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I ROCK GLACIER TARDO-PLEISTOCENICI ED OLOCENI DELL'APPENNINO - ETÀ, DISTRIBUZIONE, SIGNIFICATO PALEOCLIMATICO

C. Giraudi
ENEA, CR Casaccia, C.P. 2400, 00100 ROMA A.D.

RIASSUNTO - Sugli Appennini sono stati individuati circa 40 rock glacier, tutti contemporanei o posteriori all'ultimo massimo glaciale. Essi si sono sviluppati in cinque diverse fasi, l'ultima delle quali databile tra circa 3000 e 780±40 anni BP; i rock glacier presenti alle quote inferiori si sono formati nel corso dell'ultimo massimo glaciale (LGM), ma il loro maggiore sviluppo ebbe luogo nelle fasi tardiglaciali.
I rock glacier si rinvengono maggiormente su quei massicci caratterizzati, durante l'LGM, da limite delle nevi (ELA) non molto basso: l'intero Appennino Settentrionale ed i massicci che avevano un ELA basso, e che attualmente sono soggetti a precipitazioni molto più elevate, ne sono risultati privi.
Inoltre i rock glacier si sviluppavano per lo più nel corso delle fasi climatiche aride o non molto umide.
Dalla distribuzione areale dei rock glacier si deduce che, durante le fasi finali dell'LGM, nel tardiglaciale e nell'Olocene iniziale, c'è stata, oltre che una migrazione verticale, anche uno spostamento verso Nord del limite della loro area di distribuzione: quindi il limite del permafrost discontinuo montano è passato da 39°55'N a 41°45'N e poi a 42°07'N. In seguito ci fu soltanto una migrazione verticale, in quanto nel tardo olocene i rock glacier hanno potuto svilupparsi solo sulle parti sommitali dei due massicci più elevati.

ABSTRACT - The Late Pleistocene and Holocene Apennine rock glaciers (Italy) – age, distribution and palaeoclimatic significance.
Rock glaciers have been found in the Gran Sasso, Greco, Maiella and Velino Massifs and in the Breccioso, Terminillo and Pollino Mounts. The Apennine rock glaciers are inactive, with the exception, perhaps, of a very small rock glacier, which might be active.
The Northern Apennines (Fig. 1) consist of ranges up to 2165 m in height, and are formed mainly by sandstones and arenaceous marls.
During the Last Glacial Maximum (LGM) and its retreat phases, in the Northern Apennines many glaciers existed: the end moraines of such glaciers have been found up to about 700 m a.s.l. The studies show that during the Last Glacial Maximum the equilibrium line altitude (ELA) was between 1300 and 1550 m. No rock glaciers are reported in bibliography. Photogeological and field researches, also, have not led to any results. According to current data, in the Northern Apennines, rock glaciers are lacking.
The highest Central Apennine Massifs (Fig. 1) consist mainly of Mesozoic and Cenozoic carbonatic rocks. In this part of the chain lie the highest massifs of the whole Apennines (Gran Sasso, 2912 m; Maiella, 2793 m; Velino 2486 m; Sibillini, 2476 m).
In the Central Apennines considerable glacial remnants are preserved, and, in particular, the features and deposits dated to the LGM and its retreat phases. The ELA during LGM was between 1500 and 1700 m, in the western portion (Fig. 1), and between 1600 and 2100 m in the central and eastern area.
The majority of the rock glaciers so far mentioned in literature are in the Central Apennines. Photogeological and field surveys have shown, however, that in the western portion of this part of the chain there are no rock glaciers, even in mountain areas higher than 2000 m. In the central and eastern parts, the rock glaciers are found above a minimum height of 1570 m, up to approximately 2550 m. All the rock glaciers have been found in places glaciated during the LGM, namely, mostly in valleys and on slopes facing NW, N and NE. The rock glaciers developed on glacial drift, and they often deform moraine ridges located on the threshold of the cirques.
The rock glaciers least weathered and covered by scanty vegetation, looking younger, develop instead on slope waste deposits. The largest rock glaciers have been found in the Maiella and Velino massifs and are about 1 km long.
The highest peaks of the Southern Apennines are Mt. Pollino (2267 m) and Mt. Sirino (2005 m). They show clear traces of glaciers dating from the LGM and their retreat phases. During the LGM, on Mt. Pollino (latitude 39°55') the equilibrium line altitude was 1800 m, while on M. Sirino it was 1600 m. Only one rock glacier has been found on Mt. Pollino. It overlies the moraine of the early phases of glacial retreat, about 1750 m a.s.l; it is older than the stadial moraine covered by loess dated 15-16,000 years BP, present also in Central Italy.
The majority of the rock glaciers were formed between 20,000 and 10,000 years BP, when the mean yearly temperatures were still 4 – 6 °C lower than the present ones; however, their geographic distribution gives rise to some important considerations.
In the Northern Apennines, (latitude above 44°N) there are no rock glaciers, while there are some at more southerly latitudes (about 40°N), in mountains of similar elevation. The ELA during the LGM reached definitely lower altitudes (1300-1550 m) than in the Central and Southern Apennines (1500-2100 m); the absence of rock glaciers thus, cannot be due to the temperature, but to the different amount of precipitation.
Even now, the highest areas of the Northern Apennines receive precipitation of between 1500 and 2000 mm/year: the values are far higher than those of the central-southern part of the chain. It is to be assumed that the lack of rock glaciers was caused by the abundant snow precipitation which insulated the ground against frost penetration, and not by temperature differences.
In the Apennine chain, about 40 rock glaciers dated to the last 20,000 years have been identified. They developed in five phases, the last one between 3000 and 780±40 years BP; the rock glaciers found at lower height were formed during the LGM, but the majority formed during the Late Glacial phases.
Rock glaciers have been found mainly on massifs with a higher ELA-LGM and a present lower precipitation rate; in the whole Northern Apennines and on the massifs with a lower ELA (currently having a higher precipitation rate) rock glaciers are lacking. Moreover, the rock glaciers developed mainly during the dryer periods or in places where precipitation were not very great.
The geographical distribution of the rock glaciers, corresponding to the boundary of the areas with mountain permafrost, suggests that, during the final phases of the LGM period, in the Late Glacial and in the early Holocene, there was also an altitude and latitude shift with a reduction of this boundary, following the temperature increase. From the altitude of 1570/1600 m, the boundary of discontinuous mountain permafrost rose to 2300/2500 m during the late Holocene, and it is now even higher. About the time of the latitude shift, the boundary migrated northwards, from 39°55'N to 41°45'N and later to 42°07'N.

Parole chiave: rock glacier, Appennino, Ultimo Massimo Glaciale, Olocene, paleoclima.
Key words: rock glacier, Apennine, Last Glacial Maximum, Holocene, paleoclimate.