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The ecology of ophiolitic scree vegetation: a survey on the northern Apennine outcrops (Italy)

Abstract

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A research programme for describing the vegetation settled on the northern Apennine ophiolitic screes and its relationship with their geochemistry is in progress. Vegetation and soil samplings in all the three different geochemical types (serpentinites, gabbros and basalts) were considered in this work.

Introduction

The northern Apennine ophiolitic outcrops are a relevant part of such areas in Italy (Vergnano Gambi 1992). They date back to the Jurassic period and the most striking of them can be seen on the northwestern edge of the chain; southeastwards the serpentine mountains progressively become blocks. Serpentinites, gabbros and diabases are the main geochemical types (Pellizzer 1961). Their altitudinal distribution is mainly included into the mixed deciduous oak wood belt; some outcrops belong also to the beech wood and to the oroboreal vegetation belts. However,it has long been known that ophiolitic outcrop geochemistry selects particular plant communities, which are feebly affected by macroclimate features (see Brooks 1987 for a review).

The "serpentine" flora includes serpentinophytes and local serpentine endemics. Many other locally rare taxa have a northern Apennine distribution linked to ultramafic soils. Phytosociological relevés (Braun Blanquet 1964) were made during the years 1993-1996.

For minimizing any possible interference of chorological factors, a narrow study area on the northern Apennine sector belonging to the Piacenza and Parma provinces was considered. The outcrops considered are included into the mixed deciduos oak belt. The corresponding bioclimate features are prevailingly submontane. Our samplings cover all the three different geochemical types of the ophiolitic substrates.

The vegetation we have studied is settled on rocks and small-stoned screes. It is characterized by a scattered pattern, whit sparse plant covers, as usual in ecological stressed habitats.

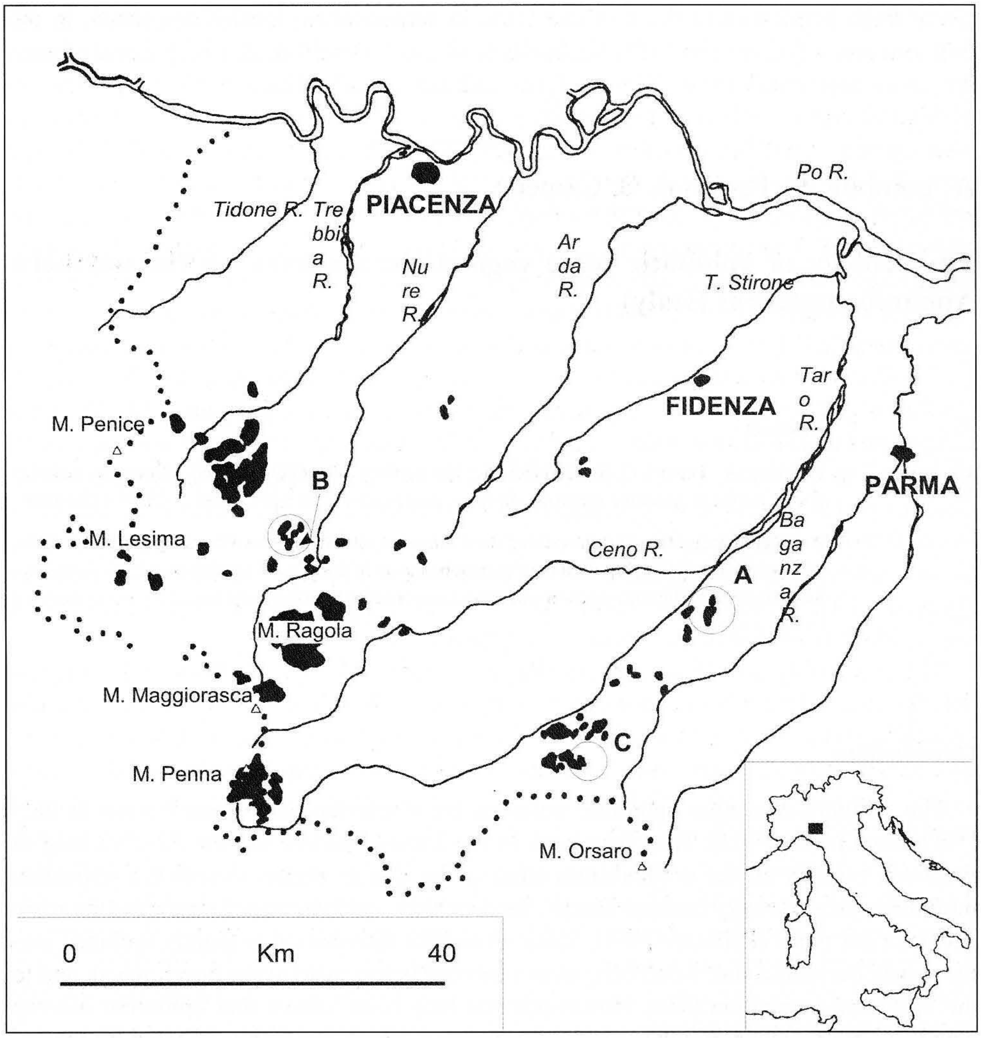

Fig. 1 The distribution of the ophiolites in the Parma and Piacenza Apennines. A. Mt. Prinzera group. B. Corchia area. C. Vigonzano area.

Study area

The study area (Fig. 1) includes: the serpentinites of Mt. Prinzera area (A; Parma province); the gabbros and diabases of the Corchia area (B; Parma province); the serpentinites, gabbros and basalts of the Vigonzano area (C; Piacenza province).

Mt. Prinzera (736 m a.s.l.) is one of the most striking ophiolitic outcrops of the northern Apennines, since it is located close to the mountain range border and dominates the clayey landscape of the surroundings. It is a huge block (about 230 ha) of ultramafic rocks included within chaotic shales, limestones and flysch. Ultramafic rocks range from relatively fresh peridotites in the southern flank to serpentinites, locally brecciated, in the northern sector (Giammetti 1963, Venturelli & al. 1997, Dinelli & al. 1997). Local climate has an average rainfall near 1000 mm/year with spring and autumn maxima. The outcrop of Mt. Prinzera lies within the submontane vegetation belt where the climax vegetation is a mesophilous mixed oakwood characterized by oaks (*Quercus pubescens* Willd., *Quercus cerris* L.) and hop-hornbeans (*Ostrya carpinifolia* Scop.). Outcropping rocks and unconsolidated debris cover approximately the 25% of the total area. Grasslands occur in the higher part of the outcrop, shrublands are widespread in the lower eastern side. Sharp changes of geomorphology and exposure produce significant edaphic and microclimatic changes. The landscape and the ecological features of the outcrop of Mt. Prinzera and its surrondings (237 ha) are protected as a Nature Reserve of the Emilia-Romagna Region.

The Corchia area is located in the Rio Manubiola valley, a tributary of the Taro river, in the Parma province. A rather large ophiolitic block (about 3 km long in a NW-SE direction) occurs on the western side of the valley. It includes serpentinites and basalts, closely associated to a granitic block. Mixed deciduous oakwoods (*Quercus pubescens* Willd, *Quercus cerris* L., *Ostrya carpinifolia* Scop.) characterize the Vegetation belt. Local climates shows an average precipitation of 1500 mm/year, with autumn and spring maxima. In this area a sulfide mineralization was also present (pyrite, chalcopyrite, linneite) (Bertolani 1962). The studied area is restricted to the foot of Groppo Maggio (820-910 m a.s.l.), which mainly includes basalts (Giammetti 1964).

The small villages of Vigonzano, Cogno San Savino and Guglieri are located in the Rio della Lobbia Valley, a left-hand tributary of the Nure valley, in the Piacenza province. The ophiolitic rocks occur as blocks included in sedimentary rocks, mainly flysch and shales of Cretaceous to Paleogene age belonging to the Ligurian sequence. In the Vigonzano-Cogno San Savino area (720-850 m a.s.l.) the most widespread rocks are basalts and basaltic breccias, but also gabbros and serpentinites occur. In the Guglieri area a small block of serpentinite is outcropping. A mixed deciduos oakwood dominated by *Quercus pubescens*, *Quercus cerris*, *Ostrya carpinifolia*, characterizes the whole area. Local climate has an average precipitation of 1200 mm/year; with autumn and winter maxima. In the Vigonzano outcrop, an economic sulfide (pyrite, chalcopyrite) mineralization occurs (Bertolani 1959, Di Corbetaldo & al. 1965). Stunted woody plants form a transition to the surrounding prevailing woodland and are diffuse in the lower part of the mine wastes too (Dinelli & al. 1996).

Data sampling and treatment

Soil sampling and analysis.- A composite soil sample was taken in each area at about 10 cm of depth. Soil samples were dried, sieved and the fraction < 2 mm retained for analysis. Bulk chemical composition was detcted by X-ray fluourescence spectrometry (Franzini & al. 1975). Soil pH was measured from a soil/deionized water suspension (20g of soil/50 ml water) after 1 hr agitation and over night rest.

Vegetation data sampling and treatment.- Seventy-five vegetation relevés were performed in the study area following the method of Braun Blanquet (Westoff & Maarel 1978). A tecnique based on the information theory (Shannon & Weaver 1949, Lausi 1972) for selecting diagnostic species was employed. The resultant data matrix (42 species × 75 relievés) was processed by multivariate analysis using the package Mulva 4 (Wildi 1991). Classification of relevès and species was made by a minimum variance clustering (Orloci 1978) applied to a dissimilarity matrix based on Euclidean distance (Orloci 1976). The reciprocal ordination of relevés and species group was performed by the analysis of concentration (AOC, Feoli & Orloci 1979).

Tab.1
Chemical composition of the ophiolitic rocks (serpentinites, gabbros, basalts) in some areas of the northern Apennine:
Cogno (V6) and **Guglieri** (VG1) in Piacenza province; **Corchia** (CR2) and **Mt. Prinzera** (PR6) in the Parma province.
Avg UFM =average composition of the ultramafic rocks (Faure,1992); Avg BAS = average data for basalts in Parma province (Beccaluva et al.,1975); Avg GAB =average data for the gabbros in the northern Apennine (Calanchi, 1993).

Sample	PR6	VG1	V3	CR2	V6	Avg UFM	Avg BAS	AvgGAB
Litology	serpent.	serpent.	basalto	basalto	gabbro			
Site	Prinzera	Guglieri	Cogno	Corchia	Cogno			
pH	6,98	8,11	7,50	7,20	7,90			
SiO2 (%)	40,95	40,33	48,12	52,65	48,54	42,36	49,8	50,75
TiO2	0,10	0,06	1,76	1,26	0,44	0,05	1,78	0,32
Al2O2	2,37	2,00	14,31	17,46	12,33	2,27	16,46	16,15
Fetot	8,46	7,50	11,01	6,41	6,84	13,78	7,89	6,47
MnO	0,10	0,09	0,20	0,16	0,15	0,2	0,15	0,13
MgO	**34,09**	**34,20**	**9,22**	**2,73**	**12,57**	38,47	6,45	9,51
CaO	**1,19**	**0,15**	**3,27**	**5,61**	**11,58**	2,24	7,44	10,68
Na2O	0,15	0,14	4,15	5,74	2,40	0,66	5,02	2,83
K2O	0,17	0,15	0,13	1,14	0,24	0,02	0,31	0,52
P205	0,03	0,03	0,22	0,15	0,01	0,04	0,23	0,01
LOI	12,39	15,35	7,61	6,68	4,91		3,76	
CaO/MgO	**0,03**	**0,01**	**0,35**	**0,92**	**2,05**	0,03	1,15	1,12
V (ppm)	62	46	222	138	78		237	
Ni	**2466**	**1750**	**71**	**103**	**10**	2000	98	78
Cr	**2231**	**2260**	**145**	**387**	**100**	1800	256	63
Co	**106**	**108**	**45**	**19**	**6**	175	43	
Cu	17	8	271	63	59	15	68	
Zn	56	34	75	65	37	40		

Results and Discussion

Chemical composition of soils.- Table 1 reports the chemical composition of soils from the ophiolitic outcrops, compared also to average values for northern Apennines (basalts and gabbros) and literature data (serpentinites). Serpentinites have distinctly lower Ca/Mg ratio (0.007-0.03) and higher concentrations of Ni, Cr and Co, which all represents limiting factors to plant growth (Proctor & Nagy 1992, Arianoutsou & al. 1992). Chromium contents are larger than average values (2231 and 2260 µg/g) whereas Co is slightly depleted. Corchia and Cogno San Savino basalts have compositions comparable with the average ones. Some differences, however, affects Mg and Ca. Also Ni and Cr display some differences, being higher in the Corchia sample. Soil pH ranges between 7 and 8.

Classification of relevés and species.- The chemical composition of the substrates acts as a substantial partition between the relevés. Two clusters are clearly recognizable (Fig. 2). The former (group A) includes the relevés carried out on the serpentinite substrates of the Mt. Prinzera (PRI-Parma Province) the Guglieri site (GUG-Piacenza Province). The latter is more eterogeneous (group B) and includes the relevés carried out on the basalts and gabbros substrates.

The subgroup 3 represents the basalts of Corchia (CORbas-Parma Province) while the subgroups 4 and 6 represent the gabbros and basalts of Cogno (COGgab e COGbas-Piacenza Province) respectively.

The subgroup 5 (PRA) represents the relevés carried out on different substrates: basalts of Corchia and serpentinites of Mt. Prinzera (CORbas + PRI). In these sites the soil is developed and the vegetation is more steady (grassland). The characteristic limiting factors of the rocky undeveloped serpentine substrates are no more active.

The species frequency (F%) and the mean cover (C) in the six groups identified by cluster analysis are reported in the Table 2. There are some differences in species number among the relevés groups. The Raunkiaer life form spectrum is dominated by hemicryptophytes (60%) and chamaephytes (29%). The ratios between these two life forms are simi-

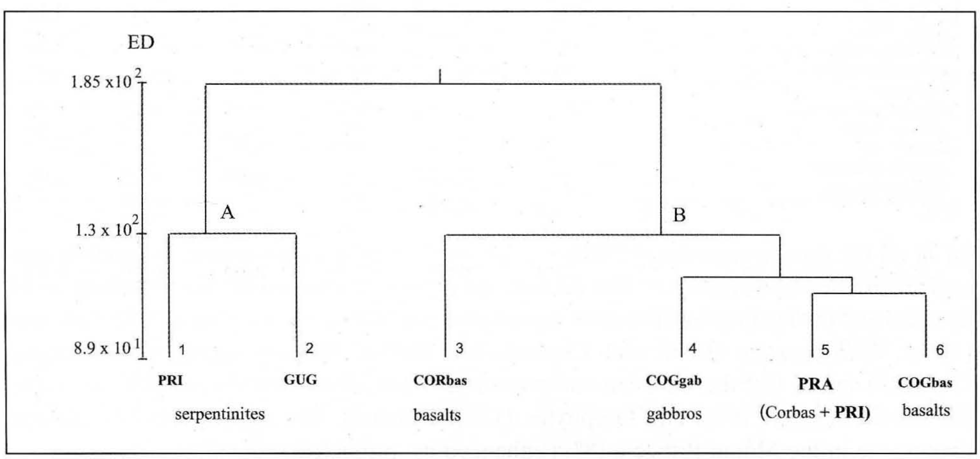

Fig. 2. Classification dendrogram of the relevés. Letters indicate the main clusters, numbers indicate the relevés groups. For the abbrevations see the text.

Tab. 2. Species frequency (F %) and Mean Cover (C) in the six groups identified by cluster analysis in the whole data set considered. + means F< 11% and C< 0,01. The serpentinophytes are indicated in bold.

		Alyssum bertolonii plant community		*Silene armeria* plant community		*Sempervivum tectorum* plant community		*Fumana procumbens* plant community		*Brachypodium rupestre* plant community		*Silene gr. italica* plant community	
		PRI		GUG		CORbas		COGgab		PRA		COGbas	
	n° relevès	15		10		13		12		4		21	
	n° species	39		37		28		20		24		33	
		F	C	F	C	F	C	F	C	F	C	F	C
S1	Festuca gr. valesiaca	73	4,05	80	3,29	77	14,6	67	1,19	75	5,65	71	6,07
	Thymus striatus	93	0,42	100	3,53	92	12,9	100	0,1	50	1,26	81	2,3
S2	Inula montana	20	0,30	80	4,76							+	+
	Euphorbia cyparissias	67	0,07	80	1,82					25	0,03		
	Centaurea gr. paniculata	87	0,41	70	1,05			25	0,03	25	0,03	29	0,03
	Melica ciliata	27	0,35	50	0.28							14	0,01
	Allium sphaerocephalon	13	0,01	40	1,51	46	0,42						
	Teucrium montanum	73	0,40	70	3,28	15	0,39	67	0,88			19	0,02
	Helicrysum italicum	73	1,23	70	1,05	46	0,42	42	0,04	50	0,05	29	1,32
	Silene armeria	73	1,56	100	17,8			17	0,43			19	0,02
	Anthericum liliago	33	0,36	70	9,25	46	0,05	50	3,17	50	1,28	48	0,28
	Brachypodium rupestre	73	1,71	50	10,8	23	0,02			100	40	24	0,02
S3	Scleranthus perennis	27	0,03	+	0,01	+	0,38			25	0,03	38	0,27
	Sedum album	53	0,38	+	0,01					50	0,05	24	1,91
	Hieracium piloselloides	47	0,05	+	0,01			25	0,03			+	+
	Hippocrepis comosa	27	0,03	+	0,01			50	0,05	25	0,03	+	+
	Potentilla hirta	47	0,05	+	0,01			+	0,01	25	0,03	14	0,01
	Echium vulgare	53	0,05	+	0,01	+	+					24	0,26
	Sedum dasyphyllum	13	0,01	20	0,02	23	0,02	62	0,07	50	0,05	19	0,02
	Dianthus gr. sylvestris	80	0,08	20	0,02	31	1,37	42	0,04	50	0,05	19	0,49
	Galium corrudifolium	80	0,08	20	0,02	62	1,78			75	0,08	19	0,02
	Biscutella laevigata subsp. prinzerae	73	0,07	20	0,02								
	Alyssum bertolonii	87	0,41	20	0,02								
	Trinia glauca	80	0,08			+	0,01						
	Minuartia laricifolia subsp. ophiolitica	80	0,73	+	0,01								
	Echinops ritro	87	1,25	+	0,5								
	Koeleria vallesiana	93	2,55	20	0,02								
	Herniaria glabra	53	0,05	20	0,02	15	0,02			25	0,03	+	+
	Cerastium arvense subsp. suffruticosum	67	0,39	+	0,01	23	0,02					+	0,24
	Thymus humifusus	87	0,74	20	0,02	60	0,06			25	0,03	33	0,5
S4	Sempervivum tectorum					92	6,74						
	Bromus erectus	40	1,85			77	13,66	+	+	25	0,03	+	+
	Centaurea gr. deusta					85	0,46					+	+
	Galium rubrum	+	0,01			38	0,42	25	0,03			33	0,03
	Potentilla tabaernaemontani			+	0,01	23	0,02	17	0,43	25	0,03	29	0,03
	Fumana procumbens	20	0,02	+	0,01	46	0,05	100	12,71			33	0,5
	Sedum acre	40	0,04	80	0,58	85	2,35	83	1,72	25	0,03	52	0,99
	Dianthus carthusianorum		0,01	30	0,03	23	0,02			25	0,03	57	2,07
	Silene gr. italica	+	0,04	20	0,02	15	0,02	17	0,43	25	0,03	86	2,68
	Stachys recta	53	0,05	30	0,07	15	0,02	42	0,04	50	1,4	67	1,59
	Teucrium chamaedrys	20	0,35	+	0,5	62	3,12			25	0,03	19	1,31
	Hieracium pilosella	+	0,01	80	0,08	31	2,91	42	0,04	25	0,03	52	6,1

lar in all the groups considered (Table 3). The perennial herbs dominate, as usual in ecological stressed environments. The 42 diagnostic taxa considered (Table 4) belong to 14 families and the leading families are *Caryophyllaceae* (19%), *Compositae* (17%), *Labiatae* (12%), *Graminaceae* (12%) and *Crassulaceae* (10%). The phytogeographic analysis (Table. 5) shows that the Eurasian component (45%) is always the dominant followed by Eurimediterranean (19%) and Orophytes (12%) elements. The higher endemic element percentage in the Mount Prinzera (8%) enhanced its protected area value.

Correlation between species and the vegetation types.- S3 and S2 species groups (Table 2, Fig. 3) characterize the Mt. Prinzera (PRI-*Alyssum bertolonii* community) and Guglieri

Tab. 3
Life form spectra of the different groups of the relevés. The last column (a) refers to the whole ophiolitic vegetation examined. Only diagnostic species were considered. Symbols as in table 2.

Groups of the relevés	**PRI**	**GUG**	**CORbas**	**COGgab**	**PRA**	**COGbas**	**a**
Number of species	**39**	**37**	**28**	**20**	**24**	**33**	**42**
Raunkiaer life form (%)							
H (hemicriptophyte)	59	57	57	60	67	64	**62**
CH (chamaephyte)	28	30	32	30	29	27	**29**
G (geophyte)	8	8	7	5	4	3	**5**
T (therophyte)	5	5	4	5	0	6	**5**

Tab. 4
Family distribution. The last column (a) refers to the whole ophiolitic vegetation examined. Only diagnostic species were considered. Symbols as in Table 2.

Groups of the relevés	**PRI**	**GUG**	**CORbas**	**COGgab**	**PRA**	**COGbas**	**a**
Number of species	**39**	**37**	**28**	**20**	**24**	**33**	**42**
Families (%)							
Caryophyllaceae	18	17	21	15	17	21	**19**
Compositae	18	19	11	20	13	18	**17**
Labiatae	13	14	18	15	17	15	**12**
Graminaceae	13	11	11	10	17	12	**12**
Crassulaceae	8	8	11	10	13	9	**10**
Rosaceae	3	6	4	10	8	6	**5**
Rubiaceae	5	3	7	5	4	6	**5**
Liliaceae	5	6	7	5	4	3	**5**
Cruciferae	5	6					**5**
Leguminosae	3	3		5	4	3	**2**
Cistaceae	3	3	4	5		3	**2**
Euphorbiaceae	3	3			4		**2**
Borraginaceae	3	3	4			3	**2**
Ombrelliferae	3		4				**2**

(GUG-*Silene armeria* community) serpentine outcrops while S4 species group is correlated to basalts and gabbros outcrops.

Serpentine-non serpentine discontinuities are the most striking, but distinct plant communities on basalts and gabbros are recognizable: *Sempervivum tectorum* L. and *Fumana procumbens* (Dunal) Green & Godr. communities respectively. Some minor correlations (Fig. 3 dotted lines) show that: 1) The group S1 (*Festuca vallesiaca* Gaudin group and

Tab. 5
Phytogeographic elements and their distribution on the groups of the relevés. The last column (a) refers to the whole ophiolitic vegetation examined. Only diagnostic species were considered. Symbols as in Table 2 species group.

Groups of the relevés	**PRI**	**GUG**	**CORbas**	**COGgab**	**PRA**	**COGbas**	**a**
Number of species	**39**	**37**	**28**	**20**	**24**	**33**	**42**
Phytogeographic elements (%)							
Eurasian	46	46	50	55	58	48	**45**
Eurimediterranean	21	22	14	20	25	21	**19**
Orophyte	10	11	14	10	4	9	**12**
Endemic	8	6	7	5		6	**10**
Stenomediterranean	5	6	4		4	3	**5**
Medit-Montane	5	6	4	5	4	6	**5**
Atlantic	3	3	4	5	4	3	**2**
Circumboreal	3	3	4		4	3	**2**

Thymus striatus var. *ophioliticus* Lacaita) occurs in a central position respect to all the relevés groups. Such species characterize the whole ophiolitic vegetation of the study area. The S1-S4 link underlined the particular ecological valence of the gabbros and the basalts group compared to the serpentines one. 2) The S2 group relating to the Guglieri outcrop is shared with the other serpentinite outcrop. The lack of typical species in Guglieri represents an impoverishment situation for the vegetation respect to that of the Mt. Prinzera. 3) The group COGbas (Cogno basalts) is the "ecological meeting point" among the species living on the gabbros and basalts and the species living on serpentinites. This group is characterized by a higher frequency of taxa generally linked to xeric habitas, which are in common with the serpentines (*Silene gr. italica* community).

Such results point out a "gradient of ecological permissiveness" from the group PRI-S3 to the group COGbas-COGgab-CORbas-S4 (arrow in Fig. 3). Bold data in Table 1 show that the increasing positive values of the Ca/Mg ratio may explicate the "decreasing serpentine factor" indicated by the arrow (Fig. 3). The change from the Mt. Prinzera serpentinites (the more selective environment) to the Cogno basalts (the less selective environment) occur through two plant communities which correspond to a decreasing numbers of taxa. The former is settled on the Guglieri group (GUG); the latter is on the most developed soil grasslands (PRA) (Fig. 2 - Tab. 2).

Conclusions

Our results shows that the Northern Apennine ophiolitic scree vegetation we have studied has a close relationship with the main geochemical features of the substrate. It seems that species compositions of plant communities is affected by different Ca/Mg ratios.

Festuca vallesiaca group and *Thymus striatus* var. *ophioliticus* characterize the whole

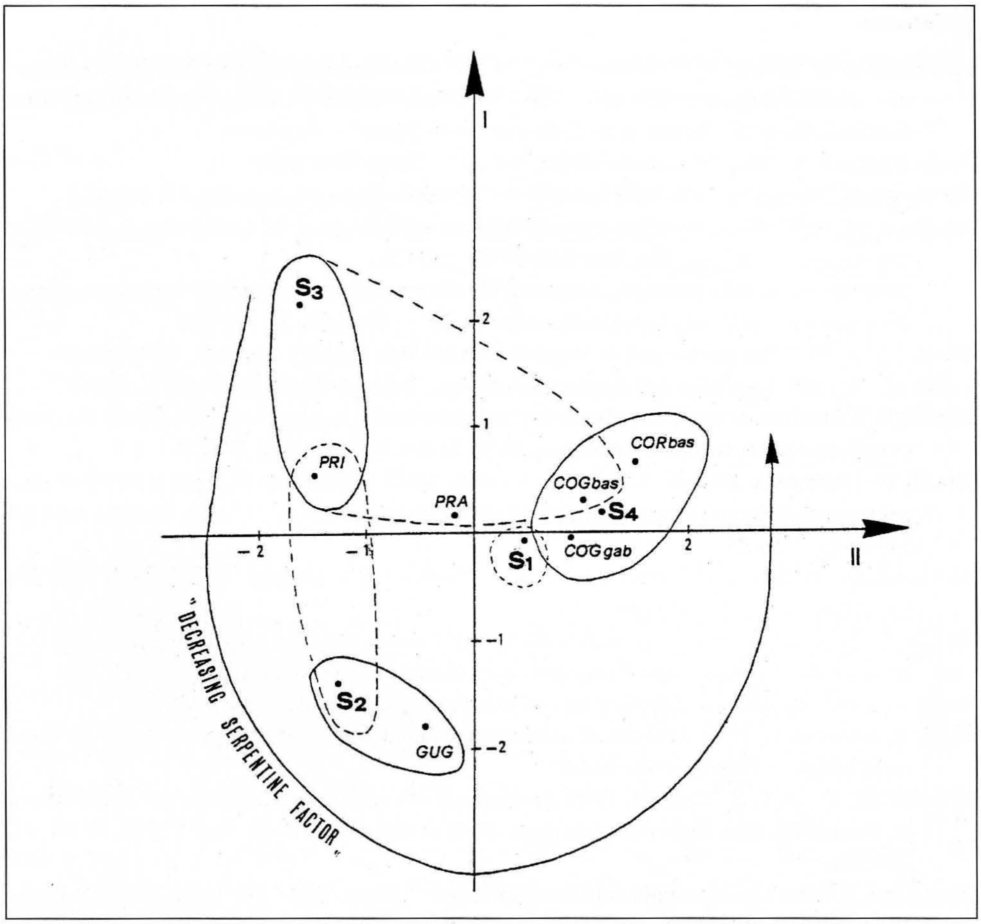

Fig. 3 Correlations among species groups (S1-S2-S3-S4) and relevé groups (PRI - GUG - COGbas - COGgab - CORbas - PRA) according to AOC. The first two variates describe the 97% of the variance of the whole data considered.

ophiolitic scree vegetation. Serpentinites are differentiated by a plant community where the most frequent taxa are *Alysssum bertolonii* Desv., *Minuartia laricifolia* (L.) Sch. & Th. subsp. *ophiolitica* Pign., *Silene armeria* L., *Koeleria vallesiana* (Honckeny) Bertol., *Thymus humifusus* Bernh., *Biscutella laevigata* subsp. *prinzerae* Raffaelli. Gabbros and diabases plant communities lack serpentinophytes and local serpentine endemics; they are only characterized by a higher frequency of taxa generally linked to xeric habitats, which are in common with the serpentinites. *Silene italica* (L.) Pers. group, *Stachys recta* L., *Sedum acre* L., *Hieracium pilosella* L., *Galium rubrum* L., are the most frequent taxa. Such results provide informations for a local use of the plant communities as geochemical indicator. Further extensive samplings are needed for obtaining reliable data for the whole northern Apennines as well as for a discussion on the syntaxonomy of such vegetation.

References

Arianoutsou, M., Rundel, P. W. & Berry, W .L. 1992: Serpentine endemics as biological indicators of soil elemental concentrations — Pp. 179-189 in: Markert, B. (ed.), Plant as Biomonitors. Indicator for heavy metals in the terrestrial environment — Weinheim

Braun Blanquet, J. 1964: Pflanzensoziologie. 3rd ed. — Wien, New York.

Beccaluva, L., Venturelli, G. & Zanzucchi, G. 1975: Ateneo Parmense, acta nat. **11**: 789-802.

Bertolani, M. 1959: Ricerche su rocce prasinitiche ed anfibolitiche e sul giacimento metallifero di Vigonzano. — Atti Soc. Nat. Mat. MO **89/90**: 112-128.

— 1962: Linneite, calcopirrotina, e strutture blenda pirrotina nelle mineralizzazioni metallifere del giacimento di Corchia (Appennino Parmense). — Per. Min. **31**: 287-301

Brooks, R. R. 1987: Serpentine and its Vegetation. A Multidisciplinary Approch. — Portland.

Calanchi, N. 1993: Le ofioliti dell'Appennino emiliano. Regione Emilia Romagna **2**: 25-54.

Dinelli, E. & Lombini, A. 1994: Metal mobility and plant uptake in copper sulphide mine spoil dump (Vigonzano mine, Northern Apennines, Italy). Miner. Petrogr. Acta. **37**: 125-140.

Dinelli, E., Lombini, A., Simoni, A. & Ferrari, C. 1996: Metal distributions in plants growing on copper mine spoil dump (Vigonzano mine, Northern Apennine, Italy). — Miner. Petrogr. Acta **50**: 241-255.

Di Corbetaldo, D. & Scotti, F. 1965: Il giacimento cuprifero di Vigonzano. — Ist. Lomb. Acc. Sci. Lett. (Rend. Sci.), **99**: 486-508.

Dinelli, E., Lombini, A., Simoni, A. & Ferrari, C. 1997: Heavy metals in serpentinite soils of selected outcrops of Piacenza and Parma provinces (Northern Apennines, Italy). **11**: 241-255

Faure, G. 1992: Principles and applications of inorganic geochemistry. — New York.

Feoli, E. & Orloci, L. 1979: Analysis of concentration and detection of underlying factors in structured tables. — Vegetatio **40**: 49-54.

Franzini, M., Leoni, L. & Saitta, M. 1975: Revisione di una metodologia analitica per fluorescenza-X, basata sulla correzione completa degli effetti di matrice. — Rend. Soc. It. Min. Petrol. **31**: 365-378.

Giammetti, F. 1963: Le serpentiniti del Monte Prinzera. — Mem. Soc. Geol. It. **4**:284-296 Bologna

— 1964: Studio petrografico sulle ofioliti di Groppo maggio e Groppo della Donna (Appennino Parmense) — L' Ateneo Parmense; Acta naturalia **35**, suppl. 1, 155 Parma.

Lausi, D. 1972: Die Logik der pflanzensoziologischen vegetationsamalyse. Ein Deutungsversuch. Pp. 17-24 in: Grundfragen und methoden der pflanzensoziologie. Ber. Int. Symp. Rinteln 1970, Junk Den Haag.

Orloci, L. 1976: Ranking species by an information criterion. — J. Ecol. **64**: 417-419.

— 1978: Multivariate analysis in vegetation research. — The Hague. Boston & London.

Pellizzer, R. 1961: Le ofioliti dell'Appennino emiliano. — Atti Acc. Sc. Ist. Bologna, Mem. s. 1. **98**: 5-183.

Proctor, J. & Nagy, L. 1992: Ultramafic rocks and their vegetation: an overview in the vegetation of ultramafic (Serpentine) soils. — Intercept **36**: 469-494.

Shannon, C. E. & Weaver, W. 1949: The mathematical theory of communication. — University of Illinois Press.

Venturelli, G. P., Contini, S., Bonazzi, A. & Mangia, A. 1997: Weathering of ultramafic rocks and elemet mobility at Mt. Prinzera, Northern Apenninies, Italy. — Min. Mag. **61**: 765-778.

Vergnano Gambi, O. 1992: The distribution and ecology of the vegetation of ultramafic soils in Italy. — Pp. 217-248 in: The ecology of areas whith serpentinized rocks: a world view. — Kluwer.

Westhoff, V. & Maarel, E. van der 1978: Pp. 287-399 in Wittaker, R. H. (ed.): Classification of plant communities, Junk, The Haugue. Boston & London.

Wildi, O. 1991: Pp. 407-428 in Feoli E. & Orloci L. (ed.): Computer assisted vegetation analysis. — The Netherlands.

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