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FIRST PALEO-ENVIRONMENTAL CONSIDERATIONS ON THE PLEISTOCENE DEPOSITS OF THE LOWER CAVE OF COVOLI DI VELO (VR - ITALY)

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ABSTRACT: From 2001 until today over 2.000 remains of *Ursus spelaeus*, cave bear of this karstic system, have emerged from the five year excavation in the Lower Cave of Covoli di Velo. Therefore this cavity has returned a real paleonthological patrimony, on which important studies have already been performed in order to get data on the population of cave bears of this karstic system.

Unfortunately, during this five year research we did not have similar luck with other species, despite evidence by various authors of the presence of a rich fauna of vertebrates in these caves in the past. In fact, few finds have been retrieved, revealing only three macro-mammal species: *Canis lupus*, *Crocuta crocuta spelaea* and *Capra ibex*.

Therefore, in these last campaigns we decided to sample different sectors and levels of excavation B, in order to get information about the micro-mammals of these Pleistocene deposits. However, the amount of determinable material, retrieved by sifting sediment, is very scarce. It was, in fact, only a few teeth and jaws that led us to identify the following species: *Glis glis*, *Microtus arvalis*, *Microtus agrestis*, *Microtus oeconomus*, *Chionomys nivalis*, *Dinaromys bogdanovi*, *Terricola* sp. (Rodentia), *Sorex minutus* (Insectivora), *Myotis blythi*, *Myotis* sp., *Miniopterus schreibersi*, *Rhinolophus* sp. (Chiroptera).

We then tried to cross examine these results with those of the pollen analysis of three samples taken from different depths of sector B. The results obtained from the pollen, combined with those of the fauna, give us interesting matters of discussion and further ideas on the possible paleo-environment of Covoli di Velo during Late Pleistocene.

Key words: Grotta inferiore, Covoli di Velo, *Ursus spelaeus*, micro-mammals, pollen, paleo-environment.

THE LOWER CAVE OF COVOLI DI VELO

The karstic system of Covoli di Velo consists of three principal cavities ("Upper Cave", "Lower Cave" or "Cave of the bear" and "Covolo dell'Acqua") and of some smaller hollows, situated in the so-called Valle del Covolo, between the villages of Velo Veronese and Selva di Progno, between 860 and 890 m a.s.l. (fig. 1).

The caves were formed by the water inside the "Grey Limestones of Noriglio" (Lower Jurassic) and consist of oolitic calcarenite, intensely and locally dolomitised, with oyster shell beds or lumachelles, laminated micrites and micrites with shale intercalations.

About 545 meters of karst net have been explored, of which 364 m belong to the system of the Upper Cave - Lower Cave, 65 m to the Covolo dell' Acqua, 40 m to the Covolo dell' Atrio and the last 75 m to the smaller hollows.

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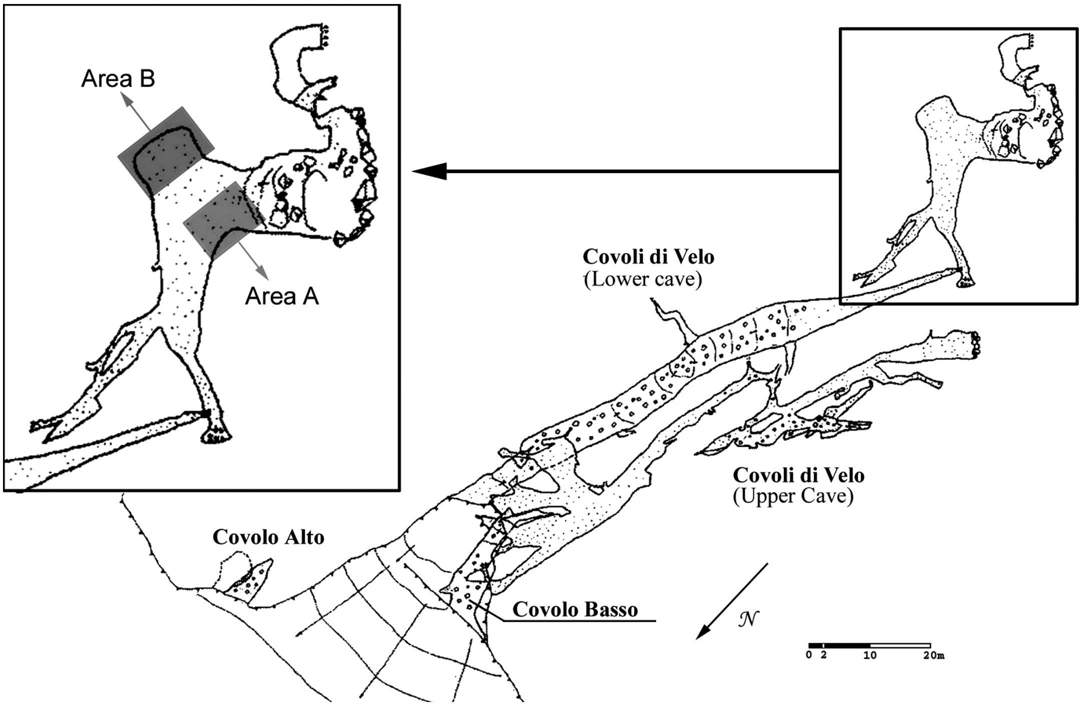

Figure 1. Planimetry of the karst system of Covoli di Velo with excavation sectors A and B (Image by G. Rossi and R. Zorzin).

The first part of the cavities is sub-horizontal and rich in alluvial sediments. The accessible parts of the complex and the presumable connections between cavities are limited due to the large alluvial and collapse deposits, which block the galleries in different places (Zorzin & Rossi, 1999; Zorzin & Bona, 2002).

At the beginning of 2001, in that one chamber, situated around 150 m from the entrance, the Section of Geology and Paleontology of the Civic Museum of Natural History in Verona undertook a series of excavations. These excavations concerned two small portions of ground, one along the west side and the other along the east side, respectively denominate sector A and sector B (fig. 2).

In sector A, an area of about 12 m^2, the following stratigraphical levels emerge: level 0, consisting of blocks of landslide of varying dimensions; levels 1 and 1b, com-

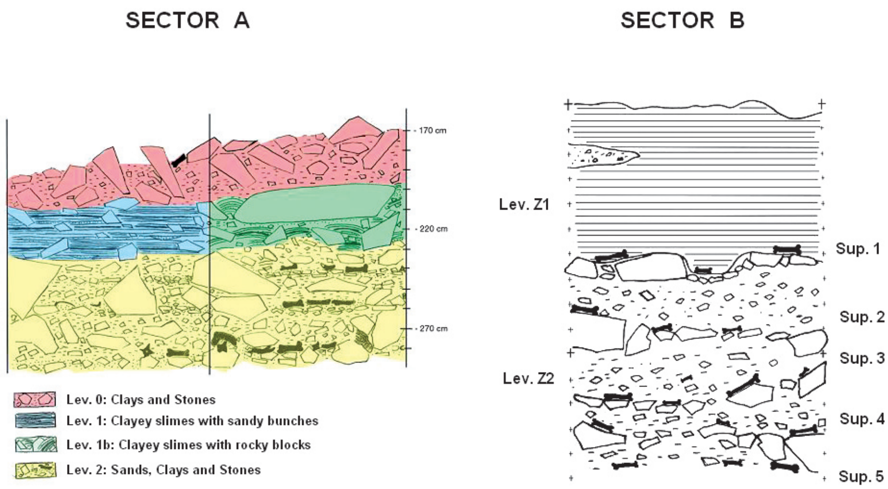

Figure 2. Stratigraphy of sectors A and B (Images by F. Bona).

Table 1.
Finds of micro-mammals recovered in excavations of Covoli di Velo.

N°	SPECIMEN	SPECIES	LEVEL
1	Hemimandible sx.	*Myotis blythi*	A3/2 (2001)
2	Hemimandible dx.	*Miniopterus schreibersi*	A3/2 (2001)
3	Hemimandible sx.	*Rhinolophus (?)*	A3/2 (2001)
4	Hemimandible dx.	*Myotis* sp.	N2/Z1 (2002)
5	M Sup.	*Myotis (?)*	N2/Z1 (2002)
6	Hemimandible dx.	*Glis glis*	N2/Z1 (2002)
7	M^1 sx.	*Glis glis*	N2/Z1 (2002)
8	P^4 sx.	*Glis glis*	N2/Z1 (2002)
9	M_1 dx.	*Glis glis*	N2/Z1 (2002)
10	M_3 dx.	*Glis glis*	N2/Z1 (2002)
11	M^3 sx.	*Glis glis*	N2/Z1 (2002)
12	P^4 sx.	*Glis glis*	N2/Z1 (2002)
13	P_4 dx.	*Glis glis*	N2/Z1 (2002)
14	M_1 dx.	*Glis glis*	M00/Z1
15	M_1 sx.	*Terricola* sp.	M00/Z1 25-50 cm
16	M_1 sx.	*Microtus agrestis*	M00/Z1 50-75 cm
17	M_1 sx.	*Microtus* gr. *arvalis-agrestis*	N1/Z1 50-75 cm
18	Hemimandible dx.	*Sorex minutus*	M00/Z1 50-75 cm
19	Hemimandible dx.	*Sorex minutus*	L2/Z1 - rehandled
20	M_1 sx.	*Microtus agrestis*	L2/Z1 - rehandled
21	M^3 dx.	*Dinaromys bogdanovi*	L2/Z1 - rehandled
22	M_1 sx.	*Microtus agrestis*	L2/Z2 Sup.2
23	M_1 dx.	*Chionomys nivalis*	N1/Z2 Sup.2
24	M_1 dx.	*Dinaromys bogdanovi*	N1/Z2 Sup.2
25	M_1 dx.	*Microtus arvalis*	L2/Z2 Sup.3
26	M_1 sx.	*Microtus arvalis*	L3/Z2 Sup.3
27	M_1 sx.	*Dinaromys bogdanovi*	L3/Z2 Sup.3
28	Hemimandible sx.	*Chionomys nivalis*	L3/Z2 Sup.4
29	M_1 sx.	*Microtus agrestis*	L2/Z2 Sup.5
30	M^s	*Dinaromys bogdanovi*	L2/Z2 Sup.5
31	M_1 sx.	*Microtus arvalis*	L3/Z2 Sup.5
32	M_1 dx.	*Microtus agrestis*	L3/Z2 Sup.5
33	M1	*Microtus oeconomus*	L3/Z2 Sup.5
34	M_1 sx.	*Chionomys nivalis*	L3/Z2 Sup.5
35	M^s	*Dinaromys bogdanovi*	N2/Z2 Sup.5

posed of clay slime and sandy bunches, with landslidden blocks in the second; level 2, formed by surfaces of clasts and alternate bones to slow of clayey slime. Sector B, of around 9 m^2, shows a stratigraphy consisting of 2 main levels: level Z1, constituted mainly by rolled clayey slime with some sandy bunches and the level Z2, formed by surfaces of clasts and alternate bones to slow clayey slime. Given the evident stratigraphical similarity, respectively between the levels 1 and 2 of the sector A and the levels Z1 and Z2 of the sector B, their correspondence is almost certain. According to these considerations, layer Z1 in sector B is designed under the new term "Unity of the slimes" and layer Z2 "Unity of the blocks". In both sectors of excavation almost 3 m below level zero of the cave is reached.

SMALL MAMMALS FAUNA

A small quantity of micro-mammals, coming to the following species, was recovered during the last campaign by sifting samples of sediment from all the squares and levels of sector B: *Glis glis*, *Microtus arvalis*, *Microtus agrestis*, *Microtus oeconomus*, *Chionomys nivalis*, *Dinaromys bogdanovi*, *Terricola* sp., *Sorex minutus*, *Myotis blythi*, *Myotis* sp., *Miniopterus schreibersi*, *Rhinolophus* sp. (tab. 1).

Some of the determined rests originate from the sifting of samples withdrawn for granulometric analysis (Accordini, 2003-2004) during the excavations 2002 and 2003 and have been found to belong to the dormouse and the bat. All other finds derive from a long sifting operation consisting of around sixty picked samples of sediment in the two following campaigns (2004 and 2005). However, the particular position of area B has not given us a great number of finds. Nevertheless, thanks to this enormous work we have succeeded in drawing a small but meaningful collection of micro-mammals (Muridae, Gliridae, Soricidae and Chiroptera).

Considering the sector B only, since sector A seems to a large extent to have been rehandled, the distribution of the various recognized species is the following (fig. 3):

"Unity of the "slimes" (level Z1): *Glis glis*, *Microtus arvalis*, *Microtus agrestis*, *Terricola* sp., *Sorex minutus*, *Myotis* sp.

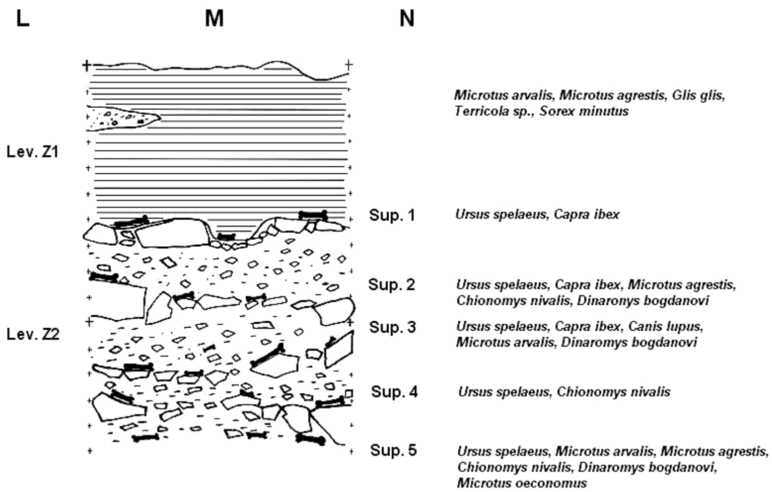

Figure 3. Distribution of determinated species in levels of sector B (Image by M. Accordini and F. Bona).

"Unity of the "blocks" (level Z2): *Ursus spelaeus*, *Canis lupus*, *Capra ibex*, *Microtus arvalis*, *Microtus agrestis*, *Microtus oeconomus*, *Chionomys nivalis*, *Dinaromys bogdanovi*, *Myotis blythi*, *Miniopterus schreibersi*, *Rhinolophus* sp.

PRELIMINARY PALEO-ENVIRONMENTAL CONSIDERATIONS ON THE SMALL MAMMALS FAUNA

The macro-fauna recognized in the Lower Cave of Covoli di Velo is composed, besides the cave bear, of *Crocuta crocuta spelaea*, *Canis lupus* and *Capra ibex*. The micro-fauna, though not very abundant, shows a higher number of species.

The constant presence of the cave bear in the lower cave allows us to report our levels to a glacial period: this kind of bear, in fact, reached its maximum development and widest distribution during the last great Würm Glaciation, extinguishing itself probably around 18-20.000 years ago.

In our evaluations we have decided not to take the wolf and the bear into account because, as is the case with most carnivores, they do not usually give precise indications from a paleo-environmental point of view.

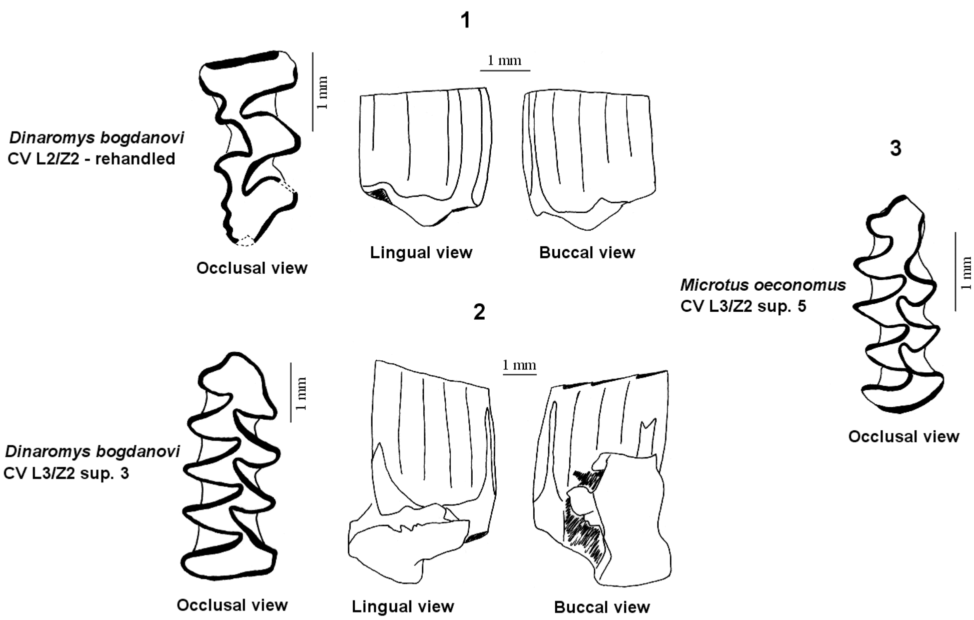

Figure 4. Molars of some rodents recovered in the Lower Cave: 1) M^3 dx. of *Dinaromys bogdanovi* (occlusal, lingual and buccal view); 2) M_1 dx. of *Dinaromys bogdanovi* (occlusal, lingual and buccal view), 3) M_1 dx. of *Microtus oeconomus* (occlusal view) (Images by F. Bona).

Other than these considerations, the presence of the ibex could also be meaningful. This species currently lives at an altitude between 1.600 and 3.000 m a.s.l., inhabiting grassy and rocky slopes above the limit of arboreal vegetation. The presence of this animal indicates open expanses with scarce vegetation, typical of a cold and arid climate. Its recovery at a lower altitude, around 880 m a.s.l., leads us to suppose that vegetation was scarce around the cave with the timber line situated much lower than it is today (Zorzin *et al.,* 2005a).

Besides the ibex, we have considered of fundamental importance the rests of micro-mammals, particularly those belonging to the rodent group (fig. 4). Above all we wish to underline the presence of various species belonging to the Microtinae subfamily, which is mainly known to inhabit meadows and alpine pastures at the borders of forests or rocky slants above the tree-line, some also reaching elevated stations up to the limit of the snows. The dormouse seems to be the only rodent, among those discoveries, which was well adapted to the woody environment in hilly and mountainous areas.

From our observations on the fauna determined up to this point, we can draw some important paleo-environmental considerations about the Karstic area of Covoli di Velo during the period of deposition of the two main levels (Unity of the "slimes" and Unity of the "blocks") of the last chamber of the Lower Cave. The presence of the ibex in the first three surfaces of level Z2 (Unity of the "blocks") leads us to hypothesize the presence of a number of open spaces with scarce forest coverage where the limit of forest extension was surely found lower than it is today. In this geological phase the climate had to be cold and the landscape rather arid. The environmental evaluations given by the ibex are also confirmed by the rests of *Chionomys nivalis* and *Dinaromys bogdanovi*, two species belonging to a cold environment which at present live on rocky mountain slopes up to elevated altitude. The other voles recovered in sector B also seem to indicate a predominantly open environment partly damp ground, above all given by the presence of *Microtus oeconomus*, besides *Microtus arvalis* and *agrestis*.

Conditions seem to change somehow in the superior level, the Z1 (Unity of the "slimes"), where the species which mostly characterize the cold environment of Z2 (*Capra ibex*, *Chionomys nivalis*, *Dinaromys bogdanovi* and *Microtus oeconomus*) disappear. The disappearance of these species and the appearance of *Glis glis* in the most superficial layer, denote without any doubt an increase of woody coverage, probably due to a phase of increasing temperature. Therefore the limit of the forest would have been at higher altitudes compared to the scenario of the underlying level. In the level of slimes *Microtus arvalis* and *agrestis* have also been found, besides the species *Terricola* and *Sorex minutes*. These species testify the existence of wide open spaces at the borders or inside the wood, where they could live.

As a result, we can hypothesize the existence of two geological periods corresponding to the first two levels dug in sector B. The first level (Unity of the "blocks"), seems to correspond to a geological phase characterized by a cold, alpine type environment, with wide open spaces and scarce forest coverage; the second level (Unity of the "slimes") seems to depict a more recent geological period, in which an increase of the temperature led to higher extension of the timber line and subsequently the return of arboreal species to the area of Covoli di Velo. Nevertheless, these considerations can only be considered preliminary and hypothetical due to the limited data currently available.

POLLEN ANALYSIS AND FLORAL-VEGETATION CONSIDERATIONS

In the 2004 campaign, besides the samples of sediment for studies on the micro-mammal finds, three core borings were performed in section B sector from which a number of samples for pollen analysis were taken. The samples, denominated 1-2-3, have been picked from the quadrant L1. The levels involved in the sampling are: level Z1 - "Unity slimes" (Sample 1), level Z2 sup.3 - "Unity blocks" (Sample 2) and level Z2 sup.5 - "Unity blocks" (Sample 3).

Samples of ca. 15-17 gs have been treated for the extraction of pollen and microchar-coals, following routine methods which include the following steps (Lowe *et al.,* 1996): addition of spores of *Lycopodium* for the calculation of concentrations (number of granules/gram = p/g), Na-pyrophosphate, HCl 10%, sifting with 7 μms nylon mesh filter, acetolysis, enrichment with liquid heavy Na-metatungstate I, HF 40%, ethanol 98%, addition of few drops of glycerine, drying in heater, assemblage of the residue with glycerinated glaze in brittle permanent. Pollen identification was performed in optic light transmitted 400x and 1000x microscope, with the aid of Palinoteca and morphological keys/atlases/works (for example: Faegri & Iversen, 1989; Moore *et al.* 1991; Reille 1992; 1995; 1998). Pollen spectra percentages have been calculated on a Pollen Sum that excludes the overrepresented Cichorioideae. The Cichorioideae have been calculated in percentage to the Pollen Sum plus themselves, in accordance to Berglund & Ralska-Jasiewiczowa (1986). The sum of categories held profitable for the discussion is represented in a histograms graph (fig. 5). The botanical

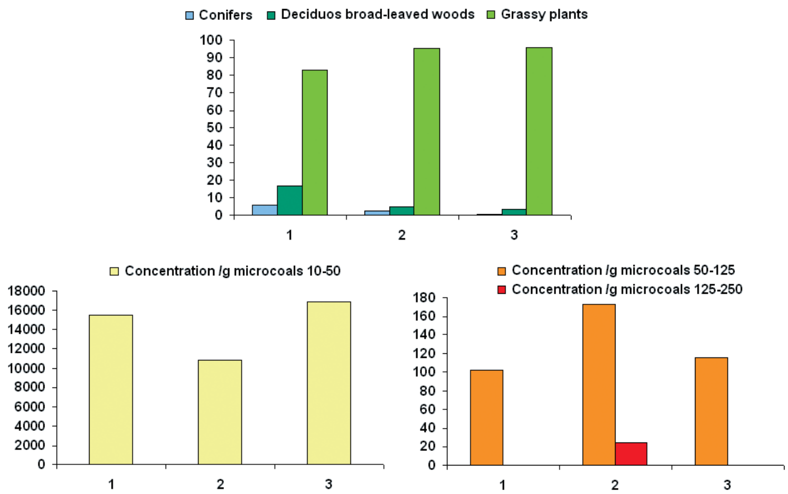

Figure 5. Up: Diagram of the percentages of the pollens of conifers, deciduous broad-leaved woods and grassy plants in the 3 samples of sediment picked in the sector B. Down: Diagrams of the concentrations of the different types of microcoals in the 3 samples (Diagrams by C. A. Accorsi *et al.*).

nomenclature is in accordance to Pignatti (1982).

The pollen contained is uniform and low, around 10^3-10^4. The highest value, around 13.000 granules/gs, has been observed in the Sample 2. In the presence stage of analyses, conditions of the grains suggest notable influxes to be attribuited to air, water, animals and eventually humans who have frequented the cave (Dimbleby, 1985; Faegri & Iversen, 1989). A high number of entomophilious taxa, among which melliferous, could be connected to the bears (for example: pollen in the fur, in coprolites...).

GENERAL CHARACTERS OF THE POLLEN SPECTRA

The pollen spectra of the three samples have a physiognomy in some ways similar (tab. 2):

1. Grassy plants clearly dominate the spectrum. In fact, they always exceed 80% and in the samples 2 and 3 (level Z2) they even exceed 90% (95-96%).

2. Grasses include a range of floral species (38-46 taxa), above all Gramineae (38-47%), Cichorioideae (10-66%), Umbelliferae (4.5-20%).

3. Woody plants, trees and bushes, are represented by more than 10 taxa in each sample. Some coniferous and various deciduous broad-leaved trees are also present. Six taxa are found in all three samples: *Alnus*, *Betula*, *Hyppophae*, *Pinus*, *Quercus deciduous*, *Salix*.

The pollen spectra also show differences that point out an overall "vegetation trend":

- progressive increase of woody plants upward, both in abundance and in diversity, as indicated by the percentage of the woody ones (4, 5, 17% in the samples 3, 2, 1 respectively) and by the number of taxa (13, 14, 18 taxa in the samples 3, 2, 1 respectively),

- an increase, from lower levels upward, of woody plants subjected to damp environments, above all meaningful in the sample 1 (6%).

Within this trend there is higher similarity between the two leading samples, 2 and 3, while sample 1 differs from both.

THE FLORA

The flora testified in the pollen spectra is quite rich, containing around a hundred types of pollen, two of which grassy plants and one woody.

Among the woody plants some conifers appear: *Pinus* (with indications of *P. mugo*), *Picea excelsa*, *Taxus* and *Juniperus* cf., and various deciduous trees, *Betula*, *Fagus*, *Castanea*, *Quercus deciduous*, *Tilia*, *Ulmus*, *Fraxinus*, *Carpinus*, *Salix*, *Corylus*, *Hipphophae*, *Ligustrum*, *Alnus*, *Populus*. In sample 2 *Quercus ilex*, a woody Mediterranean evergreen is present. The grassy flora is very rich: Gramineae, Compositae (among which very abundant Cichorioideae in the superior sample, followed by *Artemisia*, *Aster* type and *Cirsium*, always well represented), very abundant Umbelliferae in the two inferior samples, then Cruciferae, *Campanula* type, Leguminosae, Labiatae etc., every family being represented by numerous pollen types.

Table 2.
Pollen spectra of the Lower Cave of Covoli di Velo (VR - Italy).

Samples n°			**1**	**2**	**3**
Depht (cm)			50	100	150
Stratigraphic Unity			Z1	Z2 sup. 3	Z2 sup. 5
Concentration (poll/g)			**1787,5**	**12626,4**	**6137,4**
WOODS-BUSHES					
BETULACEAE	*Alnus* cf. *glutinosa*	A/ar,LD,IG	1,1		
	A. cf. *incana*	A/ar,LD,IG		0,2	
	A. undiff.	A/ar,LD,IG	1,1	0,2	0,7
	Betula	A/ar,LD	1,4	0,2	0,6
CISTACEAE	*Helianthemum*	ar,LD		0,2	
CORYLACEAE	*Corylus avellana*	A/ar,LD,Q	0,3		0,3
	Carpinus betulus	A,LD,Q			0,1
CUPRESSACEAE	*Juniperus* type	ar,CF	0,5	0,4	
	Juniperus cf.	ar,CF	0,5	0,1	
ELAEGNACEAE	*Hippophae* cf.	ar	0,3	0,1	0,4
EPHEDRACEAE	*Ephedra* cf.	ar,CF	0,5		
FAGACEAE	*Castanea*	A,LD,C	0,3		0,1
	Fagus sylvatica	A,LD	0,3		
	Quercus decidue	A,LD,Q	1,6	0,1	0,4
	Quercus ilex type	A/ar,M		0,2	
OLEACEAE	*Fraxinus ornus*	A,LD,Q	0,8		
	Fraxinus cf.	A,LD,Q	0,3		
	Ligustrum	ar,LD, Q	0,3		
PINACEAE	*Picea*	A,CF	0,3		
	Pinus	A,CF	4,1	2,0	0,2
ROSACEAE	*Rubus* cf. *chamaemorus*	ar/LD			0,3
	Rubus undiff.	ar,LD		0,1	
SALICACEAE	*Salix*	A/ar,LD,IG	3,0	0,5	0,2
TAXACEAE	*Taxus* cf.	ar/A,CF			0,1
TILIACEAE	*Tilia* cf. *platyphyllos*	A,LD,Q		0,1	0,1
ULMACEAE	*Ulmus*	A,LD,Q		0,1	0,1
THYMELEACEAE	*Daphne*	ar/LD	0,3		
Forest coverage			***16,8***	***4,8***	***3,8***
GRASSY PLANTS					
ALISMATACEAE	*Alisma*			0,2	
BORAGINACEAE	Boraginaceae			0,1	0,1
CAMPANULACEAE	*Campanula*		1,1	1,5	2,7
CARYOPHYLLACEAE	*Cerastium fontanum* type	As	0,3		0,4
	Caryophyllaceae undiff.		0,5	1,0	1,3
CHENOPODIACEAE	Chenopodiaceae	As	3,5	0,4	0,6
COMPOSITAE	*Ambrosia* type		0,3	0,5	
	Anthemis type	As	2,2	0,7	3,6
	Artemisia	As	4,3	5,7	3,9
	Aster type		6,3	1,6	6,3
	Centaurea nigra type	As	1,9	0,5	0,8
	Cirsium	As	2,7	1,6	3,8
	Asteroideae undiff.			0,7	1,1
	Cichorioideae	***As***	***66,0***	***10,2***	***10,0***
CONVOLVULACEAE	*Convolvulus*	As			0,3
	Cuscuta cf.	As		0,2	0,6
CRASSULACEAE	*Sedum* cf.		0,5		
CRUCIFERAE	*Brassica* type		0,3		
	Hornungia type		3,3	0,1	0,8
	Cruciferae undiff.				
CYPERACEAE	Cyperaceae	ig	0,8	1,1	0,3
DIPSACACEAE	Dipsacaceae			0,2	0,2
GENTIANACEAE	*Gentianella*				0,1
GRAMINEAE	*Hordeum* group	c,cer	0,3	0,1	0,3
	Glyceria cf.	ig			0,3
	Phragmites type		0,8	2,6	2,2
	Gramineae spontaneous group		36,7	44,5	37,0
HALORAGACEAE	*Myriophyllum*	id/el		0,1	
HYPERICACEAE	*Hypericum*			0,1	0,1
LABIATAE	*Mentha* type			0,1	0,1
	Stachys type		0,3	0,5	
	Labiatae undiff.		1,4	1,0	0,2
LEGUMINOSAE	*Hedysarum* cf.			0,2	
LEGUMINOSAE	*Lotus*		0,5		
	Onobrychis cf.			0,2	
	Leguminosae undiff.		1,4	0,6	0,7
LILIACEAE	Liliaceae		0,3		
MENYANTHACEAE	*Menyanthes*				0,1
PLANTAGINACEAE	*Plantago media/major* type	As	1,6		0,1
	P. undiff.	As	1,4	0,9	1,0
POLEMONIACEAE	*Polemonium*				0,1

continued

Table 2 *(continued)*

POLYGONACEAE	*Polygonum aviculare* type	As	0,3		0,3
	Rumex	As		0,1	
RANUNCULACEAE	*Aconitum*			0,1	0,2
	Actaea			0,1	
	Anemone type		0,3	0,7	
	Clematis cf.		0,3		
	Consolida				0,1
	Ranunculus type		0,8		0,2
	Thalictrum flavum type		1,4	0,7	0,4
	Ranunculaceae undiff.		0,5	1,1	2,1
ROSACEAE	*Aphanes/Alchemilla* type	As		0,2	0,9
	Filipendula			0,2	
	Fragaria cf.		0,3	0,1	0,2
	Potentilla type		0,8		
	Rosaceae undiff.		0,3	1,1	1,2
RUBIACEAE	*Galium* type		0,8	1,5	0,3
SAGITTARIACEAE	*Sagittaria* cf.	ig		0,5	
SAXIFRAGACEAE	*Saxifraga* cf.				0,4
SCROPHULARIACEAE	*Melampyrum*				0,1
	Scrophulariaceae undiff.			0,2	0,1
UMBELLIFERAE	*Bupleurum* cf.		0,8		
	Umbelliferae undiff.		3,5	20,1	19,9
URTICACEAE	*Thesium*			0,1	
	Urtica dioica type	As	0,5	0,2	
VALERIANACEAE	*Valeriana*			0,1	0,1
Grassy plants sum					
Pollen counts			***1082***	***898***	***990***
POLLEN SUM (Cichorioideae excluded)			***368***	***806***	***900***
NUMBER OF TAXA			**56**	**60**	**58**
INDETERMINABLE					1,0
PTERIDOPHYTA					
HYPOLEPIDACEAE	*Pteridium*		1,1	2,0	
MONOLETE undiff.			5,2	7,0	2,0
TRILETE undiff.			0,5	1,0	
TOTAL			*6,8*	*10,1*	*2,0*
ALIA					
Spores of mushrooms			++	+	++
Sphagnum			+	+	+
Concentrycistes			+	+	+
Secondary deposition			+	+	
Rehandled				+	
SUMMARY					
Woods		A	14,4	3,8	2,9
Bushes		ar	2,4	1,0	0,9
Conifers		CF	6,0	2,5	0,3
Deciduous broad-leaved woods		LD (A+ar)	16,8	4,8	3,8
Quercetum (*Acer campestre* type + *Carpinus betulus* + *Ostrya carp./Carpin. orientalis* +*Fraxinus excelsior* type+ F. *ornus*+*Quercus* dec. + *Tilia* + *Ulmus*)		Q	3,3	0,4	1,1
Mediterranean plants		M		0,2	
Hydrophyle woods		IG	5,2	1,0	0,9
Cultivated grassy plants		C	0,3		0,1
Grassy plants		E	83,2	95,0	96,0
Hydrophytes + elophytes grassy plants		ig+id/el	0,8	1,7	0,7
Cultivated/cultivable grass		c	0,3	0,1	0,3
Cereals		ce	0,3	0,1	0,3
Grassy anthropic indicator plants		As	18,8	10,7	16,2
Damp environments (Total hydro-hygro-elophytes)		IG+ig+id/el	6,0	2,7	1,6
Cultivated areas (Total cultivated plants)		C + c	0,5	0,1	0,4
Anthropic environment (Total anthropic indicators)		C + c+ As	16,3	9,3	11,2

Various finds of nitrophilious plants such as Chenopodiaceae, *Rumex*, *Urtica dioica* type, which can be connected to the circulation of animals and/or to the anthropic frequentation, appear as well. These belong to the group of anthropogenetic indicators, in which pollens of *Hordeum* group, recovered in the three samples, are also present, possibly indicating the presence of cereals in compatible contexts. Plants belonging to damp environments, represented by hydrophytes and hygrophytes/elophytes (*Alisma*, *Menyanthes trifoliata*, *Myriophyllum*, *Nymphaea*, *Phragmites* type, Cyperaceae), added to trees such as willows, alder-trees and poplars have modest, but meaningful presences. Particularly interesting are the water clover (*Menyanthes trifoliata*), a northern species growing in swamps and marshes on the damp environment vegetation which was found in the leading sample, and *Sphagnum*, found in all samples, mostly typical of peat-bogs.

LANDSCAPE PATTERNS OF VEGETATION AND HYPOTHESIS ON CHRONOLOGY

Landscape patterns of vegetation are connected to pollen spectra samples (from the cave), whose formation, as already reminded, influxed due to the frequentation of animals privileging entomophile entities (above all grassy plants), to loss of the anemophile ones, among which the greatest part of recovered woody plants reverts, could have contributed notably. Also keeping in mind the possible bottom respect to the eolic influx in the two inferior samples, the vegetation is characterized by grassy formations, probably primary grasslands, above the tree-line. Such grasslands are dominated by Gramineae, as well as a vast number of other grassy plants, among which Campanulaceae, Compositae, Cruciferae, Leguminosae, Liliaceae, Rosaceae, Ranunculaceae, Umbelliferae.

Therefore the landscape would appear to depict wide open spaces, typical of alpine landscape, characterized by grasslands, with a few watercourses or water mirrors that could account for the presence of hydro/hygrophytes: a scenario in accordance with our faunistic finds. Forest formations are situated in foundation, presumably to lower quotas of Covoli di Velo, which leads us to hypothesize a descent of the forest due to the rigidity of the climate that appears severe, cold and arid.

Nevertheless, we noticed that the woody plants are quite different, containing testimonies of broad-leaved woods from pollen which is not particularly widespread (for example *Tilia*). Together with pollen documents of the ilex, this could signal the proximity of a place of shelter. However, we cannot exclude the influx from a long distance, particularly for the ilex. In the superior sample an increase in broad-leaved woods, particular the mesophile, signals a climatic improvement in terms of temperature, with an increase of damp too, testimonied by the sensitive growth of woody plants associated to damp grounds.

The pollen spectra seem to testify the existence of geological time period, during which, or rather, at the end of which, meaningful climatic changes brought warmer and damper conditions. Even though much caution is required in setting hypothesis of chronology, given the limited number of samples, the two inferior samples can be compatible with a Pleistocene age around the maximum glacial (around 18.000 years 14C from the present), while the superior sample is, at the moment, hardly connected to a precise chronological phase.

MICRO-COALS

The micro-coals have been read according to the method adjusted by Bosi and Accorsi (in press). Carbonaceous particles, in modest concentrations (max 10^4) in all samples, signal the possibility of a constant presence of regional fires, although it cannot be specified whether the typology is natural or anthropic. Coals of the two smaller classes (inferior to 125 μms) are always present, more abundant in samples 1 and 3; class size "very large" (>250 μms) is always absent, whereas class size "large" (125-250 μms) is present only in sample 2. For this reason we can imagine the presence of fires, anthropic or not, in the immediate proximities of the cave (Mooney *et al.,* 2001) and to the casual transport of traces of these fires in the cave aside, for instance, of the great mammals which frequented it.

CONCLUSIONS

Among the over 2.000 rests recovered and determined during five years' excavations, 99% belong to *Ursus spelaeus* (fig. 6). A morphological and morphometric analysis of this species has brought the followings results: analysis of the long bones reveal that the lowest number of bears frequenting the cave is estimated to be around ninety individuals. The greater part belongs to cubs at different phases of growth and to young animals, whereas the adults are fewer in number; among adult individuals, females are more numerous than males (Zorzin *et al.,* 2005b).

The other species of macro-vertebrates are *Canis lupus*, *Crocuta crocuta spelaea* and *Capra ibex*. The fauna of micro-mammals is composed of: *Glis glis*, *Microtus arvalis*, *Microtus agrestis*, *Microtus oeconomus*, *Chionomys*

Figure 6. Finds of cave bear emerged in the excavation (Photo by F. Bona).

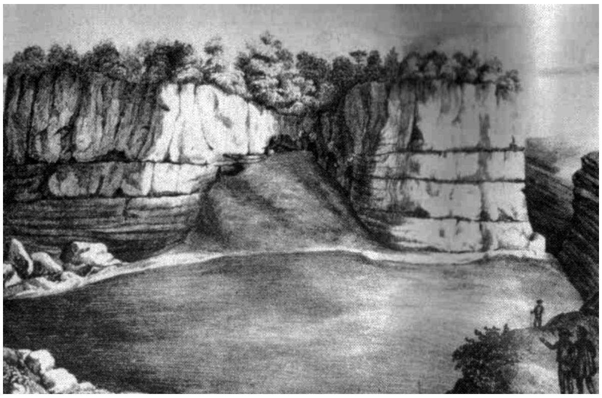

Figure 7. Landscape of Covoli di Velo (Figure by A. Massalongo, 1851).

nivalis, *Dinaromys bogdanovi*, *Terricola* sp., *Sorex minutus*, *Myotis blythi*, *Myotis sp.*, *Miniopterus schreibersi*, *Rhinolophus* sp.

Analysis of pollen present in levels of sector B have allowed us to identify the following species: *Pinus*, *Picea excelsa*, *Taxus* and *Juniperus* (conifers), *Betula*, *Fagus*, *Castanea*, *Quercus*, *Tilia*, *Ulmus*, *Fraxinus*, *Carpinus*, *Salix*, *Corylus*, *Hipphophae*, *Ligustrum*, *Alnus*, *Populus* (broad-leaved trees), *Quercus ilex* (Sample 2); Gramineae, Compositae, Brassicaceae, Campanulaceae, Fabaceae, Liliaceae, Rosaceae, Ranunculaceae, Umbellifere Apiaceae, Cyperaceae, Lamiaceae, Chenopodiaceae, hydrophyte and hygrophyte plants, *Sphagnum*.

Combining the observations on the fauna with the results of the pollen analyses a few important preliminary paleo-environmental considerations can be made. In Unity of the "blocks", the rodents and the ibex, combined with pollen data, reveal an open, grassy alpine-type landscape (fig. 7), with meadows among the rocks, few trees, and a rather cold climate. In Unity of the "slimes", the dormouse, which lives in areas covered by broad-leaved woods and conifers, is abundant, confirming the increase of woody plants in this layer as shown by the pollen. Despite the forest landscape, areas of open expanses are left on the borders or inside the woods, as demonstrated by rests of Microtinae found in this layer. This gives evidence of a climatic change from cold to warmer and more humid conditions. However, these conclusions would need to be confirmed by further studies on more samples. Given the importance of Covoli di Velo as a site of paleontological interest, it would be advisable to collect many new samples for pollen and microfauna study, which will be one of the priorities of the following excavations.

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