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Permafrost conditions in the Mediterranean region since the Last Glaciation

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Abstract

Quaternary climate variability has conditioned the spatial distribution of glacial and periglacial processes in the Mediterranean region, and therefore the area under permafrost conditions. In this paper, we examine the evolution of permafrost regime in the Mediterranean basin since the Last Glaciation until nowadays. Glacial stages favoured the expansion of glaciers in mountain ranges and periglacial processes and permafrost at lower elevations. The temperature increase recorded during interglacial phases - such as the Holocene - conditioned the disappearance or substantial retreat of glaciers and the migration of permafrost and periglacial processes to higher elevations.

Keywords: Mediterranean region, permafrost, Last Glacial Maximum, deglaciation, Holocene.

Introduction

Present and past distribution of cold-climate geomorphological processes in the Mediterranean region is largely conditioned by the rough orography and wide spectrum of microclimatic conditions prevailing in the region. Both glacial and periglacial processes since the Last Glaciation have been almost exclusively restricted in mountain environments, as well as permafrost conditions. Here, we examine permafrost conditions in the Mediterranean region taking into account five periods: Last Glaciation, deglaciation, Holocene, Little Ice Age (LIA) and present-day.

Results and discussion

The distribution of currently inactive permafrost-derived landforms and sedimentary records indicates that the lower limit of permafrost during the Last Glaciation was ca. 1000 m lower than present (Oliva et al., 2016). Permafrost was also widespread in non-glaciated slopes above the snowline forming rock glaciers and block streams, as well as in relatively flat summit areas where meter-sized stone circles developed (Fig.1). As in most areas of the Northern Hemisphere, the deglaciation in the Mediterranean region started ca. 19-20 ka (Hughes, & Woodward, 2016). The exposed terrain by retreating glaciers was affected by paraglacial dynamics and intense periglacial processes, mostly associated with permafrost conditions. Many rock glaciers, protalus lobes and block streams formed in

these recently deglaciated environments, becoming gradually inactive as temperatures rose during the Bølling-Allerød. Following the Younger Dryas glacial advance, the last major deglaciation in Mediterranean mountains took place during the Early Holocene together with a progressive shift of the periglacial belt to higher elevations (Oliva et al., 2016).

It is unlikely that widespread permafrost has existed in Mediterranean mountains during the Holocene, except sporadically in the highest massifs exceeding 2500-3000 m. The colder climate prevailing during the LIA favoured a minor glacial advance and the spatial expansion of permafrost, with the development of new protalus lobes and rock glaciers in the highest massifs. Finally, the marked warming that has occurred since the second half of the 20th century has led to glacial retreat and/or complete melting, increased paraglacial activity, migration of periglacial processes to the highest areas and degradation of alpine permafrost along with geoecological changes.

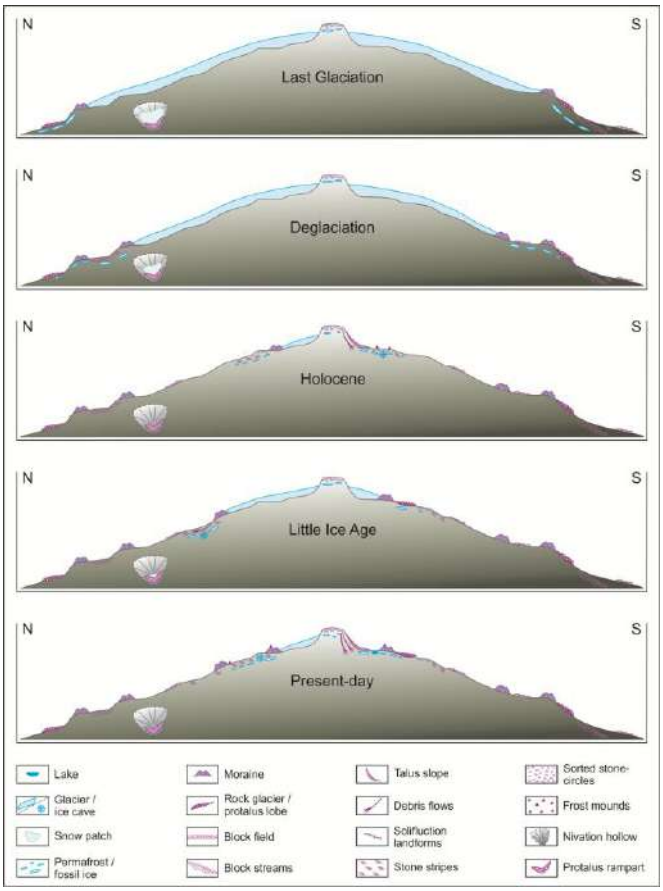

Figure 1. Geomorphological sketch of the formation of different generations of permafrost-related features in Mediterranean mountains since the Last Glaciation.

Conclusions

Today, cold-climate geomorphological processes in the Mediterranean region are restricted to the highest mountain environments. However, climate conditions prevailing during the Late Pleistocene and Holocene have conditioned significant spatio-temporal variations of the glacial and periglacial domain in these mountains, including permafrost.

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