

# The Quaternary evolution of the Adige Valley near the city of Trento (Northern Italy) as deduced from wells and radiocarbon dating. Preliminary results

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**ABSTRACT** - FUGANTI A., BAZZOLI G., MORTEANI G., 1998 - The Quaternary evolution of the Adige Valley near the city of Trento (Northern Italy) as deduced from wells and radiocarbon dating. Preliminary results. [L'evoluzione quaternaria della Valle dell'Adige presso Trento (Italia settentrionale) in base a pozzi profondi e datazioni con radiocarbonio. Risultati preliminari]. *Studi Trent. Sci. Nat., Acta Geol.*, vol. 73, pp. 93-97.

In three wells drilled in the south of the city of Trento into the sediments filling the valley of the Adige river at 11, 31 to 33, 130 and 139 m depth fragments of wood have been found and dated by radiocarbon method. From this dating results that the sedimentation rate in the valley of the Adige river was around 10,000 years B.C. extremely high, up to 130 mm/y and decreased after that time rapidly to a rate of around 2 to 3 mm/y remaining rather constant until now. The high sedimentation rates around 10,000 years B.C. correspond to the climatic optimum that produced a rapid deglaciation in the Alps and an uplift of the Mediterranean Sea.

**PAROLE CHIAVE:** *Messiniano, Tardo Pleistocene, Olocene, deglaciazione würmiana, datazione con radiocarbonio, Valle dell'Adige, Trento, Italia.*

**KEY WORDS:** *Messinian, Late Pleistocene, Holocene, Würmian deglaciation, radiocarbon age determination, Adige Valley, Trento, Italy.*

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## 1. INTRODUCTION

Inbetween 1995 and 1997 the Società Industriale Trentina who supplies with drinking water the city of Trento drilled in the city under the supervision of the authors the wells Fersina 1 and Fersina 2 near the confluence of the Fersina and the Adige rivers. The main purpose of these two wells, distant about 36 m from each other, was to test the sediments as aquifers for the production of

drinking water for the city of Trento. The sedimentary sequence in this area was known until now only for a depth of about 200 m. The well Fersina 1 was drilled down to a depth of 423 m but did not reach the bedrock due to the fact that the drill hole was originally planned to reach only a depth of 300 m and the equipment and the diameter of the hole were not suitable to a depth of more than 423 m. The well Fersina 1 was designed as an exploration one. The well Fersina 2 was planned as, and is still now, a productive water well, producing the water

from an aquifer found inbetween 156 and 184 m from the actual surface.

The well at Via Verdi is 30 m deep and was drilled in 1996 for a hydrogeological study near the crossing of the railway and the Via Verdi in the city of Trento.

In the present paper the results of the radio-carbon dating of the wood fragments recovered during drilling are used to discuss in connection with a first sedimentological analysis of the drilled material the geological evolution of the Adige valley in the late Quaternary, focussing on the last 12,000 years of the Holocene.

## 2. GEOLOGY

As shown in Fig. 1 the valley of the Adige river begins at the pass of Resia, crosses the southern flank of the Eastern Alps to the city of Verona where it enters into the Po Plain. Like the Po river the Adige river flows into the Adriatic Sea. In the upper part the valley of the Adige river is found in metamorphic rocks of the Austroalpine unit. From Merano until Verona it crosses the South Alpine units, composed mostly by Mesozoic carbonatic sediments and the predominantly rhyolitic volcanic rocks of the Permian Atesina Volcanic Complex.

The Austroalpine and South Alpine units were deformed by the Alpine orogenesis in Cretaceous to late Miocene times. The uplift, consequent exhumation and erosion started immediately after the end of the orogenic movements.

The early geological evolution of the Adige river valley should be fundamentally very similar to that of other Alpine valleys. According to BINI *et al.* (1978), CITA (1990), CITA & CORSELLI (1993) the first deep erosion of the south Alpine valleys, like those of the Lombardy and of Switzerland, are due to the crisis of salinity of the Mediterranean sea during the Messinian in the uppermost Neogene. In this period the Mediterranean sea was a close basin isolated from the Atlantic ocean and therefore subject to a dramatic decrease of the water level due to the evaporation. A geophysical study of the now sediment-filled Alpine valleys draining to the Mediterranean shows that these are deep canyons, filled by Pliocene to Quaternary sediments and in part by lakes (FINCH, 1978). Not only the Alpine, but all big valleys in the circum-Mediterranean area from the Nile to the Rhône show such a deep erosion in consequence of the Messinian event (CITA & CORSELLI, 1993). It is very likely therefore that the Adige river valley was

eroded deeply during the Messinian to a depth of 500 to 550 m, a depth below the maximum depth of 423 m reached by the well Fersina 1. The actual surface of the Adige valley at Trento is at 190 to 200 m above sea level. At the end of the Messinian and the beginning of the Pliocene the climate was characterized by a general cooling down (MUELSE & STATTEGER, 1997).

Already VENZO (1943) supposed that, due to the erosion between the late Tertiary and the end

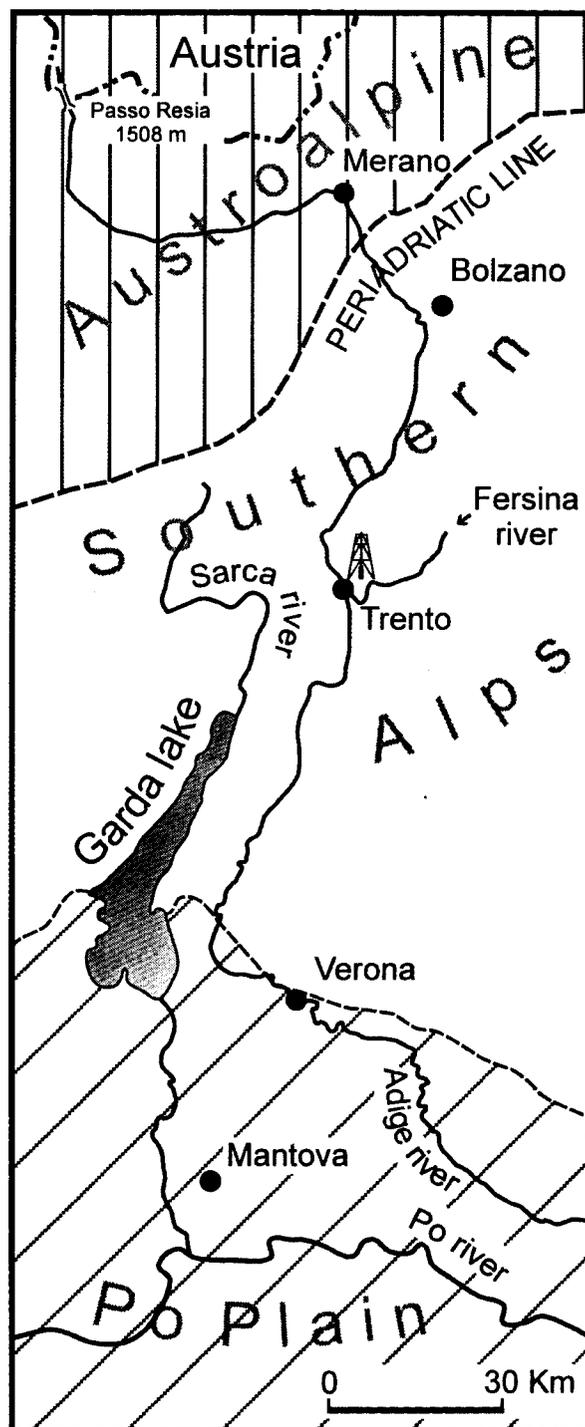


Fig. 1 - Sketch map showing the main geographical and geological units crossed by the Adige river valley in N Italy.  
Fig. 1 - Schema raffigurante le principali unità geografiche e geologiche attraversate dalla Valle dell'Adige.

of the Würm glaciation, the Adige valley was eroded to a total depth of more than 800 m. In the Riß-Würm interglacial period the valley was partially filled by sediments. According to PENCK & BRÜCKNER (1909) Quaternary age traditional classification the Würmian glaciers eroded then at least 150 m. The sediments found now in the first 200 m of the sedimentary sequence filling the Adige valley are according to VENZO (1955) predominantly of lacustrine type.

The maximum expansion of the glaciers in the alpine region occurred in the Würm period, about 24,000 years ago, coinciding with the minimum of insolation in the northern hemisphere produced by the precession of the equinoxes (HAY *et al.*, 1997). This minimum in the insolation was followed by an increasing insolation with a related temperature maximum at about 12,000 years B.P. This climatic optimum corresponds to the general deglaciation of the Alps and at a global level to an increase of the sea level of about 130 m (HAYS *et al.*, 1976; BINI *et al.*, 1978; OROMBELLI, 1990; MÜLLER, 1995; ANTONIOLI & FERRANTI, 1996; HAY *et al.*, 1997). The Holocene was a time of relative sea level stability, following a rapid 130 m rise from the lowstand during the last glacial maximum (HAY *et al.*, 1997). Also FAIRBANKS (1989), studying the evolution of the coral barriers of the Barbados, found that the sea level was at about 18,000 years B.P. 121 m below the actual one. The increase of the sea level was not homogeneous. It was very rapid until 12,000 to 8,000 years B.P., after that the increase slowed markedly down. FAIRBANKS (1989) suggests also a two step deglaciation model with a first deglaciation at about 14,000 to 12,000 years B.P. and a second one between 10,000 and 7,000 years B.P. These two periods are separated by a mid-glacial pause. In consequence of those two deglaciations two melting water pulses occurred at about 12,000 and 9,500 years B.P.

### 3. STRATIGRAPHY OF THE WELLS

The sediments found in the wells are predominantly fine grained (clay, silt and sand). Only inbetween 189 and 149 m and 22 to 0 m two gravel levels are found. The lower gravel level can be subdivided into a lower sublevel where the pebbles embedded into a sandy matrix are volcanic rocks originating from the Atesina Volcanic Complex (AVC), magmatic rocks of the Presanella-Adamello intrusion, Triassic dolomites and only subordinate phyllites and an upper sublevel where the pebbles are less rounded than in the lower horizon and are set in a more clayish matrix. The pebbles are in this sublevel predominantly high to medium grade metamorphic rocks originating from the central Alps north of the study area, whereas the pebbles deriving from the volcanic rocks of the AVC are only a minority. The sand fraction is composed by grains which can be referred to rocks very similar to those forming the more coarse-grained pebble fraction. The details of the stratigraphy are currently being studied.

### 4. RADIOCARBON DATING

In the wells Fersina 1 and Fersina 2 wood fragments have been found. In the well Fersina 1 the wood fragments have been found at a depth of 33 m, in the well Fersina 2 at a depth inbetween 31 and 32 m, 32 and 33 m, at 130 metres and at 139 m. Also in the well of Via Verdi, found in town at a distance of about 2.5 km from the wells Fersina 1 and Fersina 2, a fragment of wood was found at 11 m depth. Age determination was made on the wood fragments with the conventional radiocarbon method, calibration is according to STUIVER & REIMER (1993). The results are given in Table 1. The

well	depth of woods (metres)	$\delta^{13}\text{C}$ ‰	conventional age $^{14}\text{C}$ B.P.	calibrated age $1\sigma$ B.C.	calibrated age $2\sigma$ B.C.
Fersina 1	33	-26.94	10,004±28	9,600 - 9,090 Ø 9,345	9,850 - 9,055
Fersina 2	31-32	-25.72	9,993±74	9,682 - 9,050 Ø 9,365	9,982 - 9,045
	32-33	-25.65	10,078±74	9,954 - 9,148 Ø 9,551	10,158 - 9,055
	130	-24.44	10,282±64	10,312 - 9,997 Ø 10,154	10,426 - 9,752
	139	-26.10	10,445±33	10,488 - 10,311 Ø 10,399	10,562 - 10,205
Via Verdi	11	-27.83	4,145±23	2,865 - 2,620 Ø 2,742	2,870 - 2,610

Tab. 1 - Results of the radiocarbon age dating of wood fragments from the wells Fersina 1, Fersina 2 and Via Verdi.

Tab. 1 - Risultati della datazione al radiocarbonio dei frammenti di legno provenienti dai pozzi Fersina 1, Fersina 2 e Via Verdi.

individual ages are inbetween 2,600 and about 10,500 years B.C. if the calibration at  $1 \sigma$  is taken into consideration.

## 5. DISCUSSION

The pieces of wood dated are found in sediments typical for lacustrine and fluvial environments, so that a possible erosion and re-sedimentation of the wood fragments can be considered. Nevertheless the fact that 1) wood fragments of about the same age have been found in different wells and 2) the radiocarbon ages are decreasing towards the surface leads to the conclusion that a re-sedimentation leading to erroneous ages must not be considered.

The radiocarbon dating of the wood fragments found at different depths indicates that the drilled sediment pile was deposited in a period of about 12,500 years but with different velocity (Tab. 2).

Tab. 2 - Sedimentation rates as calculated from average radiocarbon ages of the wood fragments found in the three wells at different depths.

Tab. 2 - *Velocità di sedimentazione calcolate in base alla media dell'età al radiocarbonio dei frammenti ritrovati in tre pozzi a profondità diverse.*

Depth (m)	Average $^{14}\text{C}$ age calibrated, B.C. (years)	Age difference (years)	Sedimentation rate (mm/year)
0	-1,998		
		4,740	2.3
11	2,742		
		6,678	2.9 - 3.3
31-33	9,420		
		734	134.2
130	10,154		
		245	36.7
139	10,399		

From the ages of the wood fragments and connected sediments it can be deduced that in the time interval between about 10,399 and 10,154 years the sedimentation rate was 36.7 mm/y, between 10,154 and 9,420 years it was 132.2 mm/y, between 9,420 and 2,742 years it was about 3 mm/y and inbetween 2,742 years and present it is 2.3 mm/y. Summarizing it can be said that the sedimentation rate in the Adige river valley was around 10,000 years B.C. very high and decreased from that rapidly to the actual sedimentation rate of about 2 to 3 mm/

y. The high sedimentation rate around 10,400 years B.C. is very likely due to the increasing temperatures, consequent deglaciation of the Alps and increase of the sea level as mentioned e.g. by OROMBELLI (1990), MÜLLER (1995), HAY *et al.* (1997) and TZEDAKIS *et al.* (1997) and corresponds in age to the first very intense glacial melt water discharge (mwp-1A) at about 11,000 B.C. as given by FAIRBANKS (1989).

In this context it is interesting to notice that all Prehistoric dwellings of late and postglacial age, i.e. between 16,000 and 8,500 years B.P., are found only on the shoulders of the actual Adige valley and at elevations between 1800 and 2300 m a.s.l. (DALMERI & LANZINGER, 1997). This could be explained by the fact that possible dwellings of that age situated in the middle of the original valley are now buried by at least 100 m of sediments.

## 6. OUTLOOK

By the study of the sediments and the radiocarbon dating of wood fragments as found in the water wells drilled in the south of Trento into the sediments of the Adige river valley the sedimentation could be preliminarily defined and related to the changing climatic conditions of the Holocene. The data obtained until now on the material from the wells will be implemented as soon as possible by a more detailed sedimentological study and age determinations by palynological methods to get the until now missing complete record of the climatic conditions and connected erosional and depositional processes of the last 12,000 years B.P. The sediment sequences drilled may provide in fact a unique opportunity to develop a complete and high-resolution record bypassing the problem posed by the reconstruction of such a record by piecing it together from isolated occurrences of often uncertain chronostratigraphic position. It is obvious that such a continuous record will be obtained only if a very minor part of the sediment pile was intermittently eroded.

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**SUMMARY** - In the present paper the results of radiocarbon age determinations of wood fragments found at 11, 31, 130 and 139 m depth in three wells drilled into the sediments filling the Adige river valley are given. One well is at a depth of 423 m still in fluvial sediments. A second well is 190 m, the third one is 30 m deep. The sediments are silt, sand and gravel. It resulted that the sedimentation around 10,000 years B.C. was with up to 130 mm/y very high, but very shortly after that decreased to a sedimentation rate of about 2 to 3 mm/y which remained rather constant until now. The high sedimentation rate found around 10,000 B.C. can be referred to the high input of sediments into the Adige river valley produced by a temperature increase, consequent rapid deglaciation of the Alps with a high rate of glacial melt water discharge and the uplift of the sea level at a global scale as well as of the Mediterranean Sea. The sedimentation rates integrate obviously over the given time intervals possible series of erosional events and sedimentation. A palynological and mineralogical study should allow a much more detailed determination of the sedimentation processes.

**RIASSUNTO** - Il lavoro espone i risultati delle determinazioni d'età con il metodo del radiocarbonio su frammenti di legno trovati alle profondità di 11, 31, 130 e 139 m in tre pozzi che hanno attraversato i sedimenti nella Valle dell'Adige a Trento. Un pozzo ha raggiunto la profondità di 423 m attraversando sedimenti ma senza raggiungere il fondo roccioso. I sedimenti sono limi, sabbie e ghiaie. Un altro pozzo ha raggiunto la profondità di 190 m. Un terzo pozzo la profondità di 30 m. Dai risultati si può dedurre che la velocità di sedimentazione negli ultimi 12.000 anni sono state differenti; attorno 10.000 anni a.C. la sedimentazione era di ca. 130 mm/a. Nei millenni seguenti la velocità si ridusse fino a 2 e 3 mm/a. L'elevata velocità di sedimentazione attorno a 10.000 anni a.C. è da attribuire alla rapida deglaciazione delle Alpi che ha generato elevato apporto di sedimenti nei fiumi; altra causa è il corrispondente rapido innalzamento del livello marino sia nel Mediterraneo che a livello globale. Non si conosce se eventi erosivi sono stati intervallati alle fasi di sedimentazione. Sono in corso studi dettagliati di tipo mineralogico e palinologico.

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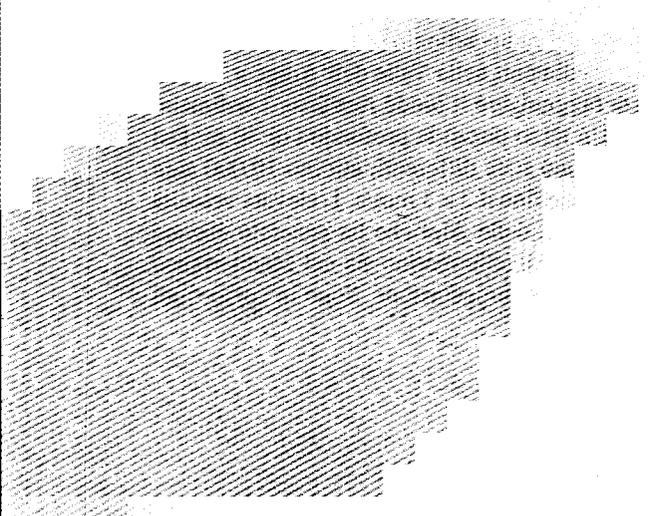
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