

Sedimentology of the matrices of tills and glaciofluvial deposits of some glaciers in the Adamello-Presanella mountain group (Trentino, Northern Italy)

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ABSTRACT- VENZO G.A., BAZZOLI G., GAJO A. - Sedimentology of the matrices of tills and glaciofluvial deposits of some glaciers in the Adamello-Presanella mountain group (Trentino, Northern Italy). [Sedimentologia delle matrici di *tills* e di depositi fluvioglaciali di alcuni ghiacciai del gruppo montuoso Adamello-Presanella (Trentino, Nord Italia)] *Studi Trent. Sci.Nat. Acta Geol.* vol. 76, pp. 33-41.

This study of the morainic-glaciofluvial systems of eight glaciers sited in the Adamello-Presanella mountain group in Trentino, Northern Italy, even if carried out on the matrices of the deposits, has shown significant differences in grain size distribution, sorting, skewness, kurtosis and roundness, which permit distinguishing the tills from their proglacial or proximate glaciofluvial sediments.

KEY WORDS: *Sedimentology, tills, glaciofluvial deposits, Adamello-Presanella mountain group, Trentino, Italy.*
PAROLE CHIAVE: *Sedimentologia, tills, depositi fluvioglaciali, gruppo montuoso Adamello-Presanella, Trentino, Italia.*

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1. INTRODUCTION

This study has been undertaken to verify whether the tills are distinguishable from their proglacial or proximate glaciofluvial deposits on the basis of the sedimentological peculiarities (mineralogical composition, grain size, mean size, sorting, skewness, kurtosis and roundness) of their matrices, namely the fine-grained (sandy, silty and clayey) material in which the coarser clastic components are embedded.

The morainic-glaciofluvial systems studied are those of eight glaciers, commonly known also as "vedrette", the traditional name used in the Central Alps instead of glacier, with which it is synonymous, sited in the mountain group formed by the Adamello and the Presanella, two contiguous massifs separated by the Genova Valley. (Fig.1)

The samples of till matrices of the following five glaciers: Lobbia, Mandrone, Nardis (orientale), Lares and Niscli, were collected from outcrops of

bare lateral moraines, in the vicinity or not far away off the glaciers front. The matrix samples of the glaciofluvial deposits (namely transported and laid down by the meltwater streams) were collected at a short distance downstream of the ice margin. The glaciofluvial samples of the Amola and Cop di Breguzzo glaciers were collected in the proglacial zone, very near (20-50 m) the glaciers front; those of the Nardis (orientale), Mandrone, Lobbia, Lares e Niscli glaciers at a distance varying from 100 to 150 m; both matrix samples of till and glaciofluvial deposit of Cornisello glacier were drawn 400 m downstream of the front.

At Tab.1, the name, type, massif, valley, surface in km² (measured in the year 1993) of the eight glaciers and the drawing altitude of the samples of tills and glaciofluvial deposits are reported. The largest glacier is the Mandrone, which covers 18.13 km²; the smallest one is the Amola covering 0.8 km². (For further information about these eight glaciers, see "Catasto dei ghiacciai Italiani" (1962) and "I ghiacciai del parco naturale Adamello-Brenta" (1994).

Tab.1-The eight glaciers and the altitude in meters of the matrix samples obtained from the tills (ti altit.) and the glaciofluvial deposits (gf altit.) The square measures are those of the year 1993.

Tab.1- Gli otto ghiacciai e l'altitudine in metri dei campioni delle matrici dei tills (ti altit.) e dei depositi fluvioglaciali (gf altit.). Le estensioni delle superfici sono quelle dell'anno 1993.

glacier	type	massif	valley	surface (km ²)	ti altit. (m)	gf altit. (m)
1 - Cornisello	gully	Presanella	Nambrone	0.38	2700	2690
2 - Amola	gully	Presanella	Nambrone	0.80	2570	2560
3 - Nardis (orientale)	cirque	Presanella	Genova	0.10	2770	2750
4 - Mandrone	plateau	Adamello	Genova	18.13	2610	2540
5 - Lobbia	plateau	Adamello	Genova	7.12	2580	2470
6 - Lares	slope	Adamello	Genova	0.54	2620	2600
7 - Niscli	slope	Adamello	Borzago	0.43	2540	2470
8 - Cop di Breguzzo	cirque	Adamello	Fumo	0.08	2540	2520



Fig. 1 - Thopographic Sketch map with the locations of the eight glaciers.

Fig. 1 - Schizzo topografico con le ubicazioni degli otto ghiacciai.

2. LITHOLOGY OF THE GLACIERS BEDROCK

The Adamello-Presanella mountain group is the outcropping top of an intrusive body (pluton) of acid crystalline rocks, generically known in the geological literature altogether as "tonalite". They are similar lithotypes, mainly granites and granodiorites, differentiated in percentage of quartz and heavy minerals, but very often not easily distinguishable to the naked eye.

3. MINERALOGICAL COMPOSITION

The mineralogical analyses were carried out on the sands of 0.600-0.425, using a binocular microscope (magnification max. 8X, min. 4X.)

To assess and compare the percentage of mineralogical composition, single grains of quartz, feldspar, micas, mafics and rock fragments were counted; keeping in mind that, besides composite grains made up by two or more minerals, in the last of these also single minerals present in very scarcely percentage (e.g. tourmalines and garnets) were put together.

The results of the analysis represented as a percentage of total grain numbers are given in Tabl. 2. As expected, due to the background lithological uniformity of the whole area (granitic and granodioritic rocks), the mineralogical composition of the sands of tills and glaciofluvial deposits of the eight glaciers turned out to be very similar, without significant variations in percentage, which is also probably due to the poor sorting of all those sediments, relative to the energy of both sedimentary environments.

There is to remark: a)-the total lack of carbonate minerals in all analysed samples; b)-the very high percentage of micas in the glaciofluvial sands of the Llobbia (58%) and Cop di Breguzzo (40%) glaciers; c)-the percentages of rock fragments, which turned out to be low in all samples when compared to the percentages found elsewhere in alpine till and glaciofluvial sands; and that is probably due to the coarse grained texture of the background rocks.

Therefore, in the case of the eight glaciers studied it is practically impossible to distinguish the tills from the glaciofluvial sediments on the basis of the mineralogical composition of their matrices.

4. GRAIN SIZE CHARACTERISTICS

The analyses of the finest portion (matrix) of each sample, that having a grain size smaller than 2.36 mm and therefore compounded by sand, silt and clay, were performed using ASTM Standard (D 422-63) sieves. Each portion was sieved at half phi grade interval (0.50) and then each fraction weighed to 0.01 gr. The fractions passing 0.075 mm sieve were subjected to hydrometer analysis when in percentage greater than 5%.

Fig. 2 shows the cumulative curves resulting from both sieve and hydrometer grain size analysis. The curves of the glaciofluvial samples are generally steeper and distributed over a wider area of the plot, whereas the till ones are very flat and lying in a narrower area.

The percentage of silt and clay is generally larger in the till matrices than in the glaciofluvial ones.

The values of the statistical parameters: mode (Md), mean size (Mz), sorting (σ_1), skewness (Sk_1), and kurtosis (K_G) calculated according to the formulas of Folk and Ward (1957), are given in Tab. 3. The values of mode and mean size of the matrices of the glaciofluvial deposits of the Nardis (orientale) Mandrone, Lares and Niscli glaciers are smaller (i.e. the sediment is coarser) than the values of the till matrices, as opposed to the results for the others four glaciers.

The sorting of the glaciofluvial samples are nevertheless smaller, (ranging from 1.50 to 1.67 = poorly sorted) than that of the till ones (ranging from 1.50 = poorly sorted to 2.66 = very poorly sorted).

The skewness values of the glaciofluvial samples are very dispersed, ranging from -0.20 = negative to 0.27 = positive skewed; whereas the values of the till samples are generally less dispersed and closer to zero or positive, with Sk_1 ranging from -0.08 = nearly symmetrical to 0.27 = positive skewed. Such small skewness values of the matrices of the tills of the eight glaciers of the Adamello-Presanella mountain group are consistent with those of the matrices of the würmian till collected from the subsoil at Bellinzona (Venzo et alii, 1999).

The kurtosis values of the matrices, whether of the tills or the glaciofluvial deposits of all the eight glaciers are close to unity. However, they are slightly larger and more dispersed in the glaciofluvial samples (K_G ranging from 0.91=mesocurtic to 1.49=leptocurtic) compared with the tills ones (K_G ranging from 0.79=platycurtic to 1.11=mesocurtic), except in the case of the Cop di Breguzzo glacier.

Tab. 2 - Mineralogical composition of 0.600-425 s.f. sands of tills and glaciofluvial deposits of the eight glaciers. Qua.= Quartz, Fel.=Feldspar, Mic.= micas, Maf.= Mafics, R.fr.= Rock fragments.

Tab. 2 - Composizione mineralogica della frazione sabbiosa 0.600-0.425 di tills e di depositi fluvioglaciali degli otto ghiacciai Qua.= Quarzo, Fel.= Felspati, Mic.= Miche, Maf.= Femici, R.fr. = Frammenti di rocce.

glacier		Qua.	Fel.	Mic.	Maf.	R.fr.
1 - Cornisello	ti	36	43	3	7	11
	gf	42	36	4	5	13
2 - Amola	ti	45	39	3	7	6
	gf	57	22	8	3	10
3 - Nardis (orientale)	ti	41	29	13	3	14
	gf	31	35	6	9	19
4 - Mandron	ti	51	28	6	0	15
	gf	67	15	11	0	7
5 - Llobbia	ti	45	32	5	4	14
	gf	28	10	58	0	4
6 - Lares	ti	64	28	1	3	4
	gf	48	38	0	4	10
7 - Niscli	ti	47	26	10	4	13
	gf	50	35	4	5	6
8 - Cop di Breguzzo	ti	50	12	23	13	2
	gf	53	6	40	0	1

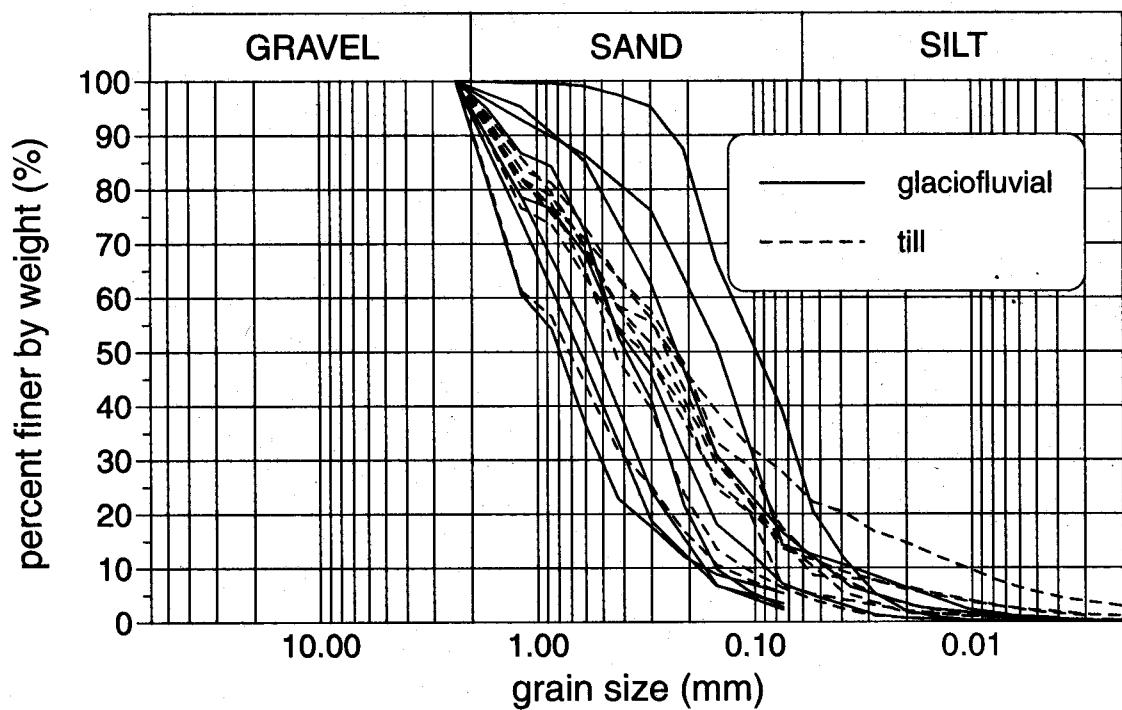


Fig.2 - Grain size cumulative curves of the matrices of tills and glaciofluvial deposits of the eight glaciers.
 Fig.2 - Curve granulometriche cumulative delle matrici di tills e depositi fluvioglaciali degli otto ghiacciai.

Tab.3 - Statistical parameters of the matrices of tills and glaciofluvial deposits of the eight glaciers.
 Tab.3 - Parametri statistici delle matrici di tills e di depositi fluvioglaciali degli otto ghiacciai.

glacier		Md (ϕ)	Mz (ϕ)	σ_1 (ϕ)	Sk ₁ (ϕ)	K _G (ϕ)
1 - Cornisello	ti	0.4848	0.6587	1.5099	0.2559	0.8553
	gf	0.8505	0.8522	1.2164	0.0767	1.0025
2 - Amola	ti	2.0468	2.4172	2.6640	0.2679	1.0040
	gf	2.8131	2.4786	1.6664	-0.1964	1.4879
3 - Nardis (orientale)	ti	2.0880	1.8034	2.0469	-0.0415	0.9973
	gf	1.3535	1.3520	1.1805	-0.0168	1.0949
4 - Mandrone	ti	1.6155	1.4925	1.7758	-0.0471	0.7860
	gf	1.4698	1.3039	1.6426	-0.0504	0.9808
5 - Lobbia	ti	2.1285	1.9073	1.9448	-0.0791	0.8902
	gf	3.3478	3.3750	1.0537	0.0574	0.9057
6 - Lares	ti	1.1901	1.1345	1.5006	0.0403	1.0804
	gf	0.6814	0.6808	1.2449	0.1038	1.0886
7 - Niscli	ti	1.6158	1.6402	1.8550	0.0611	0.9601
	gf	0.3414	0.4656	1.4103	0.2696	1.1342
8 - Cop di Breguzzo	ti	1.8170	1.7179	2.0786	0.0758	1.1067
	gf	2.1380	2.2349	1.5508	0.1146	0.9835

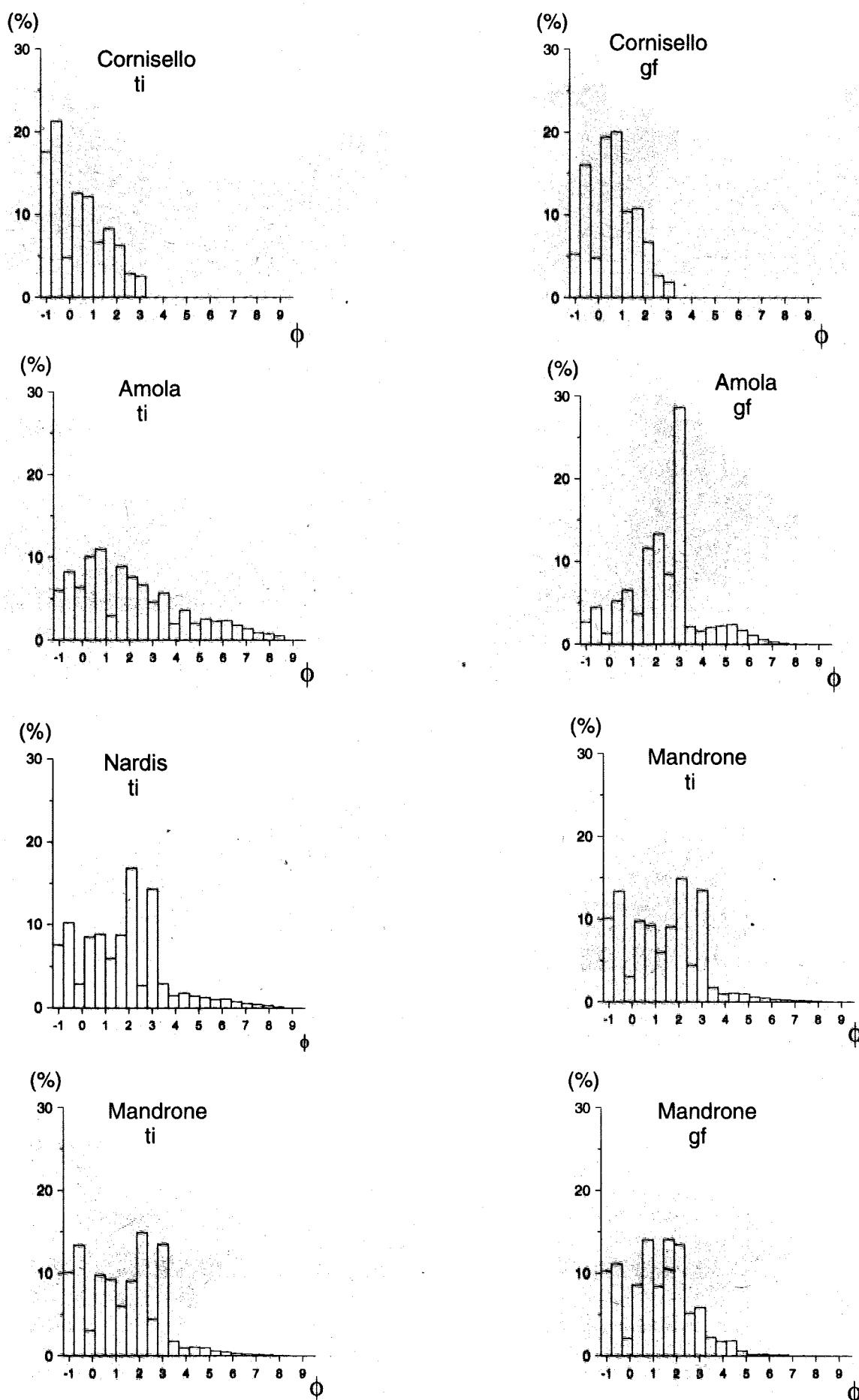


Fig. 3 - Hystograms and sieve fractions of the matrices of tills (ti) and glaciofluvial deposits (gf) of the eight glaciers.
Fig. 3 - Istogrammi e classi granulometriche delle matrici di tills (ti) e di depositi fluvioglaciali (gf) degli otto ghiacciai.

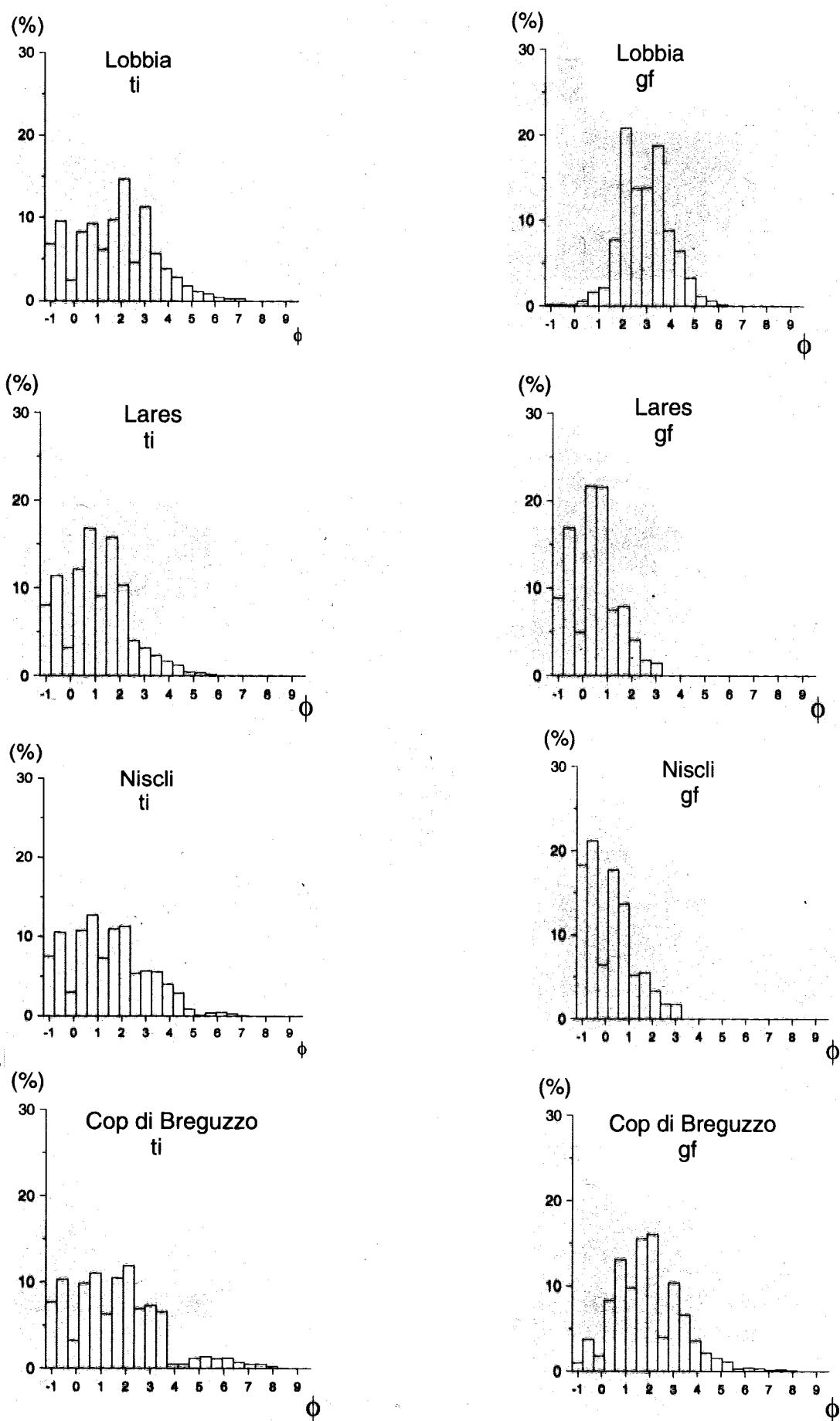


Fig. 3 - Hystograms and sieve fractions of the matrices of tills (ti) and glaciofluvial deposits (gf) of the eight glaciers.
Fig. 3 - Istogrammi e classi granulometriche delle matrici di tills (ti) e di depositi fluvioglaciali (gf) degli otto ghiacciai.

The histograms of Fig. 3, evaluated from both sieve and hydrometer grain size analyses show that the matrices of the glaciofluvial deposits are generally two or three modal, except for the glaciofluvial sample coming from the Amola glacier which is polymodal. The till matrices, characterized by large amounts of the

finer fractions, appear to be polymodal or flat, without any mode.

Similar results were obtained by German et alii (1979) about the tills and the glaciofluvial sediments at the margin of the Roser glacier in Switzerland.

5. ROUNDNESS

Tab. 4 - Roundness degree of the quartz grains of the 0.600-0.425 s.f. sands of tills (R_t) and glaciofluvial deposits (R_{gf}) of the eight glaciers: 1=Cornisello, 2=Amola, 3=Nardis (orientale), 4=Mandrone, 5=Lobbia, 6=Lares, 7=Niscli, 8=Cop di Breguzzo.

Tab. 4 - Grado di arrotondamento dei granuli di quarzo della frazione sabbiosa 0.600-0.425 di tills (R_t) e di depositi fluvioglaciali (R_{gf}) degli otto ghiacciai: 1=Cornisello, 2=Amola, 3=Nardis (orientale), 4=Mandrone, 5=Lobbia, 6=Lares, 7=Niscli, 8=Cop di Breguzzo.

glacier	1	2	3	4	5	6	7	8	mean
R _t	26.5	26.7	27.0	26.5	26.5	26.5	26.8	25.6	26.5
R _{gf}	29.5	30.0	29.9	30.5	29.6	29.8	29.5	29.2	29.7

The roundness degree has been determined on vitreous quartz grains of the 0,600-0,425 sieve fraction using the method and roundness scale of Powers (1953). This fraction was selected because it is the coarsest one present in all samples in quantities sufficient for comparative analysis, the results of which are showed in Tab.4.

The roundness degree of the quartz grains of 0,600-0,425 s.f. of tills of the eight glaciers is nearly the same throughout, varying from 25.6 as minimum to 27.0 as maximum, with mean 26.5 that is approximately intermediate between angular and subangular, whereas the roundness degree of the quartz grains of the same s.f. of the glaciofluvial sands varies from 29.2 to 30.05, with mean 29.7 that is definitely sub angular (Tab.4). Therefore the roundness degree of the glaciofluvial sands turns out to be always higher than that of the till sands. Such an improved degree is chiefly determined by the presence of a not negligible

percentage of subrounded grains (from minimum 12% to maximum 22%, with mean 17%) in the glaciofluvial sands, whereas in the till sands the sub rounded grains are very rare (from minimum 2% to maximum 6%, with average 4%). No rounded and well rounded quartz grains were found, either in morainic or in glaciofluvial samples (Tab.5).

VAN HUSEN (1979) already ascertained that in the melting areas the fluvial rearrangement causes a roundness degree improvement of the values due to ice transportation, even of small boulders of 2-6.3 mm. Our investigations on the till and glaciofluvial deposits of the eight glaciers mentioned have shown that a very short melt stream transport (as in the proglacial area or a little further downstream) is sufficient to improve the roundness of much smaller clasts, like those of the medium sands.

6. CONCLUSIONS

Grain size analysis, calculation of sedimentary parameters and determination of the roundness of their medium sands, though carried out only on the finest part (matrix) of the sediments, have shown significant different sedimentological characteristics that permit to distinguish the tills from the glaciofluvial deposits. More precisely:

1- the percentage of silt and clay is generally larger in the till matrices than in the glaciofluvial ones;

2- the sorting of the matrices of the glaciofluvial deposits is smaller than that of the till ones ;

3- the skewness values of the matrices of the glaciofluvial deposits are dispersed from positive to negative, whereas those of the tills are less dispersed, being close to zero or positive;

4- the matrices of the glaciofluvial deposits are generally two or three modal, whereas those of the tills are polymodal or flat;

5- the roundness degree of the glaciofluvial medium sands is always higher than that of the same till sands;

6- though in all samples close to unity, kurtosis

Tab. 5 - Percentage distribution in the roundness classes of Powers (1953) of the quartz grains of 0.600-0.425 s.f. sands of tills (ti) and glaciofluvial deposits (gf) of the eight glaciers: VA=very angular, A=angular, SA=subangular, SR=subrounded, R=rounded, WR=well rounded.

Tab. 5 - Distribuzione percentuale nelle classi di arrotondamento di Powers (1953) dei granuli di quarzo della frazione sabbiosa 0.600-0.425 di tills (ti) e di depositi fluvioglaciali (gf) degli otto ghiacciai: VA=molto angoloso, A=angoloso, SA=subangoloso, SR=subarrotondato, R=arrotondato, VR=bene arrotondato.

glacier		VA (%)	A (%)	SA (%)	SR (%)	R (%)	WR (%)
1 - Cornisello	ti	4	38	54	4	-	-
	gf	-	20	68	12	-	-
2 - Amola	ti	2	28	56	4	-	-
	gf	-	20	64	16	-	-
3 - Nardis (orientale)	ti	-	36	62	2	-	-
	gf	2	22	56	20	-	-
4 - Mandrone	ti	6	36	52	6	-	-
	gf	2	8	76	14	-	-
5 - Lobbia	ti	2	38	58	2	-	-
	gf	-	26	56	18	-	-
6 - Lares	ti	4	34	30	2	-	-
	gf	2	26	50	22	-	-
7 - Niscli	ti	4	36	54	6	-	-
	gf	2	24	56	18	-	-
8 - Cop di Breguzzo	ti	12	32	52	4	-	-
	gf	2	22	62	14	-	-
Mean	ti	4	36	56	4	-	-
	gf	1	21	61	17	-	-

values came out slightly larger and more dispersed in the glaciofluvial than in till matrices, except for the Cop di Breguzzo glacier.

On the other hand:

7- mode and mean size offer no clear help in distinguishing between the two types of sediments,

8- all till and glaciofluvial medium sands exhibit very similar mineralogical composition, due to the background lithological uniformity.

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SUMMARY - This study has been undertaken in order to verify whether the tills are distinguishable from the proglacial or proximate glaciofluvial deposits on the basis of the sedimentological peculiarities of their matrices, that is the finest fraction formed by sands, silt and clay. The morainic-glaciofluvial systems studied are those of the glaciers Cornisello, Amola, Nardis (orientale), Mandrone, Lobbia, Lares, Niscli and Cop di Breguzzo sited in the Adamello-Presanella mountain group in Trentino-Northern Italy, which is the outcropping top of an acid-crystalline (granites and granodiorites) pluton. To this aim, mineralogical composition, grain size distribution, mean size, sorting, skewness, kurtosis and roundness were determined. Even if carried out on the finest part of the deposits, the sedimentological analyses have shown significant differences in grain size distribution, sorting, skewness, kurtosis, and roundness, which permit distinguishing the tills from the glaciofluvial sediments transported and deposited by the melting streams in proglacial environment or a little further downstream.

RIASSUNTO - Lo studio è stato intrapreso per verificare se i *tills* sono distinguibili dai depositi fluvioglaciali prossimali per le diverse peculiarità sedimentologiche delle loro matrici, ossia della loro parte più fine, quella costituita da sabbia, silt e argilla. A questo scopo su matrici di *tills* e di depositi fluvioglaciali degli otto ghiacciai: Cornisello, Amola, Orientale di Nardis,

Mandrone, Lobbia, Lares, Niscli e Cop di Breguzzo, tutti del gruppo montuoso Adamello-Presanella (Trentino-Nord Italia) che è la sommità affiorante di un plutone acido cristallino di graniti e granodioriti, sono state eseguite le analisi mineralogiche, delle mode, delle medie, dei coefficienti di cernita, di asimmetria, di appuntimento e di arrotondamento. Benché limitate alla frazione più fine dei depositi, le indagini sedimentologiche hanno dimostrato che vi sono diversità di distribuzione granulometrica e differenze dei valori dei coefficienti di cernita, di asimmetria, di appuntimento e di arrotondamento delle matrici che permettono di distinguere quelle dei *tills* da quelle dei fluvioglaciali depositi dal deflusso idrico di scioglimento glaciale in ambienti proglaciali o prossimali.

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