Summary of the master's degree thesis in Applied Geology by: **Camilla Cappelletti**

ACCURATE GEOMORPHOLOGICAL MAPPING AND PEDOLOGICAL SURVEY OF THE STOLEMBERG PERIGLACIAL HIGHPLAIN (MONTE ROSA) FOR THE RECONSTRUCTION OF ITS ENVIRONMENTAL EVOLUTION

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INTRODUCTION

Object of the thesis is the geomorphological analysis of periglacial landforms and processes within an anthropized area of high mountain and the subsequent interpretation of their distribution and change over time, in relation to the alpine regional morpho-geodynamic context. The surveyed area is located on the border between Valsesia (Piemonte Region) and Gressoney Valley (Valle d'Aosta Autonomous Region) at the base of the southern slope of Monte Rosa (Western Alps), at an altitude of about 3100 meters

In the area a study of extreme detail (about 20,000 square meters) was carried out on the Stolemberg plateau at an altitude of about 3100. This place represents an "atelier" of landforms and deposits of different origins, in which the holocenic glacial heritage expressed in many ways (mountain bumps, striated rocks ...) has undergone significant changes in the post-glacial period; in permafrost, in particular, numerous cryotic processes have been generated which have contributed to the substantial remodeling of this high-altitude sector of the Alpine landscape. The alternation of different climatic conditions starting from the Pleistocene, and in particular the recent climatic warming, are the main responsible for these transformations

METHOD

A multidisciplinary approach has been suggested to obtain the prefixed objectives: a) detailed geomorphological field-survey (traditional and digital, supported by geoSITlab-UniTO laboratory); b) drone photogrammetry (in collaboration with the IMAGEO spin-off company); c) pedological survey (in collaboration with the DiSAFA-UniTO department).

In the survey phase, particular attention was paid to the identification of the geomorphological evidence deriving from the cryotic remodeling of deposits (mesoforms and microforms), in order to obtain useful indications concerning the distribution of periglacial processes in the area investigated. We also proceeded to the detection of the different morphostructural linear elements (fractures in the substrate, possible fault systems, etc.) and of the structures linked to the action of gravity (trenches, sliding niches, etc.), with the purpose of relating location, direction of flow and type of periglacial features with the activation of tectonic-gravitative movements succeeded over time. A description of all the forms and deposits observed during the surveys was then made, explaining the illustrative notes in the cartography produced.

DATA COLLECTION AND PROCESSING

The implementation of a work approach of this kind was fundamental in order to correctly set the data collection and their final interpretation; already from the conceptual analysis, in fact, it has been realized that the glacial and periglacial processes controlled by the climate could develop in dynamic interaction not only with the litho-structural and tectonic structure but also with the gravitational movements of the slope. This could explain the geodiversity of forms and, above all, of horizons of soils of the Stolemberg Plain, apparently richer than the previous cognitive framework.

Through an analysis of historical data and literature, recent spatio-temporal variations of the glacial masses of the southern slope of Monte Rosa have been outlined and subsequently the geomorphological structure of the investigated area has been analyzed in extreme detail. The description of the forms and deposits observed during the survey work was presented in the form of explaning notes to the 1:500 geomorphological map, realized with the support of geomatic tools and methodologies (drone photogrammetry, GIS). The climate classification of the area, the literature data and the evidence of the geomorphological survey indicate that, similarly to what is found in the Alpine context, the study area has been characterized by a progressive and significant areal and volumetric decrease in the glacial masses and that different morphogenetic processes have then affected the sectors freed from these. This made it possible to distinguish in the Stolemberg Plain and in the facing areas: sectors currently undergoing deglaciation (paraglacial environment) and non-glacial sectors for several centuries / millennia in which frost action prevails (periglacial environment).

The Stolemberg Plain is an example of a periglacial environment containing relict glacial forms. In particular, it is modeled by successive phases of pulsation, stasis and retreat of the Bors Glacier. Evidences of this phenomenon are the striated rocks detected in the south-eastern portion of the area, as well as the prevalence of undifferentiated till within the area. Their altimetric and planimetric distribution allows us to hypothesize that the original glacier extended continually up to the Foric Pass (2432 m), modeling the scarps that delimited the terminal glacial tongue in the rocky substratum.

The glacial modeling, however, has interacted with the structural-tectonic arrangement of the area; in fact, the original glacial modeling surface is delimited in the eastern portion by a sub-vertical slope with orientation about NW-SE and intensely fractured outcropping substrate. At the edge of this slope and parallel to it, an intensely deformed area develops due to gravitational phenomena. Seven steps with NW-SE orientation were found similarly to the numerous fractures identified in the outcropping rocky substrate: about 135, distinct between closed and open, whose orientation varies, in fact, between NE-SW and NW-SE. Moreover, the same rocky substrate turns out to be:

- loose: 17 outcrops

- disjointed: 39 outcrops

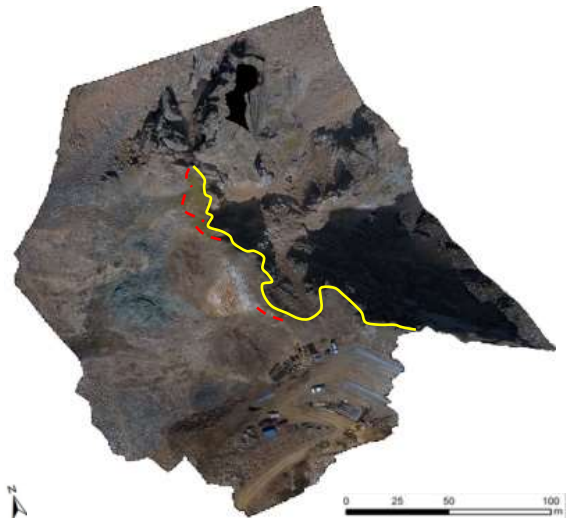

Figure 1. Orthophotos in which are visible the ever-changing escarpment (yellow line) and some of the main steps (red hatch) near the this one

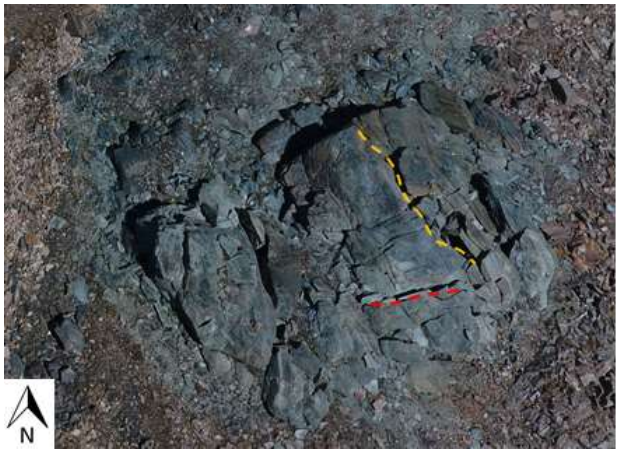

Figure 2: Outcrop of metabasite in which are visible the two fracture families: NW-SE (yellow hatch) and NE-SW (red hatch) (nadiral image by IMAGEO S.r.l) (coord. 412035.9, 5081194.5)

INTERPRETATIONS

The data collected led to the conclusion that the Stolemberg Plain is undergoing a slow but constant deep gravitational deformation, with the activation of overturning phenomena at the slope described above. The progressive opening of the fractures which involves the rocky substratum leads to the formation of isolated rocky wedges which can then easily undergo tipping over time. The same steps analyzed can represent, at the macroscale, some areas of probable gravitational collapse.

After the gradual contraction of the glaciers and the activation of tectonic-gravitative phenomena which profoundly altered the geomorphological structure of the plateau, the large amounts of glacial deposits were affected by cryotic processes and the establishment of permafrost, as evidenced by the distribution of the periglacial forms indicated in the geomorphological mapping cretaed in this work. This means that the glacial, periglacial and tectonic-gravitative environment are closely related here. The interactions are such that the genesis or evolution of a form can be linked to the coexistence of the three environments mentioned above. A good example is the blockstream orientations completely coinciding with the fracturing of the substrate described above:

- NW-SE: 4 blockstream

-NE-SW 19 blockstream

It is therefore clear that the transition from a glacial to periglacial environment, in interaction with the tectonic-structural structure of the area, is also reflected in the geomorphological dynamics of the detected area. This evolution is an example of space / time overlap, able to condition and define the structure of the areas of recent deglaciation.

Figure 3. Soli-gelifluction lobe located in the ivestigated area, with a linear extension of about 3 meters (coord.: 412032.6, 5081210.7)

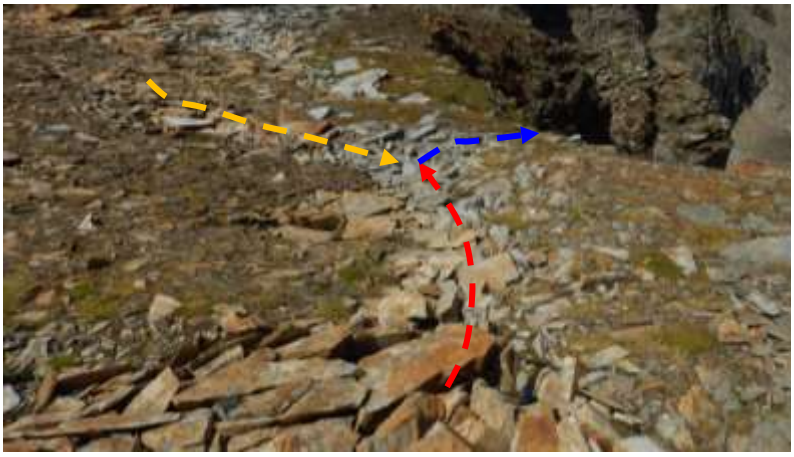

Figure 4. Two blockstream which, in NW-SE direction (yellow) and SE-NW (red) converge into a single flow (blue) which branches off towards the main escarpment (coord. 412035.9, 5081194.5)

The pedological classification carried out (through the creation of profiles and samplings), allowed an analysis on the interaction between the periglacial forms described above and the genesis-development of deep pedogenetic horizons. From the literature it emerges clearly that the relationship superficial patterned ground - underlying soil is, in fact, a fundamental factor since the spatial arrangement of fine particles and clasts on the surface creates a strong small-scale variability in the distribution of soil properties.

In general, in mountain areas at mid-latitudes, a reduced water content and few active cryoturbed soils are reported, probably due to a deep active layer (1-8 meters) (BOCKHEIM et al., 2014). In contrast to this observation, in the detected area the huge availability of water (coming, in particular, from snow fusion and precipitations) permits the formation of ice lenses during the cold season and this is evidenced by the numerous periglacial forms detected.

On the basis of these observations, the thesis focused on the ways in which frost action and the consequent genesis of periglacial features have influenced the chemical-physical properties of the investigated soils.

The presence of ice in the ground is first of all highlighted by silt caps located in all ground horizons. The latter, as already described above, can in fact be generated by pressure phenomena induced by the growth of ice lenses and / or by the bidirectional seasonal freezing of the active layer (UGOLINI et al., 2006).

As a conclusion, the geomorphological and pedological investigations of extreme detail supported by the application of geomatic methodologies, proved to be a useful tool for interpreting the evolution of the Stolemberg Highplain. The glacial and periglacial processes, controlled by the climatic factor and developed in dynamic interaction with the lito-structural arrangement of the investigated area, have generated a geodiversity of forms and, above all, of pedological horizons richer and more varied than the. previous cognitive knowledge. Now, it is important to understand that this is a relevant geoheritage to be protected, being in a moment of great vulnerability due to present-day increased human impact and rapid climate change within the Alps.

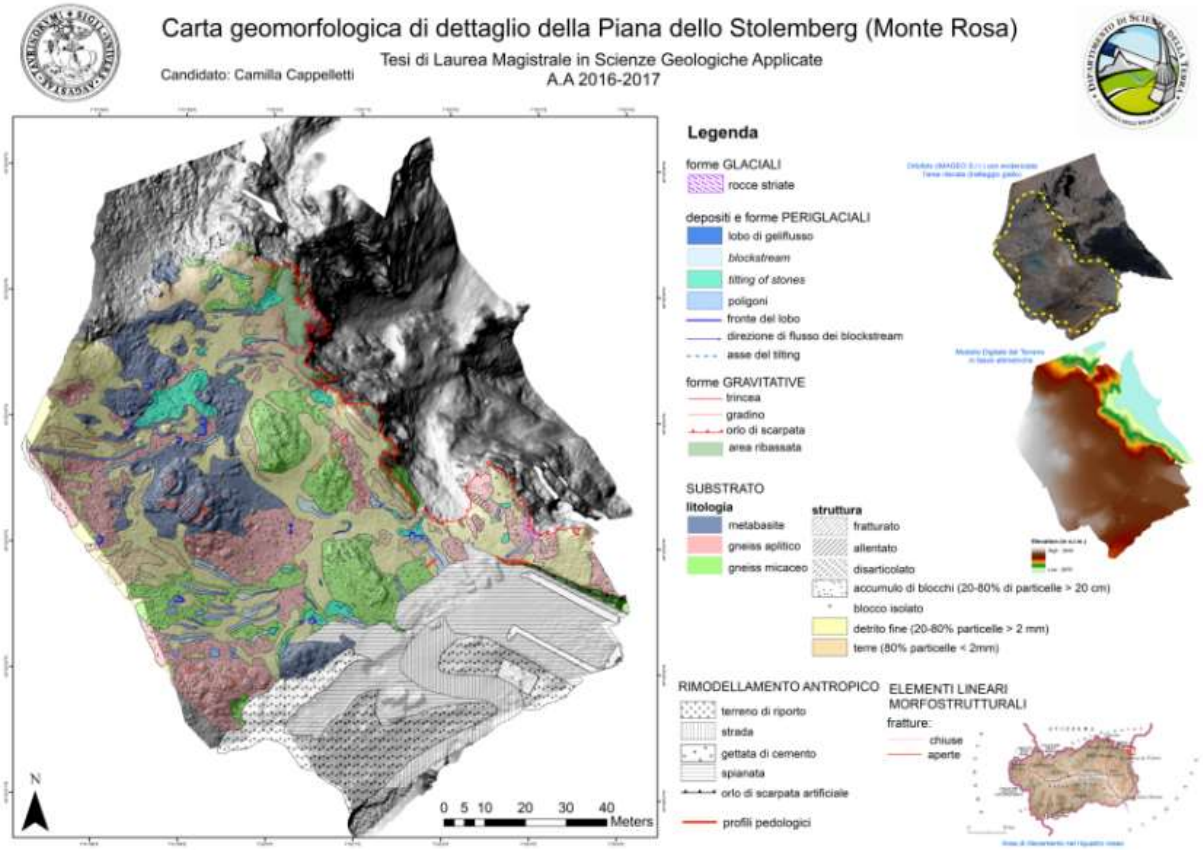

Figura 5. Geomorphological map realised during this work

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