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The effects of human impact on the arboreal vegetation near ancient iron smelting sites in Val Gabbia, northern Italy

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Abstract. Changes in arboreal vegetation near ancient iron smelting sites in Val Gabbia, a lateral valley of Val Camonica, Brescia, northern Italy, were studied using charcoal analysis at three archaeological sites. The charcoal samples analysed derive from charcoal stores and furnaces used for iron ore smelting during different periods spanning the interval A.D. 500 to 1700. As a reliable description of the woodland cover in the valley during this period does not exist, charcoal analysis is a useful approach for studying the effect of human impact on a forest exploited for the iron industry. Our results indicate that the conifer forest, consisting of *Abies alba*, *Picea abies* and/or *Larix decidua*, which was present in the early stages was replaced after 600 years by a mixed forest and, 300 years later, by a degraded forest dominated by *Ostrya carpinifolia*, a typical pioneer species. The youngest period is characterised by the reconstitution of a mixed forest with coniferous and deciduous trees.

Key words: Charcoal analysis – Ancient woodlands – Human impact – Iron industry – Northern Italy

Introduction

The importance of the analysis of charcoal fragments found in an archaeological context as a palaeoecological and palaeoethnological discipline has been recognised by several authors (cf. Neumann 1992). Charcoal, deriving from the partial combustion of wood collected by ancient communities, may be associated with archaeological structures, or it may be scattered in the archaeological strata or occur in the waste collected in dry pits. Charcoal analyses have contributed greatly to our knowledge of prehistoric environments and the manner in which human activity impacted on them (Vernet et al. 1983, 1987; Marziani et al. 1991, 1992, 1996; Badal et al. 1994; Figueiral 1995, 1996; Barakat 1995; Machado Yanes et al. 1997). In this study we have analysed charcoal gathered during the 1995-1996 in the course of the archaeological investigations conducted by Prof. Marco Tizzoni, Bergamo University, on the ancient iron industry in Val Gabbia, near Bienno, a small town in Val Camonica, northern Italy. Charcoals found in Val Gabbia are derived from iron ore smelting contexts rather than from normal domestic fires.

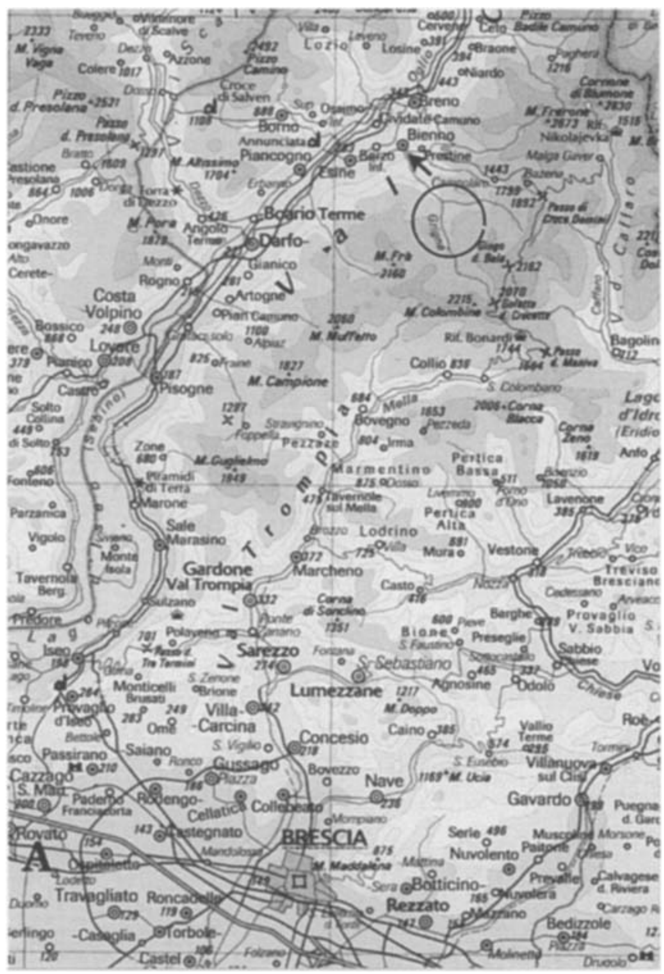

Fig. 1. Map of part of northern Italy that includes the town of Brescia, Bienno *(arrow)* and the area of the excavations *(circled)*

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The analysis of these rather recent charcoals is interesting because a reliable description of the arboreal vegetation present in Val Gabbia during the period in question is not available. The only available information dates back to 1609 when Giovanni da Lezze described the iron industry of Bienno and mentioned the forest of Val Gabbia as being characterised by very large and beautiful trees, which are referred to by the old Italian words *pagari* and *larisi* which indicate *Abies* or *Picea* and *Larix*, respectively.

The archaeological site

Val Gabbia is a short and steep lateral valley of Val Camonica, in Brescia province, which starts near the village of Bienno (Fig. 1). The ancient iron furnaces have been localised by the discovery of several fragments of partially smelted iron ore and by the colour of the soil which appeared black due to presence of small charcoal fragments. The following three sites have been excavated: Ponte di Val Gabbia I (1315 m asl), Ponte di Val Gabbia II (1300 m asl) and Ponte di Val Gabbia III (1375 m asl). Chronological details are given in Table 1. The specific age ranges are based on ^{14}C dates provided by the Radiocarbon Laboratory, British Museum. The calibrated age ranges at 95% probability, as provided by the calibration program OxCal v2.18 (Bronk Ramsey 1995; note: all dates are quoted in calibrated/calendar years). The stratigraphy at Ponte di Val Gabbia III, where four charcoal layers were recorded, is shown in Fig. 2.

In the present study, charcoal found in charcoal stores and furnaces that were used for the smelting of iron ore extracted from the mines of Piazzalunga, which are located nearby, has been analysed.

Table 1. Details relating to the chronology of the investigated sites

Site	Age (A.D.)	Archaeological period
Ponte di Val Gabbia I	590- 680	Longobard period
Ponte di val Gabbia II	560- 760	Longobard period
Ponte di val Gabbia III	C17- C18	Based on archaeological evidence
(4 layers)	1440-1640	Renaissance/Modern period
	1170-1280	Late medieval
	410- 600	Late-Roman and Longobard periods

C17-C18, Seventeenth to eighteenth century

Materials and methods

All the charcoal fragments, found in charcoal stores and furnaces, were large and well preserved. For the first period (A.D. 410-760), a large number of fragments were collected at random, independent of size, and all specimens were analysed (Table 2). For the other periods, all available fragments were collected and analysed. The quantitative analysis was based on the number of fragments following the methods outlined in Chabal (1990) and Badal Garcia (1992).

Charcoal fragments were broken manually to obtain a transverse fracture and analysed under a stereomicroscope for initial identification. Some samples of each taxon were examined with a scanning electron microscope (Cambridge Stereoscan 250 MK2) and SEM photographs taken to facilitate confirmation of the identification. For this purpose charcoal fragments were fractured to obtain a clean surface and coated with gold in a Nanotech Sputter Coater. Identification of charcoals was based on atlases of wood structure (Grosser 1977; Schweingruber 1990) and on our own collection of charcoal specimens and photographs. Where necessary both transversal and longitudinal fractures (radial and tangential) were examined as part of the identification procedure.

Table 2. Numbers of charcoal pieces analysed

	Ponte di Val Gabbia II	Ponte di Val Gabbia III	Total
First period A.D. 410-760	694	968	1662
Second period A.D. 1170-1280	-	91	91
Third period A.D. 1440-1640	-	187	187
Fourth period 17^{th} and 18^{th} centuries	-	56	56

Note: no charcoal recorded at Ponte di Val Gabbia I

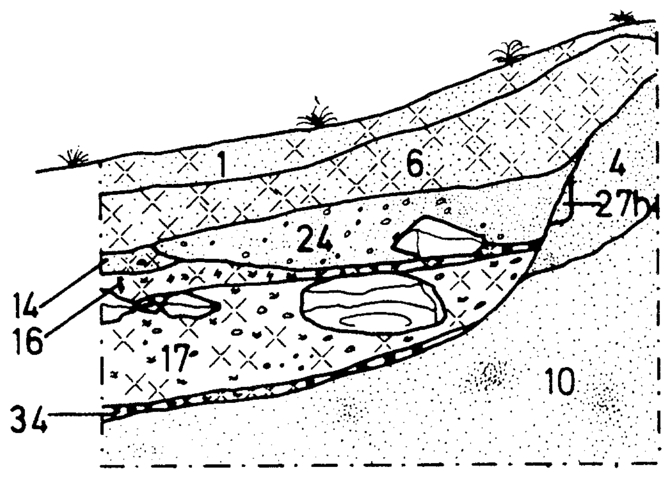
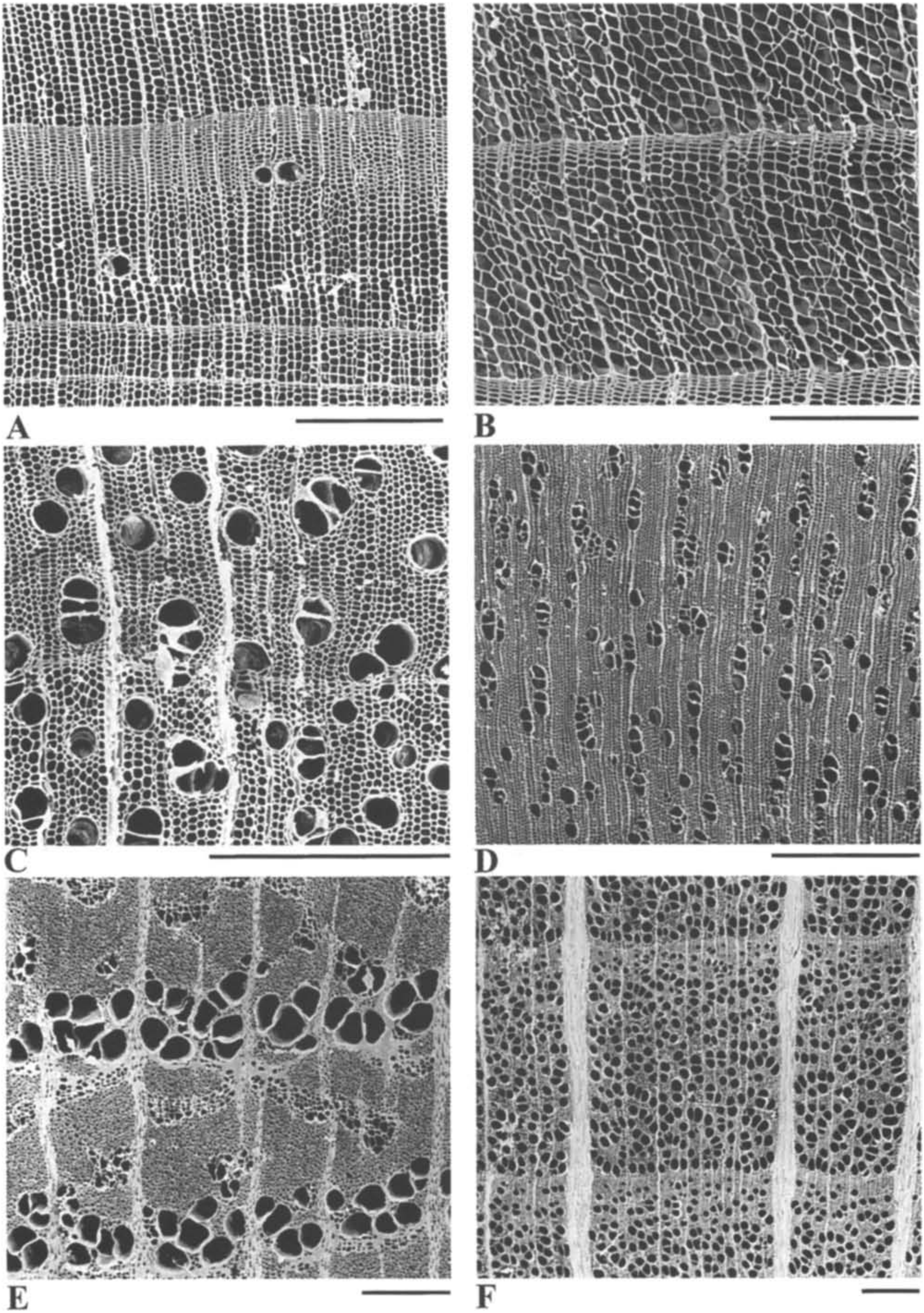


Fig. 2. Schematic sketch showing the stratigraphy in a cutting at Ponte Val Gabbia III. Due to the presence of trees and rocks, large-scale excavation was impossible so that the archaeological exploration was done by making cuttings. Charcoal-rich layers *34* and *17* relate to the first period (A.D. 410-660); layer *16* relates to the second period (A.D. 1170-1280)

Fig. 3. SEM micrographs of a transverse fracture of **A** *Picea abies* or *Larix decidua*, **B** *Abies alba*, **C** *Acer* sp., **D** *Ostrya carpinifolia*, **E** *Laburnum* sp. and **F** *Fagus sylvatica*. The scale is indicated by a bar 300 μm long


A
B
C
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Results

The principal characteristics used by us for identification purposes were the presence or absence of resin canals in coniferous wood, and porosity, aspect and type of aggregation of vessels and width of rays in dicotyledonous wood.

Among the charcoals gathered at the two sites we have identified the following taxa: *Abies alba*, *Picea abies* and/or *Larix decidua*, *Ostrya carpinifolia*, *Fagus sylvatica*, *Salix* sp., *Laburnum* sp. and *Acer* sp. SEM photographs of the transversal fractures of some charcoal fragments are given in Fig. 3.

The identification of *A. alba* was based on the absence of resin canals and spiral thickenings in the longitudinal walls of the tracheids (not shown). *P. abies* and *L. decidua* cannot be distinguished on the basis of their wood anatomy (Schweingruber 1990) and both may have been present in the forest. In a typical coniferous forest in the study area, *A. alba*, *P. abies* and *L. decidua* are often associated. The last two species may be distinguished from *Pinus* on the basis of size of the resin canals (larger in *Pinus*) and the maximum height of the rays (higher in *Picea*/*Larix*) (not shown). Among the identified hardwoods, *O. carpinifolia*, *Salix* sp., *Laburnum* sp. and *Acer* sp. are pioneer trees/shrubs that colonise deforested area. *Salix* has been distinguished from *Populus* on the basis of the typical heterogeneous rays (Fig. 4).

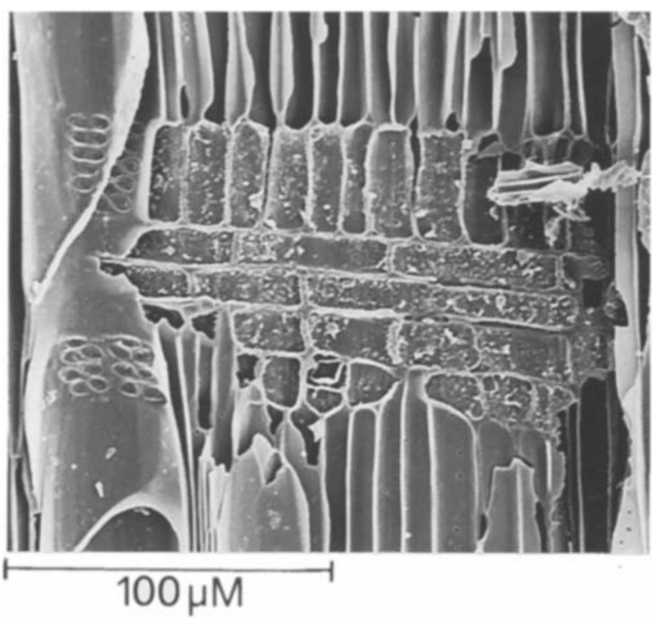

Fig. 4. Radial fracture of *Salix*. Note the typical heterogeneous ray

The results of the quantitative analysis of identified taxa from the different sites and periods are presented in Fig. 5. In the first period (A.D. 410-760), *A. alba*, *P. abies* and/or *L. decidua*, which are recorded with a frequency of 56% and 42%, respectively, are dominant. The remaining 2% of the charcoals include five hardwoods, namely *O. carpinifolia*, *F. sylvatica*, *Salix* sp., *Laburnum sp.* and *Acer* sp.

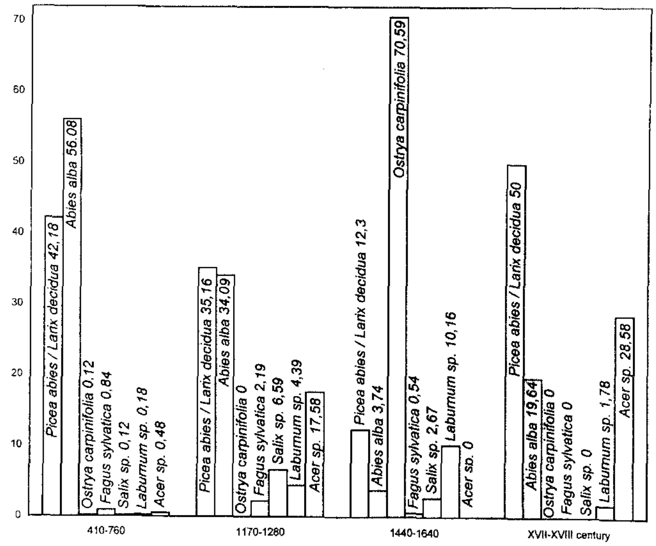

Fig. 5. Percentage relative frequencies of the various taxa represented in the charcoal fragments, the fragments having been assigned to one of the four recognised periods

In the second period (A.D. 1170-1280), charcoals from conifers decreased to 69% (*A. alba*, 35%, and *P. abies* and/or *L. decidua*, 34%), while hardwoods are at 31%. In the latter group, *Acer sp.* (17.5%) is the most abundant, followed by *Salix sp.* (6.5%), *Laburnum sp.* (4%) and *F. sylvatica* (2%).

During the third period (A.D. 1440-1640), the frequency of conifer charcoals drastically decreased to 16% (*P. abies* and/or *L. decidua*, 12%; *A. alba*, 4%), while hardwoods rise to 84%. In the latter, *O. carpinifolia* (70%) is dominant and *Laburnum sp.* (10%) and *Salix sp.* (3%) are also recorded.

In the last period (seventeenth to eighteenth centuries), *O. carpinifolia* is no longer recorded and was replaced by the conifers which attained once again 70%, with *P. abies* and/or *L. decidua* at 50%. *Acer sp.* and *Laburnum sp.* constituted 28% and 2%, respectively, of the charcoals.

Discussion

As already mentioned, the analysed charcoals derive from wood used in the local iron industry rather than arising from domestic or related contexts. As not all kinds of wood are equally suitable for charcoal preparation, a selection process during wood collection may be postulated. The most abundant taxa, however, are the conifers *A. alba*, *P. abies* and/or *L. decidua*. Of these, only the last mentioned is suitable for preparing charcoal. The yield from *A. alba* and *P. abies* is very low. Hardwoods such as *Fagus*, *Acer* and *Ostrya* are excellent for charcoal preparation (Castaldi 1923), but they have low frequency in the identified charcoals. An exception is *O. carpinifolia* which, during the third period, is the most abundant charcoal. From these data, it may be concluded that all the available trees were utilised without prior selection, and that the relative frequencies of different taxa in the charcoals probably reflect the frequencies of the particular trees in the ancient forest.

The results of charcoal analysis give a picture of the evolution of a forest that has been heavily exploited as source of wood for iron industry. The coniferous forest present during the Longobard period, was replaced some 600 years later by a typical mixed forest of conifers and dicotyledons. This period was followed by a particularly heavy utilisation of the forest which, 300 years later, appears to be completely degraded. *O. carpinifolia,* a typical pioneer plant that colonises areas deforested and/or disturbed by landslides, is now the dominant species (A.D. 1440-1640). Evidence for landslides has come to light during archaeological excavations in the region (M. Tizzoni, personal communication). In the final period, *O. carpinifolia* disappears probably as a result of it being heavily harvested for charcoal production during the previous period, and also due to the re-establishment of the mixed forest of conifers and deciduous trees. The very low frequency of *F. sylvatica* (0-2%), which is a tree of the late stage of woodland succession, may be due to exploitation in earlier periods.

The effect of long-term exploitation of the forest is still visible in Val Gabbia. Aerial photographs taken in the 1960s show the area devoid of any type of forest and utilised as pasture land. As pasture declined, the area has been reafforested with *P. abies* and deciduous trees such as *Acer* and *Laburnum* have regenerated.

To our knowledge, this is the first report of the impact of the iron smelting industry on the vegetation of an alpine valley. Further studies of archaeological sites connected with iron smelting are obviously desirable to validate the hypotheses regarding the impact of these activities on woodland vegetation.

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