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MARTA PAPPALARDO (*)

REMARKS UPON THE PRESENT-DAY CONDITION OF THE GLACIERS IN THE ITALIAN MARITIME ALPS

ABSTRACT: PAPPALARDO M., *Remarks upon the present-day condition of the glaciers in the Italian Maritime Alps.* (IT ISSN 0391-9838, 1999).

The six remaining glaciers of the Italian Maritime Alps have today more characteristics in common with those present in the Apennine and in the Hyberian Mountain Chains than those typically alpine. In spite of their limited extension, they have attracted the interest of observers since the end of the past century. Reports of their observation and data obtained from their monitoring are then available in great amount although not recorded with continuity. During the last ten years new studies upon them have been undertaken, and their present-day conditions are rather well known. The intention of this note is mainly to demonstrate the necessity to orient the studies on these glaciers towards the survey of the processes occurring by their forefield. Investigating the transition from the influence of glacial to that of periglacial environment in this particular part of the glacier basin permits to better understand the model according to which extinction takes place.

RIASSUNTO: PAPPALARDO M., *Considerazioni sullo stato attuale dei ghiacciai nelle Alpi Marittime Italiane.* (IT ISSN 0391-9838, 1999).

I sei ghiacciai ancora presenti nelle Alpi Marittime Italiane hanno oggi più caratteristiche in comune con quelli presenti in Appennino e nelle catene montuose iberiche che con quelli tipicamente alpini. Nonostante la loro limitata estensione essi hanno attratto l'attenzione degli osservatori sin dalla fine dello scorso secolo. I resoconti delle osservazioni ed i dati di oscillazione frontale, sebbene non sempre continui, costituiscono una messe di informazioni disponibili. Durante gli ultimi dieci anni sono nuovamente fioriti gli studi su questi corpi glaciali, e la loro condizione attuale è piuttosto ben documentata. Questa nota si propone di dimostrare la necessità di orientare gli studi sui ghiacciai in questione verso un'analisi dei processi che agiscono in prossimità delle fronti. Studiare la transizione dall'agente glaciale a quello periglaciale in questo particolare tratto del bacino permette di comprendere il meccanismo secondo il quale questi ghiacciai si estinguono.

(*) *Dipartimento di Scienze della Terra, Università di Pisa, via S. Maria 53, 56126 Pisa.*

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HISTORICAL RECORDS

Within the data collected on glacialism in the Italian Alps from the end of the Little Ice Age to the present day those concerning the Maritime Alps apparently have a marginal importance, because of the poor extension that glaciers had in this sector of the Alpine Chain in their most recent phase of expansion.

In spite of this they have been the object of observations and investigations since the end of the last century as well as of regular scientific surveys from 1911, first on behalf of the «Commissione del CAI per lo studio dei ghiacciai» and later of the «Comitato Glaciologico Italiano». The amount of data available about their evolution shows the interest this topic has caught during the past century.

The five main ice bodies present in the Maritime Alps were first measured by Mader in 1896 (Mader, 1896). He reported their area, maximum length and width and maximum and minimum elevation, together with the average dip of the basins. These data can be considered rather reliable, if compared with the estimates that can be made of the maximum extension of the bodies during the Little Ice Age according to the location of the related moraines. They were surveyed in a period of scarce yearly rainfall, so that the main problem observers have ever had to cope with in this area, i.e. sheltering of the snouts by snow persisting late in the Summer, could be overcome. This is due to the occurrence of heavy snowfalls during Spring, that have affected the observations in recent years but are often reported for the past century.

Since 1911 these glaciers have been visited by Roccati (1912-1925), who gave an important contribution to the definition of the characteristics of the main ice bodies, and started their topographical mapping; he never succeded in obtaining continuous data of frontal fluctuations. His work was efficiently carried on by Camoletto (1928-1943), who completed the topographical surveys and reported yearly

oscillations of snouts for over ten years without interruption. He tried as well to relate these data with the climatic record available.

During World War II and in the years that immediately followed it observations and measurements, although scattered, continued, so that a marked phase of ice retreat was documented. In the 50s and 60s systematic glacier survey was carried on by the Comitato Glaciologico operator Piero Rachetto, so that a continuous set of fluctuation measurements is available for this period. Afterwards, unfortunately, observations were interrupted if we except a few reports (Chiadò, 1975, 1979, 1981; Peretti & Tirone, 1986; Peretti, 1987). This gap occurs soon after the publication of the inventory of the Italian glaciers, the «Catasto dei Ghiacciai Italiani» (Comitato Glaciologico Italiano - CNR, 1959-62), which contains poorly reliable data about the glaciers of the Maritime Alps.

Since 1989 new surveys have been yearly made by a new operator of the the Comitato Glaciologico Italiano, Alessandro Viotti, who tried to establish again continuous monitoring of frontal fluctuations by means of new signals. The amount of data and the rich photographic documentation collected in these last ten years, mainly unpublished, themselves justify the effort made and by the Comitato Glaciologico Italiano to start again surveying this sector of the Alps that had been completely abandoned.

Meanwhile researches concerning the surviving glaciers in the Maritime Alps had a new impulse. A long term scientific research about glacial morphology in this area started by the end of the 80s (Federici & Pappalardo, 1991). Within this work Rapetti & Vittorini (1992) tried to estabilish a relationship between some aspects of climate in the area and the presence of the small glaciers in the Maritime Alps. They highlighted on one hand a recent decrease of the yearly snowfall amount and on the other a limited decrease of temperatures in Spring and Summer. These two factors are playing a contrasting role on the persistence of the ice bodies. From their data an interesting change in the precipitations seasonality can be inferred as well: during the 80s in fact the maximum of rainfall was experienced in springtime whereas in the past it occurred in Winter.

In 1994 the results of the studies undertaken in the Italian Maritime Alps by some English researchers were published (Gellatly & *alii*, 1994). The work was supported by the European Community and the fieldwork, which took place during 1990 and 1992 Summers permitted to complete the topographical mapping of three of the six still existing glaciers and to collect an amount of data about the position of the snouts terminations. The synthesis presented is not completely representative of the amount of work that has been done. The topographic mappings could have been presented in a more legible form, with reference to the topography of the surrounding area, and the sketches of the three Gelas Glaciers cannot be georeferentiated in order to locate them precisely on the existing topographical map or to compare them with those done in the past. Unfortunately some confusion is made by the Authors with the names of the glaciers, so that it is not easy for the reader to compare the record presented with the reports of the past, unless he has a deep knowledge of the places and of the related literature. Historical data have been collected very carefully but the criteria used for their selection are not clear.

In 1995 some of the results of the researches about the glaciers of the Maritime Alps carried on with the behalf of the Comitato Glaciologico Italiano since the end of the 80s were presented (Federici & Pappalardo, 1995). The work offers a detailed synthesis of the frontal fluctuations and changes in extension that have affected these ice bodies, relating them to the morphological context (particularly with the morphometrical parameters of cirques) and to the climatic record. Historical data were carefully selected and different degrees of confidence were attributed to the observers. The limit of this paper is, like the one cited before, its synthetic character. A detailed description of the precise condition of the remaining ice bodies and an analysis of their single time-distance curves is still missing.

TOWARDS EXTINCTION

The six main glaciers of the Maritime Alps had been estimated by Mader to be those in the Clapier-Maledia-Gelas group (tab. 1). At the beginning of this century many other, less extended ice bodies were observed in this part of the Alps (a complete list is in Sacco, 1912)and some of them, such as the Lourousa or the De Cessole Glaciers have not completely melt out still today. The six ones described by Mader, though have been, since the end of the Little Ice Age, and are still the most extended, although some of them have now reached a dimension lower than 6 ha, a value which is conventionally considered by the Comitato Glaciologico Italiano as a limit value to distinguish between a glacier and a glacieret.

TABLE 1 - Extensions of the main glaciers of the Maritime Alps in 1896 and in 1992

Name Roccati, 1912	Extension in 1896 Mader, 1896	Extension in 1992 Gellatly & *alii*, 1994
Clapier	35	6.2
Peirabroc	17.5	8.6
Maledia	26	2.4
Gelas E	26.5	3.3
Gelas NE	13	5.25
Gelas N	—	4.8

The Comitato Glaciologico surveys have concerned during the last decade the Clapier, Maledia and Peirabroc Glaciers; the Northeastern Gelas Glacier, instead, has been visited again since 1995. The most recent frontal fluctuations recorded, though, might be not really indicative of a true movement of the ice masses. Among the many observations that can be read in one century's surveys reports particularly meaningful is the remark Roccati made in 1912. He considered that five of the six glaciers listed in tab. 1 (excepted the Maledia Glacier) show marked irregu-

larities in their long profile, corresponding to sharp increases in the steepness of the rock basement. In connection with such features during Summertime ice appears also in those years when snow-banks persist hiding most of the glacier surface. This type of bedrock morphology greatly conditions the features of these glaciers, as it is exemplified by the case of the Eastern Gelas Glacier which in 1929 appeared in its medium-low part divided into two tongues, as the thinning of its body caused the emergence of a huge rock divide in the middle of the basin (Camoletto, 1930). Such irregularities in the long profile are typical morphostructural features of the Maritime Alps slopes and they have been carefully investigated (Ribolini, 1997); from a glaciological point of view their presence is important as they tend to separate the ice body into two parts as the ice thickness decreases, the lower of which becomes inactive.

The case of the Clapier Glacier is the best documented one. This ice body at the end of the past century consisted of two branches, flowing together little above its snout, which was located at an altitude of 2550 m. The minor branch gradually melt out and the remaining part was divided into two portions, an upper and a lower one that could be distinguished already in the 30s and were separated by a steep step in the bedrock at about 2625 m. Camoletto (1931) clearly understood that the lower part, he observed covered with debris, had become inactive (fig. 1). The separation between the two portions went on during the years: the upper one retreated and in the lower the mixture of ice and debris (more and more rich in debris), got a plastic behaviour and formed the typical flow structures that can be observed today. The mobility of this ice cored debris confused the observers that surveyed this glacier after Camoletto and they estimated the position of the glacier snout to be lower than the actual position. According to the Catasto dei Ghiacciai Italiani the Clapier reached in 1958 the minimum altitude of 2586 m, Chiadò (1978) locates the snout at 2550 m and Viotti (1989) at 2615. Viotti himself during the next years' surveys (accompanied by myself) realised that a big boulder located at 2580 m was moving independently from the glacier snout. At present the glacier descends only to 2660 m, as was mapped in the 1992 survey. I think that the exact location of the tongue delimited by Gellatly & *alii* (1994) was probably an indispensable simplification. It would be worth to investigate the physical limit between purely glacial processes occurring by the snout of the glacier and those typically periglacial affecting the forefield, in order to understand if a separation belt exists or if the transition between one process and the other is gradual.

The Gelas Glaciers seem to be following the same evolution model, and permafrost creeping occurs in the debris mantling the slope from the present-day position of their snout, located at about 2850 m, downwards for a few hundred of meters. The Peirabroc Glacier, for which the most complete set of frontal fluctuation data is available, terminates according to Viotti (1989) and to Gellatly & *alii* (1994) at 2440 m. Although I have always seen the snout of this glacier sheltered by snow patches even late in Summer I think it would be worth checking out more carefully its true position, as the termination might be above the stated point and the ice visible in the lower part not linked to the main body. The Peirabroc is among the glaciers considered here the one that has shown the least significant tendency to recession, but a retreat from 2475 to 2440 in almost one century seems too limited compared with the rates of the others; the Catasto dei Ghiacciai Italiani reports for this glacier a minimum elevation of 2584 m.

The survey of the Maritime Alps glaciers, although little extended and next to extinction has not only a documentary value. Their importance lies in their marginality,

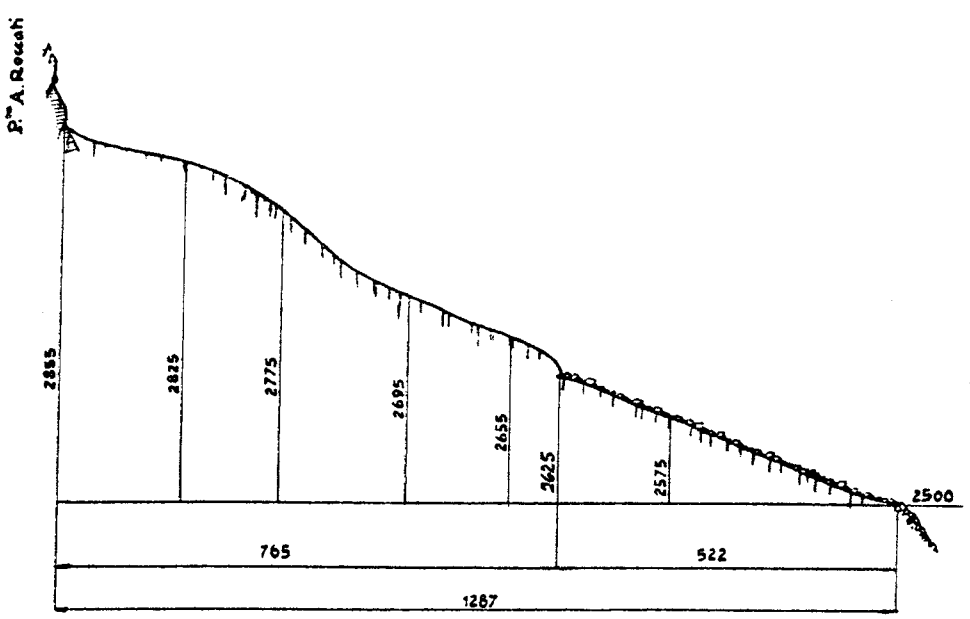

FIG. 1 - Long profile of the Clapier Glacier drawn by Camoletto (1931). The bipartition of the ice body is highlighted.

so that they can be considered more similar to those present in the Apennine (Smiraglia, 1992) and in the Hyberian Mountain Chains (Arenillas & *alii*, 1992; Gomez Ortiz & Salvador Franch, 1997) than those typically alpine, for the predominant climatic influence of the Mediterranean Basin.

A detailed study of the forefields of these glaciers would permit to understand the sequence of processes through which they are getting to extintion. I am persuaded, therefor, that monitoring of their snouts, in this stage of their evolution, should be focused on the comprehension of the processes occurring when transition between the glacial and the periglacial environment takes place.

To achieve this purpose it is necessary that the researchers operating in this alpine sector, comparing one another's results and ideas, stimulate a debate on the subject, so that the Comitato Glaciologico Italiano becomes aware of the interest and peculiarity of the matter and supports with its operators this aspect of the reserch.

REFERENCES

ARENILLAS M., CANTARINO I., MARTINEZ R. MARTINEZ DE PISON E. & PEDRERO A. (1992) - *I Ghiacciai dei Pirenei Spagnoli.* Geogr. Fis. Dinam. Quat., 15, 21-30.

CAMOLETTO C.F. (1928) - *Risultati della campagna glaciologica nelle Alpi Marittime nell'estate 1927.* Boll. Com. Glac. It., ser. 1, 8, 11-21.

CAMOLETTO C.F. (1929) - *Relazioni delle campagne glaciologiche. Alpi Marittime.* Boll. Com. Glac. It., ser. 1, 9, 253-259.

CAMOLETTO C.F. (1930) - *Osservazioni e rilievi sui ghiacciai delle Alpi Marittime.* Boll. Com. Glac. It., ser. 1, 10, 25-44.

CAMOLETTO C.F. (1931) - *Le variazioni periodiche dei ghiacciai delle Alpi Marittime (1893-1930).* Boll. Com. Glac. It., ser. 1, 11, 189-212.

CAMOLETTO C.F. -(1931) - *Il Gruppo Clapier-Maledia-Gelas.* Boll. Com. Glac. It., ser 1, 12, 29-57.

CAMOLETTO C.F. (1933) - *Relazioni delle campagne glaciologiche del 1932. Alpi Marittime.* Boll. Com. Glac. It., ser. 1, 13, 173-177.

CAMOLETTO C.F. (1934, 1935,1936 1937, 1938, 1939, 1940, 1942, 1943) - *Relazioni delle campagne glaciologiche. Alpi Marittime.* Boll. Com. Glac. It., ser. 1, 14, 15, 16, 16, 17, 18, 19, 20, 22, 23.

CHIADÒ V. (1975) - *Relazioni delle campagne glaciologiche. Alpi Marittime.* Boll. Com. Glac. It., ser. 2, 22, 192-195.

CHIADÒ V. (1979) - *Relazione della Campagna Glaciologica 1978. Alpi Marittime.* Geogr. Fis. Dinam. Quat., 2, 130-131.

CHIADÒ V. (1981) - *Relazione della Campagna Glaciologica 1980. Alpi Marittime.* Geogr. Fis. Dinam. Quat., 4, p. 143.

COMITATO GLACIOLOGICO ITALIANO - C.N.R. (1959-62) - *Catasto dei Ghiacciai Italiani.* 4 voll., Com. Glac. It, Torino.

FEDERICI P.R. & PAPPALARDO M. (1991) - *Nota introduttiva alla morfologia glaciale della Valle del Gesso di Entracque (Gruppo dell'Argentera, Alpi Marittime).* In: Gruppo Nazionale di Geografia Fisica e Geomorfologia, Guida all'Escursione Primaverile, Cuneo, 28-31 Maggio 1991, 13-16.

FEDERICI P.R. & PAPPALARDO M. (1995) - *L'evoluzione recente dei ghiacciai delle Alpi Marittime.* Proceedings of the conference: «Cento anni di ricerca glaciologica in Italia», Torino 19-20 Ottobre 1995, Geogr. Fis. Dinam. Quat., 18, 257-269.

GELLATLY A.F., GROVE J.M., LATHAM R. & PARKINSON R.J. (1994) - *Observations of the glaciers in the southern Maritime Alps (Italy).* Rèv. Gèom. Dynam., 63 (3), 93-107.

GOMEZ ORTIZ A. & SALVADOR FRANCH F. (1997) - *El glaciarismo de Sierra Nevada, el mas meridional de Europa.* Proceedings of the conference: «Las huellas glaciares del la montañas españolas», Santiago de Compostela, 1997, 385-430.

MADER F. (1896) - *Escursioni e studi nelle Alpi Marittime.* Boll. CAI, 29 181-193.

PERETTI S. & TIRONE P. (1986) - *Relazione della Campagna Glaciologica 1985. Alpi Marittime.* Geogr. Fis. Dinam. Quat., 9, 91-92.

PERETTI S. (1987) - *Relazione della Campagna Glaciologica 1986. Alpi Marittime.* Geogr. Fis. Dinam. Quat., 10, p. 231.

RAPETTI F. & VITTORINI S. (1992) - *Aspetti del clima del bacino del Gesso, (Alpi Marittime) in relazione alla presenza di alcuni piccoli ghiacciai.* Geogr. Fis. Dinam. Quat., 15, 149-158.

RIBOLINI A. (1998) - *Il ruolo morfostrutturale e morfoselettivo delle rocce milonitiche nella parte sud-orientale del massiccio cristallino dell'Argentera (Alpi Marittime).* Boll. Soc. Geol. It., 117, 657-677.

ROCCATI A. (1912) - *I ghiacciai del Gruppo Clapier-Maledia-Gelas (Alpi Marittime).* Riv. Mens. CAI, 31 (5), 3-10.

ROCCATI A. (1913) - *I Ghiacciai del Gruppo Clapier-Maledia-Gelas (Alpi Marittime). Campagna glaciologica compiuta durante l'estate del 1912.* Riv. C.A.I., 32 (5), 141-148.

ROCCATI A. (1914) - *Campagna glaciologica nelle Alpi Marittime durante l'estate 1913.* Boll. Com. Glac. It., ser. 1, 1, 15-30.

ROCCATI A. (1916) - *Campagna glaciologica nelle Alpi Marittime durante l'estate 1915.* Boll. Com. Glac. It., ser. 1, 2, 44-50.

ROCCATI A. (1925) - *I ghiacciai delle Alpi Marittime Orientali durante il periodo 1921-24.* Boll. Com. Glac. It., ser. 1, 7, 47-57.

SACCO F. (1912) - *I ghiacciai antichi ed attuali delle Alpi Marittime.* Atti Soc. It. Sc. Nat, 51, 100-127.

SMIRAGLIA C. & VEGETTI O. (1992) - *Recenti osservazioni sul Ghiacciaio del Calderone.* Boll. Soc. Geogr. It., ser. 11, 4, 269-302.

VIOTTI A. (1990) - *Relazione della Campagna Glaciologica 1989. Alpi Marittime.* Geogr. Fis. Dinam. Quat., 13, p. 200.