Geogr. Fis. Dinam. Quat.,
17 (1994), 67-72, 5 figg., 1 tab.

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LATE PLEISTOCENE GEOMORPHOLOGICAL EVOLUTION IN THE VALLONE BELLUNESE, SOUTHERN ALPS (ITALY)

ABSTRACT: PELLEGRINI G.B. & SURIAN N., *Late Pleistocene geomorphological evaluation in the Vallone Bellunese, Southern Alps (Italy).* (IT ISSN 0391-9838, 1994).

In the Vallone Bellunese, Southern Alps, Late Pleistocene, and in particular the last advance phase of the Würm glaciation, is well documented by many and different erosional and constructional glacial landforms. It has been possible, therefore, by using different data collected over some years (detailed geomorphological maps, drillings, radiometric datings, geophysical investigations, etc.), to reconstruct an up-to-date chronological outline of the geomorphological evolution of this area during Late Pleistocene. From these data the interstadial phase preceding the last advance of the Würm glaciation comes out with greater evidence than before, also for this sector of the Alps, as also some recent Aurignacian archeological discoveries have confirmed. On the other hand, there are still unsolved problems as to the chronostratigraphic interpretation of some conglomerates, which are definitely older than the last advance of the Würm glaciation and are at different altitudes and in different stratigraphic situations in the valley.

KEY WORDS: Geomorphological evolution, Würm glaciation, Late Pleistocene, Vallone Bellunese, Southern Alps.

RIASSUNTO: PELLEGRINI G.B. & SURIAN N., *Evoluzione geomorfologica del Vallone Bellunese nel Pleistocene Superiore.* (IT ISSN 0391-9838, 1994).

Nel Vallone Bellunese (Alpi Meridionali) il Pleistocene Superiore, ed in particolar modo l'ultima fase di espansione della glaciazione würmiana, è ben documentata da numerose e differenti forme d'erosione e d'accumulo glaciali. È stato quindi possibile, utilizzando i vari dati raccolti nel corso di alcuni anni (cartografia geomorfologica di dettaglio, sondaggi geognostici, datazioni radiometriche, sondaggi geofisici, ecc.), ricostruire un quadro cronologico aggiornato sull'evoluzione geomorfologica di quest'area durante il Pleistocene Superiore. Da tali dati emerge con maggiore precisione rispetto al passato, anche per questo settore delle Alpi, la fase interstadiale che precede l'ultima espansione della glaciazione würmiana, come confermano anche i recenti ritrovamenti archeologici dell'Aurignaziano. Risulta invece ancora problematica l'interpretazione cronostratigrafica di alcuni lembi conglomeratici, certamente più antichi dell'ultima espansione della glaciazione würmiana, presenti a quote differenti e in differenti contesti stratigrafici.

TERMINI CHIAVE: Evoluzione geomorfologica, Glaciazione würmiana, Pleistocene Superiore, Vallone Bellunese, Alpi meridionali.

INTRODUCTION

This research can be included in a critical review regarding the last interglacial-glacial cycle in the Southern Alps, which has been going on, for the last ten years, also in Italy (OROMBELLI, 1983).

Late Pleistocene deposits are widespread in the Alps. On the other hand, the present knowledge on Late Pleistocene, both for the Italian slope of the Alps and for the Eastern Alps (FLIRI, 1988; VAN HUSEN, 1989), points out that most of these deposits do not date back before the last Würm glacial phase, which took place between 24,000 and 16,000 years ago (FLIRI, 1988).

In Pleistocene the Piave glacier, in the eastern sector of the Southern Alps, filled most of the Vallone Bellunese and flowed towards the Venetian Plain in two branches, the Quero one, along the present Piave Valley, and the Gai — Vittorio Veneto one, along the Lapisina Valley. This glacier was studied by BRÜCKNER (1909) and many Italian researchers (TARAMELLI, 1883; DAL PIAZ, 1896 and 1912; CASTIGLIONI B., 1923; VENZO, 1939) in the past. They very well defined the size of this glacier both in alpine and prealpine valleys and in its piedmont terminus. Instead, the data concerning interglacial and interstadial phases are still uncertain. More specific researches were started by CASTIGLIONI G.B. (1964) and FUCHS (1969) in the sixties, and then continued by PELLEGRINI (1970, 1975, and 1979) and others (TESSARI, 1973; CASADORO & *alii*, 1976; VENZO, 1977; GAREIS, 1981).

Here is presented a chronological outline of the Vallone Bellunese evolution during Late Pleistocene based on different data collected in the last years.

GEOMORPHOLOGICAL, STRATIGRAPHICAL, CHRONOLOGICAL AND ARCHEOLOGICAL DATA

Geomorphological researches, mainly based on field surveys and aerial photographs interpretation, have been

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Communication presented at the Third International Geomorphology Conference, Hamilton (Canada), August 23-28, 1993.

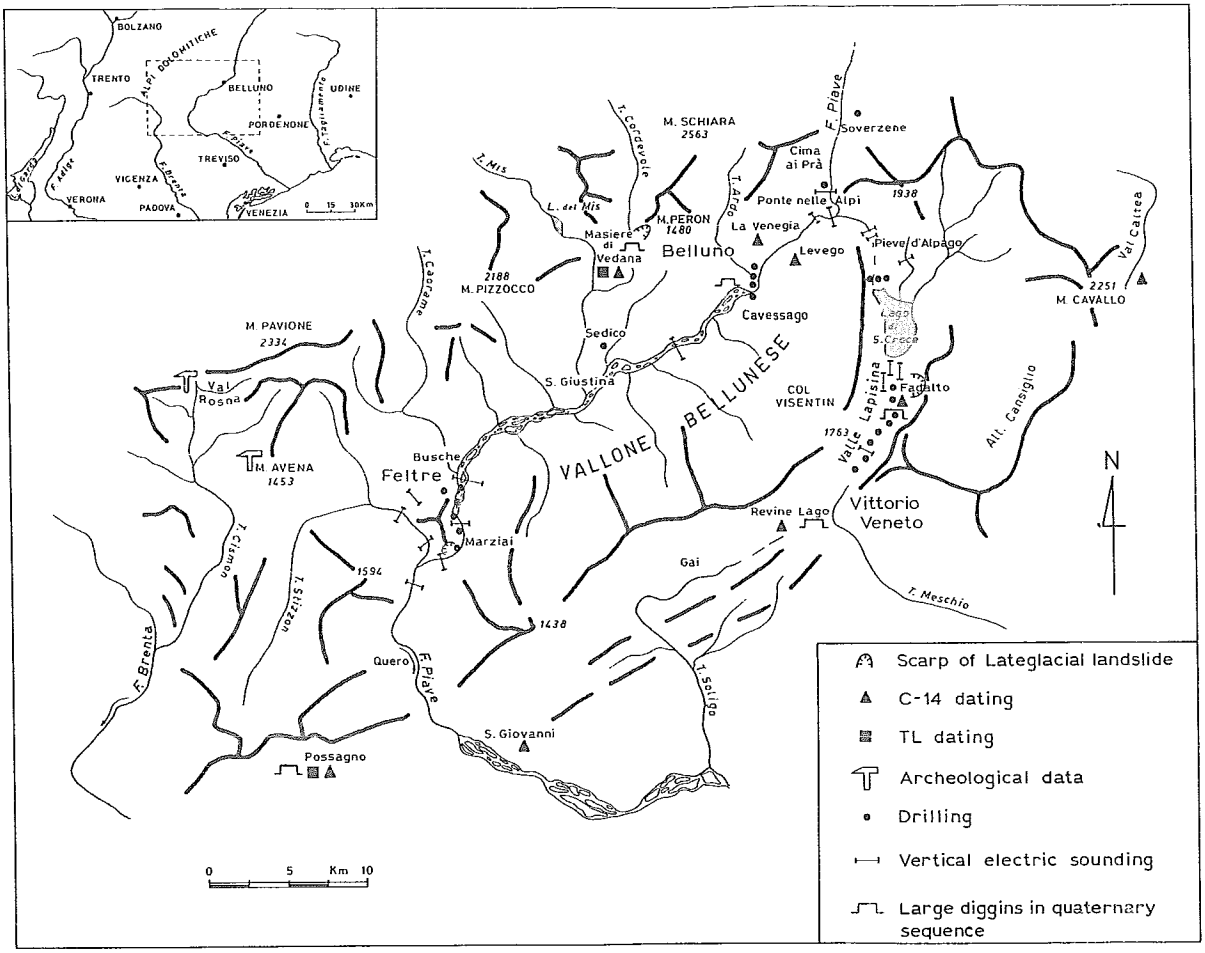

FIG. 1 - Sketch showing the examined area.

integrated with geophysical investigations and drillings concerning stratigraphy and buried morphologies. In addition to geomorphological considerations, chronological data were derived from radiometric datings (^{14}C and TL) and results of archeological researches (fig. 1).

We have carried out a field survey at 1:10,000 scale in order to work out the «Belluno» Sheet (063) of the Geomorphological Map of Italy at 1:50,000 scale (1). Through this survey it was possible to point out some standard stratigraphic sections which, together with radiometric datings, have been very meaningful for a Late Pleistocene paleogeographic reconstruction of this area. They are five natural sections characterized by depositional and erosive events mainly concerning the last interglacial-glacial cycle; also their position is important to interpret the geomorphological evolution of the Vallone Bellunese. Our aim is to recognize, also in this sector of the Alps, the interstadial phase preceding the last Würm glacial advance. Besides, we will discuss the character of some conglomerates and their chronostratigraphic position. In fact these deposits, though similar as regards lithological and sedimentological characters, are at different altitudes and stratigraphic situations.

Sass Muss section («Masiere di Vedana») (fig. 2)

The most significative of the sections we have examined is the one located at Sass Muss, along the river bed of the Cordevole, which is a tributary to the Piave river.

1 - Bedrock composed by Bolago Marl (Lower Miocene); it outcrops along the Cordevole river bed at 330 m.

2 - Vertical wall of about 30 m composed by the fluvial Roe Conglomerate; sub-horizontal attitude, texture clast-supported with lithologies of the Cordevole valley.

3 - Paleosol thick 60 cm, reddish brown (5YR 4/3), cut off in the upper part. TL age: 107,000 ± 16,000 years BP.

4 - Till with clasts of the Vallone Bellunese, dark grey colour, variable thickness from a few meters to about ten meters. The limit with the overlying glacial deposits is irregular and shows some deformations due to active ice, as it can be clearly observed in some quarries near Sass Muss. The age of some wood fragments, found in a clayey silt

(1) This geomorphological map has been realized by Padua University and Veneto Region researchers, and it will be published by the Servizio Geologico Nazionale.

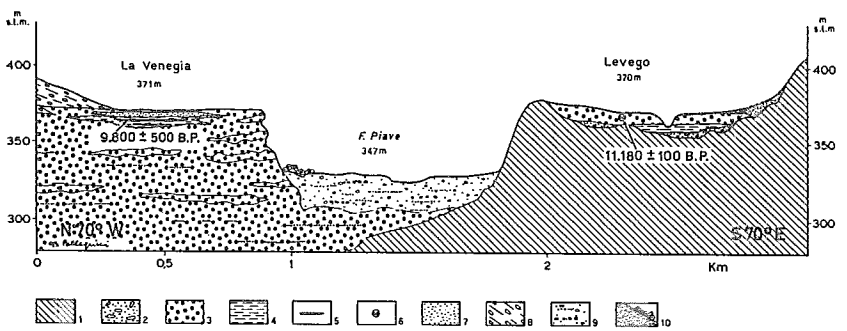

FIG. 2 - Sass Muss section («Masiere di Vedana»). 1: Bedrock (Lower Miocene); 2: Roe Conglomerate; 3: Paleosol (Eem interglacial); 4: Glacial deposit (First Würm glacial phase); 5: Glaciolacustrine deposit (Last Würm glacial phase); 6: Glacial deposit (Last Würm glacial phase); 7: «Marocca del Cordevole», landslide deposit transported by the glacier; 8: Landslide deposit mainly.

level near the limit with the overlying deposits, is 38,000 ± 2,000, 42,000 ± 3,100 and more than 43,000 years BP (^{14}C datings).

5 - Glaciolacustrine deposits in a depression of Roe Conglomerate, covered with a glacial deposit constituted of limestones and dolomites. The age of these sediments, with TL method, is 19,700 ± 3,000 years BP.

6 - Glacial deposits with limestones and dolomites, variable thickness from a few meters to about twenty meters, white colour, clasts often smaller than 20 cm, fine matrix strongly consolidated. It differs from the previous till for the absence of the typical lithologies of the Vallone Bellunese, such as Scaglia Rossa and Flysch of Belluno.

7 - «Marocca del Cordevole» (landslide deposit transported by the glacier), about ten meters thick, constitued of four lithologies: Soccher limestone, Rosso Ammonitico, Fonzaso Formation and Vajont limestone. It is a diamicton with angular clasts.

8 - Landslide deposit with big blocks, often thicker than 20 m; in this section the deposit is constituted only of Vajont limestone elements.

Ponte nelle Alpi-Cadola section (fig. 3)

Also the Ponte nelle Alpi-Cadola section deals with a fluvial conglomerate that outcrops, near Cadola, along the left bank of the Piave river for about one hundred meters; besides a little hill is constituted of this conglomerate. This fluvial deposit doesn't lie directly on the bedrock, at 374 m of altitude, for the presence on the bottom of glacial sediments with a thickness of some meters.

1 - Bedrock constituted of marls (Eocene).

2 - Glacial deposit, about 3 meters thick, with striated pebbles.

3 - Deposit composed by strongly cemented levels of gravel and sand; the levels are disposed like concentric vaults, inside which there is a sediment, not much cemented, similar to a glacial deposit. It is an esker deposit.

4 - Cemented glaciofluvial deposit (Cadola conglomerate) composed by gravel levels with some sandy intercalations; levels dip northward like the bedrock, therefore with an opposite direction, as to that of the Piave flow.

5 - Glacial deposit of the Piave valley, with variable thickness from few centimeters to some meters, overlying the Cadola conglomerate.

6 - Clayey silt lacustrine deposit.

7 - Recent Piave fluvial deposits, mainly composed by gravel.

Cavessago section (fig. 4)

The Cavessago conglomerates differ from those of the two previous sections because, even if they have similar sedimentological characteristics, they are far from the present Piave river bed and at more elevate altitudes.

Also these conglomerates were moulded by the Piave glacier, which, in its last advance phase, left only a thin deposit.

1 - Bedrock composed by flysch (Eocene).

2 - Cavessago conglomerate: composed by quite well rounded pebbles, sometimes with an imbricated structure; its maximum thickness is 50 m; the bedding is clearly seen in all sections and only along the scarp parallel to the Vallone Bellunese axis the bedding is, in some cases, subvertical; in the lower part of the conglomerate there are some big sandstone slabs, coming from the local bedrock (Belluno flysch), in a silty sand matrix, with non striated clasts. So there are not enough elements to infer the presence of a glacial deposit.

3 - Glacial deposit, with striated pebbles, variable thickness, lithologies of the Piave valley.

Sections of the Belluno terrace

These two last sections deal with glaciofluvial and fluvial deposits of the Piave valley bottom and represent the phase of Lateglacial filling that took place after the retreat of last Würm glacier.

Levego section (fig. 5)

— Bedrock constituted of Belluno flysch (Eocene).

— Glacial deposit of the Piave valley, variable thickness, with a lot of silty sand matrix and some rounded blocks.

— Fluvial deposits composed by clayey silt passing upward to gravelly sand and gravel. In this transition zone, at 3.5 meters depth, some trunks were found in a subhorizontal position; ^{14}C analyses indicate that the age of one of these trunks is 11,180 ± 100 years BP.

La Venegia section (fig. 5)

— Glaciofluvial and fluvial deposits of the Piave valley, over ninety meters thick (drillings), sub-horizontal attitude, sometimes cemented; they constitute the main Belluno terrace.

— Clayey silt deposits present in lens of one to two meters in the fluvial deposits mentioned above, rich of organic material, whose age results 9,800 ± 500 years BP (^{14}C).

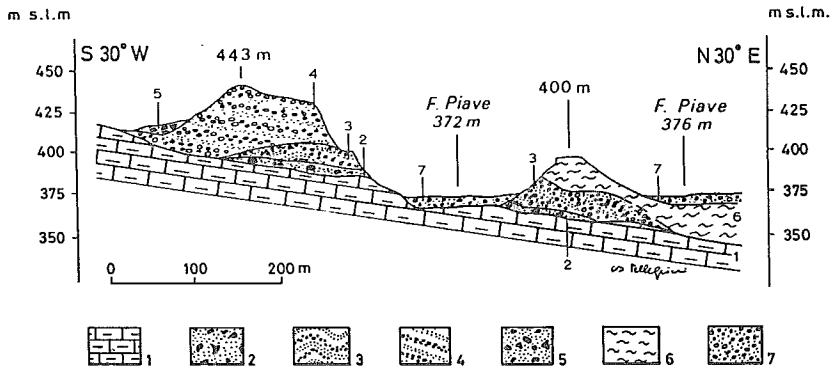

FIG. 3 - Ponte nelle Alpi-Cadola section. 1: Bedrock (Eocene); 2: Glacial deposit; 3: Esker deposit (conglomerate); 4: Glaciofluvial deposit («Cadola conglomerate»); 5: Glacial deposit (Last Würm glacial phase); 6: Lacustrine deposit; 7: Fluvial deposit mainly gravelly (Recent).

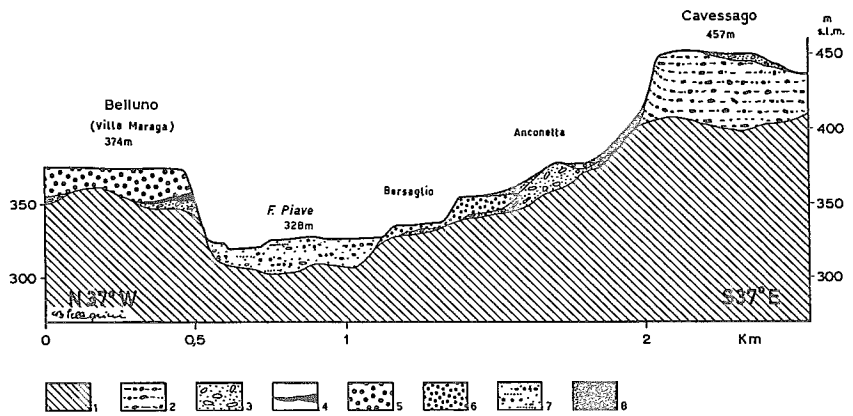

FIG. 4 - Cavessago section. 1: Bedrock (Eocene); 2: Cavessago conglomerate; 3: Glacial deposit (Last Würm glacial phase); 4: Horizon rich of organic material; 5: Glaciofluvial and fluvial deposits; 6: Fluvial deposit (Holocene); 7: Fluvial deposit (Recent); 8: Slope debris.

— Fluvial deposits, two to three meters thick, passing from gravel to sand and silt (normal grading); they represent the end of the aggradation process of the Belluno terrace.

Archeological data

Some recent archeological discoveries in the Vallone Bellunese and in the surrounding area have given important data to reconstruct a chronological outline of Late Pleistocene in this prealpine area (PADOVAN, 1981; LANZINGER, 1984; MONDINI & VILLABRUNA, 1988). On Mt. Avena, near Feltre, Aurignacian artifacts were found at 1.430 m of altitude, therefore at an altitude higher than the one reached by the Piave glacier during the last Würm phase. Moreover, quite unusally, some Aurignacian artifacts were found in a glacial deposit near Pian di Coltura (739-800 m) in the Vallone Bellunese at an altitude lower than the one reached by the glacier.

Besides, in Val Rosna (Val Cismon) some ^{14}C datings obtained from an Epigravettian sepulture gave it an age between 12,150 ± 110 and 11,910 ± 110 years BP.

DATA INTERPRETATION AND LATE PLEISTOCENE CHRONOLOGICAL OUTLINE

The above illustrated data allow some stratigraphic and chronological considerations which enrich the present knowledge about the Late Pleistocene evolution in this alpine sector (tab. 1). Particularly in the Sass Muss section (fig. 2) the paleosol, present on the Cordevole conglomerate and dated 107,000 ± 16,000 years BP, gives evidence, for the first time in the Belluno area, of the Eem interglacial phase or IGL 1.

As regards the fluvial deposit underlying this paleosol, we can say that its minimum age is 107,000 ± 16,000 years BP. That define more precisely what was already said by previous authors who, in general terms, assigned this deposit to the Riss-Würm interglacial phase (VENZO, 1939).

The chronostratigraphic position of the Cadola-Ponte nelle Alpi and Cavessago conglomerates is more uncertain because there are no radiometric datings in both cases. Anyway at Cadola the cemented glaciofluvial deposit is on a lodgement till of the Piave glacier. So it is possible to relate this glacial deposit to the first Würm glacial phase or to a previous glacial phase. The conglomerates overlying this deposit can be assigned, in the first hypothesis, to the interstadial Würm phase and the overlying glacial deposit to the last Würm glacial phase (fig. 3).

The interpretation of the Cavessago conglomerates is more complex, because there are no underlying glacial deposits; besides these conglomerates are at about 90 m higher than the present Piave river bed. Some geomorphological considerations based on the altitude of the deposit top, which is much higher than those of the other glaciofluvial and fluvial deposits in the valley, and its sedimentological aspects, like subvertical bedding, let us think of ice contact deposits (kame terrace) of a not well defined pleistocenic glacial phase (fig. 4).

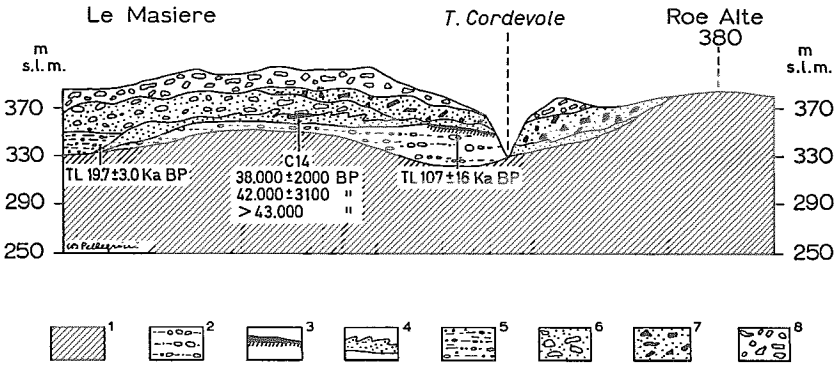

FIG. 5 - Levego-La Venegia section. 1: Bedrock (Eocene); 2: Glacial deposit (Last Würm glacial phase); 3: Glaciofluvial and fluvial deposits (prevailing gravel); 4: Fluvial deposit (prevailing silt and clay); 5: Level rich of organic material; 6: Trunk; 7: Sandy fluvial deposit; 8: Slope debris; 9: Fluvial deposit; 10: Colluvial deposit.

Table 1 - Late Pleistocene chronological outline of the Vallone Bellunese (Southern Alps).

		^{14}C dating	T.L. dating	Archeological data	Geomorphological and sedimentological data	Author
LATE PLEISTOCENE	LATE GLACIAL	11,180 ± 100			Wood in fluvial deposits of Belluno terrace (Levego, 370 m)	Pellegrini (1979)
		11,910 ± 110 11,910 ± 160 12,040 ± 125 12,150 ± 110		Epigravettian sepolture in Val Rosna (490 m)		Mondini - Villabruna (1988)
		14,370 ± 115 14,765 ± 135			Trunks at Revine (260 m)	Casadoro et al. (1976)
	LAST WÜRM GLACIAL PHASE				Moraine ridge at Col Palù-Vena D'oro (620 m)	Pellegrini (1970)
					Moraine ridge at Mt. Pascolet (1130 m)	Castiglioni B. (1923)
			19,700 ± 3,000		Glaciolacustrine deposits at Sass Muss (340 m)	Pellegrini-Dowgiallo Proszynska (1990)
	INTERSTADIAL WÜRM PHASE			Mt. Avena (1430 m) Aurignacian artifacts		Lanzinger (1984)
				Pian di Coltura: Aurignacian artifacts (740 m)		Padovan (1981)
		29,350 ± 460			Wood in Caltea Valley (907 m)	Fuchs (1969)
		38,000 ± 2,000 42,000 ± 3,100 > 43,000			Wood fragments in clayey silt sediments, Sass Muss (360 m)	Pellegrini (1994)
	FIRST WÜRM GLACIAL PHASE				Glacial deposit at Cadola (?) (390 m)	Pellegrini (1979)
					Glacial deposit at Sass Muss (340 m)	Pellegrini (1994)
	EEM INTERGLACIAL PHASE		107,000 ± 16,000		Sass Muss paleosol (350 m)	Pellegrini - Dowgiallo Proszynska (1990)

The first Würm glacial phase is proved in the Sass Muss section where a glacial deposit is underlying a clayey silt level containing wood fragments; the age of these fragments resulted between > 43,000 and 38,000 ± 2,000 years BP.

The Würm interstadial phase is pointed out both by the Aurignacian archeological discoveries at Mt. Avena (1430 m) and by a ^{14}C dating in the Caltea Valley, east to the examined area, with an age of 29,350 ± 460 years BP (FUCHS, 1969). Besides the just mentioned wood fragments at Sass Muss prove the presence of arboreal vegetation in the valley bottom during that period.

The last Würm glacial phase is well documented, even if there is only one dating for this period; this dating was obtained with the TL method for glaciolacustrine deposits at Sass Muss.

The moraine ridges at higher altitudes, up to 1130 m, are considered to belong to this glacial phase and in par-

ticular to its maximum expansion phase. These moraines have no particular pedogenetic horizons indicating an older age. The sequence of moraine ridges at lower altitudes gives evidence of the various pulsations of the glacier in its retreat phase. In addition to moraine ridges there are other glacial lanforms, such as kame terraces, overdeepened hollows, roches moutonnées, etc.

In the retreat phase of the last Würm glacier and in Lateglacial, many landslides took place in Vallone Bellunese and in the surrounding areas. The cause for these phenomena seems to be related with the retreat of a big volume of ice which, at its maximum expansion, had a thickness of about 800 m. Some landslides were (Marziai landslide) (2) or are still (Fadalto landslide) an obstruction for the flow of the water towards the plain, causing the formation of lakes.

Quite different was the evolution of the Mt. Peron landslide. In fact it took place when the Cordevole glacier, already separated from the Piave glacier, was still in the Vallone Bellunese. The landslide debris (see the Sass Muss section), that now constitutes the big accumulation of Masiere di Vedana, was transported for some kilometres by the glacier before its deposition (SQUINABOL, 1902).

Finally we can mention that some radiometric datings carried out at Revine (CASADORO & *alii*, 1976) point out that at 14,765 ± 135 years BP the retreat phase of the glacier had just begun, even if it is not clear whether the glacier was still in the main valley.

The valley bottom filling took place in Lateglacial, as indicated by two radiometric datings in the deposits of the main Belluno terrace. From an environmental point of view the discovery of an Epigravettian sepulture in Val Rosna Valley bottom is significant: this means that 12,000 years BP this area was completly clear of ice.

CONCLUSIONS

The suggested geomorphological reconstruction and the chronological outline (tab. 1), though not final as different researches are still going on in this area, are important, since the present knowledges concerning the glacial and interglacial Pleistocene stages in the Southern Alps are few, compared to those about the northern slope of the Alps, or even North Europe and North America. Moreover, this chronological outline seems to fit very well both the one proposed by VAN HUSEN (1989) for the Late Pleistocene in the Eastern Alps and the one regarding glaciations in the Northern Hemisphere (SIBRAVA & *alii*, 1986).

Finally, also for this alpine sector, we recognize some important morphological phenomena, such as big landslides, formations of lakes, etc., as typical of a radical climatic change, from a glacial to an interglacial period; besides these phenomena represent the beginning of the main filling phase of valley bottoms.

(2) We refer to a lake, originated by the Marziai Late glacial landslide, which was filled up by the alluvial deposits of the Piave River.

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