BUILDING AND ECONOMIC GROWTH
IN SOUTHERN EUROPE (1050–1300)

THE MEDIEVAL COUNTRYSIDE

VOLUME 26

General Editor
Phillipp Schofield, Aberystwyth University

Editorial Board
Laurent Feller, Université Paris 1 Panthéon-Sorbonne
Paul Freedman, Yale University
Thomas Lindkvist, Göteborgs universitet
Sigrid Hirbodian, Universität Tübingen
Piotr Górecki, University of California, Riverside
Sandro Carocci, Università degli Studi di Roma Tor Vergata
Julio Escalona, Consejo Superior de Investigaciones Científicas, Madrid
Pere Benito i Monclús, Universitat de Lleida

PETRIFYING
WEALTH

The four-volume sub-series 'Petrifying Wealth' explores the sudden ubiquity of masonry construction between 1050 and 1300 in Southern Europe and its profound effect on the European landscape. New questions about wealth, society, and medieval building are explored, which highlight the link between construction in durable materials and the shaping of individual, collective, and territorial identities: the birth of a new, long-lasting panorama, epitomising the way we see the space and territory of Europe nowadays.

VOLUME 2

Building and Economic Growth in Southern Europe (1050–1300)

Edited by

SANDRO CAROCCI *and* ALESSIO FIORE

BREPOLS

***Petrifying Wealth. The Southern European Shift to Masonry as Collective Investment in Identity, c. 1050–1300* is funded by an ERC/European Research Council Advanced Grant (grant number 695515).**

Cover image: 'Stonemasons at work', Girona Cathedral, Romanesque cloister, west gallery. Twelfth century. Photo: Federico Del Tredici.

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library.

© 2024, Brepols Publishers n.v., Turnhout, Belgium.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise without the prior permission of the publisher.

ISBN: 978-2-503-60541-8
e-ISBN: 978-2-503-60543-2
DOI: 10.1484/M.TMC-EB.5.132952

ISSN: 1784-8814
e-ISSN: 2294-8430

Printed in the EU on acid-free paper.

D/2024/0095/138

Table of Contents

List of Illustrations 7

Introduction: Building Economic Growth in Southern Europe
Alessio Fiore 9

Part I
Farming

Storing for the Economy? Landed Estates and their Buildings in Northern and Central Italy, Twelfth and Thirteenth Centuries
Lorenzo Tabarrini 19

El *mansus* de la Cataluña Vieja medieval: La implantación de un señorío constructivo
Víctor Farías Zurita 39

Reflections on the Archaeology of Cereal Storage in Medieval Italy
Giovanna Bianchi 57

***Extrahere cequiam:* Irrigation Canal Building and Agricultural Hydraulics in the Crown of Aragon (1170–1300)**
Josep Torró 79

Canal-Digging in the Age of Economic Expansion: Northern Italy, Eleventh–Thirteenth Centuries
Fabrizio Pagnoni 101

Part II
Manufacturing

La expansión de la molinería hidráulica en Cataluña (siglos XI–XIII): Acerca de la construcción de molinos y sus promotores
Jordi Morelló Baget 123

Productive Buildings and Economic Growth: Iron-Working in Central and Northern Italy (Eleventh–Thirteenth Centuries)
Maria Elena Cortese 149

Building for the Market: Residential Properties in Medieval Italy (*c.* 1070–1250)
Alessio Fiore 169

Part III
Connecting

Petrified Nodes: Bridges and Economic Growth (Tuscany, 1050–1200)
Paolo Tomei 189

Porti, cantieri e arsenali
Pinuccia F. Simbula 215

Conclusions
Sandro Carocci 243

Index 259

List of Illustrations

Reflections on the Archaeology of Cereal Storage in Medieval Italy — *Giovanna Bianchi*

Figure 4.1. Location of sites mentioned in this chapter. 58

Figure 4.2. Rocca degli Alberti (Monterotondo M.mo, GR). In the centre of the photo are the remains of the silos. 60

Figure 4.3. Rocca degli Alberti (Monterotondo M.mo, GR). The excavation area with the tenth-century walls and the remains of the granary marked with dark shading. 62

Figure 4.4. Vetricella. Aerial view (drone) of the excavation of the centre of the court of Valli. Circles indicate places where the remains of seeds (carporests) accumulate. 70

Extrahere cequiam:* Irrigation Canal-Building and Agricultural Hydraulics in the Crown of Aragon (1170–1300) — *Josep Torró

Figure 5.1. The Crown of Aragon: frontier advances (1080–1245) and the location of major Christian hydraulic works. 80

Figure 5.2. Canal network in Teruel in the mid-thirteenth century. 84

Figure 5.3. The new canal of Alzira built by royal initiative in 1258–1272. 86

Figure 5.4. The new canal of Vila-real built by royal initiative in 1272–1281. 87

La expansión de la molinería hidráulica en Cataluña (siglos XI–XIII) — *Jordi Morelló Baget*

Figura 7.1. Molino dels Cups, al lado del río Cardener. Primera noticia documental: 1080 (reformado en torno a 1224). 130

Figura 7.2. La construcción de molinos en Cataluña (siglos XI–XIII). 132

Figura 7.3. La construcción de batanes en Cataluña (siglos XII–XIII). 134

Tabla 7.1. Periodización de molinos en construcción. 133

Petrified Nodes: Bridges and Economic Growth (Tuscany, 1050–1200) — *Paolo Tomei*

Figure 10.1. 'Cittadine borghigiane' and major communication routes. 190

Figure 10.2. River crossings and docking points. 193

Figure 10.3. Confluence of the Arno and the *Arme*: tenth to eleventh centuries. 199

Figure 10.4. Investments and disputes over bridges: temporal rhythm. 201

Figure 10.5. Confluence of the Arno and the *Arme*: twelfth to thirteenth centuries. 203

MARIA ELENA CORTESE

Productive Buildings and Economic Growth

Iron-Working in Central and Northern Italy (Eleventh–Thirteenth Centuries)

A few years ago, in an essay entitled *Prima della crescita* (Before Growth), Chris Wickham noted that historians had often used mentions of merchants, craftspeople, or luxury products as evidence for establishing a chronology of economic growth in the Middle Ages; but he also underlined that before 1150 these attestations do not really tell us very much about economic structures. Indeed, only the development of the mass production — such as of fabrics, metals, and pottery — can be considered an effective proxy for understanding economic trends.[1] Medieval metal-working can certainly be studied in this perspective. The two major Italian mining and metallurgical districts — the Alps and Tuscany (including the island of Elba) — will therefore be the focus of the following pages, and they will be compared in order to identify common lines of development. However, it is necessary to briefly explain why I have chosen to deal only with the production of iron and not with that of precious metals too, which were also present in both areas.

First of all, the exploitation of precious minerals (particularly silver) must mainly be considered in relation to coinage. Even if silver was a recurrent concern for the public authorities and appears in the written sources quite often, the total volume of this raw material that was put into circulation was far lower than what was required to meet the considerable demand for iron which came from many human activities. Therefore, the production of silver reflects economic phenomena less directly than that of iron. Secondly, technological aspects are essential for interpreting the topographical location of ironworks, their management, and also the evolution of their material structure. In this regard, it should be emphasized right from the start that substantial technical innovations were introduced into iron-making in the period we are dealing with, which allowed for a real increase in productivity. This aspect, however,

1 Wickham, 'Prima della crescita'.

Maria Elena Cortese (mariaelena.cortese@unige.it)
is associate professor at the University of Genoa.

This is an open access article made available under a CC BY-NC 4.0 International License

Building and Economic Growth in Southern Europe (1050–1300), ed. by Sandro Carocci and Alessio Fiore, (Turnhout: Brepols, 2024), pp. 149–168 BREPOLS PUBLISHERS 10.1484/M.TMC-EB.5.137978

is less relevant to the processing of coinage metals, whose working techniques did not undergo major changes to the same degree. But in order to understand what happened between *c.* 1050 and *c.* 1300, it is necessary to at least briefly mention the immediately preceding centuries.

Between the ninth and the tenth centuries, both in Tuscany and in northern Italy, iron production certainly took place on estates (*curtes*) owned by important churches — the only ones to have preserved written documents — which had incorporated considerable fiscal assets. Payments of rents in iron to ecclesiastical landowners are repeatedly mentioned. The analysis of these sources makes it possible to draw a distinction between the delivery of certain iron objects (*ferramenta*, *vomeri*, etc.) by individual tenants and that of far from negligible amounts of goods — above all raw iron (*ferrum*) — by both large or small groups of tenants who lived within *curtes* located in, or near, Alpine and pre-Alpine mining areas. In the former case we may suppose that the people involved were blacksmiths who at most could exploit modest local deposits for limited primary production; in the latter case, both the smelting and the forging took place in the context of a rather specialized activity, which would appear to have been based on the work of groups of craftsmen.[2] In the same period in Tuscany we can catch a glimpse of a rather complex system for the exploitation of Elban iron deposits, from which high-quality hematite was extracted. This activity could not have been managed only at the local level, but presupposed the existence of sea routes connecting the Tuscan archipelago's islands to southern *Tuscia*'s coast and the port of Pisa.[3] Archaeological research carried out at the end of the last century has indeed documented the processing of Elban hematite both in some sites (probably small open settlements) on the coastal strip in front of the island (Gulf of Follonica), and in urban centres (Pisa).[4] This activity thus seems to be part of a system coordinated in some way by a central power — the kings or the highest public officials in the region (the margraves of *Tuscia*) — who also exercised control over vast fiscal assets in the Maremma area.

These hypotheses seem to be strengthened by recent archaeological research carried out in the coastal hinterland of the upper Maremma and in the nearby mining district of the Colline Metallifere. In the Donoratico site, which almost certainly belonged to an important royal monastery (San Pietro a Monteverdi), the processing of Elban hematite took place at the end of the ninth/beginning of the tenth century, when the site underwent major building renovation; this initiative can be attributed to a subject with

2 Cortese, 'Beni fiscali'.

3 Concerning Pisa's maritime activity in this period, see Tangheroni and others, 'Pisa e il Mediterraneo', pp. 116–29.

4 Gulf of Follonica: Baiocco and others, *Metallurgia antica e medievale*, pp. 80, 88, 136; Cucini, 'L'insediamento altomedievale'; Cucini and Tizzoni, *Le antiche scorie*, pp. 56–58, 73. Pisa: Corretti, 'L'attività', p. 87.

a large amount of power, who was certainly also able to ensure the supply of hematite from the nearby island of Elba. All stages of the metallurgical cycle were carried out at the site, from the smelting of hematite to the forging of objects; however, the structures' remains and the amount of slag suggest the presence of small ironworks, which only functioned to meet the internal needs of the site.[5] Quite a different picture emerges from another case-study: the excavations at Vetricella, in the Pecora valley immediately behind the plain of Follonica. This site should probably be identified as the place where the central settlement of a royal *curtis* (called Valli) was located.[6] In the tenth century the main specialized production activity at Vetricella was precisely iron-working: hundreds of metal fragments have been found (many of which were probably destined for recycling), as well as slag leftover from forging, small metal bars, and ingots with traces of hammering.[7] The number of iron objects found in Vetricella is far greater than that found in numerous other excavated sites in this part of the region. As regards the productive activity on the site, as proposed by archaeologists, it is very probable that this was a management centre which coordinated the final production of iron artefacts. In other words, fragmentary objects to be recycled were brought and stored here, along with semi-finished ones (ingots, bars) which came from other places where the ore was smelted.[8] More specifically, since no remains of furnaces or slags from the first iron-working phase have been identified in Vetricella, it may be supposed that the sites with evidence of hematite reduction identified in the Gulf of Follonica were part of a more complex system, which had Vetricella at its centre.[9] Given the considerable number of artefacts, their production may have been intended to meet the needs not only of this *curtis*, but of other, more distant fiscal estates too, considering that the location of the site — at the centre of a web of canals and wetlands close to the coast — allowed easy access to the sea.

The situation in Vetricella, moreover, makes it possible in my opinion to draw a comparison with the coeval case of the royal *curtis* of Darfo, in Valcamonica (Bergamo). From a 1047 privilege granted by Emperor Henry III, we know that the inhabitants of the nearby Val di Scalve — an area in which iron deposits are plentiful and iron-working is well attested even in the following centuries — were required every year to pay the *curtis* of Darfo 'libras mille ferri' (one thousand pounds of iron), that is at least 400 kg of raw metal, in exchange for the authorization to freely trade the iron produced in the valley in a large area of the kingdom.[10] Since the privilege explicitly refers to

5 Bianchi and others, 'Archeologia di un cantiere'; Panichi, 'La produzione', p. 212.
6 Bianchi, *Archeologia dei beni*.
7 Agostini, 'The Metal Finds'.
8 Agostini, 'The Metal Finds', p. 44; Bianchi, *Archeologia dei beni*, chapter 1; Marasco and Briano, 'The Stratigraphic', p. 15.
9 See above, note 4.
10 *Heinrici III. diplomata*, ed. by Bresslau and Kehr, no. 199.

an ancient custom, it seems likely that mining and metallurgical production in the Val di Scalve dated back at least to the tenth century. The royal estate therefore appears to be a central place where iron tithes converged from the contiguous mining areas subject to imperial jurisdiction; this metal may have been destined for subsequent processing in Darfo itself, or the iron blooms may have been redistributed to other places within an economic circuit controlled by the public authorities themselves.

While during the eleventh century no significant novelties are noticeable in the written and archaeological sources, the late eleventh/early twelfth century must be identified as the real point of divergence between the productive system for precious metals and iron-working. Although both sectors were developing, in this phase they became incomparable in terms of the volume of production and amount of raw materials consumed (ore, charcoal). Secondly, the need to supply the considerable quantities of iron necessary for all the expanding sectors of the economy (agriculture, construction, craftsmanship, shipbuilding, the manufacturing of military equipment and so on) stimulated the large-scale exploitation of districts with a high concentration of good quality ore, which acquired a much greater strategic importance compared to the previous period, when even modest local deposits were used. It therefore became necessary to invest in the control of larger areas, and to carefully choose the sites for structures associated with production: the availability of vast woodlands, the abundance and quality of the mineral, access to markets and ease of transport became the determining factors about whether to enhance old metallurgical districts or to create new ones. This does not mean that iron production did not continue to satisfy local needs, since minor deposits were also exploited. For this phase, it is important to underline the coexistence of two different productive systems. This dual system is clearly visible in Tuscany, the most studied Italian region, thanks to the archaeological evidence available.

The first system involves limited smelting and forging activities under the direct control of lay and ecclesiastical landlords. Traces of Elban hematite reduction, dating back to between the eleventh and thirteenth centuries, have been identified in numerous castles both in the southern area of the region (Valli, Pero/Castellaccio, Montioni, Alma/Poggio Castello, Castel Maus, Rocca San Silvestro, Grosseto, Rocchette Pannocchieschi)[11] and in the northern one (Terrazzana, in the upper Valdinievole).[12] Iron was worked near some monastic centres, too, as is shown by the written sources for Santa Trinità di Montecalvo (Monte Amiata), by the excavation of the abbey of San Salvatore all'Amiata and by surface surveys in the Maremma area (San Quirico di Populonia, San

11 Baiocco and others, *Metallurgia antica e medievale*, pp. 85, 90, 122–23; Bruttini, 'Minatori e signorie'; Citter, ed., *Archeologia urbana*; Cucini and Tizzoni, *Le antiche scorie*, pp. 58, 75, 110–11, 123, 148, 204–05; Francovich, *Rocca S. Silvestro*, pp. 58–60, 84.

12 Quirós Castillo, *El incastellamento*, p. 63.

Pancrazio al Fango, San Bartolomeo di Sestinga).[13] The best studied case is Rocca San Silvestro: the iron-working area — located not inside a building, but sheltered by a wooden roof — included a bloomery for the reduction of the ore, a heating space for the iron blooms, and an intermediate one where the anvil was placed for beating and forging tools. The furnace was made up of a clay floor bordered on one side by a low wall to shelter the bellows from the fire. Both in Tuscany and in northern Italy, small areas for the forging and maintenance of iron tools were also frequently situated inside castles. Again, they were very simple structures, which can be classified as belonging to the bowl type, as in the case of the furnace excavated in the castle of Manzano, in Piedmont, which was located in an open space protected by a wooden shelter connected to an house.[14] However, in all these cases we should exclude any entrepreneurial role in iron production on the part of the local lords. These metallurgical activities were only linked to the phase of castle building, or they testify to a limited investment and appear to have been aimed at satisfying everyday needs in the settlements. Their topographical location also reflects the different control that local lords exercised over these limited activities, compared to their control over structures dedicated to the processing of coinage metals. The most evident case is again Rocca San Silvestro: here copper and lead ore (galena, an important source of silver) were processed inside the castle, while iron was produced in an area outside the walls.[15] A similar pattern is also repeated in the castle of Terrazzana, where the remains of a furnace for the reduction of Elban hematite were found in the immediate vicinity of the castle walls, but still outside of it.[16] In conclusion, while it is believed that from the eleventh century onward rural lords in Tuscany played a relevant role in the exploitation of coinage metals — leading both to the birth of new 'mining castles' and to the reorganizing of metallurgical settlements — there was no investment in iron-working aimed at producing a surplus for the market, as this activity was only undertaken to meet local needs.

This productive system was more or less in line with those of the previous centuries. In parallel to it, however, a new and very different form of organization was emerging in Tuscany, based on a more intense exploitation of the Elban mines. Starting from the last years of the eleventh century, the Pisan sources attest that groups of specialized artisans (*fabri*) seasonally migrated from the city toward Elba island and the Tyrrhenian coast to work the hematite extracted from the Elban mines, under the protection of the Pisan bishop (and therefore of the urban community). From this moment onward,

---

13 Cambi and Dallai, 'Archeologia di un monastero', p. 205; Cucini and Tizzoni, *Le antiche scorie*, pp. 58–59; Farinelli, 'Le risorse minerarie', pp. 43–44; Farinelli and Francovich, 'Potere e attività'.

14 On Tuscany, see Cortese, 'Il ferro a Pistoia', p. 330; Bruttini, 'Minatori e signorie', pp. 76–78; Tronti and Valenti, 'Gli spazi', pp. 225–27; on Piedmont, see Micheletto, 'Il castello di Manzano'; Micheletto, 'Archeologia dei metalli'; Negro Ponzi Mancini, ed., *S. Michele di Trino*.

15 Francovich and Wickham, 'Uno scavo archeologico'.

16 Quirós Castillo, *El incastellamento*, p. 63.

Elba and the Maremma coastal strip were affected by Pisa's expansionism; by the end of the twelfth century, they had fallen under the full control of the Pisan church and the urban commune.[17] Archaeological surveys have made it possible to identify dozens of hematite reduction sites on the island of Elba, in the Gulf of Follonica, in the Alma valley and on the promontory of Piombino, datable between the twelfth and the beginning of the fourteenth century. In these sites no traces of buildings were found, apart from short-lived structures; the furnaces were located in the open air or under wooden shelters, and probably the craftsmen themselves were housed in temporary shelters. Therefore, it does not seem as though permanent settlements linked to metallurgical activities were ever established in this scarcely populated area. The productive structures appear rather homogeneous in their main features: they were quite simple, with a limited activity over time (judging from the small size of the slag heaps), and were destroyed at the end of each smelting process to make room for new furnaces, which partially reused the remains from previous smelting cycles.[18]

The stages of production were limited to the reduction of the ore into iron blooms. Conversely, the transformation into finished products had to take place elsewhere, probably for the most part inside the city. It was thus possible to reduce the costs of transporting raw ore and charcoal, which was consumed in large quantities during the first metallurgical phase. At the same time, in Pisa — which expanded rapidly beyond its old Roman walls — iron-working no longer took place in the central area, but moved to the more peripheral one of Kinzica, beyond the Arno, where — from the twelfth century onward — a craft district had been established for the production and sale of glass and metal objects.[19] As far as the technical aspects and material structures are concerned, there is no noticeable difference between the sites related to the Pisan blacksmiths' activity and those located inside castles in the same period. However, one major difference lies in Pisa's overall organization of iron production: the city became increasingly active as a maritime centre and embarked on the wide-scale exploitation of Elban deposits to satisfy the growing demand for iron, which was not only consumed within the city itself, but also traded on the Mediterranean market. In my opinion, the specific concept of 'medieval industry' can therefore be applied to this productive system, according to the meaning proposed by Philippe Braunstein and more recently reaffirmed by Chaterine Verna, namely the kind of activity 'capable

17 References to written sources and bibliography in Cortese, 'Il ferro a Pistoia', pp. 333–36, Garzella, 'Fabri e fabricae'.

18 Baiocco and others, *Metallurgia antica e medievale*; Corretti, *Metallurgia medievale*; Corretti, 'L'attività'; Cucini and Tizzoni, *Le antiche scorie*; Gelichi, 'Impianti per la lavorazione'; Martin, 'Trial Excavations'; Dallai, 'Opifici metallurgici'; Corretti, Chiarantini, Giuntoli, Benvenuti, Cambi, Firmati, Isola and Pagliantini, 'Un sito di lavorazione'.

19 Corretti, 'L'attività', p. 100; Carrera and others, 'Le ceramiche'; Garzella, 'Fabri e fabricae', pp. 46–47.

de livrer une production quantitativement importante, régulière, de qualité constante et reconnue comme telle sur le marché; une production qui dépasse les échanges locaux'.[20]

Let us now turn toward the Alps, and more specifically Lombardy. In the mining valleys, the bishops of Bergamo and Brescia had extensive lordships, as did — to a lesser extent — certain monasteries such as Santa Giulia (Brescia), Astino and Pontida (Bergamo). These churches also maintained important rights over the mines, due to the predominantly public origin of their assets.[21] However, it is very difficult to assess the role played by the rural lords in promoting iron-working in this period because, unlike in Tuscany, no archaeological research has been carried out and the written sources (with the sole exception of the aforementioned privilege bestowed by Henry III) do not mention the excavation and working of iron before the twelfth century, only referring to the 'vena argenti' (silver ore).

The lords' interest in the exploitation of iron in any case seems to have been limited, as already noted in relation to Tuscany. Considering the dossier on the Seriana Valley mines preserved by the episcopal archives of Bergamo[22] — within which only two documents concern iron — we notice that it was only at a late stage that the bishops tried to include iron in the list of their seigneurial revenues, while previously the iron deposits would appear to have been freely exploited by the valley community. In 1145, the consuls of Bergamo adjudicated between Bishop Gregory and the *vicini* of Ardesio regarding the dispute over the Monte Sicco iron ore and other mines in Ardesio valley. On the basis of the witness statements, they established that 'per plus quadraginta annis homines de Ardescie fodisse et tenuisse venas ferri in Cornelio Bagitene et Cornelio Garbiasca, et ubi invente fuissent, et carbones fecisse in comuni' (since more than forty years, the inhabitants of Ardesio had owned and mined the iron mines in Cornelio Bagitene and Cornelio Garbiasca, wherever they were located, and had in common produced charcoal), and moreover that 'ipsas venas et venam ferri in monte Sicco reperti, iure usuque homines vallis de Ardescie posse fodere et uti' (the same iron mines and the iron mine discovered in Monte Sicco could be exploited according to custom and right of the Ardesio valley inhabitants). The consuls therefore ruled that the inhabitants of the Ardesio valley could extract and work the ore without infringing upon the bishop's rights in terms of hunting and mountain grazing. Consequently they needed the bishop's permission to make charcoal for iron-working from wood collected in all

20 Braunstein, 'L'industrie'; Verna, 'Innovations et métallurgies', p. 624. See also Beck, ed., *L'innovation technique*.

21 Menant, 'Aspects', pp. 22–24.

22 'Possedimenti', ed. by Barachetti.

the forests in the valley; however, the bishop could in no way prohibit the Ardesio inhabitants from building iron furnaces.[23]

This document shows that iron production had existed for a long time in the Ardesio valley, alongside that of silver, and that the inhabitants had enjoyed the freedom to extract the ore until then. The dispute with the bishop therefore reflects the moment — in the first half of the twelfth century — when iron production had become more intense and was beginning to look like a profitable business. Only then did the bishop try to redefine relations with the rural community, by imposing his seigneurial rights on a resource over which the community had customarily exercised rights of use. But by then it was too late, as the well-established local community was capable of defending its autonomy *vis-à-vis* their lord by resorting to the support of the urban commune, which was also certainly interested in exercising control over this activity. It is also clear from this text that mining, charcoal production, and the running of furnaces were all managed by the inhabitants of the valley in a largely collective manner. Anyway, a community-based management of iron production was already visible in the aforementioned privilege granted to the inhabitants of the Val di Scalve by Henry III in 1047. Indeed the *homines habitantes in Monte Scalfi* emerge as a group capable of directly engaging with the imperial authorities to protect their commercial interests, and who were also able to ensure an extensive production of iron already in the first half of the eleventh century.[24] Other texts too show the dynamism of this community already in the first decades of the century, when the men of the Val di Scalve came into conflict with the inhabitants of the nearby village of Burno, in Valcamonica, over the exploitation of Monte Negrino, which was under the jurisdiction of the bishops of Brescia and Bergamo and of the counts of Bergamo.[25]

In 1179 the *universitas Ardesii*, which by then had its own consuls, again challenged the episcopal claims and, in return for a payment of one thousand and fifteen *lire*, obtained from Bishop Guala confirmation of a series of concessions previously granted by Oberto da Vimercate (he was a canon of the church of Bergamo, who had previously held the Ardesio *districtus* in fief) concerning matters of justice, exploitation of the woods, hunting, and the local market. The community also obtained

> potestatem utendi fluminibus et traendi aquas, levandi furnos ferri et fusinas argenti et furnellos argenti et fullos et molendinos et facere

---

23 'Possedimenti', ed. by Barachetti, Part II, no. V.

24 Menant, 'Pour un'histoire', p. 785: since the payment was probably 1/10 of the overall production, an annual production of between four and five tons can be assumed. See also Fiore, 'The Knots', p. 199.

25 *Codex diplomaticus civitatis et ecclesiæ Bergomatis*, ed. by Lupo, II, col. 491 (1018). See also: *I placiti del Regnum Italiae*, ed. by Manaresi, III, no. 471 (1091); *Codex diplomaticus civitatis et ecclesiæ Bergomatis*, ed. by Lupo, II, col. 775 (after 1091).

> quicquid voluerint et piscandi in ipsis fluminibus atque pontes levandi et omnia predicta hedificia que iam fatta sunt sibi concessit, et etiam pontiaticum eis concessit [...] salvo omni iure et omni districto quod pertinet ad factum argenti
>
> > (the right to use rivers and divert water, to build iron furnaces and silver workshops, fulling mills and mills, and to do everything they wanted to do, and also to fish in those rivers and to build bridges; besides he granted to them all the already existing buildings and the right to use bridges, but excluding any rights concerning the production of silver).[26]

Thus, the community's right to extract iron was implicitly confirmed (in fact, it was not mentioned at all), while it was necessary for the community to redeem its rights over water resources, woodland, and the building of production structures (metallurgical workshops, mills, and fulling mills). Moreover, from this charter it is possible to infer that there were numerous iron furnaces, as well as silver ones, and that they represented a common feature in Alpine valleys at that time. Indeed, as previously noted, to obtain large volumes of metal it was necessary to multiply the number of workshops — although, as we will see, this document seems to prove the presence in the valleys of the first technical innovation used for the processing of minerals.

In Tuscany, in this moment of economic expansion, the initiative of reorganizing the production system in a sparsely populated area had come from an urban commune. In the Alpine area, by contrast, it is clear that the local rural communities played the leading role in mining and iron processing during the central centuries of the Middle Ages. On the one hand, the likely reason for this is that for a long time iron, as a non-precious mineral, was not subject to any stringent controls by landlords. On the other hand, what probably also came into play were factors more directly related to the way in which the work was organized, since the production of much larger quantities of metal required the involvement of substantial human groups for the extraction of the metal and the initial processing stages. After all, both the documents concerning the *Scalvini* and those concerning Ardesio show that in these areas — populous ones relatively close to fast developing urban communes — it was rather difficult for the lords to control the local communities, which were already strong in the first half of the twelfth century and had had their own political institutions from at least the second half of that century.

The thirteenth century undoubtedly marked a turning point for medieval iron production, which began with the spread of some fundamental technical innovations. After a long period in which bloomery iron smelting had not enjoyed any kind of mechanization, the first change occurred with the appear-

---

26 'Possedimenti', ed. by Barachetti, Part II, no. VI.

ance of bloomeries equipped with water-powered hammers (often referred to by scholars as *moulins à fer*), thanks to a system that was technically not very dissimilar to that already used in fulling mills. This novelty — which made it possible to considerably reduce human work both for the hammering of the blooms and for the forging — had already appeared in several European mining districts (France, Sweden, Germany) in the first half of the twelfth century. In all likelihood, this innovation was the result of a series of small modifications and gradual improvements introduced in the production process as a whole. In Italy structures of this kind seem to be attested by the aforementioned Ardesio document (1179), in which the valley community focused on the need to have free access to the use of water for a series of craft activities, among which metallurgical ones are mentioned together with mills and fulling mills.[27]

However, the key technical innovation in iron-working was not the introduction of mechanized hammers, but the use of water power to operate the bellows. The technology involved here was more complicated and innovative: for it made it possible to obtain particularly high temperatures and, moreover, to constantly control them, thereby avoiding the kind of sudden changes that were fatal for the success of such operations. From the thirteenth century onward we therefore witness the spread of a new kind of iron bloomeries, equipped with hydraulic bellows, and a profound restructuring of the work process, which led to the achievement of higher productive levels. Indeed, more or less simultaneously throughout Europe, the written sources increasingly began to include technical terms used by notaries to refer to specialized production workshops, and which seem unmistakably connected to the use of water power.

In many European regions most bloomeries with hydraulic bellows continued to produce iron by the 'direct method', that is: the ore was transformed into spongy iron in one step and mostly also in the same furnace. But in some valleys of the Lombard Alps, the so-called 'indirect method' was also developed, whereby iron ore was first reduced to a hot liquid metal, which is called cast iron, thanks to the high temperatures reached in the furnaces (equipped with water-powered bellows). This iron had a high carbon content which had to be removed, in order to get forgeable iron, by reheating and oxidizing it; and this was achieved by blowing air into a charcoal-fired hearth using bellows.[28]

Rolf Sprandel, observing the duplication of the terms designating ironworks (*furnum* and *fucina*) in documents from this period, hypothesized that this technique appeared in the first half of the thirteenth century.[29]

---

27 See above, note 26.

28 General picture and bibliography in Cortese, *L'acqua, il grano, il ferro*; Verna, 'Innovations et métallurgies'.

29 Sprandel, *Das Eisengewerbe*, pp. 226–31; Sprandel, 'Die oberitalienische Eisenproduktion', pp. 315–16.

Sprandel's hypothesis was convincingly taken up by François Menant, on the basis of further attestations: in particular, a charter from Bergamo dated 1227 — which can be interpreted as evidence of the transition from rent in iron produced with the direct method to a new kind of rent in steel (*ferrum coctum*) — and the mention of steel and cast iron in the Bergamo customs tariffs (*c.* 1240).[30] Certainly, a furnace equipped with hydraulic installations located in Val di Scalve is described in a document laying out the boundaries of the communities of Schilpario, Vilmaggiore and Barzesto (1251), mentioning a 'furnum de ferro cum suis juribus et pertinentiis et clusis et acqueductibus et schirpio et utensilibus, que ipsa vicinia habet' (an iron furnace with its rights and belongings, and dams and channels, equipment and tools, belonging to the near community).[31] This change corresponded to an increasing and more selective demand for metal, both for forgeable iron bars and for steel. Some regions therefore began to specialize in production for more distant markets. In the first half of the thirteenth century production would appear to have been conspicuous, as shown by the multiplication of customs tariffs on metals — especially those on iron — in all Lombard cities, which suggests the existence of a trade network.[32] From the second half of the thirteenth century onward, the application of water power in Alpine ironworks undoubtedly also contributed to the decreasing importance of silver deposits in the Western Alps.[33] It is significant, for example, that the *teloneum ferri* (tax on the sale of ore, iron, and steel) was established by the commune of Bergamo in 1245 and became an important source of revenue, whereas previously the city government had mainly been interested in silver, as is evidenced by its disputes with the local bishop over the Ardesio mines.[34] The same change is also clear in Piedmont, in the mines of Val Chisone (in particular Perosa Argentina), where at the end of the thirteenth century the production of iron greatly exceeded that of silver.[35]

The water-powered production facilities required powerful and complex machinery, capable of simultaneously moving the bellows of the furnace, those of the refinery (in the case of an indirect process) and the hammer in the forge; and they had to be located along watercourses with an adequate capacity and a sufficient drop to spin the wheels. It was therefore in this phase that more permanent buildings appeared, which lasted a certain number of years. These were larger, built from non-perishable materials, equipped with canals and reservoirs and provided with accommodation for the workers. Furthermore, the furnace structure in the Alpine area began to develop

30 Menant, 'Pour un'histoire', pp. 784–85 and nn 7, 51, 52. This hypothesis is criticized in Arnoux, 'Moulins à fer', p. 31.
31 Finazzi, *Sulle antiche miniere*, p. 15.
32 Menant, 'Pour un'histoire', p. 785 and n. 59.
33 Belhoste, 'Mutations techniques'.
34 Mainoni, 'La politica dell'argento', p. 443.
35 Patria, 'In fodina veteri'.

considerably in height, sparking an evolution that led to the development of the 'cannecchio bresciano' and then to the blast furnace.[36] Furnaces were expensive installations which also required rights over the use of water. Moreover, these very recognizable structures in the valleys' landscape became a central element not only for production, but also for settlements and social organization. Each furnace had its own name (from the place where it stood) and in several cases metallurgical villages began to be mentioned in the documents, as did working districts in which furnaces were associated with a set of *fusine*: in Piedmont, for example, from the mid-thirteenth century onward various settlements arose in mining areas, marked by toponyms that often referred to the presence of a furnace on the site. In some cases it seems that these villages sprung up or came together precisely around this kind of productive structures.[37] They were normally owned by the local communities, which rented them out and also encouraged the building of new *fusine*, ensuring that communal woods could be exploited.

Therefore, from the end of the twelfth century onward, in settlements such as Ardesio, Bovegno, and Bormio, the working of iron stimulated the rise of an elite group of entrepreneurs — supported by the local community — who were able to negotiate their autonomy in the use of certain resources both with the old lords and with the city communes.[38] Certainly, the nearby urban communes (Bergamo, Brescia) tried to gain control over iron production and in particular to keep the final stages of the work — the most profitable — within their own walls. However, in the Alpine area, the mining valleys always remained important centres for the production of iron, steel, and also finished objects, employing hundreds of people and generating significant economic revenues. Therefore, this activity represented a very important factor that allowed local communities to maintain a degree of autonomy and made it difficult for the urban authorities and great city merchants to control them.[39]

In Tuscany too the new techniques spread in the second half of the thirteenth century in various inland areas, all rich in water and woodlands (Mount Amiata, the Merse valley, Garfagnana, Pistoiese, Casentino).[40] It was probably only in this period that larger and better organized workshops appeared and began to be run at an entrepreneurial scale, in response to the quickly developing market economy. The establishment of workshops of this kind, which had an innovative feature, led to the appearance of new technical terms, used by notaries to indicate these structures in the documents (*fabrica*, *fabrica aque*, *hedificium fabrice*).

---

36 See above, n. 28.

37 Di Gangi, *L'attività estrattiva*, pp. 351–53.

38 Menant, 'Pour un'histoire', p. 785 and n. 57; Arnoux, 'Innovation technique', pp. 217–18.

39 Menant, 'Pour un'histoire'; Menant, 'La metallurgie'.

40 Mount Amiata: Cortese, 'Opifici idraulici'; Merse valley: Cortese, *L'acqua, il grano, il ferro*, pp. 188–95; Garfagnana: Quirós Castillo, *El incastellamento*, pp. 161–63; Pistoiese: Cortese, 'Il ferro a Pistoia'; Casentino: Barlucchi, 'La lavorazione del ferro'.

Unlike in the Alpine valleys, in Tuscany water-powered ironworks processed the ore exclusively by the direct method, while the indirect method in the region dates back to the middle of the sixteenth century, when it was introduced on the initiative of Cosimo I de' Medici. In any case, the spread of the new hydraulic techniques certainly brought about a change in terms both of the location of productive districts and of the material configuration of the workshops, even though few sources explicitly mention the presence of hammers or bellows — they generally only specify that the workshops were located along rivers and streams and equipped with weirs, channels, and water reservoirs. In this phase, the furnaces were always located inside a building and no longer in the open; the buildings were characterized by a rather substantial material structure, sometimes flanked by houses for the workers and service structures, particularly charcoal deposits. To build an iron workshop powered by hydraulic energy, it was necessary to have a good level of technical knowledge and considerable accuracy in the installation of infrastructure and water wheels.

A clear example can be found in a contract drawn up in 1281 by the abbot of San Salvatore al Monte Amiata with Ranieri di Bianca, an inhabitant of Castel di Badia. This document is particularly rich in detail, and it is the first to clearly refer to the construction of an iron mill in the area. First of all, the abbot guaranteed Ranieri a ten-year concession for a fulling mill located near the castle to be converted 'ad faciendum et hedificandum fabricam aque' (into an iron workshop).[41] The concession included 'omnibus canalibus sive saiettulis et aliis edificiis necessariis ad faciendum fabricam aque' (all the channels and buildings necessary to set up the ironworks), as well as an area 'ad faciendum et edificandum unam domum pro carbonaria ad retinendum carbonem pro dicta fabrica' (to construct a building for the storing of charcoal). Secondly, the abbot granted Ranieri the woodlands of Mount Amiata, for collecting the timber for the charcoal necessary for the new *fabrica*. The clauses relating to charcoal production, moreover, suggest that this was a multi-functional workshop, in which both the reduction of the ore and the forging of finished objects was performed, because both raw ore and semi-finished iron were supplied (*venam*, *ferrum*). Finally, the contract specified that Ranieri would pay rent for four years, after which time the abbey would have the right to enter into a partnership with Ranieri and share his profits, investments, and expenses.

Another interesting document is a contract drawn up in 1296 by the commune of Seggiano, which would appear to have played a leading role in this dynamic economic period, both as the owner of iron workshops and as an economic actor supporting private investments.[42] In that year the commune

41 Siena, Archivio di Stato, Conventi, 4, 1281 luglio 16. For more details, see Cortese, 'Opifici idraulici', pp. 336–38.

42 Siena, Archivio di Stato, Diplomatico, Riformagioni, 1296 maggio 22. For more details, see

sold to a group of private entrepreneurs two parts of three water-powered workshops on the torrent Vivo, in the vicinity of the castle: a fulling mill and two iron workshops (the former seems to have been a water-powered forge, the latter were workshops for reducing the ore and forging objects). In addition, the commune granted these private entrepreneurs permission to build a new iron workshop on the Vivo, intended to be shared — again in a kind of joint venture — by the community and the entrepreneurs. Reading this document, we should note the community's concern to maintain a monopoly over production activities and to promote those controlled by the commune itself. The document also safeguarded the interests of the inhabitants of Seggiano, to whom the semi-finished products from these factories were to be sold at a set price. Great care was taken to facilitate in every way the supply of the raw materials necessary for the economic venture: the commune guaranteed the possibility of producing charcoal (and also of collecting the wood necessary for the maintenance of dams and channels) in all the woodlands within the territory of Seggiano; it also granted the entrepreneurs permission to collect all the timber necessary to build the new *fabrica*, with its dams and channels, and to build houses (*domos*: for the iron-workers?) next to the workshops. For the next five years, the entrepreneurs had the permission to buy plots of land with chestnut trees (particularly good for iron production) from private inhabitants of the district. In the whole territory of Seggiano, people were only allowed to make charcoal for these iron workshops; they could bring charcoal to the *fabricae* owned by the commune without paying any tax or toll. The management of the communal woodland, therefore, not only supported the traditional economic activities in the area, but was also promptly designed to sustain the new production activities, which were initially controlled by the commune in association with local entrepreneurs.

On the whole, a comparison between the Amiata texts and what is known about the Alpine valleys is quite revealing. In this context, too, the initiative of the local elites should be emphasized. Certainly, it is important to bear in mind that in Tuscany some Cistercian monasteries also played a leading role as promoters of iron-working; however, a careful reading of the sources shows that they became engaged in this profitable new activity later than the communities in the countryside and individual local entrepreneurs. The latter would instead appear to have taken on a leading role, seizing the opportunities offered by the increase in the demand for iron and the lowering of production costs caused by the spread of new techniques in the region.[43] A clear difference with respect to what had happened in the Alpine valleys, however, lies in the fact that the communities in the Siena territory, as time

---

Cortese, 'Opifici idraulici', pp. 338–41.

43 About the role played by the Cistercian monasteries of San Galgano (Merse valley) and San Salvatore al Monte Amiata, see Cortese, 'Medieval Iron-Working' and Cortese, 'Cistercian Monasteries'.

went by, completely lost control over both the production structures and the management of the woodlands, which increasingly fell under the direct or indirect control of the dominant city or of important urban of merchant and banking families.[44]

Let me now add some brief final remarks. Functional buildings for metallurgical production can provide valuable evidence when evaluating economic growth in medieval Western Europe. Indeed, a phase of intense growth usually implies a multiplication of buildings linked to economic activities, often associated with a significant material transformation of existing structures. However, as far as iron production is concerned, the two aspects must be considered separately. For a long time, as we have seen in the previous pages, medieval industry remained 'extensive' — that is, not based on the increase of individual units' productivity — yet capable of responding to the growing demand for metal essentially through the multiplication of small production structures, which continued to be more or less similar to the early medieval ones. This situation was in line with the general characteristics of the starting phase of the expansion of the European economy, already before the year 1000. In this long phase, economic growth was characterized by a gradual increase in the overall output of goods produced: we can therefore define this growth as 'extensive' or 'quantitative'. But, in this context, production increased because, along with the amount of raw materials and energy used, the number of producers also increased. Consequently, assuming that the labour productivity remained the same, the *pro capite* amount of each final product also remained roughly the same as before.[45]

When it comes to iron-working, a first phase of change and intensification is noticeable in the first half of the twelfth century in both the areas we have considered. In the Alps, we have witnessed an increase in mining and metallurgy among valley communities, as shown by the document from Ardesio (1145). This increase was accompanied by the introduction of the first technical improvement with the appearance of machinery driven by water power (so-called iron mills, equipped only with hydraulic hammers). The same intensification was recorded in Tuscany, but in this region it was the result of the stimulus provided by Pisa through the exploitation of the Elban mines. This led to a complete overhaul of the production system, based on the seasonal migration of specialized workers and on the proliferation of small ironworks in the Maremma coastal area.

Iron-working really took off, however, in the thirteenth century, when more complex and efficient production methods and equipment began to spread, which ensured a greater volume of production. Thus the energy sources used,

---

44 On Alpine iron-working between fourteenth and fifteenth centuries, see the contributions collected in Braunstein, ed., *La sidérurgie alpine*; on Tuscany: Barlucchi, 'Strutture produttive'; Cortese, *L'acqua, il grano, il ferro*; Cortese, 'Opifici idraulici'.

45 For a general picture see: Cortonesi and Palermo, *La prima espansione*, Chapter 2.

and the way in which they were used, became absolutely crucial. The process of reducing the ore was enhanced, on the one hand, by furnaces that proved to be more efficient in harnessing fuel energy and, on the other, by that fact that the energy of water was applied to new machinery, which made it possible to achieve the highest productivity at the lowest possible cost. It was at this time that in various parts of Europe the 'extensive' iron industry was replaced by an 'intensive' one: the productivity of single units was increased by technical improvements and innovations which, for the first time, had a major impact on the material structure of production buildings.

Works Cited

Manuscripts and Archival Sources

Siena, Archivio di Stato, Conventi, 4, 1281 luglio 16
——, Diplomatico, Riformagioni, 1296 aprile 26

Primary Sources

Codex diplomaticus civitatis et ecclesiæ Bergomatis, ed. by Mario Lupo, 2 vols (Bergamo: Typographia Vincentii Antoine, 1784–1799)
Heinrici III. diplomata, ed. by Harry Bresslau and Paul Fridolin Kehr, in Monumenta Germaniae Historica: Diplomata regum et imperatorum Germaniae, 5 (Berlin: Weidmann, 1831)
I placiti del Regnum Italiae, ed. by Cesare Manaresi, 1 (Roma: Istituto storico italiano per il Medio Evo, 1955)
'Possedimenti del vescovo di Bergamo nella valle di Ardesio: documenti dei secc. XI-XV', ed. by Gianni Barachetti, *Bergomum*, 75 (1980)

Secondary Works

Agostini, Alexander, 'The Metal Finds from the Site of Vetricella (Scarlino, Grosseto): a Revised Interpretation (8th–13th Centuries)', in *The nEU-Med Project: Vetricella, an Early Medieval Royal Property on Tuscany's Mediterranean*, ed. by Giovanna Bianchi and Richard Hodges (Florence: All'insegna del Giglio, 2020), pp. 33–50
Arnoux, Mathieux, 'Innovation technique, intervention publique et organisation du marché: aux origines du district sidérurgique de la Valteline (XIII^{e}-XIV^{e} siècles)', in *La sidérurgie alpine en Italie (XIIe-XVIIe siècle)*, ed. by Philippe Braunstein (Rome: École Française de Rome, 2001), pp. 215–52
——, 'Moulins à fer et procédé indirect. Énergie hydraulique et innovation dans la sidérurgie européenne (XIII^{e}-XVI^{e} s.)', in *I mulini nell'Europa medievale*, ed. by Paola Galetti and Pierre Racine (Bologna: Clueb, 2003), pp. 1–12
Baiocco, Gianni, Fausto Bucci, Luca Ferretti, Nello Geri, Rino Magagnini, and Luca Verdini, *Metallurgia antica e medievale nel golfo di Follonica* (Follonica: Comitato pro Ex Ilva, 1990)

Barlucchi, Andrea, 'La lavorazione del ferro nell'economia casentinese alla fine del Medioevo (tra Campaldino e la battaglia di Anghiari)', *Annali Aretini*, 14 (2006) 169–200

——, 'Strutture produttive industriali di proprietà comunale: fornaci, fabbriche e gualchiere nel contado della toscana interna (secoli XIII–XV)', in *Beni comuni e strutture della proprietà. Dinamiche e conflitti in area toscana fra basso medioevo ed età contemporanea*, ed. by Giuseppe V. Parigino (Florence: Associazione di studi storici Elio Conti, 2017), pp. 99–130

Beck, Patrice, ed., *L'innovation technique au Moyen Age* (Paris: Édition Errance, 1998)

Belhoste, Jean-François, 'Mutations techniques et filières marchandes dans la sidérurgie alpine entre XIIIe et XVIe siècle', in *La sidérurgie alpine en Italie (XIIe-XVIIe siècle)*, ed. by Philippe Braunstein (Rome: École Française de Rome, 2001), pp. 515–92

Bianchi, Giovanna, *Archeologia dei beni pubblici. Alle origini della crescita economica in una regione mediterranea (secc. IX–XI)* (Florence: All'Insegna del Giglio, 2022)

Bianchi, Giovanna, Giuseppe Fichera, Domenico Miriello, Nicoletta Chiarelli, and Gino Crisci, 'Archeologia di un cantiere curtense: il caso del castello di Donoratico tra IX e X secolo. Sequenze stratigrafiche e analisi archeometriche', *Archeologia dell'architettura*, 16 (2011), 34–50

Bianchi, Giovanna, and Richard Hodges, eds, *The nEU-Med Project: Vetricella, an Early Medieval Royal Property on Tuscany's Mediterranean* (Florence: All'insegna del Giglio, 2020)

Braunstein, Philippe, 'L'industrie à la fin du Moyen Âge: un objet historique nouveau?', in *La France n'est-elle pas douée pour l'industrie?*, ed. by Louis Bergeron and Patrice Bourdelais (Paris: Belin, 1998), pp. 25–40

——, ed., *La sidérurgie alpine en Italie (XIIe-XVIIe siècle)* (Rome: École Française de Rome, 2001)

Bruttini, Jacopo, 'Minatori e signorie nelle Colline Metallifere: il sistema produttivo dei metalli monetabili nel Medioevo' (unpublished doctoral dissertation, University of Siena, 2014)

Cambi, Franco, and Luisa Dallai, 'Archeologia di un monastero: gli scavi a S. Salvatore al Monte Amiata', *Archeologia Medievale*, 27 (2000), 193–210

Carrera, Francesco, Beatrice Fatighenti, and Caterina Toscani, 'Le ceramiche e le attività produttive. Recenti acquisizioni da un quartiere artigianale di Chinzica (PI)', in *Actas do X Congresso Internacional a Cerâmica Medieval no Mediterrâneo*, ed. by Maria José Gonçalves and Susana Gómez Martínez (Silves: Câmara Municipal de Silves, 2015), pp. 114–24

Citter, Carlo, ed., *Archeologia urbana a Grosseto. Origine e sviluppo di una città medievale nella 'Toscana delle città deboli'. Le ricerche 1997–2005. II: edizione degli scavi urbani 1998–2005. Dall'insediamento stabile alla città in pietra e laterizio (VII–XV secolo)* (Florence: All'Insegna del Giglio, 2007)

Corretti, Alessandro, 'L'attività metallurgica', in *Ricerche di archeologia medievale a Pisa. I. Piazza dei Cavalieri, la campagna di scavo 1993*, ed. by Silvia Bruni,

Elisabetta Abela, and Graziella Berti (Florence: All'Insegna del Giglio, 2000), pp. 83–100

——, *Metallurgia medievale all'isola d'Elba* (Florence: All'Insegna del Giglio, 1991)

Corretti, Alessandro, Laura Chiarantini, Giulia Giuntoli, Marco Benvenuti, Franco Cambi, Marco Firmati, Carlo Isola, and Laura Pagliantini, 'Un sito di lavorazione del ferro da Monte Strega (Rio nell'Elba, Livorno). Nuovi dati sulle attività dei fabri pisani all'Elba nel Medioevo', in *Atti del VI Congresso Nazionale di Archeologia Medievale* (Florence, All'Insegna del Giglio, 2012), pp. 650–55

Cortese, Maria Elena, *L'acqua, il grano, il ferro. Opifici idraulici medievali nel bacino Farma-Merse* (Florence: All'insegna del Giglio, 1997)

——, 'Beni fiscali e attività minerario-metallurgiche nell'Italia centro-settentrionale (secc. VIII-XI)', *Reti Medievali Rivista*, 24.1 (2023), 251–83

——, 'Cistercian Monasteries and Water-Powered Ironworking: Two Case-Studies in Medieval Tuscany', in *L'industrie cistercienne (XII^e–XXI^e siècle)*, ed. by Arnaud Baudin and Paul Benoit (Paris: Somogy, 2019), pp. 115–26

——, 'Il ferro a Pistoia nel contesto della siderurgia medievale in Toscana: una prospettiva di lungo periodo', in *La Pistoia comunale nel contesto toscano ed europeo (secoli XIII–XIV)*, ed. by Pietro Gualtieri (Pistoia: Società Pistoiese di Storia Patria, 2008), pp. 321–48

——, 'Medieval Iron-Working on the Mount Amiata: Technology, Economy, Environments (Siena, Italy, 13th–14th Centuries')', in *Artisans, industrie — Nouvelles révolutions du Moyen Âge à nos jours*, ed. by Natacha Coquery, Liliane Hilaire-Pérez, Line Sallmann, and Catherine Verna (Lyon: ENS Editions, 2004), pp. 149–60

——, 'Opifici idraulici per la lavorazione del ferro nel comprensorio del Monte Amiata (secc. XIII–XIV)', in *I mulini nell'Europa medievale*, ed. by Paola Galetti and Pierre Racine (Bologna: Clueb, 2003), pp. 329–50

Cortonesi, Alfio, and Luciano Palermo, *La prima espansione economica europea. Secoli XI–XV* (Rome: Carocci, 2019)

Cucini, Costanza, 'L'insediamento altomedievale del podere Aione (Follonica – GR)', *Archeologia medievale*, 16 (1989), 499–512

Cucini, Costanza, and Marco Tizzoni, *Le antiche scorie del golfo di Follonica (Toscana). Una proposta di tipologia* (Milan: Edizioni Et, 1992)

Dallai, Luisa, 'Opifici metallurgici sul promontorio di Piombino. Primi dati topografici', in *II congresso nazionale di archeologia medievale*, ed. by Gian Pietro Brogiolo (Florence: All'Insegna del Giglio, 2000), pp. 186–201

Di Gangi, Giorgio, *L'attività mineraria e metallurgica nelle Alpi occidentali italiane nel Medioevo* (Oxford: BAR, 2001)

Farinelli, Roberto, 'Le risorse minerarie amiatine e il loro sfruttamento', in *Carta archeologica della provincia di Siena, II, Il Monte Amiata*, ed. by Franco Cambi (Siena: Periccioli, 1996), pp. 39–55

Farinelli, Roberto, and Riccardo Francovich, 'Potere e attività minerarie nella Toscana altomedievale', in *La storia dell'Alto Medioevo italiano (VI–X secolo)*

alla luce dell'archeologia, ed. by Riccardo Francovich and Ghislaine Noyé (Florence: All'Insegna del Giglio, 1994), pp. 443–63

Fiore, Alessio, 'The Knots and the Nets: Fisc, Rural Estates and Cities in the Written Sources (Northern Italy, c. 800–1000)', in *The nEU-Med Project: Vetricella, an Early Medieval Royal Property on Tuscany's Mediterranean*, ed. by Giovanna Bianchi and Richard Hodges (Florence: All'insegna del Giglio, 2020), pp. 197–206

Finazzi, Giovanni Maria, *Sulle antiche miniere di Bergamo* (Milan: Società per la pubblicazione degli annali universali delle scienze e dell'industria, 1860)

Francovich, Riccardo, *Rocca S. Silvestro* (Rome: Leonardo-De Luca, 1991)

Francovich, Riccardo, and Chris Wickham, 'Uno scavo archeologico ed il problema dello sviluppo della signoria territoriale: Rocca S. Silvestro ed i rapporti di produzione minerari', *Archeologia Medievale*, 21 (1994), 7–30

Garzella, Gabriella, 'Fabri e fabricae *a Pisa: una presenza nel cuore della città medioevale*', in *Ricerche di archeologia medievale a Pisa. I. Piazza dei Cavalieri, la campagna di scavo 1993*, ed. by Silvia Bruni, Elisabetta Abela, and Graziella Berti (Florence: All'Insegna del Giglio, 2000), pp. 37–49

Gelichi, Sauro, 'Impianti per la lavorazione del ferro sul promontorio di Piombino. Contributo archeologico alla conoscenza di attività proto-industriali sulla costa tirrenica', *Ricerche Storiche*, 14.1 (1984), 37–47

Mainoni, Patrizia, 'La politica dell'argento e del ferro nella Lombardia medievale', in *La sidérurgie alpine en Italie (XIIe-XVIIe siècle)*, ed. by Philippe Braunstein (Rome: École Française de Rome, 2001), pp. 418–54

Marasco, Lorenzo, and Arianna Briano, 'The Stratigraphic Sequence at the Site of Vetricella (Scarlino, Grosseto): Preliminary Results from the Study of an Early Medieval Assemblage', in *The nEU-Med Project: Vetricella, an Early Medieval Royal Property on Tuscany's Mediterranean*, ed. by Giovanna Bianchi and Richard Hodges (Florence: All'insegna del Giglio, 2020), pp. 9–22

Martin, Sally, 'Trial Excavations on Monte Serra, Elba: a Medieval Workshop', *Archeologia Medievale*, 21 (1994), 233–50

Menant, François, 'Aspects de l'économie et de la société dans les vallées lombardes aux derniers siècles du moyen âge', in *La sidérurgie alpine en Italie (XIIe-XVIIe siècle)*, ed. by Philippe Braunstein (Rome: École Française de Rome, 2001), pp. 3–30

——, 'La métallurgie lombarde au Moyen Age', in *Hommes et travail du métal dans les villes médiévales*, ed. by Paul Benoit and Denis Cailleaux (Paris: Association pour l'édition et la diffusion des études historiques, 1988), pp. 127–62

——, 'Pour une histoire médiévale de l'entreprise minière en Lombardie', *Annales. Economies, Sociétés, Civilisations*, 42.4 (1987), 779–96

Micheletto, Egle, 'Archeologia dei metalli in Piemonte dall'età tardoromana al medioevo. Appunti per una schedatura preliminare', in *Miniere, fucine e metallurgia nel Piemonte medievale e moderno*, ed. by Rinaldo Comba (Cuneo: Società per gli Studi Storici di Cuneo, 1999), pp. 1–25

——, 'Il castello di Manzano. Note su uno studio in corso nel territorio di Cherasco', *Alba Pompeia*, 11 (1990), 65–79

Negro Ponzi Mancini, Maria Maddalena, ed., *S. Michele di Trino (VC). Dal villaggio romano al castello medievale* (Florence: All'insegna del Giglio, 1999)

Panichi, Francesca, 'La produzione medievale del ferro nella Toscana meridionale' (unpublished doctoral dissertation, University of Siena, 2008)

Patria, Luca, 'In fodina veteri: prospezioni minerarie e pratiche metallurgiche nelle Alpi Cozie (secoli XII–XIV)', in *Miniere, fucine e metallurgia nel Piemonte medievale e moderno*, ed. by Rinaldo Comba (Cuneo: Società per gli Studi Storici di Cuneo, 1999), pp. 27–64

Quirós Castillo, Juan Antonio, *El incastellamento en el territorio de la ciudad de Luca (Toscana). Poder y territorio entre la Alta Edad Media y el siglo XII* (Oxford: Oxford University Press, 1999)

Sprandel, Rolf, *Das Eisengewerbe in Mittelalter* (Stuttgard: Hiersemann, 1968)

——, 'Die oberitalienische Eisenproduktion im Mittelalter', *Rivista trimestrale di storia sociale ed economica*, 52.3 (1965), 289–329

Tangheroni, Marco, Catia Renzi Rizzo, and Graziella Berti, 'Pisa e il Mediterraneo nei secoli VII–XIII: l'apporto congiunto delle fonti scritte e di quelle archeologiche', in *Il mare, la terra, il ferro. Ricerche su Pisa medievale (secoli VII–XIII)*, ed. by Marco Tangheroni, Catia Renzi Rizzo, and Graziella Berti (Pisa: Pacini, 2004), pp. 109–42

Tronti, Carlo, and Marco Valenti, 'Gli spazi del settore B', in *Poggio Imperiale a Poggibonsi: dal villaggio di capanne al castello di pietra*, ed. by Marco Valenti (Firenze: All'Insegna del Giglio, 1996), pp. 225–31

Verna, Catherine, 'Innovations et métallurgies en Méditerranée occidentale (XIII^{e}-XV^{e} siècles)', *Anuario de Estudios Medievales*, 41.2 (2011), 623–44

Wickham, Chris, 'Prima della crescita: quale società?', in *La crescita economica dell'Occidente medievale. Un tema storico non ancora esaurito*, ed. by Franco Franceschi (Pistoia: Centro Italiano di Studi di Storia e d'Arte, 2017), pp. 93–106