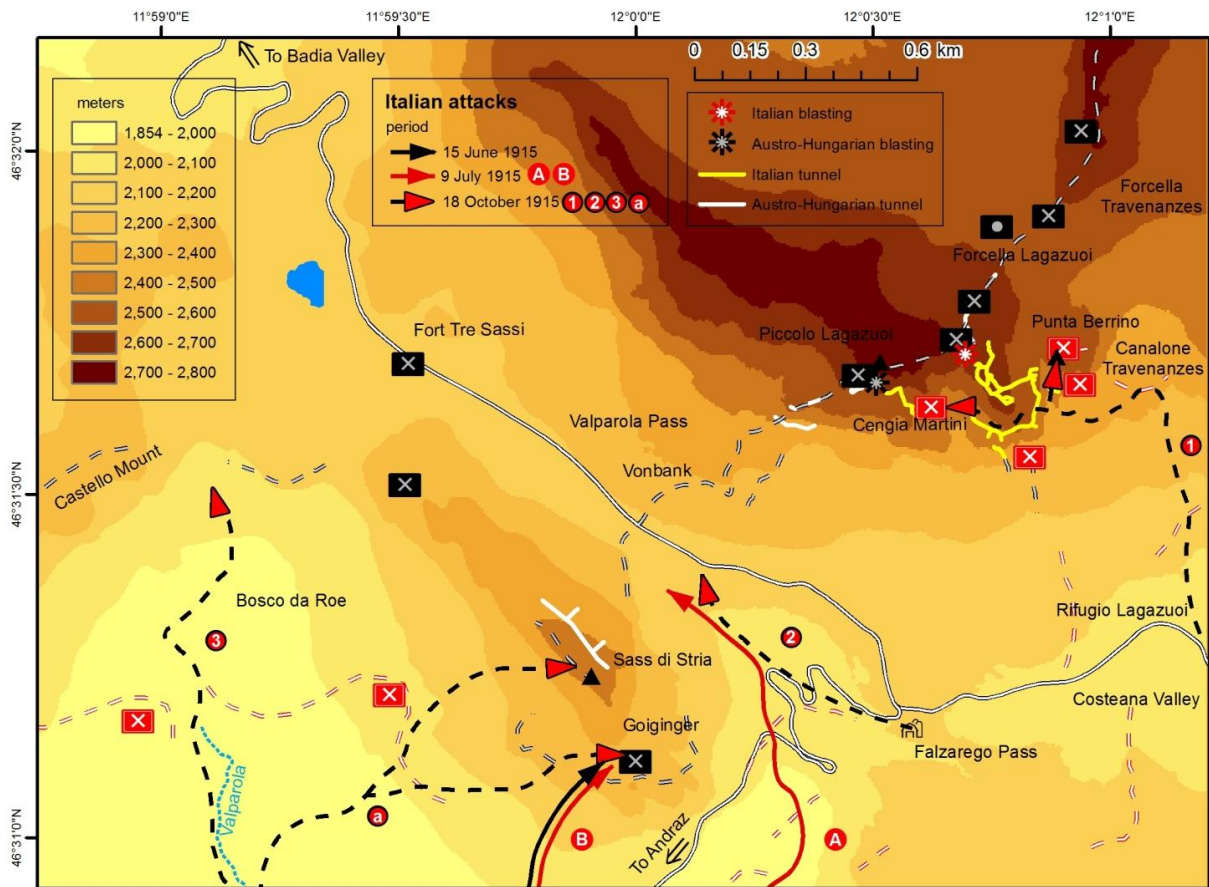


Figure 14 - Valparola Pass military history map.

#### 5.4.3 Comments about the relation between geomorphology and military events

The Valparola Pass was particularly important in the context of the military operations in the Dolomites because it was the most direct access to the Badia Valley. It constituted a bottleneck easily controlled from the summit of the Lagazuoi to north-east and the crest of the Sass di Stria to the southwest.

At the beginning of the war, the Austro-Hungarians occupied the highest summits (Grande Lagazuoi, Piccolo Lagazuoi, Sass di Stria and the higher sector of the Valparola Pass). The line of defence followed the joining between the peaks along the change of slope where it was easier to dominate the attackers in the area of horizontal movement and where the slope at the foot of the defenders was steeper. The defensive line was elongated resulting in this way much more effective. Where the trenches and defences were particularly exposed to the enemy or where there was no ground to provide suitable locations, soldiers from both sides dug galleries on the mountainsides. The same tunnels were also used for the war of mine. The trenches were built with stone walls (sangars) using blocks from the landslide and slope deposits; when on bare rock they were excavated, such as in Sass di Stria.

The goal of the fighting was twofold: (1) to gain the dominant positions that control the access corridors and (2) the conquest of the passes.



The Italian attacks on the higher positions occurred in two phases: a) movement to reach the top, especially along rocky gullies that allowed soldiers to shelter, and b) close fighting at higher elevations.

In all cases in which Italians fought in the open field and starting from the bottom, they were rejected. Invariably, if the defender could dominate the space of movement of the attacker being in an elevated position, the attack failed.

The attacks on the Sass di Stria, occurred following the minimum slope and along stretches as possible repaired. The Sass di Stria was occupied by the Austro-Hungarian, which dominated the Valparola and the Falzarego passes, and also a stretch of 'Road of the Dolomites'. The inclined profile of the crest dipping north-east and the favourable inclination of the layers provided an easy access only to the Austrian, while the Italians had to climb very steep cliffs. The steep sides of the Sass di Stria were a sort of natural bulwark.

The arrangement of the Austro-Hungarian defence was fully controlled by the geomorphological setting. Also the location of the trenches that cut transversally the valley was conditioned by the longitudinal gradient changes which placed the Austro-Hungarians in a dominant position.

Considering the Italian attacks to the Lagazuoi, the presence of the typical dolomitic morphology given by steep walls, with ravines and spurs, allowed a slight, but sufficient, shelter to the 'Alpini's' attack. They could climb the wall and effectively occupy the Cengia Martini, arriving just 150 m from the Austro-Hungarian line. The Cengia Martini, formed along a secondary thrust, allowed Italians to occupy approximately 200 m of wall at about 2500 m a.s.l., away from Austrian shooting, roll bombs thrown from above and mines.

The Piccolo Lagazuoi was particularly affected by the 'tunnel warfare' that altered the morphology of the places creating deep scars on the slopes formed by craters and debris cones generated by the explosions.

Actions at high altitude became a mountaineering warfare where the training and the movement capability of the soldiers in extreme conditions prevailed. The movement was no longer of great masses of men, horizontally, but of small groups, vertically.

Today the area of the Lagazuoi presents its trenches, tunnels, huts, signs of collapse and explosion and accumulation of debris at the foot of the slopes. The blast of the five mines which took place from January 1, 1916 to September 16, 1917 generated two large debris cones at the foot of the south face of the Lagazuoi. The explosions also created large craters in the summit walls and deep fractures opened on the vertical side. In the northern side of the Sass di Stria it is still preserved a 500 m long tunnel dug by the Austrians and used as warehouse, kitchens, dining rooms, depots, garrisons and accommodation. It presents a dozen louvers open on the sidewalls. Italians dug a helical tunnel under the Piccolo Lagazuoi 1100 m long, still passable today.

## **6. Conclusions**

The border between Italy and Austria followed the geomorphological limits and had a sinusoidal pattern. In order to shorten the front and to settle a more favourable defensive line, the Austro-Hungarians retreated for many kilometers in several places. This is especially

true for the Som Pauses area. The takeover of the passes meant to open the door to the Austrian territory allowing you reach the main objective: the Val Pusteria. The geomorphology of the Dolomites provided top heights (over 3000 m a.s.l.) with steep or vertical walls many hundreds of meters high. The invasion of the Austrian territory with a whole army would have been possible only through the main valleys leading to Alpine passes. The passes were all dominated by high summits, which allowed Austro-Hungarian to hold positions at the top controlling the movement along the valleys (very often narrow, apart from Montecroce Comelico Pass). The high elevations and the limited space for manoeuvre led to failure all Italian attacks. Italian forces had to move uphill with slopes inclination beyond the operational capabilities of the troops. So, missing the opportunity to deploy troops in a wide front, the Italian numerical superiority was thwarted.

Only the attacks carried out by small units with alpine experience allowed to achieve limited tactical goals (winning the Sentinella Pass, the Piccolo Lagazuoi and the Cengia Martini). The height and steepness of the slopes made the Austro-Hungarians to easily defend the peaks. The fights were repeated for two and a half years, without achieving significant results.

When the war turned to 'tunnel warfare', the dolomitic formations lets dig long tunnels in the mountains, allowing the soldiers to live more comfortably in relation to hard alpine climate, especially during winter, to effectively protect themselves against the shelling of artillery (which were always very little conclusive) and to preside the tops being in a protected position. Debris accumulations allowed to make use of stones and blocks for the construction of sangar, trenches and shelters making the trench warfare very different from the Western Front in France and Belgium. While the presence of the high vertical walls formed a natural defence against Italian attacks, the slopes facing the Austrian territory were usually protected from direct Italian artillery fire and hidden by enemy observers who could not effectively direct the shooting. The slope gradients were generally favourable to the Austrians, being lower on the northern quadrants.

Dolomite is a compact rock, which allows the realization of tunnels capable of self-sustaining (and then with a limited danger of collapses). This facilitated the 'tunnel warfare' (among the case studies in this paper we consider only the Lagazuoi, but mines were realized in many tens of sites along the Dolomitic front). The compactness of the rock and the effort to drill tunnels required many months of hard work gaining results absolutely disproportionate to the effort made.

According to Porro (1889) "it can be assumed that in most cases of war in mountainous terrain, valleys represent, from the military point of view, the geographic elements that have the greatest strategic, logistical, and tactical importance". He also emphasized the fact that in the theoretical study of the military functions of mountain valleys, special consideration must be given to the mountain range in which they are located (for example, direction inside it and spatial relations with other geographical features), shape and size (Porro, 1989).

In conclusion, the characteristic landscape of the Dolomites created unique morphologies with high peaks, steep slopes and narrow valleys. The battles turned immediately to the conquest of the summit positions, whose domain ensured the defence of the Austrian territory during the whole war. The conquest of the top positions was essential also for directing the artillery fire so that the Austrian supply lines, placed in a tight angle, could be little affected by the Italian batteries.

Geomorphology played a fundamental role, altering the balance of forces, the military training and the amount of supplies, which, in open field, have a predominant part. The organization of Austro-Hungarian defences and the Italian plans of attack seem to have followed the same scheme, mostly because of the warfare environment in which they took place.

## 7. Acknowledgements

This research was funded by the Foundation for University and High Culture in the Province of Belluno and the MIUR ex60% funds (A. Bondesan). The authors thank Francesco Ferrarese of the University of Padua, Department of Historical and Geographic Sciences and the Ancient World, for his expertise with GIS, and Elena macron for her contributions regarding the study of the Valparola Pass.

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## CHAPTER 4

# Assessing the Trafficability for the Eastern Tyrol Front during the Great War

*«Every exertion of physical force  
if made upwards is more difficult  
than if it is made in the contrary direction (downwards);  
consequently it must be so in fighting»  
(Clausewitz, 1832)*

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### Abstract

From the autumn of 1914, the Austro-Hungarians started to prepare themselves for the possibility of an Italian offence. They decided to defend Tyrol to the utmost by building field fortifications which formed the Tyrol Defence Line (TDL). Mountainous areas such as the one in which the TDL was located are characterized by obstacles to trafficability, which affect movement and deployment of troops (Clausewitz, 1832). Conditions of trafficability along the TDL were modelled using a GIS-based approach known as cost distance analysis. Cost distance analysis in this study is a model for assessing the 'cost' of troop movement /deployment across a given terrain. By assigning a cost for each class of slope, the main geographical factor which determines trafficability in tactics, a cost distance analysis was conducted to determine the cumulative trafficability cost for an offence by Italian lines to the Austro-Hungarian lines of defence. Trafficability conditions were assessed for the period before the war in the entire Eastern Tyrol Front (from Valsugana to Cresta Carnica) and for the first period of war in the Dolomites area (from Costabella to Cresta Carnica). The main result of this research empirically demonstrates that, for the analyzed portion, the perimeter to be defended along the TDL was roughly the same length as the one along the political border before the First World War. This allows us to reconsider, from a military perspective, one of the main geographical characteristics pondered by many historians: the length of the TDL. This study provides a new approach for modelling trafficability along defence lines in mountainous terrain.

**Keywords:** First World War, Italian Front, Tyrol, Dolomites, Trafficability, Military Geography, Cost Distance Analysis, Military Theory, Clausewitz.

## 1. History of lines in eastern Tyrol

### *1.1 Lines before the war*

The possibility of being constrained to fight on a third front, in addition to the Russian and the Serbian fronts, presented a great challenge to the Austro-Hungarian Army. Ten months after the beginning of the European conflict, when Italy declared war, the Austro-Hungarian high command decided that the new Southwest Front had to take a defensive stance, waiting for a better moment to mount an attack. On 28 May 1915, the commander of the Southwest Front was instructed "to defend Tyrol to the utmost with the troops to be found there, to oppose the enemy invasion of Carinthia, the coast lands and Carniola while conceding the smallest possible amount of ground, and eventually to strike back with as strong a blow as possible" (AOH, 1930-39, vol. 2, p. 564).

The prevailing defensive concept was the line of defence.<sup>1</sup> By the autumn of 1914, this kind of defence was already commonly used in Europe. Indeed, the new war had made it clear how important it was to utilize the defensive stance and extensive field fortifications, which, increasing in number, formed lines to repulse enemy attacks as well as lines from where attacks were launched.<sup>2</sup>

The use of lines of resistance became even more extensive after the first months of war. Considering the results of the Italian attempts to breakthrough the Austro-Hungarian defences in the Carso in the summer of 1915, the AOH (Austrian official history) explains: "Commanders at all levels agreed that the front line had to be the main line of resistance. At the time, this belief was an elementary doctrine on all fronts [...]. Moreover, since any construction was so difficult (referring to the rocky terrains, as are those of many parts of Tyrol front), it was best to devote all efforts to strengthening one position" (AOH, 1930-39, vol. 3, p. 359).

However, before the war, no one would have predicted hundreds of kilometres of lines of defence made by almost continuous field fortifications and barbed wire. Before the First World War, the defence of Tyrol was principally assigned to the permanent fortifications located behind and near the political border,<sup>3</sup> which prevented the use of penetration routes into Tyrol by the Italians.<sup>4</sup>

But when the European war started and the threat of an Italian offence became increasingly likely, the permanent fortifications were considered insufficient, and the Austro-Hungarian High Command had to make a decision about where to place the field fortifications to

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<sup>1</sup> In this paper, 'line of defence' and 'line of resistance' are used as synonyms.

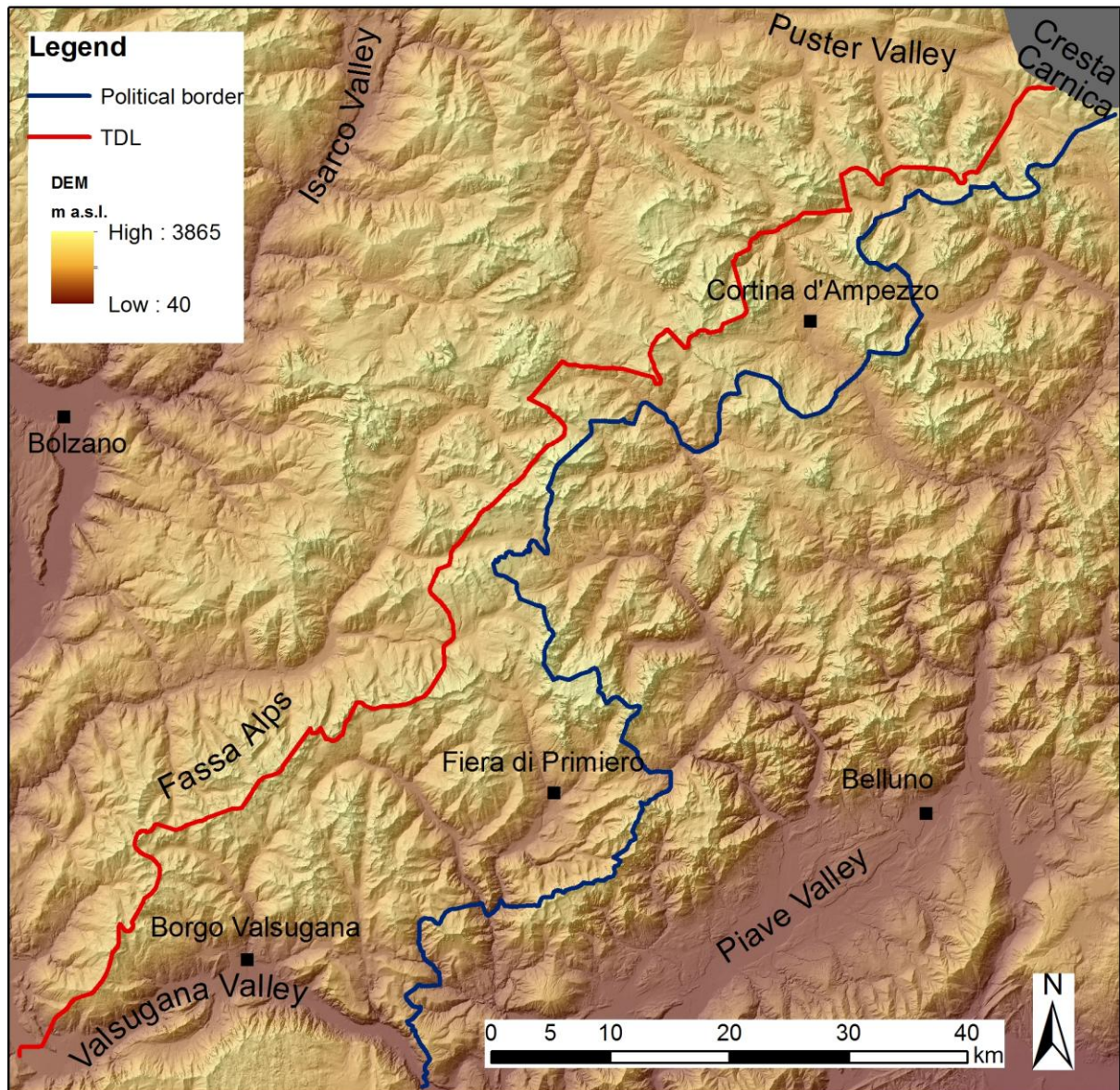
<sup>2</sup> See Pieri (1998) for further information on the strength of defence during the First World War; Breda (2010) deals with the characteristics of lines of defence that spread over Europe.

<sup>3</sup> The defence of Tyrol region represented a challenge for the Austro-Hungarians. It was sorely tested by the battles of the Third Italian War of Independence in 1866 (i.e., Bizzoca and Valsugana), and the challenge became even greater after that war, because the resulting political settlement placed Tyrol in a salient, surrounded by Italy on three sides (AOH, 1930-39, vol. 2, p. 567). The problem was tackled soon after 1866, when the Austro-Hungarians created a program for the fortification of the region.

Further considerations of the military problem of the defence of Tyrol can be found in Pozzato (work in progress).

<sup>4</sup> More information about the evolution of the fortification programs can be found in Rosner (2003).

prevent the passage of the Italians. The Austro-Hungarians chose to abandon the political border and strengthen the line linking the permanent fortifications running along the watershed of the Fassa Alps (AOH, 1930-39, vol. 2, p. 567), later known as the Tyrol Line of Defence (TDL) (figure 1).<sup>5,6</sup>



**Figure 1** - The political border and Tyrol Defence Line (TDL), from the Valsugana to Cresta Carnica

However, the choice to leave the political border was not an easy one: At the beginning of the 20<sup>th</sup> century in Europe, every sovereign state viewed every square meter of its territory as having a transcendent supra-national value far exceeding ordinary military or political

<sup>5</sup> In German “verteidigungslinie” or “widerstandslinie”.

<sup>6</sup> Other localizations of the TDL were also considered. See for example General Dankl’s proposal (AOH, 1930-39, vol. 2).



convention.<sup>7</sup> Hence, the state would have militarily defended even peripheral territories at a very high cost. From that perspective, every political border was potentially a front of war. Thus, long before any concrete possibilities of war, the military characteristics of the political border were studied very carefully by both parties. In particular, with regard to the specific location of the border. The documents produced by the Austro-Hungarian and Italian International Commission of 1911 on the boundary<sup>8</sup> demonstrate that military considerations of a tactical nature were part of the debates. The fact that this was not a choice easily made can also be seen from military history sources that analyzed the Austro-Hungarian/Italian front of war during First World War; these sources often compared the TDL with the political border. These comparisons dealt with military considerations, specifically, the advantages that stemmed from the location of the TDL and the disadvantages that would have resulted if the political border had been maintained.

One key characteristic considered by the military literature was the length of both lines. The AOH explains: “the Austrians had decided to shorten their front by giving up the most forward parts of the 450 km long border and by basing their defence on the line of permanent fortifications and along the watershed of the Fassa Alps; this saved about 100 km” (AOH, 1930-39, vol. 2, p. 567).

The length was seen as important, primarily, because a shorter line meant abandoning part of the territory to the enemy, which, as we said, was considered a drastic decision.<sup>9</sup> But also the length has been highly regarded because a shorter line would have given the defenders an advantage in reducing the perimeter that had to be garrisoned, and so, an advantage in increasing the number of troops freed. As in 1915 Austria-Hungary was hard pressed in Russia and Serbia, in Italy was staged an economy of force operation, thus for many authors this was one of the main reasons for the retreat. This can be seen, for example, in Lichem (1993), who claimed that “it was essential to significantly shorten the front line”.

For others, a shorter front length seems to be a consequence of a decision on the location made in order to take advantage from other military aspects. The ‘Beihefte zu Streffleurs Militärblatt’ (1918) asserted that the line of defence could not coincide with the political border because it had to adapt to the terrain.

### ***1.2 Lines during the first period of war in the Dolomites***

Contrary to the Austro-Hungarian strategy, the Italian plan of operation against the Empire was offensive. Furthermore, the first main attack that the Italian high command decided to lead concerned Tyrol. In particular, it had to be launched from the Dolomites region, a part of the Tyrol front, and it aimed to reach the Puster Valley, an important line of communication in Tyrol. This offensive was assigned to the 4<sup>th</sup> Army, which was deployed in

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<sup>7</sup> In Italy General Antonino di Giorgio coined the term “pregiudizio territoriale” for this concept. More information can be found in Del Negro (1994).

<sup>8</sup> The International Commission of 1911, integrated in large part by military personnel of both countries, was among other tasks appointed to resolve different controversies regarding the location of the political border. More information about the works of the commission can be found in Adami (1930).

<sup>9</sup> In this regard, it is also important to consider that Tyrol was the sector of the Italian/Austro-Hungarian Front with the largest area of voluntary withdrawal by the Dual Monarchy.

the Dolomites region, from the Croda Grande, in the group of the Pale di San Martino, to the Peralba Mount, in the Cresta Carnica. For the rest of the Tyrol front, the established strategic concept at the beginning of the operations was defensive, even if tactical attacks on the TDL were also proposed, in order to improve the tactical conditions of the Italian line of defence for those zones.<sup>10</sup>

Specifically to the area of the Dolomites, on 1 June 1915, Gen. Nava, commander of the 4<sup>th</sup> Army, ordered a general advance to establish a line for offence near the Austro-Hungarians' permanent fortresses which had to be attacked.<sup>11</sup>

By the end of the spring 1915, the 4<sup>th</sup> Army managed to advance over the political border and to prepare the line for offence, except for the zone containing the military works of Landro – Plätzwiese (AOH, 1930-39). Besides these achievements, the Italians also attempted to occupy Austro-Hungarian positions of the TDL, or beyond the TDL. However, this last goal largely failed, and the penetrations that were achieved did not last.

Meanwhile, the Austro-Hungarians managed to move forward on the TDL in two areas: Piana Mount and the Montecroce di Comelico Pass.

After the last action in the spring period on 18 June, there followed a period in which the 4<sup>th</sup> Army prepared for the attacks that would lead it to achieve its mission, the completion of the line for offence and overcoming the TDL. Meanwhile, the batteries of heavy artillery, expected for the engagement against the enemy's fortresses, had moved to the front and stood ready.

All the attacks led by the 4<sup>th</sup> Army during the summer period were in the sector from Mesola Mount to Peralba Mount. In the southern part of the deployment of the 4<sup>th</sup> Army, from Croda Grande to Mesola Mount, there were no major Italian attempts to overcome the Austro-Hungarian defences.

The offences followed one another with intervals between them. The first ones started with an artillery bombardment on 5 July. On 7 July the infantry moved forward from the prepared line for offence, and on 11 July the attacks were stopped by the Austrians. They resumed during the period of 15-20 July, again without achieving the expected objectives. In the third period of attacks, from 31 July to 4 August, the command of the 4<sup>th</sup> Army focused on more limited goals. Without insisting on direct attacks against the main defensive works, the forces were instructed to reach a more advanced line for offence, which, nonetheless, at many points corresponded with the TDL. On 13 September the command of the 4<sup>th</sup> Army declared that the goals which had been assigned from the beginning of the war, and even those more modest goals declared at the end of July, could not be achieved before the arrival of the cold season. Therefore during the second half of September, it conducted an even less ambitious program (IOH, 1927-88, vol. 2, p. 362).

Despite this sequence of vigorous attacks, very few of them resulted in the occupation of Austro-Hungarian positions. Overall, the line for offence was moved forward, very close to

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<sup>10</sup> For more information, see the document "Varianti alle direttive emanate in data 1 Settembre 1914 dal Capo di S. M. dell'Esercito ai comandanti di armata ed al comandante della zona Carnia", of 1 April 1915 (IOH, 1927-88, vol. 2 bis).

<sup>11</sup> For more information, see the document "Ordine di operazione n. 3 del comando della 4<sup>a</sup> Armata per la marcia in avanti su tutta la fronte", of 1 June 1915 (IOH, 1927-88, vol. 2 bis).

the TDL; the AOH reported that “in several places the enemy was so near that our men could see the whites of their eyes” (AOH, 1930-39, vol. 3, p. 370).

Concerning the TDL, during the summer period it was moved forward by the Austro-Hungarian in two areas, without any fighting. In the upper Cordevole Valley, the TDL was moved from the Pordoi Pass to the Sasso di Mezzodi – Chertz line (AOH, 1930-39). The other advancement of the TDL was done in the northern spurs of the Cristallo Group (AOH, 1930-39).

## 2. The property of trafficability in military theory

“There are three properties through which the terrain has an influence on action in war; that is, as presenting an obstacle to trafficability,<sup>12</sup> as an obstacle to an extensive view, and as protection against the effect of fire-arms; all other effects may be traced back to these three” (Clausewitz, 1832).<sup>13</sup> Further, each kind of terrain has its own effect on the three properties.

For Clausewitz, it is possible to determine three main classes of countries from the different kinds of terrain: “mountainous countries, countries little cultivated and covered with woods and marshes, and the well cultivated” (1832). Therefore, also every class of country will be characterized by different effects on the three properties.

Mountainous countries, which are characterized by high absolute elevations and great difference of elevation between its various areas (Porro, 1898), have the most serious obstacles to trafficability. There, trafficability takes effect in two ways, “because in some parts the country is quite impassable, and where it is practicable we must move slower and with greater difficulty” (Clausewitz, 1832). The first problem impacts deployment, increasing the partitions of forces, while the second one impacts movement, increasing the time and difficulty of travelling.<sup>14</sup> Both of these effects appear in mountainous countries both for tactics and for strategy.

There are many geographical characteristics of mountainous countries creating obstacles to trafficability, including characteristics of geomorphology, hydrography, meteorology, vegetation<sup>15</sup> and anthropogeography. However, from a tactical perspective, the geographical characteristic of mountainous countries that largely determines obstacles to trafficability and distinguishing it from flat countries is the high difference of elevation according to the planimetric distance, which can be expressed in terms of slope angle.

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<sup>12</sup> For Porro (1898) trafficability is the property that is most relevant to the military study of the terrain.

<sup>13</sup> The word used by Clausewitz (1832) is “zuganges”. We have chosen to translate “zuganges” as “trafficability”. However, the consulted English translation, made by Graham in 1873, used other terms to translate the word “zuganges”. Thus, inside the quotations from Clausewitz that were extracted from the Graham translation, we used the word “trafficability”. We also used the word “terrain” rather than “ground”.

<sup>14</sup> Mountainous countries also have a “special property peculiar to itself, that one point commands another”. It is “this peculiarity which causes the great partition of forces” in operations carried on amongst mountainous countries (Clausewitz, 1832).

<sup>15</sup> Clausewitz (1832) also considered the influence that forested terrain, which is very common in mountainous countries, has on movement and deployment.

Due to this geographical characteristic, difficulty of movement and deployment is beneficial largely for those in possession of the elevations and is detrimental for those who have to attack from below against an elevated position.<sup>16</sup> This was exactly the situation that occurred along the largest part of the Tyrol western front, when Italians tried to attack the Austro-Hungarian positions of the TDL.

### 3. The GIS Analysis

#### **3.1. Geo-Historical material used**

##### *3.1.1 The political border before the First World War*

For the location of the political border before the First World War, we used the maps of the Italian Touring Club (1:100.000), *fogli*: Pieve di Cadore, Trento and Rovereto-Schio, drawn on the basis of the Italian Military Geographical Institute (IGM) topographical map; we also used the IGM (1:25,000) maps of the *foglio* Feltre. All of them were issued before the war.

##### *3.1.2 The Tyrol Defence Line*

The TDL has been depicted based on the 27° annexe/II° part/II° volume of the AOH. This annexe contains two maps at the scale 1:200.000 with no geographic coordinate references, 'The Fights in Tyrol in May and June 1915' and 'The Fights in the Dolomites in July and August 1915'. These two maps present few topographic elements, which were drawn on the basis of the same topographical base. Therefore, concerning these elements, the two maps are identical.

Besides toponyms and topographic elements, the maps present military information. In particular, for both the counterposed State's armies, the maps show the main units deployed and the main attacks that occurred. The maps also show the location of the defence positions of the Austro-Hungarian army, which are marked with blue linear and punctual symbols.

The lines showing the defence positions are between 0.5 mm and 1 mm wide. Even though this variation in width is almost imperceptible, this range corresponds to 100 m – 200 m on the ground.

The lines of the defence positions are either continuous, such the one which encircles the fortified town of Trento, or drawn by segments of different length distanced at irregular intervals, as for TLD.

The line of the TDL is also present on both maps, at some parts as a double entry. Where the double entry is associated with a date, indicated near the lines, it corresponds with a previous location and a second location of the defences. But it occurs also in a few other places where a double entry is drawn without a reference to a date.

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<sup>16</sup> But it is necessary to consider that these advantages and disadvantages cannot be regarded as absolute. About the advantage which stems from the difficulty to movement, Clausewitz specified that it is not "always in favour of the side occupying the higher position; it is only so when his opponent wishes to attack him" (Clausewitz, 1832).

The second type of symbol for defence positions concerns punctual elements. They represent permanent fortifications and other kinds of emplacement. They appear in front of, behind or among the segments of the TDL.

From 'The Fights in Tyrol in May and June 1915' we obtained the lines that we have called the Tyrol Line of Defence (TDL) and the Tyrol Line of Defence at the End of the Spring (TDLESp). From 'The Fights in the Dolomites in July and August 1915', we obtained the line that we have called the Tyrol Line of Defence at the End of the Summer (TDLESu).

### *3.1.3 The Italian military lines*

The Italian lines have been depicted from the maps n. 13 to n. 21/III° part/II° volume of the Italian official history (IOH). Those maps correspond to the ones of the 'Great Map of the Italian Kingdom', issued by the IGM, thus have the same characteristics, including the same topographical information, scale (1:100,000) and coordinate system.

In those maps, military information about the Austro-Hungarian and Italian armies was overlaid on the 'Great Map of the Italian Kingdom'. The symbols for military information are either linear or punctual.

From this source we obtained the lines for offence that we have called the Italian Line at the End of the Spring (ILESp) and the Italian Line at the End of the Summer (ILESu). For the area between the Costabella and the Cresta Carnica, the two lines follow a unique entry, are continuous, and are 1 mm wide, corresponding to 100 m on the ground.

### *3.1.4 DEM*

The DEM utilized (spatial resolution 10 m) was obtained from resampling and joining the DEMs issued by the administrations of the province of Bolzano (resolution 20 m), the province of Trento (resolution 10 m) and the Veneto region (resolution 5 m).

## **3.2. Data pre-elaboration**

### *3.2.1 Georeferencing the sources*

The maps of the IOH (1:100,000) were georeferenced by using the marks of the coordinate grid present at the corners of each map. We used a 1<sup>st</sup> order polynomial method. The mean of the Root Mean Square (RMS) for all the maps was 75 m, around three quarters of a millimetre on the 1:100,000 map.

As the AOH maps do not present geographic coordinate references, georeferencing was carried out using ground control points correlated to the 1:100,000 IGM map.

For the map 'The Fights in Tyrol in May and June 1915', we used 35 points and a 1<sup>st</sup> order polynomial method; the obtained RMS was 103 m.

As both the Austrian maps were obtained from the same topographical base, the map 'The Fights in the Dolomites in July and August 1915' was overlaid on the georeferenced 'The Fights in Tyrol in May and June 1915' map. The alignment was made using 37 topographic homologous elements in the two maps. Homologous points were used to interpolate the whole map by a spline method, that consent to have an RMS between the two maps equal to zero.

### 3.2.2 Vectorization of the military lines

Except for the political border before the First World War, considered as a possible line of defence that never existed, every digitalized line has been interpreted as the location of the different military lines at the end of a specific period. Therefore:

- the TDL from the Valsugana Valley to the Cresta Carnica is the Austro-Hungarian military line before the war started
- the TDLESp and the ILESp from the Costabella to the Cresta Carnica are the military lines of the respective armies at the end of the spring period of war, and
- the TDLESu and the ILESu from the Costabella to the Cresta Carnica are the military lines of the respective armies at the end of the summer period of war.

In order to conduct some of the spatial analysis in this paper, the three TDLs, which on the maps of the AOH were drawn by segments of different length, were considered as continuous lines. In consequence, the vectorized segments were linked each other by the least distance, becoming a unique vector line.

Particularly on the the TDL and TDLESp, where the line drawn at the source (i.e., the map 'The Fights in Tyrol in May and June 1915') followed a double entry without any reference to time, the segments chosen for vectorization were the outer ones. This occurred specifically in the areas of La Portella (Lagorai Chain), Travignolo Valley, Col di Lana and Lagazuoi.

On the contrary, where the line followed a double entry indicating an evolution of the TDL position by the indication of a date, the former location was used to define the TDL while the more recent location was used to define the TDLESp. Hence, the TDLESp is identical to the TDL except for the areas of Piana Mount and Montecroce di Comelico Pass, where the defence positions were moved forward.

Punctual elements drawn at the source were included in the TDL and TDLESp only when they were considered to harmoniously continue the trace of the segments, and where the segments were more distanced (in the area east of the Pordoi Pass and in the Landro Valley).

Similarly, regarding the TDLESu, where the line drawn at the source (i.e., the map 'The Fights in the Dolomites in July and August 1915') followed a double entry without any reference to time, the segments chosen for vectorization were the outer ones. Specifically, this choice regarded segments present in the areas of Col di Lana, Landro – Plätzwiese<sup>17</sup> and Sesto Valley.<sup>18</sup> Further choices inside the vectorization process were made for each particular area:

- For Sass di Stria, no segment was drawn at the source. As this mountain was strongly held by the Austro-Hungarians and the Italians were never able to establish a position there permanently, we created a segment identical to the one for the Sass di Stria inside the map 'The Fights in Tyrol in May and June 1915'.
- For the area of the Tofane Group, the textual information of the AOH and of the IOH agree that Forcella Fontananegra was conquered by the Italians in August, so the drawn segment at the source there was not considered.

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<sup>17</sup> Where the defence positions were moved forward to the Mount Piana during the spring period of war.

<sup>18</sup> Where the defence positions were moved forward, near the Montecroce di Comelico Pass, during the spring period of war.

- For the Cristallo Group, no segment was drawn at the source. However, both official histories agree that the defence positions were moved to the northern spurs of that massif. Thereby, three segments were created, one on Punta del Forame, one on Costabella of the Cristallo Group<sup>19</sup> and the last one on Fumo Mount. Their locations were obtained from the sketch 'The Italian attack – 11-26 September 1915 – Group of the Cristallo and Popena' (Berti, 1982).

At the end of the vectorization process, there was an incongruous overlap between the Austro-Hungarian and the Italian lines at some points. This was due to cartographic error<sup>20</sup> and to the fact that, particularly during the summer period, the lines of both the armies were very close to each other.

In order to avoid this overlap between TDLESp and the ILESp, two of the segments of the TDLESp (one in Passo della Sentinella and one in Val Fiscalina) were drawn northward in the same position that they have in the TDLESu line.

In order to avoid overlap between TDLESu and the ILESu, we took the following steps:

- On the Piana Mount<sup>21</sup> both the lines were moved back and the distance between them was determined inside a range from 60 m to 150 m.
- On the southern side of Sass di Stria, the ILESu was moved southward and the distance between the lines was determined inside a range from 100 m to 150 m.

### ***3.3. Elaborations***

As we stated in Section 2, slope is the major factor determining trafficability; therefore, the specific location of the Austro-Hungarian lines of defence and of the Italian lines for offence determined the trafficability of the terrain where the Italians had to deploy and from which they launched their assault.

#### *3.3.1 Slope classification surface*

The first step in the study of the conditions of trafficability was to calculate and classify the slope for the areas between the Austro-Hungarian line of defence and the Italian line for offence.

Our classification of slope in relation to trafficability was based upon Marinelli's classification (1883-1902, vol. 1, p. 318)<sup>22</sup> (Table 1). The only variation introduced to Marinelli's classification is the limit between the two last classes, which we have changed from 45° to 37°. That is because, for Marinelli, 37° represents the slope of a hillside almost inaccessible

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<sup>19</sup> This Costabella is different from the one that is named in other parts of this paper, which is southern to the Marmolada Group.

<sup>20</sup> The accuracy of the localization of the lines in our GIS has to consider the cartographic errors of the sources made by the cartographers (diffused errors, difficult to quantify) and those due to our "pre-elaborations" (i.e., digitalization of the sources, georeferencing, change of scale and cartographic projection). At the moment it is not possible to estimate this accurately.

<sup>21</sup> This overlapping runs for 1.2 km, ranging from a minimum distance of 160 m to a maximum distance of 450 m. This overlapping stems from cartographic error, but it is important to consider that in some parts of the Mount Piana region, the enemies' positions were as close as 20 m to each other.

<sup>22</sup> Marinelli's classification was the one considered by Porro (1989) in his treatise on military geography.

without steps. Therefore, for our purposes, we identify this angle of slope as the limit of trafficability for an attack made by simple infantry, without considering the use of alpine climbing techniques.

### 3.3.2 *Map of the conditions of trafficability*

After determining the classification of slope, it was necessary to establish a method that would let us assess the conditions of trafficability created by the different classes of slopes between the Austro-Hungarian line of defence and the Italian line for offence.

Considering this aim, cost distance analysis was a useful GIS tool.<sup>23</sup> This kind of spatial analysis considers the contribution of each cell in which the ground is divided along the least accumulation possible. The contribution from each cell we called trafficability cost<sup>24</sup>, and was a function of the cost that we assigned to each class of slope and the distance from the Italian line for offence.

The assigned cost to each class of slope (Table 2) was determined according to the fact that higher slopes present higher obstacles to trafficability. The only class of slope not assigned a value was the highest, because it was considered impassable and was therefore excluded from any further calculation. Therefore, the accumulation of trafficability costs was calculated from the Italian lines for offence through the least cumulative approaches to Austro-Hungarian line of defence, without considering the impassable zones or the zones of the other three classes of slope encircled by impassable zones.

For the period before the war, as there were not yet Italian offensive lines, we drew hypothetical lines located 1,500 m in front of the Austro-Hungarian lines. The 1,500 m distance threshold was chosen as it is the distance at which trafficability has the biggest impact on tactical actions, because 1,500 m was the area within which the Austro-Hungarian rifles and infantry arms were effective.

On the contrary, for the period during the war (i.e., the spring and the summer 1915), we considered, as the Italian line for offence, the ILESp and ILESu lines. Only where these lines determined an accumulated trafficability cost higher than that determined by the hypothetical 1,500 m line was this last line chosen for analysis.

We measured the accumulated trafficability cost for a buffer area of 200 m of the Austro-Hungarian lines, in order to minimize uncertainty of location stemming from cartographic error.

The resulted accumulated trafficability costs were classified as follows:

1. **Good conditions of trafficability** – values of accumulated trafficability costs which are minor or equal to that resulting from an approach, from the Italian line to the Austro-Hungarian line, of 1500 m and entirely through zones of *gentle* class of slope;
2. **Difficult conditions of trafficability** - values of accumulated trafficability costs which are higher than those of the class *good* and minor or equal to that resulting, from an approach from the Italian line to the Austro-Hungarian line, of 1500 m and entirely through zones of *moderate* class of slope;

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<sup>23</sup> Further information about this tool can be obtained from the ArcGis Tutorial.

<sup>24</sup> Trafficability cost = the cost assigned to each class of slope x distance.



3. **Very difficult conditions of trafficability** - values of accumulated trafficability costs which are higher than those of the class *difficult*.

The resulting map of conditions of trafficability (an excerpt of them is represented in figures 2,3,4 and 5), therefore, presents three classes of trafficable conditions and one class identified as impassable.

### 3.4. Results

The resulting zones of different classes of conditions of trafficability were analyzed according to their spatial parameters.

#### 3.4.1 *Comparison of the TDL and the political border before the First World War, from Valsugana to Cresta Carnica (tables 3 - 4)*

The *impassable* class represents 51.8% of the political border length and 42.1% of the TDL length. Thus, even though the TDL was shorter than the political border—188,540 m compared to 162,390 m—the extent of the three classes of trafficable conditions together was almost the same, 90,810 m for the political border and 93,960 m for the TDL. That means that the perimeter to be defended was almost the same, or rather, around 3 km longer for the TDL.

Even though there was a greater total length of impassable zones on the TDL than on the political border, the TDL had the advantage of a larger number of separate *impassable* zones. Indeed, along the political border these zones occurred every 208 m on average, while along the TDL they occurred every 151 m. This could have resulted in a higher partition of the Italian forces.

Another tactical advantage of the TDL has to do with the *very difficult* zones, which represent 51.6% of the trafficable length of the political border, compared to 59.8% on the TDL. This increase, meant that there were more zones where movements of Italian infantry would have been slower and more difficult.

Even if the *good* zones doubled in number, the absolute total length of these zones along the TDL is still very low, just 1,350 m. Thus, it seems that, overall, the tactical conditions for defence which stemmed from trafficability were better for the location of the TDL than for that of the political border.

#### 3.4.2 *Comparison between the situation at the end of the spring and that at the end of the summer, from Costabella to Cresta Carnica (table 5 - 6)*

The situation at the end of the summer saw an increase in the extent of the *impassable* zones compared to the situation at the end of the spring: 41,430 m at the end of the summer compared to 36,710 m at the end of the spring. There was also an increase in the percentage of *impassable* zones: 46.2% at the end of the summer compared to 40.5% at the end of the spring. Therefore, the defensive line at the end of the summer reduced the extent of the zones of trafficable conditions by almost 5 km, leading to a reduction of the perimeter to be defended.

However, even though there was an increase in the extent of the *impassable* zones, it did not correspond to an increase of the number of *impassable* zones, but rather the opposite:

By the end of the summer they occurred every 297 m on average, along the entire line, while at the end of the spring they occurred every 254 m. Also, the conditions of the trafficable zones became more favourable for the attackers, because:

- the *very difficult* zones were reduced, from 59.6% at the end of the spring to 42.5% at the end of the summer;
- the *good* zones increased, from 5.6% at the end of the spring to 14.9% at the end of the summer and reached a length of 7,210 m, divided into 31 zones.

Thus, it seems that, even if there was a decrease in the length of the perimeter to be defended, the tactical conditions of trafficability improved for the attackers. This was mainly due to the fact that the Italians moved the line for offence forward, reducing obstacles to trafficability.

#### 4. Conclusions

Overall, the cartographic material obtained from the AOH and the IOH was useful for spatial analysis of large parts of the front. However, they could not be used for detailed analysis of smaller areas due to their relatively small scale and poor accuracy of the information contained.<sup>25</sup> In the future, for further detailed analysis, it might be necessary to find more detailed cartographic sources.

As for the theory and methodology adopted, this paper seems to confirm that slope is one of the most significant geographical factors in determining obstacles to trafficability in mountain warfare. However, it is still the case that many other geographical factors also present obstacles to trafficability, such as snow and river valleys.

This paper provides new insight into one of the geographical aspects which were largely considered about the former political border and the TDL: the length of the lines. In particular, for the area analyzed, the decision to defend the line of the TDL, instead of the line of former political border, did not correspond to a reduction of the perimeter to be defended from a tactical point of view. Thus, from this perspective, the shorter length of the TDL cannot be considered a military advantage.

In support of this consideration, Valori (1925) wrote, "In some sectors the mountainous character of the front was accentuated to the point of making it almost impassable; therefore, except for a few passes, saddles and valleys interposed, it can be said that those sectors were virtually neutralized, and must be subtracted from the total extent of the line of actual contact between the opposing armies".

Even though the analyzed sector represents just around a third of the entire TDL, these results raise many interesting questions for further research. These questions do not just aim to extend this approach to the rest of the TDL and to the Isonzo front, where the chosen line of defence was also different from the political border, but also to clarify which aspects of geography: 1) were considered when decisions on the lines of defence's location were

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<sup>25</sup> In the note n. 19 we mentioned the cartographic error of the sources. We presume that in large part this is due to the fact that the military information in the consulted maps was obtained from consulting different preceding sources, rather than the result of a topographical survey.

made,<sup>26</sup> and 2) effectively determine a military advantage or a disadvantage (tactically, strategically and logistically).

Our analyses found that the location chosen for the TDL, even if it did not reduce the perimeter to be defended, created better tactical conditions for defence, at least from the perspective of obstacles to trafficability.

Additionally, the Italians, by moving their line of offence forward during the summer, managed to improve the obstacle to trafficability which would have affected the time and difficulty that their infantry attack would have to face. Indeed, this movement of the offensive line continued to be encouraged by the commandants during the battles which took place in the Dolomites during the autumn. Still, on 4 November 1915, General Segato, commandant of the 1<sup>st</sup> Army Corps of the 4<sup>th</sup> Army, gave instructions for a new attack against the Col di Lana, saying that it was “superfluous to repeat that not only should you always maintain contact with the enemy, but that every day you should try to gain ground, even if it is only a few meters, by using trenches or by destroying their work, especially the barbed wire, but avoiding for this purpose the use of artillery”.<sup>27</sup>

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<sup>26</sup> We already mentioned the 'Beihefte zu Streffleurs Militärblatt' (1918), which asserted that the reason why the TDL could not coincide with the political border was because it had to adapt to the terrain. Other reasons for the decision, besides the terrain, concerned the use of the already existing permanent fortification, and most likely the necessity of shortening the supply lines from the logistical bases.

<sup>27</sup> Document n. 232 (IOH, vol2bis).

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## 6. Acknowledgements

This research was made possible by funds received by the *Fondazione per l'Università e l'Alta Cultura in Provincia di Belluno* and by EX 60% Bondesan (60A05 - 4084/14 and 8555/13: Geomorphology and geomorphological mapping of alpine environments, alluvial plains and deserts in the Mediterranean Basin).

The authors want to acknowledge the library of the Geography Section of the University of Padova, the library of the *Biblioteca Universitaria of Padova*, the library of the *Circolo Unificato dell'Esercito* of Padova and Annamaria Trama of the library of the *Istituto italiano per gli studi storici* for the bibliographic and cartographic material provided; Michael B. Barret, Nicola Fontana of the *Museo storico italino della Guerra*, Michael E. Hodgson of the University of South Carolina, and Paolo Pozzato for the bibliographic material provided and the expertise shared; and Giada Peterle and Lara Thieme for helping with the translations from German and Scribendi for the editing of the English.

## 7. Attachments

G. Marinelli's slope classification		G. Marinelli's modified slope classification	
Gentle	< 10°	Gentle	< 10°
Moderate	10° - 25°	Moderate	10° - 25°
Steep	25° - 45°	Steep	25° - 37°
Cliff	> 45°	Very steep	> 37°

**Table 1** - On the left G. Marinelli's slope classification (1898), on the right the slope classification used for the analysis performed in this paper.

G. Marinelli's modified slope classification		Cost value
Gentle	< 10°	1
Moderate	10° - 25°	4
Steep	25° - 37°	16
Very steep	> 37°	No value (infinite)

**Table 2** - Cost assigned to the slope classification, in order to conduct the cost distance analysis.

Classes of conditions of trafficability	Number of separated zones	Total area (mq)	Total length (m)	% on the length of the zones of trafficable conditions	% on the length of the line	Average distance between separated zones of impassable conditions (m)
Good	2	128700	640	0,7%	0,3%	
Difficult	155	8658900	43290	47,7%	23,0%	
Very difficult	461	9376100	46880	51,6%	24,9%	
Impassable	906	19546800	97730		51,8%	208
<i>Length of the line (m)</i>			<b>188540</b>		<b>100%</b>	
<i>Length of the zones of trafficable conditions (m)</i>			<b>90810</b>	<b>100%</b>		

**Table 3** - The political border before the First World War, from the Valsugana to the Cresta Carnica.

Classes of conditions of trafficability	Number of separated zones	Total area (mq)	Total length (m)	% on the length of the zones of trafficable conditions	% on the length of the line	Average distance between separated zones of impassable conditions (m)
Good	7	270600	1350	1,4%	0,8%	
Difficult	96	7286300	36430	38,8%	22,4%	
Very difficult	472	11235900	56180	59,8%	34,6%	
Impassable	1073	13685300	68430		42,1%	151
<i>Length of the line (m)</i>			<b>162390</b>		<b>100%</b>	
<i>Length of the zones of trafficable conditions (m)</i>			<b>93960</b>	<b>100%</b>		

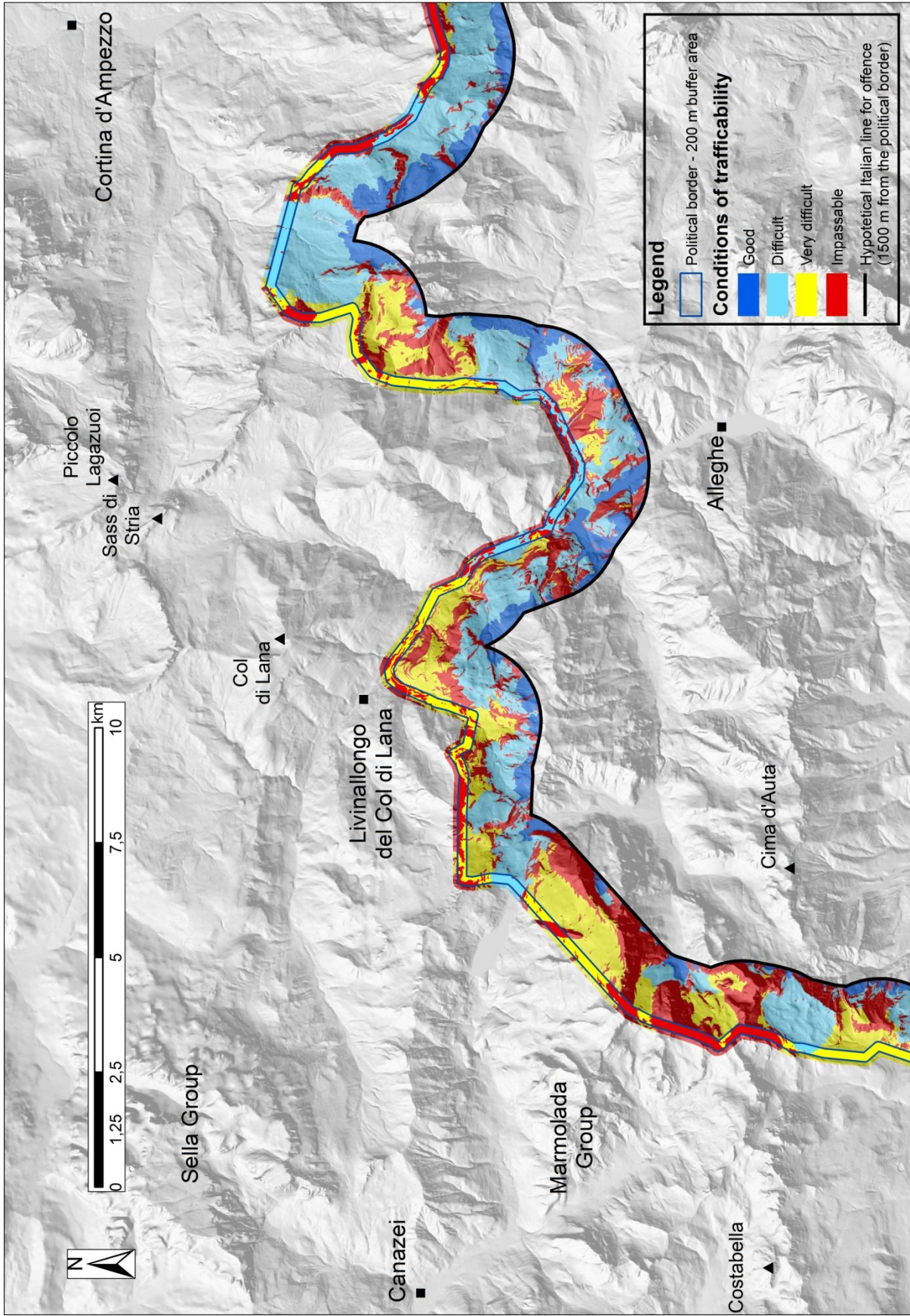
**Table 4** - The TDL, from the Valsugana to the Cresta Carnica.

Classes of conditions of trafficability	Number of separated zones	Total area (mq)	Total length (m)	% on the length of the zones of trafficable conditions	% on the length of the line	Average distance between separated zones of impassable conditions (m)
Good	8	600300	3000	5,6%	3,3%	
Difficult	70	3753100	18770	34,8%	20,7%	
Very difficult	220	6424070	32120	59,6%	35,5%	
Impassable	356	7342530	36710		40,5%	254
<i>Length of the line (m)</i>			<b>90600</b>		<b>100%</b>	
<i>Length of the zones of trafficable conditions (m)</i>			<b>53890</b>	<b>100%</b>		

**Table 5** - The trafficability conditions at the end of the spring, from Costabella to Cresta Carnica.

Classes of conditions of trafficability	Number of separated zones	Total area (mq)	Total length (m)	% on the length of the zones of trafficable conditions	% on the length of the line	Average distance between separated zones of impassable conditions (m)
Good	31	1442190	7210	14,9%	8,0%	
Difficult	106	4112600	20560	42,5%	22,9%	
Very difficult	178	4110300	20550	42,5%	22,9%	
Impassable	302	8285960	41430		46,2%	297
<i>Length of the line (m)</i>			<b>89750</b>		<b>100%</b>	
<i>Length of the zones of trafficable conditions (m)</i>			<b>48320</b>	<b>100%</b>		

**Table 6** - The trafficability conditions at the end of the summer, from Costabella to Cresta Carnica.



**Figure 2** - Excerpt of the Map of Conditions of Trafficability - Political border.

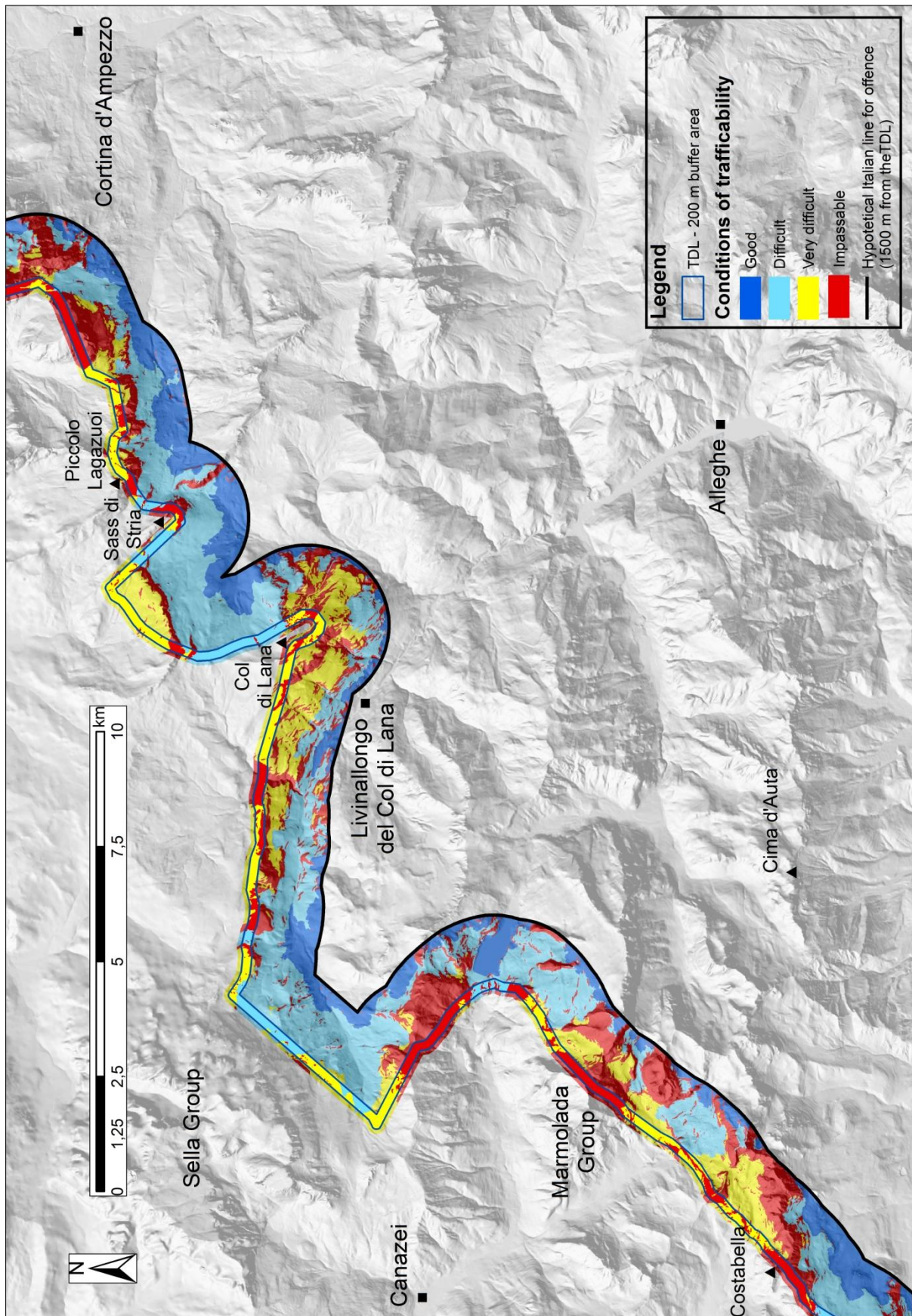
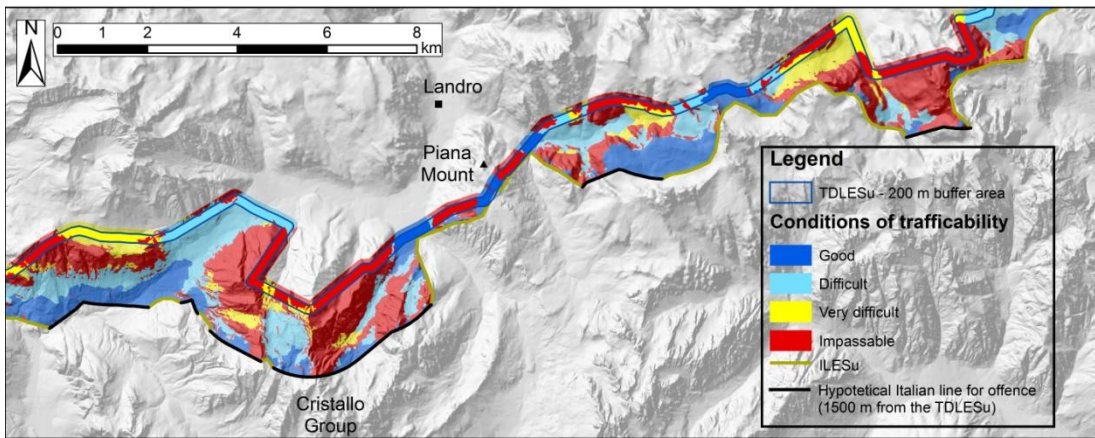
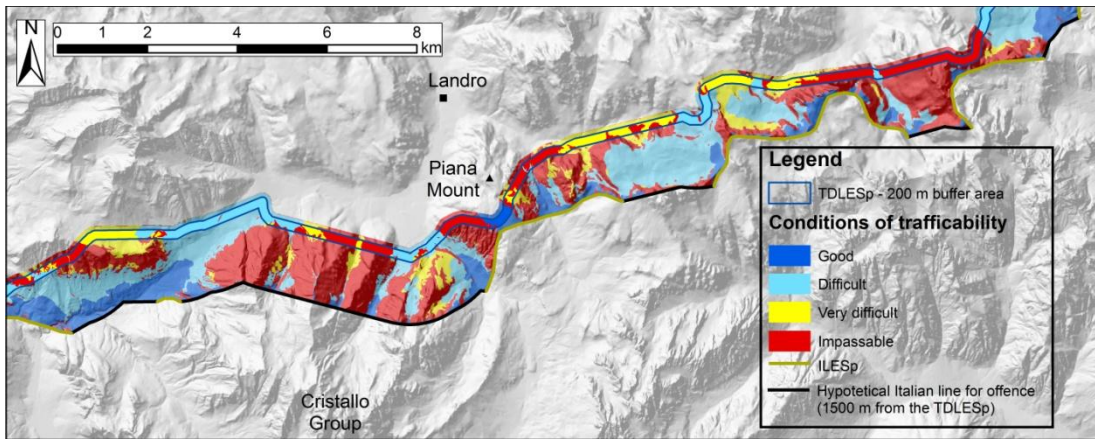


Figure 3 - Excerpt of the Map of Conditions of Trafficability - TDL





**Figure 4** - Excerpt of the Map of Conditions of Trafficability – Spring

**Figure 5** - Excerpt of the Map of Conditions of Trafficability – Summer

## CONCLUSIONS

“[...] there is an element of paramount importance in determining the operation plan that is constant in any case, that is the terrain, which determines the extent of the obstacle in the case of an offensive war, and the viability that establishes the logistical possibility to overcome this obstacle with a given force”

L. Cadorna, *La guerra alla fronte italiana*, I, pp. 23–4

The celebration of the centenary of the First World War (2014-2018) presents an opportunity for an overall reconsideration of the event that helped define the 20<sup>th</sup> century. Such an examination must include ‘the reasons of arms’ and the logics that presided over their use (Pozzato, 2015). In this context, and considering the lack of recent historiography concerned with the influence of geography on past military events, the central theme proposed by the Ph.D. scholarship represented a promising area for research.

Particularly to Italian military historiography on the First World War, the importance of examining history through a military geography approach becomes even greater, since the geography of the Italian/Austro-Hungarian theatre of war has been deemed one of the main factors that determined the conflict’s outcome.

This thesis studied the influence of geography on the Eastern Tyrol front in the First World War, particularly the geography of the Dolomites front. To reach this aim, the research produced four papers. The first paper, which considered the factors and origins of the Cadore offensive’s failure in Italian Historiography, provided the main guidelines that have been followed in the formulation of the rest of the papers. Among its outcomes, the first paper showed the necessity for a further characterization of the military value of terrain (i.e., the role it played during the offensive) and the necessity of further studies concerning its change over time and its associated assessments.

On the trail of this later and considering that precisely terrain and logistic infrastructure constitute the base of an operation plan, the second paper focused of Cadorna’s military assessments for the Cadore offensive’s geography. The analysis was restricted to a theoretical assessment, which should limit the influences of other elements of military elements. The results suggested that Cadorna’s theoretical values of the Cadore offensive’s geography are difficult to support, if are just taken into account the aspects that should be considered in theoretical assessment of geographic elements: intrinsic conditions, lying posture in the battlefield, relations with other geographical features and orientation related to military action.

This led to the hypothesis that possibly Cadorna did not fully considered the terrain element in his military assessment. This hypothesis, also asserted by Rochat (Isnenghi and Rochat, 2008), could be considered when regarding tactics and logistics; Botti (1991) considered logistics perhaps the weakest and less realistic side of Cadorna’s operational design. Cardona

may have favoured an strategic point of view and focused on other elements with military influence

Following the first paper's outcomes, the third and the four papers aimed to achieve a better characterization of the military value of the terrain element through an empirical analysis of physical geography and its influence on military operations.

The third paper studied the influence of geomorphology on the Cadore offensive. To reach this purpose, a geomorphological and a military history map were made for four of the most important areas in the Dolomites front. In particular, the steep and high valleys' sides, part of the unique geomorphology of the Dolomites, determined unassailable positions from where the defenders, with protected and sometime relatively accessible rear lines, precluded the use of the valley, due to the visual control and the use of crossfire. From that point of view, topography, as the result of the particular morphogenetic processes which took place in the region, can be considered as one of the main geographical aspects that controlled the development and the outcomes of battles in the Dolomites front.

The fourth paper focused on the trafficability of the terrain in Eastern Tyrol, where the Italian attack was launched, or should have been launched. It provided a characterization of the obstacle to trafficability, one of the most important properties through which terrain influence on war in mountainous countries (Clausewitz, 1832). Its results led to a new insight into one of the geographical aspects which were largely considered about the line of the former political border and the Tyrol Defence Line (TDL): the length of the lines. In fact, for the analyzed area, the results demonstrated that the decision to defend the line of the TDL, instead of the line of former political border, did not correspond to a reduction of the perimeter to be defended. Thus, from this perspective, the shorter length of the TDL cannot be considered a military advantage.

Finally, the conducted research backed up the premises upon which it was based. Examining history through a military geography approach allowed for addressing some themes never before considered, such as the theoretical assessments at the base of Cadorna's planning, and raised other themes for discussion, such as the reduction of the front that ensued the voluntary withdrawal of the Austro-Hungarians from the marginal territories of Tyrol. The research results provided a broad overview of the geography's significance, particularly on the Dolomites front. Indeed, the research considered the theoretical and empirical points of view, the tactical and strategic points of view, and the local and regional points of view. The original methodologies adopted proved to be a useful complement to military history studies. In particular, the GIS methodology provided valuable support for an integrated analysis between spatial and temporal dimensions.

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## ACKNOWLEDGEMENTS

First, I have to acknowledge the Foundation for University and High Culture in the Province of Belluno for the PhD scholarship and Professor Aldino Bondesan, who made possible this opportunity.

Secondly, I would like to thank the Department of Historical Geographical and Antiquity Sciences at the University of Padova. In particular, I want to express deep gratitude to the Geography Section (ex-Department of Geography 'G. Morandini'). The personal relationships which were built during these years, and the acknowledgment I received for myself and my work from many persons whom I highly esteem in this section, marked my life.

Outside the Geography Section, I also owe acknowledgements to Professor Del Negro and Professor Pozzato for their expertise and the material they shared with me; Professor Hodgson, for the expertise and encouragement provided; General Pino, for his genuine helpfulness and for the material he shared with me; Professor Sarcoli, for her patience and teaching; and Professor Shea, for his very important teachings and for encouraging me. Also, special thanks to Professor and Brigadier General Barrett, who from the beginning and then through the years demonstrated a great helpfulness, provided useful expertise and, most of all, was encouraging.

For the corrections in English, I have to acknowledge Scribendi© and A. Baldi, G. Curello, D. Reghelin, M. Petit and Professor Sours.

Last but not for least, thanks to the '2001 Padova Master Swimming Team'; swimming was essential. In particular, their trainers M. Zuin and E. Fabrizio and the 'line 6'; thanks for putting up with me.

Of course, thanks to my family and my friends.



