



ECOLOGICAL CHANGES AND HUMAN INTERACTION IN VALCAMONICA, THE ROCK ART VALLEY, SINCE THE LAST DEGLACIATION

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ABSTRACT: Valcamonica is known all over the world for the development of rock art between the Lateglacial and the Middle Ages. We present here an updated synthesis on the environmental history of Valcamonica, focussing on the relationships between natural ecosystems, climate and human peopling.

Among the natural archives reviewed, a reference is the Pian di Gembro succession, a middle-altitude site offering a chronologically and taxonomically highly-resolved ecological investigation for the last 15.5 cal ka BP. For this site we present quantitative reconstructions of climate parameters obtained from fossil pollen spectra.

The deglaciation of the valley floor occurred about 18-17.5 cal ka BP. Remnants of a hut and rock engravings, referred to the Upper Paleolithic, are indication of human groups on the valley floor, possibly related to hunting activities on wild mammals sheltering in newly-established pine and larch forests. Lowering of the timberline and expansion of xerophytic formations affected the montane and subalpine belts in the Younger Dryas. Fast afforestation and timberline rise mark the Holocene onset, as a result of abrupt climate improvement. A phase of hemispheric climate change, also recorded in ice cores at 8.2 cal ka BP, promoted the expansion of spruce and fir at middle altitudes. Very high treeline altitudes (> 2,600 m asl) were withstood between 9.1-7.4 cal ka BP, as testified by finds of *Pinus cembra* trunks and seeds of relevant age in high-altitude mires. In this span, high-altitude camps of Mesolithic hunters, moving seasonally from the valley floor, left traces of forest fires, in the forms of charcoal fragments from hearths and pits with heat-fractured pebbles. Archaeological and palaeoecological data suggest peopling discontinuity between 7.5 to ca. 6.5 cal ka BP, when farming started to develop. The oldest cereal pollen grain is detected at ca. 6 cal ka BP, consistently with the cultural chronology of early settlements in Valcamonica. Mountain pastoralism is documented only for later periods (Bronze Age onward) but detecting earliest traces high-altitude husbandry needs further research at subalpine areas preserving natural archives.

Alpine pastures and cereal fields further expanded since the Early Bronze Age, despite a poor archaeological record for the period. During the first millennium BC rock art spread across Valcamonica. Iron Age and Roman time display high rates of forest exploitation, often related to iron-smelting activities, and agriculture expansion. Chestnut and walnut appear between the I BC - II AD centuries.

Keywords: vegetation history, climate reconstruction, Late Glacial, Holocene, human impact.

1. INTRODUCTION

The history of past landscapes and climate is a scientifically and socially relevant research topic. The recent IPCC Fifth Assessment Report (AR5) resumes the state-of-the-art of the scientific knowledge on climate change and its effects on modern and past societies in terms of impact, adaptation, and mitigation (IPCC, 2014). Holocene climate changes deeply affected the development of Alpine civilisations, but, interestingly, knowledge on past climate regimes plays an important role also in the elaboration of future scenarios.

Prior to the onset of written sources and instrumental records, information on past landscapes and climate variables can be obtained from natural archives. Thanks to the information retrieved from sediment cores drilled in basins located from the valley floor to the subalpine belt, the history of Alpine valleys can be traced back to the last deglaciation.

Valcamonica, the cradle of the most important rock art culture of the Alps (UNESCO, 1979), is one of the hotspots for disentangling the history of ecological relationships between human civilizations, mountain environment, and climate change. Despite extensive work so far done surveying (Ruggiero & Poggiani Keller, 2014) and interpreting (De Marinis & Fossati, 2012; CCSP, 2013) rock art, expression of the inhabitants of the valley from the middle Neolithic to the Middle Ages, there are still many gaps in material culture and environmental frameworks.

Geographically, the rock art phenomenon covers the whole territory of the Valley - from Lovere to Ponte di Legno, with more than 1,500 engraved rocks grouped in about 170 sites - and shows a figurative language that varies from symbolic to more naturalistic and narrative elements. Its chronology, however, is extremely difficult to be defined. On the one hand a relative chronology can be established based on the recognition of a stylistic

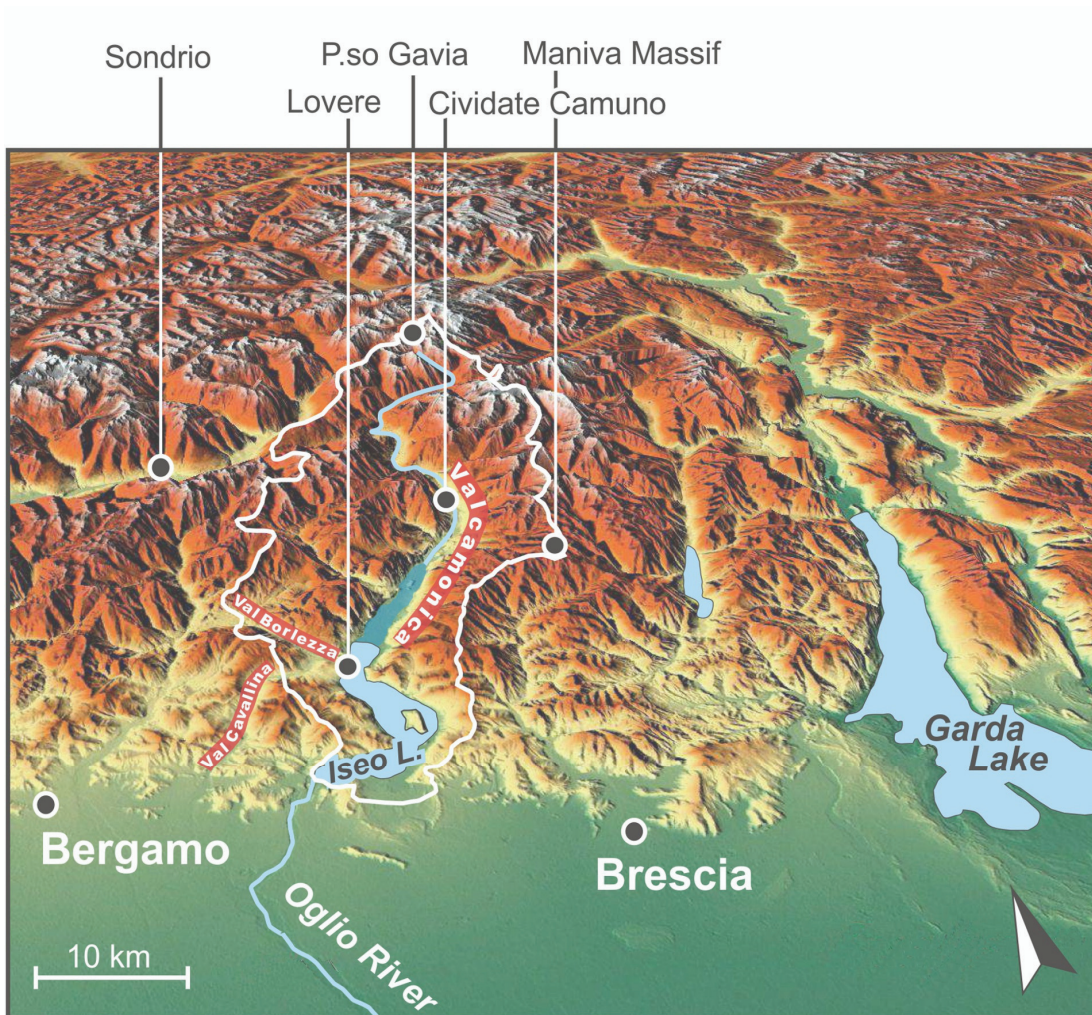


Fig. 1 - Location of the Valcamonica in the Italian Alps and of main reference geographic areas and towns mentioned in the text. A white line shows the Oglio River catchment closed at the outlet of the Iseo Lake. The dark blue area marks the reconstructed extent of the Iseo Lake at the time of deglaciation, about 18-17.5 cal ka BP.

evolution and on the superimposition of the figures; on the other hand, elements that allow anchoring this sequence to an absolute chronology are very few (e.g. figures of weapons with recognizable morphological features). Furthermore, contexts in which archaeological levels stratigraphically investigated were found in connection with engraved rocks are rare.

In any case, rock art is the evidence of the close relationship between the first human communities and the territory. Though the knowledge of contemporary archaeological contexts is not detailed, in the last few years, thanks also to the opening of the MUPRE - The National Prehistory Museum of Valle Camonica (Poggiani Keller, in press) increasing attention is given to the study of settlements, necropolis and cult places related to rock art sites. In this way, the development of rock art styles is seen as a reflection of the different phases of population of the valley and of the exploitation of its natural resources by humans. In fact, the engraving tradition persisted for a longer period during which

the society expression of human groups inhabiting the valley has become increasingly complex. This complexity is also related to the economic aspects, namely subsistence economy and food production, as well as to climate and other natural triggers. For this reason, there is an increasing need for interaction between different disciplines, such as palaeoclimatology, archaeology, archaeozoology and palaeobotany.

In this paper we provide a synthesis of the current knowledge on regional landscape, climate and human history of the Oglio River catchment, i.e. the Valcamonica and its tributary valleys (Fig. 1 and 2). We will focus on stratigraphic archives accumulated within lakes and mires containing an organic fraction, made up by macroscopic and microscopic plant debris and remains of terrestrial and aquatic invertebrates. The detailed analysis of these remains (tens to hundreds of samples along a stratigraphic column), supported by ^{14}C chronologies, provide data on past vegetation structure, land

use changes, occurrence of human settlement and activities. The archives considered in this review are mostly in an “off-site” position, in the sense of Edwards (1991). We use the term “off-site” for sites external to human settlements, not directly biased by processes leading to the formation of archaeological deposits. Those are often affected by erosional hiatuses and/or display the rapid accumulation of debris connected to human activities, thus failing in recording the environmental history with stratigraphic continuity and appropriate resolution.

By comparing several off-site records, the palaeoecological analysis may disentangle the impact of man and of climate. Detail on each site can be found in Tab. 1, their chronological extent is shown in Fig. 4 (see hereinafter).

In this perspective recent pollen-based mean annual temperature reconstructions of Late Glacial to Holocene at one site (Pian di Gembro, site 7 in Fig. 2 and Fig. 3) are of help (Fig. 5). This is the first quantitative palaeoclimate evidence for Valcamonica, and is still open to further improvements. First we'll introduce the palaeoclimatic framework as the prerequisite for evaluating the subsequent palaeoecological history.

2. QUANTITATIVE RECONSTRUCTIONS OF PAST CLIMATE PARAMETERS FROM ECOLOGICAL ARCHIVES

The availability of huge amounts of data describing past environments, both in the terrestrial and aquatic realms (pollen, plant macrofossils, charcoal and wood logs, chironomids, freshwater algae, dinocysts, Foraminifera, ostracoda and so on), raises the question of whether this information can be used for quantitative and not simply qualitative reconstructions. We concentrate here on pollen, its use as climate predictor is supported by some basic biological assumptions: if vegetation is a function of climate and pollen is a function of vegetation, then pollen is a suitable proxy for climate reconstructions.

Methodological and statistical guidelines (Juggins & Birks, 2012) can be profitably applied on already published palynological records for a direct comparison between vegetation and climate. The recent release of the EMPD (European Modern Pollen Database: Davis et al., 2013) allow the relationships between modern pollen and associated climate data to be modelled numerically to obtain transfer functions which convert fossil pollen data into quantitative estimates of past environmental variables (Birks, 2003).

In this paper we used one of the best Late Glacial - Holocene pollen record available in the Alps, located at the watershed between Valcamonica and Valtellina, to obtain the first quantitative palaeoclimate estimation for this area. The record chosen is that from Pian di Gembro: this pollen record was published nearly 15 years

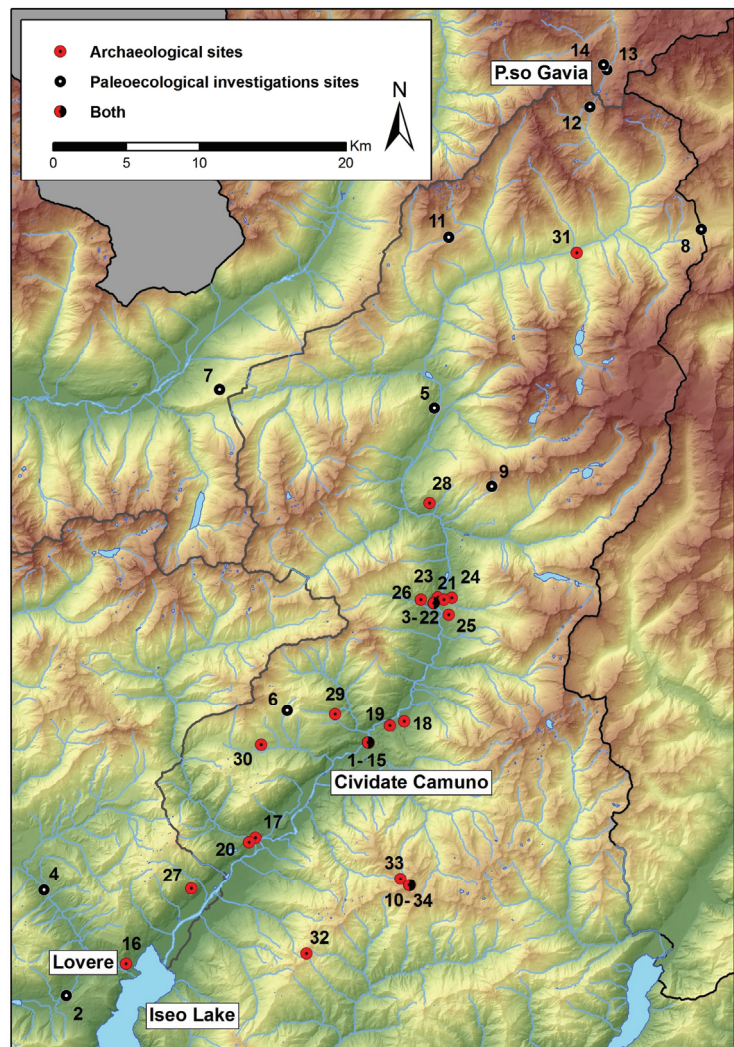


Fig. 2 - Location of sites mentioned in the text. See Tab. 1 for site numbers and information.

ago (Pini, 2002) but, at that time, the idea of using pollen spectra as climate proxy was not in discussion.

3. THE PALAEOCLIMATE HISTORY. FIRST PALAEO-TEMPERATURE RECONSTRUCTION FOR THE LAST 15.5 CAL KA BP BASED ON THE PIAN DI GEMBRO POLLEN RECORD

Palynological records obtained from off-site stratigraphies provide the opportunity to develop continuous series of quantitative estimations of past temperature and precipitations. For the purpose of this paper we selected the Pian di Gembro pollen record as it is one of the highly-resolved (chronologically and taxonomically) palaeoecological studies so far carried out at alpine scale and, most important, it falls inside the geographical area considered for this review paper. The site complies to the off-site requirement, being several km far from known archaeological areas. The Pian di Gembro pollen record straddles a time interval of nearly 16 thou-

Site name	Site typology	Altitude	Coordinates from Google Earth	Reference	
Sites used for paleoecological investigations					
1	Cividate Camuno, via Ponte Vecchio 10	archeological stratigraphy	285 m	45°56'43.74"N 10°16'42.87"E	Pini & Ravazzi, 2010
2	Lago di Gaiano	lake	341 m	45°47'32.09"N 10°00'34.52"E	Gehrig, 1997
3	Capo di Ponte, fraz. Cemmo - Pian delle Greppe	colluvial deposits and soils	403 m	46°01'51.625"N 10°20'18.123"E	Pini et al., 2013
4	Torbiera di Cerete	peat bog	462 m	45°51'26.31"N 9°59'28.67"E	Ravazzi et al., 2012
5	Palù di Sonico, uppermost peat bog	mire	660 m	46°09'07"N 10°20'32"E	Gehrig, 1997
6	Lago di Lova	lake	1299 m	45°57'58"N 10°12'28"E	Gehrig, 1997
7	Pian di Gembro	peat bog	1350 m	46°09'52.85"N 10°09'07.86"E	Pini, 2002
8	Torbiera Alpe Paiole - Passo del Tonale	peat bog	1883 m	46°15'30.56"N 10°34'53.05"E	Gehrig, 1997
9	Torbiera Dos del Curù	peat bog	1975 m	46°06'09.54"N 10°23'30.21"E	Ravazzi et al., 2014
10	Laghetti del Crestoso	lake	2001 m	45°51'25.87"N 10°18'46.02"E	Scaife, 1997
11	Col Carette di Val Bighera	peat bog	2087 m	46°15'24"N 10°21'26"E	Gehrig, 1997
12	Torbiera del Lago Nero - Passo Gavia	fen	2389 m	46°20'07.55"N 10°29'04.68" E	Aceti, 2006
13	Buried peat, Rifugio Berni - Torrente Gavia	slope deposits	2530 m	46°21'28.27"N 10°30'01.43"E	Aceti, 2006
14	Torbiera della Costa	mire	2590 m	46°21'40"N 10°29'51"E	unpublished data
Archeological sites cited in the text					
15	Cividate Camuno, Via Palazzo Malegno, Via Cavour	hut (settlement)	308 m	45°56'43,019"N 10°16'44,673"E	Poggiani Keller, 1999, 2004, 2010; Baglioni & Martini, 2009
16	Loveve, Colle del Lazzaretto	settlement	314 m	45°48'40,621"N 10°3'44,415"E	Poggiani Keller, 2000
17	Darfo Boario Terme, Luine	settlement rock art site	322 m	45°53'17,482"N 10°10'41,257"E	Anati, 1982; De Marinis, 1989
18	Breno, Val Morina	necropolis	323 m	45°57'29,800"N 10°18'38,822"E	Bertolone et al., 1956-1957
19	Breno, Castello	hut (settlement)	353 m	45°57'20,434"N 10°17'53,106"E	Fedele, 1988; De Marinis, 1989
20	Darfo Boario Terme, loc. Corna	settlement	354 m	45°53'6,997"N 10°10'20,654"E	Solano, 2010
21	Capo di Ponte, Le Sante	votive fire	400 m	46°1'58,548"N 10°20'51,034"E	Solano, 2008
22	Capo di Ponte, fraz. Cemmo - Pian delle Greppe	settlement ceremonial center	403 m	46°1'51,625"N 10°20'18,123"E	Poggiani Keller, 2006; Poggiani Keller et al., 2014
23	Capo di Ponte, Seradina	settlement rock art site	460 m	46°2'4,091"N 10°20'31,952"E	Ingravallo, 1984
24	Capo di Ponte, Dos dell'Arca	settlement rock art site	464 m	46°2'2,437"N 10°21'15,798"E	Anati, 1968; De Marinis, 1989
25	Ceto, Foppe di Nadro riparo 2	settlement necropolis	526 m	46°1'24,893"N 10°21'6,144"E	Biagi, 1983; Zanettin, 1983
26	Capo di Ponte, fraz. Pescarzo	settlement	637 m	46°1'59,679"N 10°19'37,224"E	Rossi, 1999, 2002
27	Rogno, Coren Pagà	settlement	653 m	45°51'24,996"N 10°7'15,393"E	Ferrari et al., 2003
28	Berzo Demo, via Kennedy	settlement	744 m	46°5'34,738"N 10°20'10,231"E	Solano & Simonotti 2008
29	Ossimo, Pat	settlement ceremonial center	813 m	45°57'47,438"N 10°15'0,043"E	Poggiani Keller, 2004, 2006
30	Borno, Valcamera	settlement	1014 m	45°56'42,202"N 10°11'2,903"E	Poggiani Keller, 2006
31	Temù, Desert	settlement	1123 m	46°14'44,435"N 10°28'13,763"E	Poggiani Keller, 2009
32	Artogne, Cascina Val Maione	seasonal camp	1786 m	45°48'57,482"N 10°13'17,151"E	Biagi, 1997; Biagi & Starnini, 2015
33	Berzo Inferiore, Mt. Colombino	seasonal camps	1998 m	45°51'40,417"N 10°18'17,900"E	Biagi, 1997
34	Bovegno, Laghetti del Crestoso	seasonal camps	2005 m	45°51'25,574"N 10°18'48,494"E	Baroni, 1997

Tab. 1 - Altitude, geographical coordinates and main references of the palaeoecological and archaeological records used to reconstruct the ecological history of Valcamonica. Site numbers according to Fig. 2. Geographical coordinates according to the EPSG 3857 Web Mercator Projection, standard for web mapping applications.

sand years, represented in 283 fossil spectra with a sampling interval of 60 years and a sound chronology relying on ten AMS ^{14}C dates from terrestrial plants and the recognition of biostratigraphic events at regional scale.

Pollen-based mean annual temperature reconstructions were obtained following the methodology described in Pini et al. (2014) and presented by Vallé et al. (2015). Two solutions (I and II, see Fig. 5) are presented; they differ in the composition of the main pollen sum used for calculation of percentage values. In solution I Gramineae are included in the pollen sum; in solution II, based on the ratio between Gramineae and *Artemisia* between 8-15.3 cal ka BP, the signal due to local grasses was distinguished and % kept outside of the pollen sum. For both solutions, the EMPD database was explored with the LWVA technique and a transfer function generated and then applied to the fossil Pian di Gembro datasets for the climate reconstructions. Mean annual temperature curves ($^{\circ}\text{C}$) so far obtained are shown in Fig. 5. These are the first direct estimation of a past climate parameter from the Central Alps, allowing comparison with other climate proxies (for example, the NGRIP $\delta^{18}\text{O}$ record). The reconstructed temperature series pinpoint events in agreement with the NGRIP record of hemispheric variability (Svensson et al., 2008) such as the temperature rise during the Bølling-Allerød interstadial and at the Holocene onset, the Younger Dryas and Preboreal coolings, the 8.2 cal ka BP event. Secular events taking place in the last 3 thousand years, such as the Early Iron Age cold phase, are detected in our temperature reconstructions and are chronologically consistent with known oscillations of large alpine glaciers (Aletsch Glacier, Holzhauser et al., 2005; Mer de Glace, Le Roy et al., 2015; not shown in Fig. 5).

A more complete set of reconstructed past climate variables (monthly to seasonal temperature and precipitation) is needed for a detailed comparison with other climate proxies. Actually, the first test performed at Pian di Gembro highlights the potential of fossil pollen spectra for quantitative estimations of temperatures and the need for regional and altitudinal analysis of the relationships between pollen rain - modern vegetation - climate parameters to improve reconstructions.

4. PALAEOECOLOGICAL HISTORY OF VALCAMONICA. THE LANDSCAPE OF THE PALEOLITHIC HUNTERS

According to palaeoecology and radiocarbon dating from lake records, the final collapse of the Oglio Glacier took place around 18.5-17.5 cal ka BP (Ravazzi et al., 2012). It can be argued that the entire valley floor and the largest alpine south-facing valleys were ice-free at the end of the Gschnitz advance, 16-15.3 cal ka BP



Fig. 3 - Panoramic view of the Pian di Gembro peat bog, a key site for the reconstruction of regional climate and environments of the last 15 cal ka BP.

(Ivy-Ochs et al., 2006). The melting of Last Glacial Maximum ice masses was followed by a millennia-long phase of slope instability and sediment readjustment, preventing a fast colonization by woody vegetation. Paraglacial conditions and a mosaic of open conifer forests on stable surfaces persisted up to the onset of the Bølling-Allerød interstadial. Evidence of fast afforestation at the interstadial onset in Valcamonica were obtained from the following lakes and mire archives: Pian di Gembro (Pini, 2002), Passo del Tonale and Col di Val Bighera (sites 8 and 11 in Fig. 2; Gehrig, 1997) and Loa peat bog (Ravazzi et al., 2014a). Some hundred years after the beginning of the Bølling-Allerød interstadial the treeline was located at ca. 1,700 m asl and conifer forests were rapidly thickening (Fig. 5 and 7, the latter hereinafter).

The occurrence of Paleolithic human peopling along the Valcamonica valley floor is suggested by quite a number of finds, hereafter briefly summarized. The find of an Upper Paleolithic hut at Cividate Camuno-Via Palazzo (site 15 in Fig. 2; Poggiani Keller, 1999; Bagliolini & Martini, 2009) represents the most significant evidence, still under study rock art figures engraved by an early "protocamuno" style at Luine (site 17 in Fig. 2; see also Fig. 4) are given a possible final Epigravettian age (Martini et al., 2009). Paleolithic finds are also dubitatively reported from the rockshelter 2 of Foppe di Nadro, at Ceto (site 25 in Fig. 2; Zanettin, 1983).

The occurrence of paleolithic groups in the valley floor can be related to the presence of wild mammals sheltering in conifer forests which were games for Upper Paleolithic hunters, their survival being dependent on the establishment of conifers (*Pinus mugo*, *Pinus cembra* and *Larix decidua*), which occurred as early as 16,700 cal a BP in Val Borlezza (Ravazzi et al., 2012), i.e. a lateral valley of middle Valcamonica (Fig. 1). However, precise age and subsistence facts for these Paleolithic settlements cannot be traced so far, given the large uncertainty of the unique radiocarbon age so far avail-

able for the hut (13,805±440 ¹⁴C a BP, 2σ calibration interval 17.9-15.5 cal ka BP, median probability 16.7 cal ka BP) and the urgent need of revising its preliminary faunal assessment (Fusco in Poggiani, 1989). Four of the figures engraved in the proto-camuno style at Luine were assigned to moose (*Alces alces*) (Anati, 1974), which occurrence is perfectly sound until the early Holocene on the southern side of the Alps (Breda, 2002), but doubts have been recently cast over the interpretation of these cervid engravings (Martini et al., 2009). Indeed, in the lateglacial, the area of Luine offered the preferred habitat for moose, as it was close to the shore of the large Iseo palaeo-lake, extending north to Cividate Camuno at the time of deglaciation (Fig. 1).

The climate deterioration of the Younger Dryas (12.8-11.7 cal ka BP) led to a lowering of the forest limit down to ca. 1,500 m asl (Ravazzi et al., 2007b) and a renewed expansion of xerophytic vegetation and grasslands affecting especially the montane and subalpine belts, while no data exist about the dynamics and peopling of the valley floor in this time span.

5. FROM THE HOLOCENE FIRST MILLENNIA TO THE ATLANTIC PERIOD, ACROSS THE 8.2 CAL KA BP EVENT, AND THE MESOLITHIC

A shift towards more negative isotopic δ¹⁸O values is recorded in polar ice cores at 11.7 cal ka BP, giving the onset to the present interglacial, i.e. the Holocene. The climate amelioration, estimated in 4-6°C warming, led to a fast timberline rise in the Alps (800 m in ca. 200-300 years, according to Tinner & Kaltenrieder, 2005), later reaching a position as high as 2,400-2,500 m in the inner Alps (Tinner, 2007). The continental climate regime that characterized the Alps during the first millennia of the Holocene abruptly ended at 8.2 cal ka BP, when moister conditions started to prevail (onset of the Atlantic period). According to Tinner & Ammann (2001) this shift was possibly related to increasing humid air masses from west and north-west, resulting in reduced annual temperatures and increasing precipitations along the Alpine Chain.

With the 8.2 cal ka BP event, *Picea abies* (spruce) and *Abies alba* (silver fir) expanded at middle altitudes in Valcamonica, as shown in the Pian di Gembro pollen record (Pini, 2002, Fig. 6 and 7). Even afterwards, the treeline remained high (> 2,600 m asl) as testified by the findings of fossil *Pinus cembra* trunks in mires at 2,400 m asl at Torbiera del Lago Nero near Passo di Gavia (site 12 in Fig. 2; Aceti, 2006) and of a pine wood at Torbiera della Costa (2,590 m asl, site 14 in Fig. 2;

Ravazzi, unpublished data), dated to 7,775±65 ¹⁴C a BP (2σ calibration interval 8.4-8.7 cal ka BP, median probability 8.55 cal ka BP). During the Atlantic period, the montane landscapes of Valtellina and Valcamonica were dominated by dense *Picea abies* and *Abies alba* forests. These trees formed a wide altitudinal belt thriving both in oceanic conditions and in relatively more continental contexts. Mixed broad-leaved forests dominated in the lower altitudes, up to 1,500 m asl. (Fig. 6 and 7).

The recent claim of Mesolithic occupation at

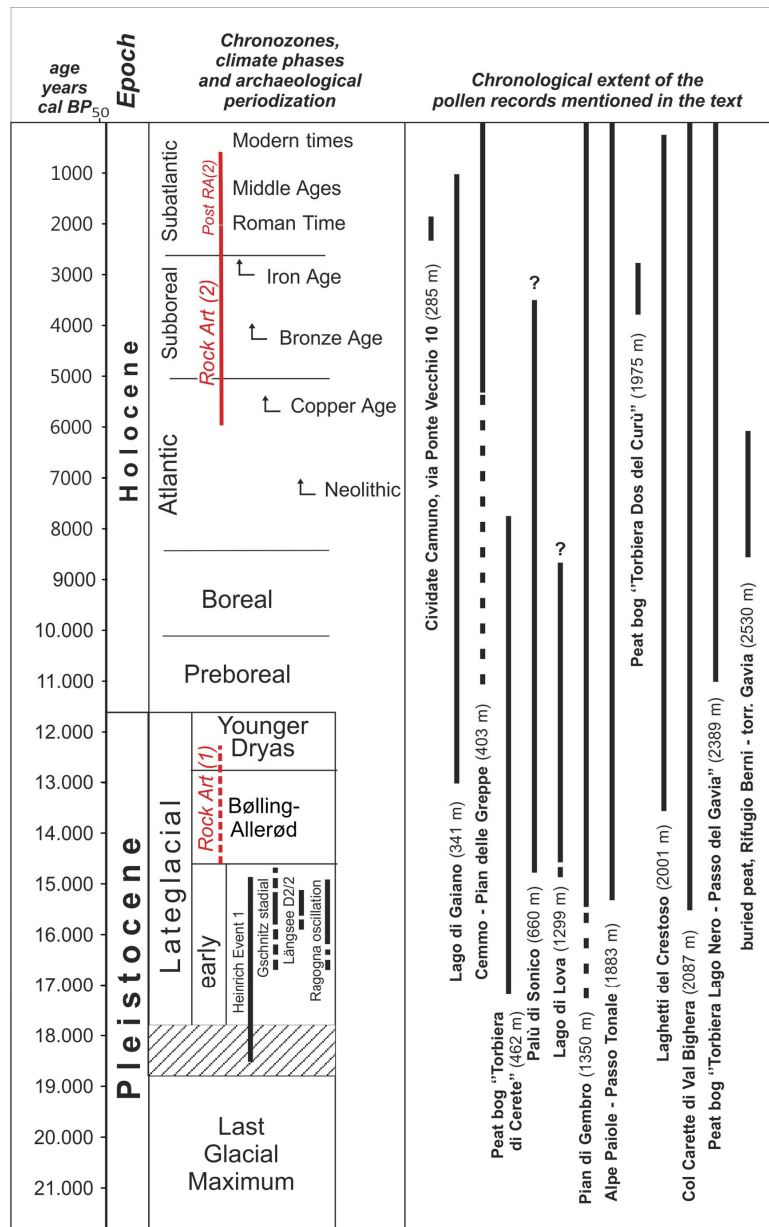


Fig. 4 - Chronozones, archaeological periodization and chronological extent of the palaeoecological records available from Valcamonica. For references on the chronostratigraphic subdivisions used in this scheme, see Fig. 5.

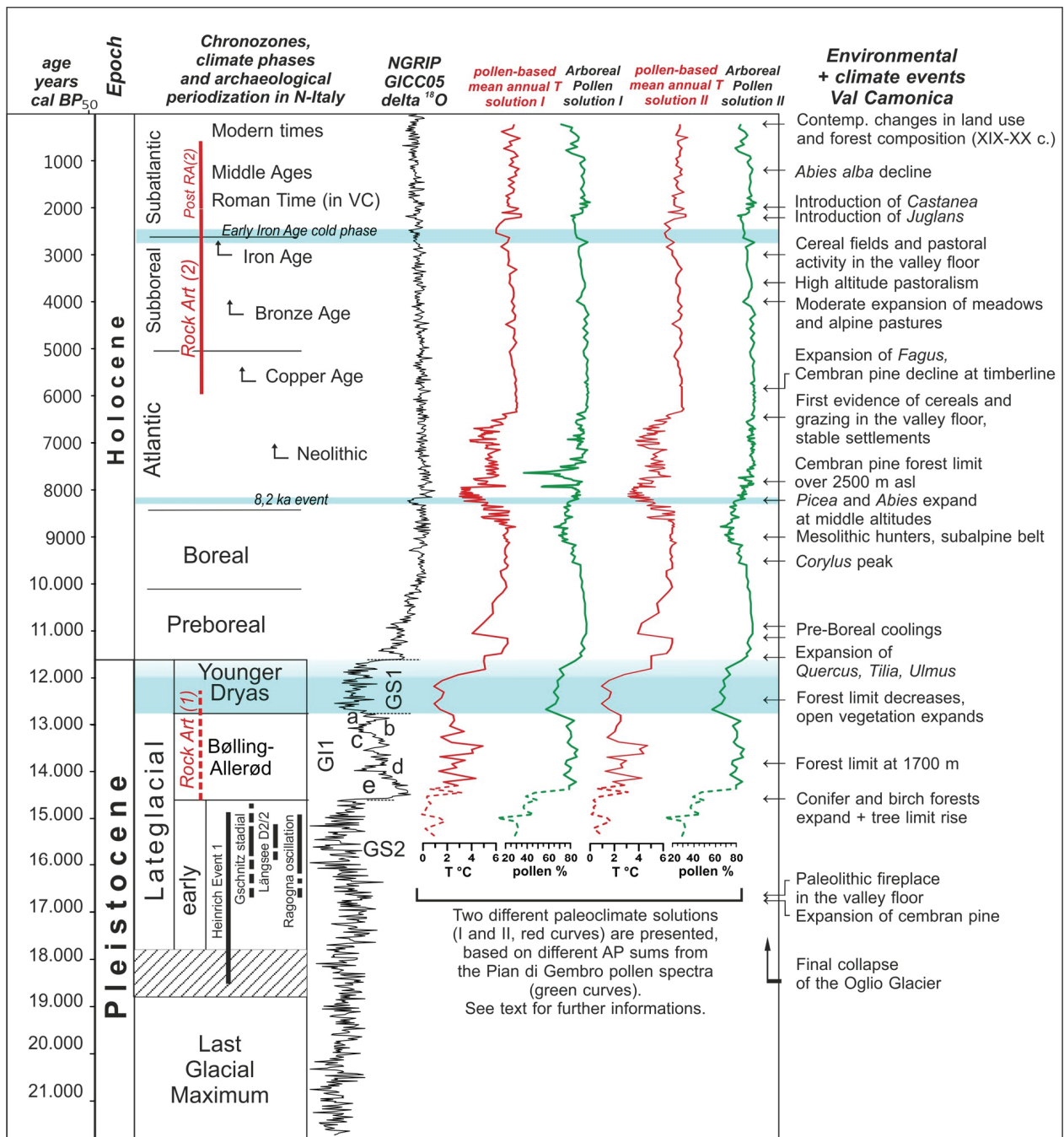


Fig. 5 - Stratigraphic scheme summarizing the main events recorded in the vegetation, climate and cultural history of Valcamonica since the last deglaciation. Chronology and climate stratigraphic subdivisions are from Orombelli & Ravazzi (1996), Ravazzi et al. (2007), Svensson et al. (2008). Duration of global LGM refer to Clark et al. (2009); Heinrich Event I to Stanford et al. (2011); Ragnogna oscillation to Ravazzi et al. (2014b); Längsee cold phase to Schmidt et al. (2012); Gschnitz stadial to Ivy-Ochs et al. (2006). Rock Art (1) from Martini et al. (2009); Rock Art (2) from De Marinis & Fossati (2012).

As for the Pian di Gembro data, solution I = Gramineae included in the pollen sum used for % calculation; solution II = local grasses excluded from the pollen sum (see also paragraph 11). Below 14,300 cal a BP, curves are dotted because of uncertainties in the age depth-model.

Light-blue bars indicate cold phases occurring during the last 12 cal ka BP and recorded both in the NGRIP isotopic record and in the preliminary temperature records from the Pian di Gembro series.

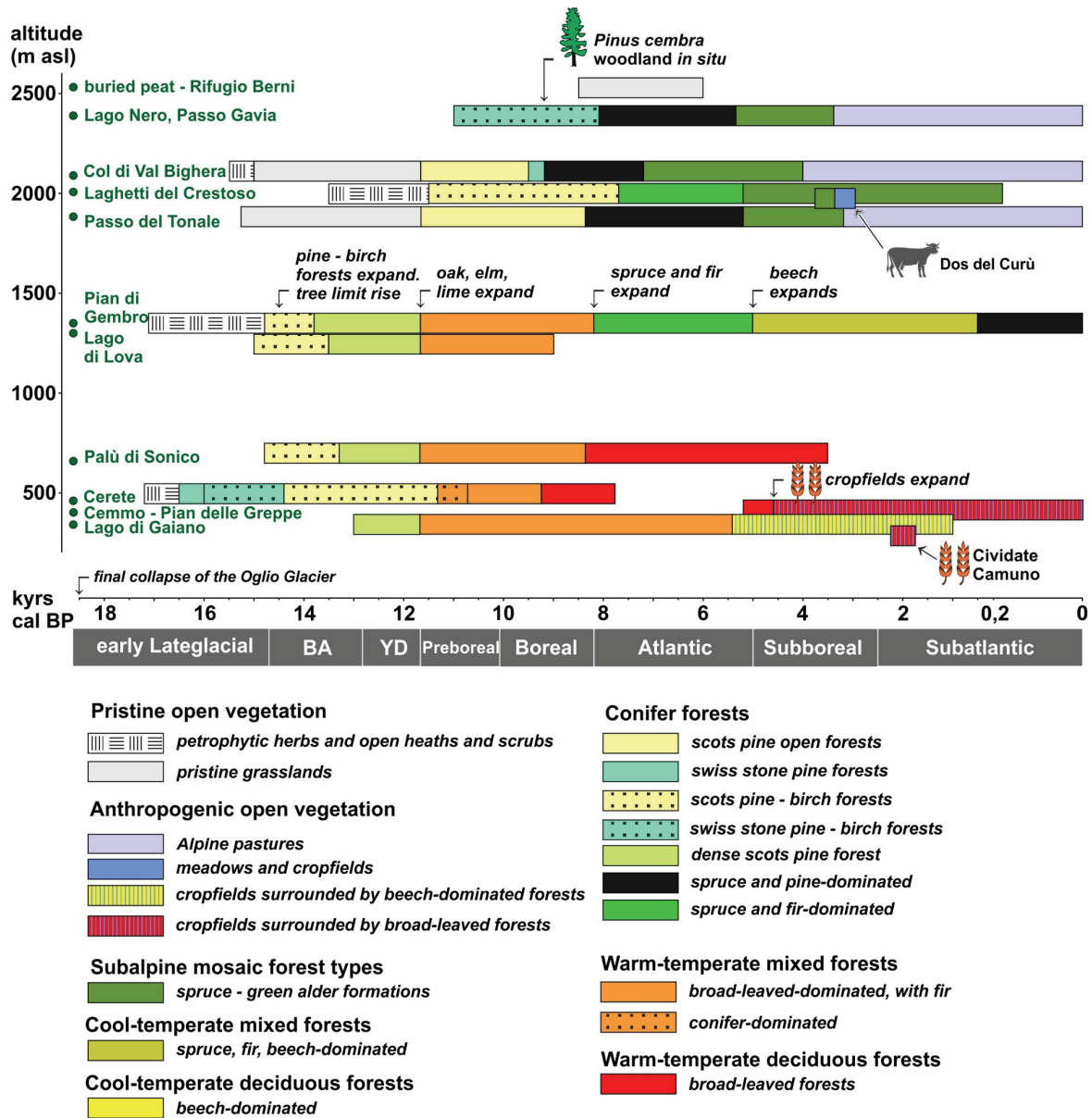


Fig. 6 - Workroom to reconstruct the vegetation history of Valcamonica during the last 18 cal ka BP. Solution presented in Fig. 5.

Cemmo, close to the valley floor (Poggiani Keller et al., 2014) deserves a specific archaeobotanical investigation. Cemmo is not the only known site in the valley floor. The already mentioned site of Cividate Camuno-Via Palazzo (Poggiani Keller, 1999, 2004) has been inhabited again during the Early Mesolithic (Sauveterrian) and the rock shelter 2 of Foppe di Nadro (Biagi, 1983) has been occupied during the Late Mesolithic (Castelnovian). In early summer, groups of hunters used to move from the valley floor to high-altitude seasonal camps, such as those identified in Malga Rondeneto and Laghi di Ravènola (first Mesolithic phase), and in Val Maione, Dosso dell'Asino, Stanga di Bassi-

nale, Sella di S. Glisente and Laghetti del Crestoso (second Mesolithic phase) along the ridge connecting Valcamonica with Valtrompia (Biagi, 1997, Biagi & Starnini 2015). Unlike other alpine valleys, Mesolithic hunters used high-altitude sites in Valcamonica even during the Castelnovian. These Mesolithic hunting activities, testified in the Maniva Massif, middle Valcamonica, are accompanied by evidence of forest fires in the subalpine belt (Baroni, 1997). A *Picea* charcoal fragment from a hearth yielded an age of $7,870 \pm 50$ ¹⁴C a BP (2σ calibration interval 8.55-8.8 cal ka BP, median probability 8.7 cal ka BP). A very similar age was obtained on charcoals from a pit with heat-fractured pebbles ($7,850 \pm 80$

^{14}C a BP, 2σ calibration interval 8.5-8.8 cal ka BP, median probability 8.67 cal ka BP). Although not strictly related to the Oglio River catchment, the Mesolithic site of Dosso Gavia (Angelucci et al., 1992) points to activities carried out by Mesolithic hunters in the highlands of the Gavia Pass (site 12 in Fig. 2). Regardless to this Mesolithic peopling, the high mountains were not settled while the Neolithic farming in Valcamonica started to develop in the subsequent millennia (Biagi & Starnini, 2015). The palaeoecological evidence presented in the following sections will also support this figure of high-altitude peopling discontinuity.

6. THE MIDDLE HOLOCENE

A pronounced expansion of *Fagus sylvatica* (beech) started as early as 5.6-5.4 cal ka BP, synchronous to many other records in N-Italy (Magri et al., 2015, Valsecchi et al., 2008). Culturally, this forest change took place during the late Neolithic, and continued in the early phases of the Copper Age. As observed at the SW-Alpine border (e.g. Brianza lakes; Wick, 1996, Gobet et al., 2000), beech expansion followed a phase of decreasing abundance of *Abies alba* pollen in sediments. *Fagus* expansion was possibly favoured by anthropic fires used by Neolithic populations for forest clearing, drastically reducing the extent of *Abies alba* stands (Wick & Möhl, 2006). Other arguments, including synchronism at wide regional scale, support a concurrent climate trigger (Valsecchi et al., 2008). Phases of cooling and wet periods drove a timberline depression in all the Alpine realm in the V millennium BC (Tinner, 2007), which is, between the Late Neolithic and the onset of the Copper Age (Pini et al., in preparation). Consistently, at Passo di Gavia, the decline of Swiss stone pine (*Pinus cembra*) and the expansion of green alder (*Alnus viridis*) scrublands are dated to 5.8-5.5 cal ka BP (Aceti, 2006, see Fig. 6 and 7). The palaeoclimatic context of Oetzi also suggests glacier advance in the second half of the VI millennium BC (Baroni & Orombelli, 1996).

The onset of early agriculture in Valcamonica is not yet properly investigated nor framed in time. This is a major gap in the current understanding of the origin and development of one of the most representative civilizations of the Alpine prehistory. The time span between 7.5-6.5 cal ka BP may be currently understood as a period of missing anthropic impact, both from cultural and palaeoecological evidence, spanning the period between the end of the Mesolithic phase and the onset of farming.

Pollen of meadow plants, such as *Rumex acetosella* type and *Ranunculus acris* type, are registered continuously at Pian di Gembro from 6.8 cal ka BP. Their interpretation is tricky, as they might be an indication of pastures some km far from the mire of Pian di Gembro or apophytes, i.e. native species taking advantage on disturbed land. This latter interpretation might be supported by the fact that the pollen of those species was present, also in the previous millennia, pointing out that they were already growing in the area. Indicators of pastures (*Plantago lanceolata* type and other herbs) and charcoal content increased ca. 6-5.8 cal ka BP (Gehrig,

1997). The oldest cereal pollen identified at Pian di Gembro dates back to ca. 6 cal ka BP (see Fig. 7). These data are consistent with the cultural chronology of early settlements from Valcamonica. Indeed, the first permanent settlements are referred to the Middle and Recent Neolithic, and dated to the V-IV millennium BC (Poggiani Keller, 2010). The relevant settlements are: Colle del Lazzaretto at Lovere (site 16 in Fig. 2), Coren Pagà at Rogno (site 27), Luine at Darfo-Boario Terme (site 17), Cividate Camuno-Via Palazzo (site 15) and Breno-Castello (site 19). They belong to Square Mouth Pottery and Lagozza Cultures, but, as far as the Recent Neolithic is concerned, they also include typical and local elements attributed to a Central Alpine or "Breno" cultural group. These settlements often show an uninterrupted occupation and testify to a significant demographic increase lasting until the end of the first millennium BC.

Megalithic sanctuaries and ceremonial centres were built in Valcamonica during the Copper Age (mid IV-III millennium BC) (Poggiani Keller, 2006); they are entitled by engraved stelae and menhir-boulders. The main sites are located on the plateau of Ossimo-Borno and at the localities of Corni Freschi at Darfo-Boario Terme and Cemmo at Capo di Ponte. Menhir-boulders are also associated with a particular stylistic phase of rock art (i.e. the style IIIA, Casini, 1994; Casini & Foscati, 2013). Together with solar and anthropomorphic figures, weapons and other symbols, there are both domestic and wild animals: cattle (yoked in ploughing scenes), swine, canids (dogs, wolves and foxes), cervids, goats (chamois and ibex) and other species, which made up the fauna of that time. The wide distribution of these sites in the territory confirm the settlement density recorded in the Late Neolithic.

7. THE QUESTION OF EARLY MOUNTAIN PASTORALISM

The timberline depression observed at Passo di Gavia in the first half of the IV millennium BC raises the question of climate change versus early mountain pastoralism and human impact on upper forest belts. Here we briefly summarize the status of the art in the Alps and in Valcamonica.

According to Barfield et al. (2003) the origins of mountain pastoralism can be framed in the IV millennium BC. The archaeological evidence underline the spread of mountain and high-altitude sites, while the exploitation of high-altitude pastures is just inferred (see Marzatico, 2007), being clearly documented the agricultural practices in the mountain belt only, without evidence of herding over the timberline. Indications for sedentary high-altitude herding in Valle d'Aosta, Western Alps (Pini et al., 2013) come from a combined analysis of palynomorphs and nutrient history in a sedimentary succession from an Alpine pond supposed to be used for animal husbandry (Pini et al., in preparation).

Here, several ^{14}C ages obtained on archaeological charcoal fragments retrieved from sites scattered in a radius of few hundred meters from the pond show a highly significant correlation with major vegetation

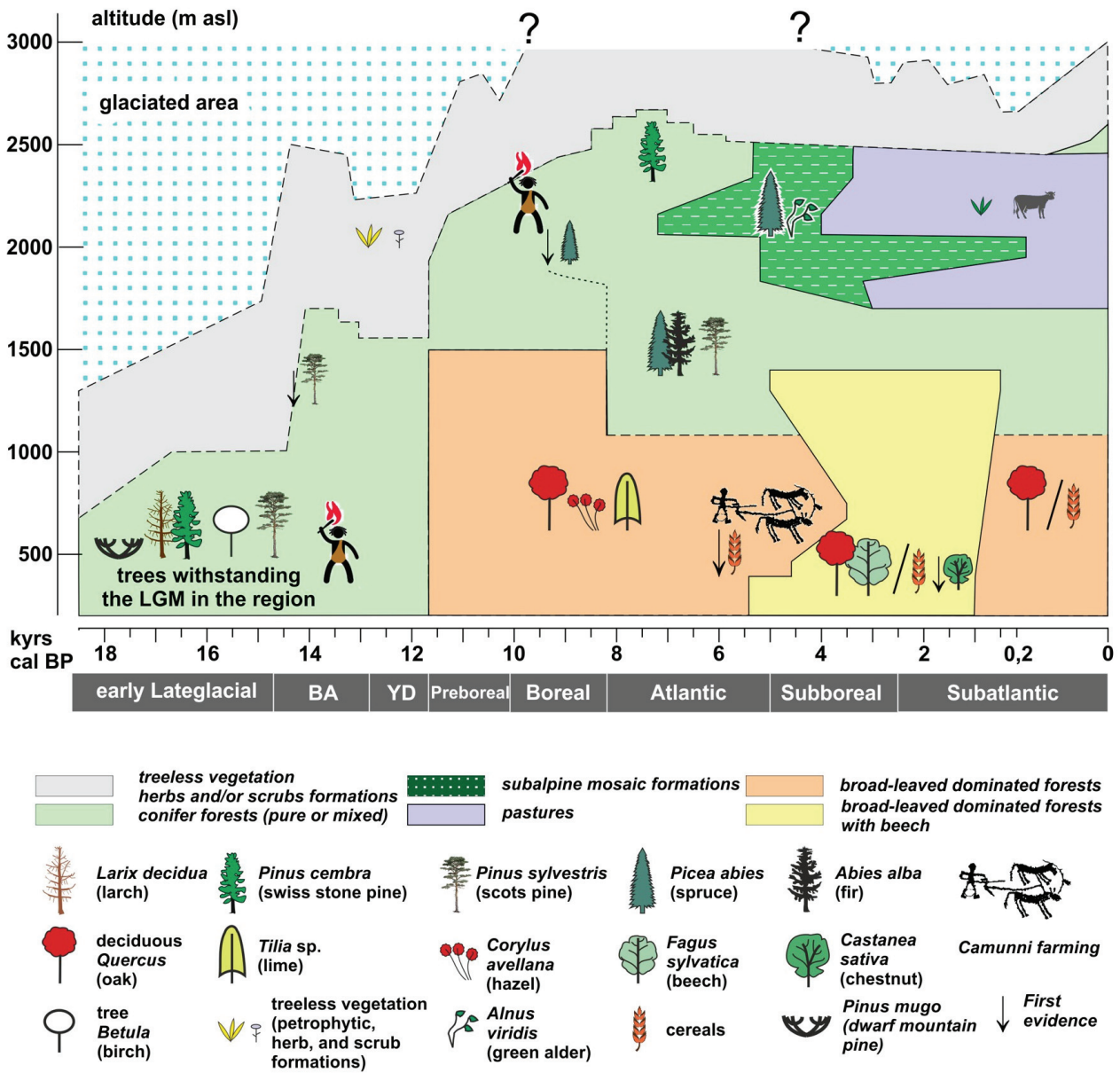


Fig. 7 - Biosketch - vegetation history Valcamonica, 18.5 cal ka ago to modern time. The reconstruction is plotted against time and altitude, to show the time-development of vegetation belts. The spatial resolution of the reconstructed ecosystems depends on the availability of fossil records at relevant altitude (see Fig. 4, 5, 6 and Tab. 1). One of the well-known ploughing scenes from the Bedoline area is here used to show the onset of agricultural practices in Valcamonica, even though we are not sure whether the plough was already used around 6 cal ka BP.

changes evidenced in the palynological record from the cored basin. The demise of conifer forests is here coupled with increasing abundance of pollen of pastures and coprophilous fungal spores (*Sordariaceae*, *Sporormiella* and *Podospora*), and enhanced phosphorous input to the basin.

Furthermore, a doubtful molecular evidence for late Neolithic cow transhumance has been recently reported for the Western French Alps (Giguet-Covex et

al., 2013). On the other hand, in the Eastern Alps the palaeobotanical evidence is restricted to the Copper/Bronze Age transition (Oeggli, 1994; Festi et al., 2014) as observed at Passo di Gavia (Aceti, 2006).

The overall framework suggests that early pastoralism developed under the effects of concurrent climate and cultural changes. A cooling triggered forest depression, with coeval expansion of subalpine scrublands and Alpine grasslands between 5.8 and 5.4 cal ka BP. In

turn this is the favourable natural setting for the development of high-altitude herding, its effective establishment depending on local features - such as accessibility, size of upland pastures, water supply - and on human cultural history. Further work is needed in Valcamonica at high-altitude pastures preserving natural archives.

8. THE ONSET OF LATE HOLOCENE THE BRONZE AGE

Around 4 cal ka BP *Fagus sylvatica* was the dominant forest tree both at the prealpine margin and in the montane belt of outer Alpine valleys. Mixed stands of beech, spruce and silver fir were common in the Central Alps up to the first half of the Subboreal period. However, in Valcamonica beech did not reach the high forest cover values reconstructed in adjacent mountain regions (Lake Lavarone, eastern sector of the Adige Valley; Filippi et al., 2005). With the onset of the Early Bronze Age, pollen types typical of pastures (*Rumex acetosa* and *acetosella* types, *Plantago lanceolata* type) and ruderal areas (*Urtica* and *Artemisia*) slightly increase in the records so far studied (Pian di Gembro, Dos del Curù) testifying to a moderate expansion of grasslands and alpine pastures at mid and high altitudes respectively (Fig. 5 to 7). Such an expansion of ruderal land and pastures is only documented in the middle and high Valcamonica, while no significant evidence emerges from the nearby Val Cavallina (Gehrig, 1997; Pini & Ravazzi, 2009, see Fig. 2). Bronze Age subalpine pastures affected the Passo del Gavia area (Aceti, 2006) and the site of Dos del Curù in Val Saviore (site 9 in Fig. 2; Ravazzi et al., 2014a). Nearby, the human presence is even attested at high-altitude areas by the discovery of bronze artefacts probably offered in votive deposits at Lago d'Arno (1,817 m asl; Pigorini, 1911).

In the nearby Swiss Alps cereal crop evidence at the montane and subalpine belt (between 1,200-1,800 m asl) is dated to the very beginning of the Bronze Age (ca. 2,200 BC) and appears to be correlated to terracing construction (Zoller, 1998).

On the whole, Bronze Age archaeological data from Valcamonica are still fairly poor. Pottery fragments coming from the long-lived settlements of Luine at Darfo-Boario Terme (Anati, 1982), Breno-Castello (Fedele, 1988) and Dos dell'Arca at Capo di Ponte (Anati, 1968), recall the Pile dwellings - Terramare Culture of the Po Valley (De Marinis, 1989). In Valcamonica there are no archaeological evidences of pile dwellings or other kinds of Bronze age dwellings and, as for the rock art, engravings of building structures do not clarify this topic. However, lake dwellings may have actually existed south of Darfo-Boario Terme: they are expected to have been buried under the late Holocene alluvial plain of the Oglio River. This fascinating hypothesis was never explored so far to our knowledge.

9. THE GROWTH OF FARMING IN THE IRON AGE

The Iron Age represents a main step of human demographic increase in the Alpine realm and is marked by the spread of metal tools for agriculture and forest

exploitation. The development of large protourban settlements and the need for wood for iron-smelting purposes promoted forest clearing and logging, especially in the valley floors, to obtain areas to be exploited for pastoralism. However, large sectors of the Alps remained uninhabited.

In Valcamonica, the settlements of Borno-Val Camera (site 30 in Fig. 2), Ossimo-Pat (site 29) and Berzo Demo (site 28) and the house of Temù-Desert (site 31, together with other sporadic finds) join those already mentioned of Darfo-Boario Terme, Cividate Camuno-Malegno, Breno and Capo di Ponte, uninterruptedly persisted until this period. From a cultural perspective, a distinct and autonomous facies developed in this territory (including the neighbouring Valtellina, Valtrompia and Valli Giudicarie). It was characterized by linguistic and epigraphic homogeneity, specific funerary practices (attested in the necropolis of Breno-Val Morina: Bertolone et al., 1956-1957) and original elements of the material culture, but also open to external influences, especially from other Central Eastern Alps cultures (De Marinis, 1992, 1999; Solano & Simonotti, 2008; Poggiani Keller, 2009; Solano, 2010).

Regardless to differential preservation of engravings due to variable weathering rate of rock surfaces in relation to rock properties, it seems that, during the first millennium BC, the rock art phenomenon spread throughout the valley. Moreover, with the transition to the Iron Age and the development of aristocratic societies a change in the rock art language also appeared; no longer schematic and symbolic but more naturalistic and narrative: armed figures and warriors, therefore, took the place of those praying and of anthropomorphic figures.

Palaeoecological records from middle and high Valcamonica point to the spread of pastoral activities, as seen at the Cemmo sanctuary (Poggiani Keller et al., 2005), and suggested by increasing extent of pastures, meadows and *Larix decidua* (larch) pollen at Pian di Gembro (Pini, 2002). Stable subalpine pastures developed also in the high Alpine belt, e.g. Passo del Gavia. From the VII century BC cereal pollen is regularly found in the Pian di Gembro record, suggesting stable human settlements and cereal fields at a few km distance.

10. FROM THE LATE IRON AGE TO THE ROMAN TIMES AND THE MIDDLE AGES

The area of Cividate Camuno yielded vestiges of an Iron Age Castelliere, a fortified borough testifying to a small pre-Roman settlement, and a Roman domus. Civitas Camunorum was actually founded by the Romans in the last decades of the I century BC, following the rules of the *ager centuriatus* system, with a theatre, an amphitheatre and thermal baths (Mariotti, 2004). At Cividate Camuno construction works and renovation of buildings in the historical city center allowed sampling an archaeological stratigraphy. Palaeobotanical evidence from via Ponte Vecchio 10 (site 1 in Fig. 2) depicts the plant landscape of the Valcamonica valley floor between the Late Iron Age and the Roman Period (Pini & Ravazzi, 2010). Broad-leaved deciduous forests with oaks, hazel, lime and elm fringed the slopes. Sinan-

thropic vegetation with cereal fields (*Avena-Triticum* type) and nitrophilous agro-pastoral habitats were widespread on flat areas and possibly on low-gradient slopes. Ruderal plant communities of urban setting can also be inferred from pollen spectra. Sediments from the analyzed profile yielded a high amount of Cichorioideae pollen, along with a general poor degree of palynomorphs preservation. How can these features be interpreted? Despite recent papers claiming the interpretation of Cichorioideae as proxy of secondary pastures and primary open habitats in the Mediterranean area (Florenzano et al., 2015 and references therein), this explanation does not seem to be satisfactory when applied to northern Italian sites and archaeological stratigraphies. Studies on modern pollen rain along different habitats on an alpine altitudinal transect (CNR-IDPA, unpublished data) are helpful in defining the Cichorioideae as non-indicator taxon, that is a single/group of species with no degree of association between parent plants and pollen. The overwhelming content of Cichorioideae pollen recorded at Civate Camuno (mean percentage values of 400%, and up to 800% in some pollen spectra) just suggests that these herbs were common in the vegetation. The huge representation of this pollen type, very often recorded in archaeological sites developed in an urban context on dry terrains, when combined with a poorly-preserved palynoflora, speaks for issues related to pollen taphonomy and preservation, rather than a true correspondence with a real vegetation. Selective degradation of pollen grains (and, on the other hand, the selective preservation of the strongest ones) is indeed a process known for oxidized sediments supporting intense bacterial activity (Dimbleby, 1985).

In 16 BC the Valcamonica was subdued and soon became part of the Roman system (for an overview: Rossi, 2007). Iron-smelting activities developed further along the prealpine margin of Lombardy. Wood resources were intensively used, leading to the disruption of native conifer forests close to mines. *Larix* parkland expanded, as a result of stock breeding practices, in more open forests. Increasing charcoal abundance in sediments points to rising anthropic pressure in the lowland and higher up. Cereal cultivations took place in lowland areas from the II century AD. Cultivated trees mainly used for human consumption such as *Juglans regia* (walnut) and *Castanea sativa* (chestnut) were introduced in the valleys of Lombardy between the I century BC and the II century AD (Drescher-Schneider, 1994; Gobet, 2000; Pini, 2002; Ravazzi et al., 2007a). This is confirmed also by the finding of walnut (*Juglans regia*) remains in the site of Pescarzo dated to II-I century BC (Castiglioni et al., 1999). Older occurrence of walnut fragments in the ritual site of Spinera at Breno, dated to V-III century BC have been interpreted as a likely long-distance transport, not a local cultivation of this tree (Castiglioni & Rottoli, 2010). Indeed, walnut pollen record dated back to VIII century BC in the central Po plain with marked Etruscan influence (Ravazzi et al., 2013).

In the Middle Ages, intense logging for iron-smelting activities (Marziani & Citterio, 1999) strongly reduced the range of *Abies alba* in Valcamonica and

nearby valleys. Open areas were then used for agro-pastoral activities.

11. CONTEMPORARY DYNAMICS THE LINK FROM THE PAST TO THE FUTURE

In contemporary times (XIX-XX century), intensive coppicing, logging and clearing in the middle Valcamonica (Pini, 2002; Pini & Ravazzi, 2009) favoured the replacement by spruce over fir and beech, thus forming a large mountain belt. Cultivation of traditional crops developed, with buckwheat (*Fagopyrum esculentum*), rye (*Secale cereale*), corn (*Zea mays*), barley (*Hordeum vulgare*), olive (*Olea europea*), potatoes (*Solanum tuberosum*) and grapes (*Vitis vinifera*). In recent years, experiments for the re-introduction of dyeing plants such as *Isatis tinctoria*, *Rubia tinctoria*, *Reseda lutea* and *Matricaria chamomilla* are going on at Civate Camuno, thanks to the collaboration of the Università della montagna in Edolo.

ACKNOWLEDGEMENTS

We dedicate this work to Prof. Carlo Andreis, professor of plant geography at the University of Milano, on the occasion of his retirement. C. Andreis and Prof. B. Ammann (Bern) promoted the palaeobotanical study of the Pian di Gembro peat bog, which forms a main reference for the vegetation history of Valcamonica.

The second author is grateful to Dr. R. Poggiani Keller for inviting him to work on environmental history and archaeobotany in Valcamonica. Thanks are also due to Prof. R.C. De Marinis for sharing ideas on the relationships between men and landscape, to Dr. M.G. Ruggiero for providing drafts of the MUPRE Short Guide, to Dr. F. Simonotti, and to Dr. S. Solano for bibliographic suggestions. We also thank Prof. B. Sala and Dr. M. Breda for providing their opinion on the cervid engravings from Luine. We are also indebted to CCSP (Centro Camuno Studi Preistorici, Capo di Ponte) for inviting us promoting researches and scientific exchange in one of the world-renowned rock art area. The authors acknowledge with thanks the advices by two reviewers.

This paper is a contribution to the CNR Research Line TA.P02.005.001. Part of this work was carried out in the framework of the CNR-DTA NextData Project.

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Ms. received: October 7, 2015

Final text received: December 11, 2015