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ARCHEOLOGIA POSTMEDIEVALE

SOCIETÀ AMBIENTE PRODUZIONE

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MONTAGNE INCISE
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Archeologia
delle risorse
nella montagna
mediterranea

CARVED MOUNTAINS
ENGRAVED STONES

Environmental
resources archaeology
in the Mediterranean
mountains

a cura di Anna Maria Stagno

2013

All'Insegna del Giglio

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Montagne incise. Pietre incise

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Carved mountains. Engraved stones

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Atti del Convegno
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a cura di
Anna Maria Stagno

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Laboratorio di Archeologia e Storia Ambientale
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Indice

The vegetation of prehistoric and historic mining sites around Sestri Levante (GE, NW-Italy)

Carlo Montanari, Bruna Ilde Menozzi*, Maria Angela Guido**

1. Introduction

It is well known that many organisms are able to report, by their presence, local ecological conditions, and so are considered bioindicators. Plants, especially if herbaceous with a small root system, are closely dependent on soil characteristics, of which they are often good indicators. In order to use them in practical applications, several species have been much studied that tolerate high concentrations of heavy metals (Ni, Cd, Cu, Pb, Zn, Co, Fe) in soil and which are often able to concentrate them in their tissues (Ernst, Weinert 1972; Dinelli, Lombini 1996; Kramer *et al.* 1997; Lombini *et al.* 1997, 1998; Lombini *et al.* 2001; Mariotti, Cornara 2001; Minguzzi, Vergnano 1948; Vergnano Gambi 1977; Vergnano Gambi *et al.* 1982). The interest of this specialisation lies not only in the value of these plants as indicators of the presence of high concentrations of noxious elements in the soil, but also in the potential, in certain cases, to use them as "natural pullers" of toxic substances from the ground or from water (phytoremediation, phytomining, phytoextraction). There is a rich literature, some of which deals with the local area, on the chemical characteristics of mining tailings, on the quality of the drainage water of these environments, and also on the anatomical and physiological adaptations of the plants that colonise them (e.g. Malgas, Vergnano 1948; Ernst *et al.* 1992; Davidson *et al.* 1996; Ernst 1998; Davidson *et al.* 2001; Maddi, Cornara 2001; Dinelli, Tateo 2002). In particular, serpentine outcrops are characterised by high levels of Nickel, Cobalt, and Chromium, and the Magnesium/Calcium ratio is high; This, together with ecological characteristics that are often associated with such sites (high temperatures on the dark ground exposed to direct sunlight, fast water flow, drought, etc.), often determine the presence of a rather specialised flora of obliged or preferential "serpentinophytes" (Pichi Sermolli 1948; Ernst 1974; Brooks 1987; Alessandrini 2001; Vergnano 1992). These are metal-tolerant species which, thanks to their physiological adaptations, are able to escape competition from species that are more competitive in less selective environments; they are herbaceous plants and dwarf shrubs that belong to different families and life forms, more or less adapted to drought; some of them are "serpentinicolous relics", which have survived only on soils unappetising for other species, and have a distribution linked to Ophiolite outcrops.

In the context of a long-running archaeological research project at the early mining site of Monte Loreto (Castiglione Chiavarese, Genoa), under the direction of Dr. Roberto Maggi (Soprintendenza Archeologica della Liguria) and Dr. Mark Pearce (University of Nottingham) (Maggi, Vignolo 1986; Maggi, Pearce 1998; 2005; Maggi *et al.* 2011; Campana *et al.* 1996, 2006; Campana, Maggi, Perace 1998; Pearce 2007, pp 62-71), a survey was carried out in order to identify species or plant populations that can characterise typological aspects or stages of different historical mining activities. This paper discusses some sites in the area of Monte Loreto and, for comparison, in the mining area of Libiola, a few kilometres away (*fig.* 1). Both sites are part of a mining complex in the hinterland of Sestri Levante (Genova), centred on ophiolitic outcrops from which primarily copper and gold were obtained at different times. The environmental situation can be considered quite similar at the two sites, both in terms of climate and geology and therefore the vegetation growing near the quarries is relatively homogeneous. It is basically the zonal vegetation of the basal coastal belt, with more or less disturbed Mediterranean woodland and evergreen sclerophyllous scrub, with a predominance of pine woodland with sparse maritime pine (*Pinus pinaster*) with brushwood of heather (*Erica arborea*) that largely replaces evergreen forest of holm-oak (*Quercetum ilicis*).

2. Area of Monte Loreto

The ophiolitic outcrops (basaltic pillows) near the village of Masso, Castiglione Chiavarese, GE) were exploited from prehistory to the twentieth century, for the extraction of copper and gold. It would therefore be interesting to identify plant species or plant populations which colonise abandoned quar-

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Archeologia Postmedievale
17, 2013, pp. 289-296

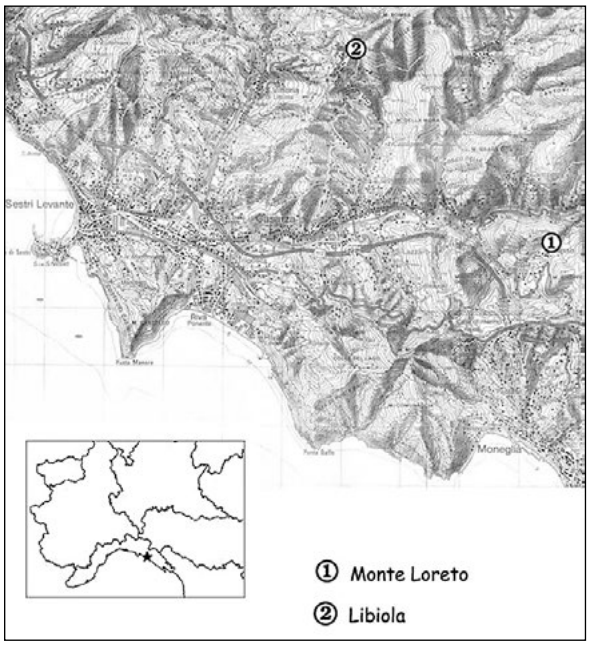

fig. 1 – Location of the mining areas studied.

ries and landfill material, in order to use them as bioindicators of geological bedrock, chronology, or of different techniques of exploitation. In this area of eight hectares three sites were studied, located just a few hundred metres from each other and related to different types and ages of exploitation.
SITE 1 (ML 8) The site is located just above the cemetery of Masso (*fig.* 2) and consists of debris of large stones resulting from prehistoric mining activities (fourth millennium BC), as evidenced by the discovery of hundreds of hammerstones (Maggi, Pearce 2005; Maggi *et al.* 2011). In the lower part, near the road leading to the church of M. Loreto, the tailings are more established and are covered by a dense shrub vegetation. At the top, the vegetation is sparse due to the increased instability of the debris and the outcropping of the basaltic bedrock. The vegetation on the debris is dominated by *Genista desoleana*, a dwarf shrub of the family Fabaceae with a scattered geographical distribution of Liguria, Tuscany (islands), Corsica and Sardinia; it is only common in Liguria towards the east. The populations of *Genista desoleana* Valsecchi in eastern Liguria were previously attributed to *Genista salzmannii* DC., and the species is indicated with this latter name in older studies. However, uncertainty remains concerning the attribution of the Ligurian specimens to this new species (Nowak 1987; Valsecchi 1993; Mariotti 1994; Vagge 1997). In this site, two phytosociological surveys were performed – which are described below – the first at the edge of the highest part of the tailing, on the basaltic outcrop (02061701), the second in the lower part, where the vegetation cover is greater (02061702) (*fig.* 3).
02061701 – Altitude 290 m a.s.l.; exposure: SE; inclination: 30°-35°; survey area 40 m²; bedrock: basaltic pillows; rock: 50%; stones: 20%; vegetation type: pioneer shrubs; coverage 30%; shrub layer: h 25 cm; coverage 28%; herbaceous layer: h 15 cm; coverage 5%; lichen layer: coverage 30% (on rocks). Notes: discontinuous vegetation on basalt outcrops and their debris; nearby there is pine woodland with undergrowth with holm-oak and heather.

Genista desoleana Valsecchi	3.2
Cistus salvifolius L.	1.1
Pinus pinaster Aiton	+.1
Jasione montana L.	1.3
Silene vulgaris (Moench) Garcke	+
Saponaria ocymoides L.	+.3
Oryzopsis miliacea (L.) Asch. et Schweinf.	1.1
Asplenium septentrionale (L.) Hoffm.	+.3
Rumex acetosella L.	+
Lichens	3.3

02061702 – alt. 270 m a.s.l.; exposure: S; incl.: 30°; survey area 60 m²; basaltic ± coarse debris; rocks: 2%; stones 1%; vegetation: shrubland; shrub layer: h 35 cm; coverage 80%; herbaceous layer: h 30 cm; coverage 10%; lichens: coverage 1%; erosion: 10%. Notes: consolidated debris; the species indicated in brackets is just at the edge of the surveyed area.

Genista desoleana Valsecchi	5.5
Cistus salvifolius L.	1.1
Saponaria ocymoides L.	1.2
Jasione montana L.	1.2
Oryzopsis miliacea (L.) Asch. et Schweinf.	1.2
Asplenium onopteris L.	+
Rumex acetosella L.	1.3
Cerastium cfr. *ligusticum* Viv.	(+)
Lichens	+
Musci	+

The main difference between the two sites seems to be the greater coverage of dwarf broom in the lowermost sector, most likely due to a greater settling of the tailings, which may have not been disturbed since the prehistoric mining activity; if so, this would show an extremely slow evolution of the vegetation cover which, over the course of several thousand years, would have only reached a relative equilibrium with a shrubby stage. The strategy of vegetative propagation of the dwarf broom is worth noting and is particularly evident in this area: the old hummocks are dead in the centre while their peripheral branches trail on the ground and take root and progressively enlarge their covering, giving a ring shape to the hummock (*fig.* 4).

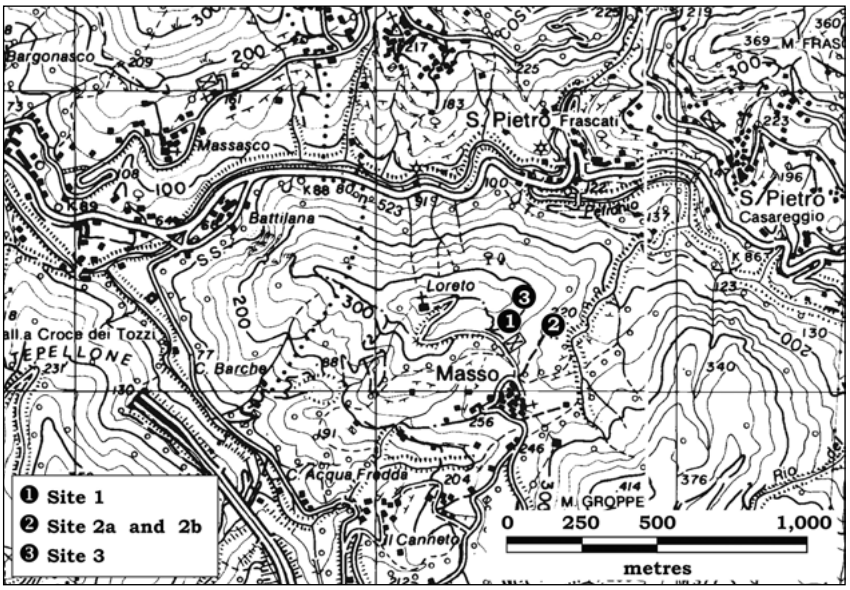

fig. 2 – Map of the area of Mount Loreto, with the location of the sites studied (from C.T.R. 232.3 Sestri Levante).

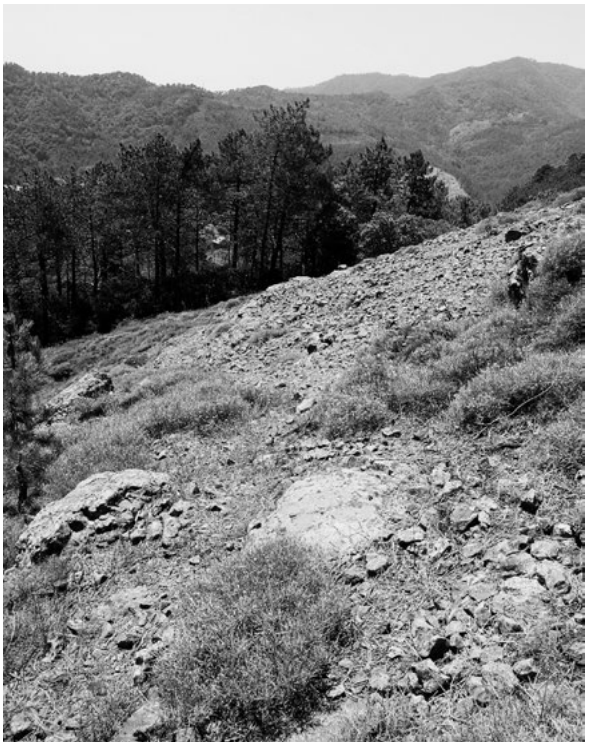

fig. 3 – M. Loreto-site 1: in foreground, discontinuous population of Genista desoleana on outcropping basalts (survey 02061701).

SITE 2 (near ML 3) (*fig.* 5): there was mining at this site in prehistoric times and also in recent times: rock surfaces (basaltic pillows) prevail, together with deposits of relatively recent (nineteenth-century) tailings and very recent spoil from archaeological excavations in recent years. It is located within walking distance, east of the Cemetery of Masso, at an altitude of about 240 m a.s.l. The tailings which are located at the mouth of the deep nineteenth-century tunnels are weakly bonded and almost devoid of vegetation, even though they show no obvious signs of recent disturbance. In this area, in the most stable microenvironments (rocks and debris in flat positions) only few dwarf shrubs and herbaceous plants have settled, among which we mention *Genista desoleana, Thymus vulgaris, Scrophularia canina, Cerastium luridum, Agrostis cf. tenuis, Stachys recta, Galium sp., Sedum rupestre, Dianthus sylvestris, Herniaria glabra.*
The following survey refers to a small area occupied by pioneer vegetation that develops starting from the flat area facing the adits, owing to the greater stability of the debris due to the presence of a tuft of *Scrophularia canina* (*fig.* 6).
SITE 2a: (02061703) poorly consolidated and very steep tailings; alt. 240 m a.s.l.; expos.: E; incl: 45°; surface 3.5 m²; basaltic debris; rock: 0%; stones: 30%; pioneer vegetation; total coverage 70% herbaceous layer: h 20 cm; eroded surface: 30%. Note: small strip along the maximum slope:

Scrophularia canina L.	3.3
Galium lucidum All.	+
Sedum rupestre L.	3.3
Herniaria glabra L.	3.3
Petrorhagia saxifraga (L.) Link.	+
Stachys recta L.	1.1
Cerastium ligusticum Viv.	+.3
Jasione montana L.	1.1
Cladonia rangiformis Hoffm. *Cladonia chlorophaea* s.l. *Parmelia tinctina* Meh. et Gill *Parmelia* sp.	1.2

fig. 4 – An old plant of Genista desoleana with its distinctive centrifugal growth.

fig. 5 – M. Loreto-site 2: in the foreground, the nineteenth-century tailings devoid of vegetation.

fig. 6 – M. Loreto-site 2: pioneer population (survey 02061703).

If the detrital cone has not been remodelled since the end of mining (in the nineteenth century), this environment is really inhospitable, since the vegetation has failed to colonise it over the course of at least a century if not to a negligible degree. It is known, however, that there were some excavations in the area during the period of World War II (Bertolani 1952). Near the large fissure which was mined during prehistory and which was recently investigated with an archaeological excavation, there is recent debris resulting from the archaeological site; the material is minute, mixed with earth, and a pioneer ephemeral population has colonised it, consisting almost exclusively of the annual *Cerastium ligusticum* (Caryophyllaceae). *Genista desoleana* is only found on stable ground, i.e. on rock outcrops or at their edges.
In order to understand if the mining tailings constitute a different microenvironment compared with the natural debris that surrounds ophiolitic outcrops and hosts particular species and plant communities, the following list of flora was compiled not far from this site: it concerns vegetation on ophiolithic debris that was not anthropogenic, in a similar situation to that of mining tailings where the debris is consolidated (SITE 2b):

Euphorbia spinosa L. subsp. *ligustica* (Fiori) Pign.
Genista desoleana Valsecchi
Thymus vulgaris L.
Satureja montana L.
Festuca ovina s.l.
Plantago serpentina All.
Galium lucidum All.
Dianthus sylvestris Wulfen
Armeria denticulata (Bertold.) DC.
Herniaria glabra L.
Linum trigynum L.
Reichardia picroides (L.) Roth
Oryzopsis miliacea (L.) Asch. et Schweinf.
Allium sp.

Here in fact different species appear which are not found on the mine tailings and that are more or less common on the ophiolitic debris of this area (e.g. *Satureja montana, Plantago serpentina, Festuca ovina s.l., Thymus vulgaris, Dianthus sylvestris, Armeria denticulata*).

SITE 3 (ML 6): a little higher, this is a terrace that was the site of several ancient mines: the first phase was in the Copper Age with exploitation of copper ore and possibly traces of cold enrichment of the mineral; then a later one, in the Byzantine period (Benente 1999). This area has been affected by the archaeological excavations in 1996-2000.
Here too one can observe a clear and characteristic difference between the vegetation of the relatively consolidated areas of the ancient tailings and those which have recently been reworked (*fig.* 7). In particular, the large ancient fan of mining spoil is almost completely covered with a population of

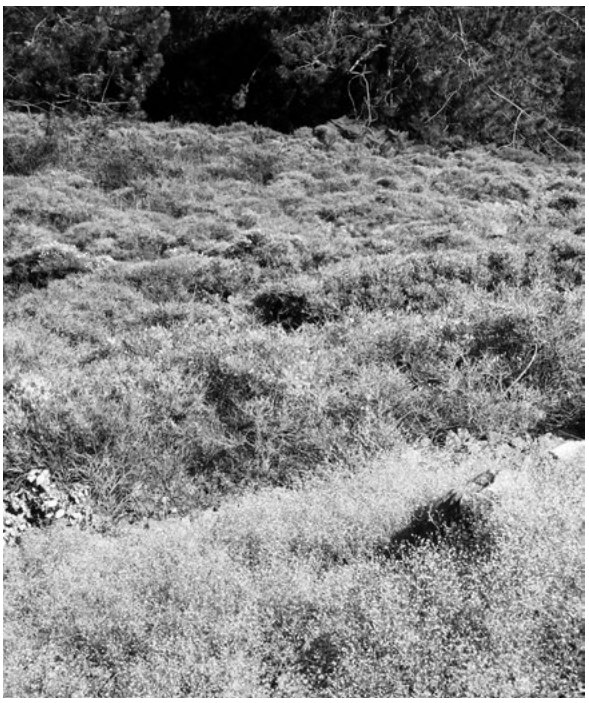

fig. 7 – M. Loreto-site 3: in the foreground, the pioneer Cerastium population on the ground recently reworked by the archeological excavation. In the background, low scrubland with Genista desoleana on consolidated coarse debris.

Genista desoleana very similar to that described for site 1: a survey is given below (02061704):
alt. 300 m a.s.l.; expos. E; incl. 28°; surface 50 m²; debris; rocks 0%; stones 10%; shrubland, coverage 90%; shrub layer: h 35 cm, coverage 90%; herbaceous layer: h 20 cm, coverage 10%; eroded surface: 5%. Notes: area not recently disturbed:

Genista desoleana Valsecchi	5.5
Cistus salvifolius L.	2.2
Saponaria ocymoides L.	+
Jasione montana L.	1.2
Oryzopsis miliacea (L.) Asch. et Schweinf.	+
Sesamoides pygmaea (Scheele) Kuntze	+.2
Silene vulgaris (Moench) Garcke	1.1
Orobanche sp.	+
Pteridium aquilinum (L.) Kuhn	+
Pinus pinaster Aiton	(+)

Only on the spoil reworked by the recent archaeological excavations are monospecific populations of *Cerastium ligusticum* observed. Nearby, a pine woodland is developing with undergrowth of heather and holm-oak; there are also terebinth and other typical Mediterranean species. Communities of *Genista desoleana* (even *sub G. salzmannii*) have been described by several authors for these and other sites in eastern Liguria (Mariotti 1986, 1994; Nowak 1987; Montanari 1988; Vagge 1997). The comparison with the situation observed for the copper mines shows a great floristic poverty in these latter cases and the lack of characteristic species (apart from the dwarf broom): therefore, typical associations such as *Euphorbio ligusticae-Genistetum desoleanae* Nowak 1987 (Vagge 1997) or *Euphorbietum spinosae-ligusticae* Hofm. et Furrer 1969 (Furrer, Hofmann 1969) cannot be identified.
It is likely that the physical-chemical conditions existing on mining tailings determine an even more selective ecology than the natural ophiolitic substrate, which is already very difficult for the vegetation: the coarse size of the stones, the high drainage, the high concentrations of salts of copper, iron and other elements, and the lack of earth, mean that almost only *Genista desoleana* is able to colonise, thanks to its powerful root system, and aims at forming monospecific populations, even if over a very long time. In this long-term trend, the centrifugal development of the broom, with the death of the central parts (*fig.* 4), probably also plays a role; this feature, which seems to be common to other species which are well adapted to specific substrates (e.g. *Minuartia laricifolia* ssp. *ophiolitica*), could be a strategy to segregate parts in which heavy metals were concentrated. However, this hypothesis needs to be tested through targeted analyses and these are planned.
An attempt was also made to assess the age of these populations of *Genista desoleana*; this species shows in many cases a semi-prostrate life form, and the plants appear at first sight rather long-standing and often rather contorted, with multiple branches from the base of the main stem. By sectioning the stem of a plant that included extensive necrotic portions with only a part of wood still functional (and a radius of approximately 8 mm), it was possible to count at least 25 very densely arranged annual rings (*fig.* 10). Taking into account the overall diameter at the base of the stem, it is likely that the specimen in question, of average size, could be more than 50 years old. As a result, large bushes of broom may even be centenarian, but further investigations are needed to verify this.

3. Area of Libiola

Prehistoric mining activity was also recorded at Libiola (Issel 1879), and this has subsequently been confirmed and dated to the Copper Age (Maggi, Del Lucchese 1989). Unfortunately, modern industrial mining (from the late nineteenth century until the 1960s) has destroyed much of the evidence

fig. 8 – Libiola: the summit plateau of the mine, colonised by small cushions of Minuartia laricifolia subsp. ophiolitica, Festuca ovina s.l. and ruderal species, especially Rubus sp.

fig. 9 – Libiola: shreds of Calluna vulgaris heath, developed on consolidated tailings.

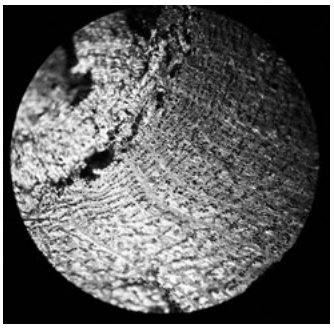

fig. 10 – Transversal section of Genista desoleana stem, showing several annual rings.

for ancient mining. Currently, the unstable tailings are practically naked, while where they have consolidated, the species that typically colonise ophiolitic outcrops are able to settle: among them we mention *Minuartia laricifolia ssp. ophiolitica, Avenella flexuosa, Sesamoides pygmaea, Juncus acutus,* while *Euphorbia ligustica* is lacking; *Buxus sempervirens, Asplenium onopteris, Armeria denticulata* are also found on outcropping rocks and on stabilised debris. The evolutionary series that develops from these early stages is typical of ophiolithic outcrops, with the arrival of small shrubs such as *Calluna vulgaris* forming a pseudo-garrigue, Mediterranean chaparral with heather and, finally, a pine woodland of maritime pine (*figg* . 8-9). On the large summit plateau of the quarry there is a situation of increased eutrophication, indicated by the spread of brambles (*Rubus* sp.) and *Inula viscosa*. On the small-stone tailings, the serpentinophyte *Minuartia laricifolia* ssp. *ophiolitica* spreads together with *Festuca ovina s.l., Scrophularia canina*, *etc.* (*fig.* 8). Here, it was impossible to identify any aspect similar to those described for the mining debris at Monte Loreto.

4. Concluding remarks

We may draw some considerations based on our preliminary investigations, carried out with the aim of establishing the relationship between the

chronology of mining tailings and the vegetation that colonises them:

1) The tailings of the examined copper mines host different plant populations, in all probability depending on the age of abandonment of mining activity, the local history, lithological and mineralogical differences and extraction techniques, even in neighbouring areas and in the same geological context.
2) The species that constitute these populations are highly selected, probably due both to physical causes (highly unstable environment at least in the early stages of colonisation, high drainage, lack of fertile soil) and to the particular chemical composition (circulating solutions rich in salts released by the ore crushing).
3) At the site of Monte Loreto, stabilised mining debris dating back to many millennia ago are occupied by populations of *Genista desoleana*; those dating back to the last few centuries are almost devoid of vegetation, while populations of annual Cariophyllaceae (*Cerastium spp.*) are ephemeral aspects colonising recent archaeological excavation spoil; these last a few seasons and probably disappear as soon as the fine and partly organic soil from the excavation is washed away by rain. Scrubland with *Genista desoleana*, floristically much richer than at the Monte Loreto sites, has been described by several authors for eastern Liguria, even on different substrates. Therefore, one cannot consider these as typically copper-loving communities, but aspects of the refuge of a relic species, *Genista desoleana*, in very selective ecological conditions to which it appears to be very well adapted.
4) The mine environment is very hostile to plant colonisation, since it is able to stay bare for a long time; at present, even after more than 4000 years, the most mature stage consists in an almost monospecific population of prostrate shrubs, even though no information is available concerning possible intermediate disturbance.
5) Only the analysis of other sites in the surroundings can indicate the existence of plant species or populations strictly related to environments of copper mining, such as to constitute biomarkers that are specific for this activity; nevertheless, on the basis of these preliminary surveys, it seems unlikely to find any.

Acknowledgements

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References

Alessandrini A. 2001, *Le ofioliti e la flora dell'Emilia-Romagna*, in *Le ofioliti, isole sulla terraferma,* Atti del convegno Nazionale (22-23 giugno 2001), Riserva Naturale Monte Prinzera, pp. 101-128.

Benente F. 1999, (*GE) Castiglione Chiavarese, miniere di Monte Loreto. 1998*, «Archeologia Medievale», 26, p. 219.

Bertolani M. 1952, *I giacimenti cupriferi nelle ofioliti di Sestri Levante (Liguria)*, «Periodico di Mineralogia», 21 (2-3), pp. 149-170.

Brooks R.R. 1987, *Serpentine and its vegetation. A multidisciplinary approach*, Ecology, Phytogeography & Physiology Series, Vol. 1. Dioscorides Press – Portland (Oregon).

Campana N., Maggi R., Pearce M. 1998, *Libiola e Monte Loreto: due miniere di rame preistoriche nella liguria orientale*, in C. D'Amico, C. Albore Livadie (a cura di), *Atti della IV Giornata Le Scienze della terra e l'Archeometria (Napoli 1997)*, Napoli, pp. 175-179.

Campana N., Maggi R., Pearce M. 1999, *Ricerche archeologiche nelle miniere di Libiola e di Monte Loreto (Genova)*. Paleoexpress, 3, pp. 9-10.

Campana *et al.* 1996 = Campana N., Maggi R., Stos Gale Z., Houghton J., *Miniere e metallurgia in Liguria fra il IV millennio e il IV secolo B.C. Un excursus*, in F. Piola Caselli, P. Piana Agostinetti (a cura di), *La miniera, l'uomo e l'ambiente. Fonti e metodi a confronto per la storia delle attività minerarie e metallurgiche in Italia*, Firenze, pp. 15-52.

Campana *et al.* 2006 = Campana N., Maggi R., Pearce M., Ottomano C., *Quanto rame? Stima della produzione mineraria del distretto di Sestri Levante fra IV e III millennio BC.* in D. Cocchi Genick (a cura di), *Atti della XXXIX Riunione Scientifica: materie prime e scambi nella preistoria italiana* (Firenze, 25-27 novembre 2004), Istituto Italiano di Preistoria e Protostoria, Vol. III, pp. 1339-1348, Firenze.

Dinelli E., Lombini A. 1996, *Metal distribution in plants growing on copper mine spoils in Northern Apennines, Italy: the evaluation of seasonal variations*, «Applied Geochemistry», 11, pp. 375-385.

Dinelli E., Cortecci G., Lucchini F. 1996, *Geochemical characterization of sulphide waste rock piles from mining workings in Northern Apennines, Emilia province, Italy*, «Mineralogica et Petrographica Acta», 39, pp. 109-123.

Dinelli E., Tateo F. 2002, *Different types of fine-grained sediments associated with acid mine drainage in the Libiola Fe-Cu mine area (Ligurian Apennines, Italy)*, «Applied Geochemistry», 17, pp. 1081-1092.

Dinelli *et al.* 2001 = Dinelli E., Lucchini F., Fabbri M., Cortecci G., *Metal distribution and environmental problems related to sulfide oxidation in the Libiola copper mine area (Ligurian Apennines, Italy)*, «Journal of Geochemical exploration», 74 (1-3), pp. 141-152.

Ernst W. 1974, *Schwermetall Vegetation der Erde*, Geobotanical Selecta, Band V. Gustav Fischer, Stuttgart.

Ernst W. 1998, *Effects of heavy metals in plants at the cellular and organismic level*, in B. Schurmann, B. Markert (eds.), *Ecotoxicology: Ecological fundamentals, Chemical Exposure, and Biological Effects*, New York, pp. 587-620.

Ernst W., Weinert H. 1972, *Lokalisation von Zink in der Blattern von Silene cucubalus Wib*. Z. «Pflanzenohysiologie», 66, pp. 258-264.

Ernst W., Verkleij J., Schat H. 1992, *Metal tolerance in plants*, «Acta Botanica Neerlandica», 41, pp. 229-248.

Furrer E., Hofmann A. 1969, *Das Euphorbietum spinosae-ligusticae, eine Serpentingesellschaft in Ligurien*, «Acta Botanica Croatica», XXVIII, pp. 81-91.

Kramer *et al.* 1997 = Kramer U., Grime G.W., Smith J., Hawes C., Baker A., *Micro-PIXE as a technique for studying Nickel localisation in leaves of the hyperaccumulator plant Alyssum lesbiacum*, «Nuclear instruments and Methods in Physics Research B», 130, pp. 346-350.

Issel A. 1879, *Sulle tracce di antichissime lavorazioni*, «Rassegna settimanale», III, 70, pp. 348-349.

Lombini *et al.* 1997 = Lombini A., Pandolfini T., Ferrari C., Dinelli E., *Cu-tolerance and accumulation of two populations of Silene armeria L. from a copper-mine and from a serpentinite outcrop (Northern Apennines, Italy)*, «OSTROM, Noumea, Doc. Sci. Tech.», 6, pp. 233-235.

Lombini *et al.* 1998 = Lombini A., Dinelli E., Ferrari C., Simoni A., *Plant-soil relantionships in the serpentinite screes of Mt. Prinzera (Northern-Apennines, Italy)*, «Journal of Geochemical Exploration», 64 (1-3), pp. 19-33.

Lombini *et al.* 2001 = Lombini A., Dinelli E., Lluganj M., Poschenrieder C., Barcelo J., *Le risposte di Silene armeria a diversi tipi di substrato,* in *Le ofioliti, isole sulla terraferma*, Atti convegno Nazionale (Riserva Nataturale Monte Prinzera, 22-23 giugno 2001), Parma, pp. 135-144.

Maggi R., Pearce M. 1998, *Les mines préhistoriques de Libiola et Monte Loreto (nouvelles fouilles)*, in *Paléométallurgie des cuivres,* Actes du colloque (Bourg-en-Bresse et Beaune, 17-18 octobre 1997), Monographies instrumentum, Montagnac, pp. 89-93.

Maggi R., Pearce M. 2005, *Mid fourth-millennium copper mining in Liguria, north-west Italy: the earliest known copper mines in Western Europe*, «Antiquity», 79 (303), pp. 66-77.

Maggi R., Vignolo M.R. 1986, *Libiola*, in *Archeologia in Liguria, III.1, Scavi e scoperte 1980-86*, Genova, pp. 41-44.

Maggi R., Del Lucchese A. 1989, *Aspects of the Copper Age in Liguria*, in *L'età del Rame in Europa*, Atti Congresso Internazionale (Viareggio, 15-18 ottobre 1987), «Rassegna di Archeologia» 7 (1988), pp. 331-338.

Maggi R., Campana N., Pearce M. 2011, *Pirotecnologia e cronologia. Novità da Monte Loreto*, in C. Giardino (a cura di), *Archeometallurgia: dalla conoscenza alla fruizione*, Atti del Workshop (Cavallino (LE), Convento dei Domenicani, 22-25 maggio 2006), Beni Archeologici – Conoscenza e Tecnologie, Quaderno 8, Bari, pp. 281-292.

Mariotti M. 1986, *Note preliminari su alcune formazioni arbustive della Liguria orientale*, «Giornale Botanico Italiano», 120 (suppl. 2), p. 160.

Mariotti M.G. 1994, *Osservazioni sulle formazioni a Buxus sempervirens e a Genista salzmannii della Liguria orientale,* «Memorie Accademia Lunigianense di scienze G. Capellini», Vol. LIX, pp. 77-125.

Mariotti M.G., Cornara L. 2001, *Analisi istochimiche su alcune specie ofiolitiche di Alyssum in relazione all'accumulo di Nickel*, in *Le ofioliti, isole sulla terraferma*, Atti convegno Nazionale (Riserva Nataturale Monte Prinzera, 22-23 giugno 2001), Parma, pp. 129-134.

Minguzzi C., Vergnano O. 1948, *Il contenuto di Nickel nelle ceneri di Alyssum bertolonii Desv. Considerazioni botaniche e geochimiche*, «Atti della Società Toscana di Scienze Naturali – Memorie serie A», 55, pp. 49-74.

Montanari C. 1988, *Note illustrative della carta della vegetazione dell'alta Val di Vara (Appennino ligure orientale)*, «Atti Istituto Botanico Laboratorio Crittogamico Università di Pavia», serie 7, Vol. 6 (1987) (suppl.), pp. 1-23.

Nowak B. 1987, *Untersuchungen zur Vegetation Ostliguriens (Italien),* Dissertationes Botanicae Band III, Berlin-Stuttgart, pp. 1-259.

Pearce M. 2007, *Bright Blades and Red Metal: essays on north Italian prehistoric metalwork*, Specialist Studies on Italy 14. London.

Pichi Sermolli R., 1948, *Flora e vegetazione delle serpentine e delle altre ofioliti dell'alta valle del Tevere (Toscana)*, «Webbia», 6, pp. 1-380.

Vagge I. 1997, *Le garighe a Genista desoleana Valsecchi ed Euphorbia spinosa L. subsp. ligustica (Fiori) Pign. della Liguria orientale (Italia NW)*, «Fitosociologia» 32, pp. 239-243.

Valsecchi F. 1993, *Il genere Genista L. in Italia. I. Le specie delle sezioni Erinacoides Spach, Ephedrospartum Spach, Aureospartum sect. nova*, «Webbia», 48, pp. 779-824.

Vergnano Gambi O. 1977, *Investigation on a Nickel accumulating plant: "Alyssum bertolonii" Desv. I. Nickel, Calcium and Magnesium content and distribution during growth*, «Webbia» 32, pp. 175-188.

Vergnano Gambi O., Gabbrielli R., Pancaro L. 1982, *Nickel, Chromium and Cobalt in plants from Italian serpentine areas,* «Acta Oecologica – Oecologia Plantarum», 3, pp. 291-306.

Vergnano Gambi O. 1992, *The distribution and ecology of the vegetation of ultramafic soils in Italy*, in B.A. Roberts, J. Proctor (eds.), *The ecology of areas with serpentinized rocks. A world view,* Dordrecht, pp. 217-247.

Abstract

The vegetation colonising the debris of some mining sites of different ages near Sestri Levante (NW-Italy) is illustrated. Different plant populations characterise the excavation sites from different periods. The prehistoric (Copper Age) mining tailings host dense shrub populations dominated by *Genista* desoleana; the nineteenth-century debris, with stones of medium size, is unstable and almost devoid of vegetation; the fine-grained and partly organic spoil from recent archaeological excavations is rapidly colonised by ephemeral populations of *Cerastium* spp. The vegetation of mining debris is different from that of the bedrock and its natural debris, although it is of the same (ophiolitic) geological type.

Key words: mines vegetation, copper mines, bioindicators, Sestri Levante, NW-Italy.

Riassunto

La vegetazione di siti minerari preistorici e storici nei dintorni di Sestri Levante (GE). Viene illustrata la vegetazione che colonizza i detriti di alcune miniere di rame presso Sestri Levante (Genova). Popolamenti vegetali diversi caratterizzano i siti di scavo di periodi storici diversi. I detriti di epoca preistorica (Età del Rame) ospitano densi popolamenti arbustivi dominati da *Genista desoleana*; le discariche del XIX sec. sono costituite da ciottoli di medie dimensioni e sono pressocchè prive di vegetazione; il materiale di granulometria fine e arricchito da detrito organico prodotto da scavi archeologici recenti è colonizzato rapidamente da popolamenti effimeri di *Cerastium* spp. La vegetazione delle discariche di miniera è diversa da quella che si insedia sulle emergenze rocciose e sui loro detriti, benché si tratti dello tipo litologico (ofioliti).

Parole chiave: vegetazione delle miniere, miniere di rame, bioindicatori, Sestri Levante, Italia nord-occidentale.

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a cura di Anna Maria Stagno

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