New Insights into an Old Iron Mining Landscape: Elba Island

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Abstract

While the ancient mining of iron ore and its further processing on Elba Island is an undeniable fact, the duration of iron production and its impact on the island's landscape is still not clear. Modern research assumes different beginnings for the exploitation and smelting of iron. In contrast, the end of iron production is dated exactly to the mid-1st century BC and linked to different reasons, including lack of fuel wood, preservation of resources, and cheaper iron from the provinces.

Our paper presents the recent archaeological results of an interdisciplinary research project on ancient iron mining and smelting on Elba. On the basis of archival material, new 14C-dates, and the current state of the art, the following aspects are discussed: 1) the chronology and (re-)location of ancient iron mines; 2) the prolonged chronology of iron smelting on Elba; 3) the development of iron processing through Elba's *longue durée.*

New radiocarbon dates and currently underestimated archaeological finds indicate a new chronology of iron production from the 6th century BC to the 2nd century AD. The topo-chronological evaluation shows a concurrent acceleration of smelting even in remote areas of Elba in order to make use of the secondary resources as well as already existing maritime trade routes. The continuation of Elban iron production after its presumed end in mid-1st century BC is contrary to the development on the Tuscan mainland.

Elba Island: a Mining Landscape for Millennia

Nothing has shaped the landscape of Elba Island more than its iron. Although there was copper production by the indigenous population during the Early Iron Age,[1] the iron mines were key to the island's history on a superregional scale. Indeed, an early beginning of iron exploitation is often cited,[2] with the first exploiters likely coming from just 11 kms across the sea. The Etruscan city-state of Populonia, already a metallurgical centre of copper smelting, transformed into a hotspot of iron processing around 600 BC (fig. 1b).[3] Fostered by the iron from Elba and other metals from the *Colline Metallifere* – the heartlands of *Etruria Mineraria*[4] – Populonia's economic importance increased. Therefore, the Syracusans raided Elba in 453/52 BC, certainly attracted by the iron deposits. Given different dangers from the south, protection of Elba became an emerging factor.[5] As a response to that, multifunctional, fortified hilltop settlements

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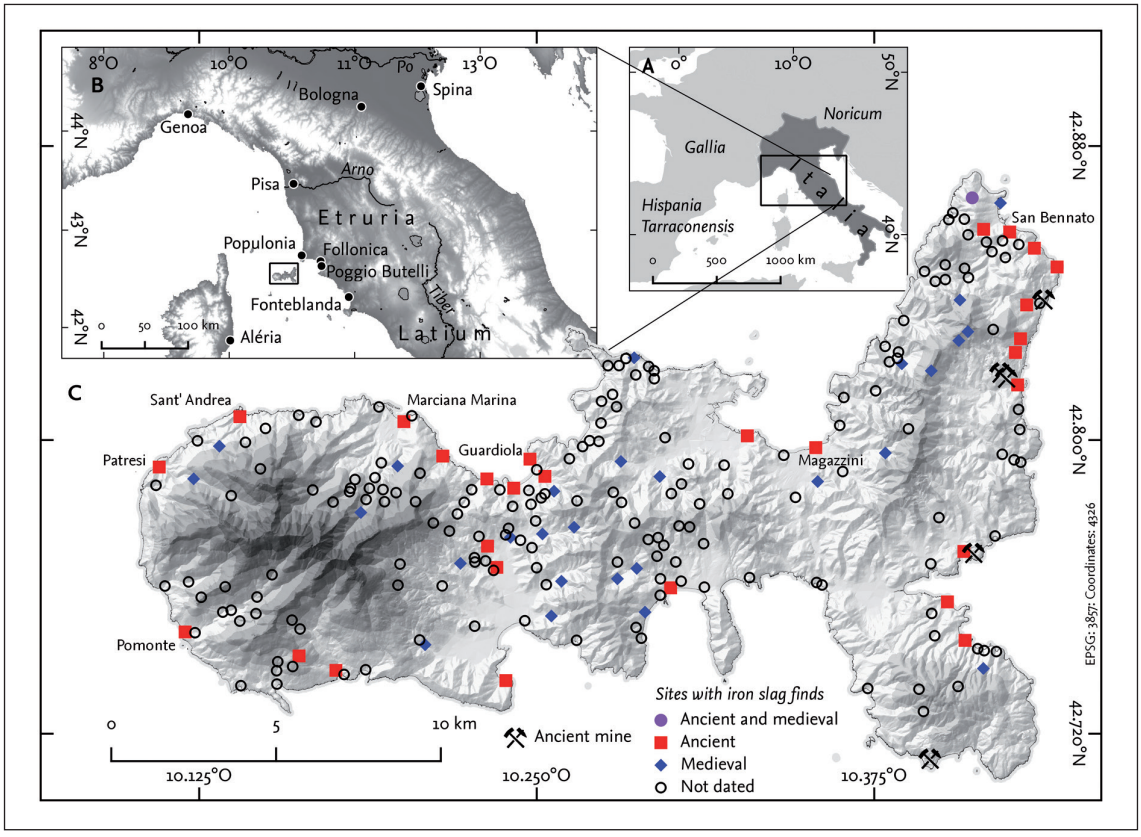

Fig. 1: A: *Italia* and adjacent provinces of the early Roman Empire – B: Location of Elba in front of Etruria – C: Map of Elban sites with iron slag finds of different smelting periods.

were built intensifying agriculture, pastoralism, and crafts. In addition to mining, these had further impact on the landscape.

With the Roman occupation of the island (1st half of the 3rd century BC), the entire island was actively used for iron production. Smelting sites were installed not only close to the mines, but also in the far west of the island to exploit all (forest) resources.[6] For more than two centuries, huge amounts of waste were dumped in the mines and tons of slag were left on the plains and beaches of Elba. Since the mid-1st century BC, Elban iron production decreased due to a lack of fuel,[7] or political decisions, such as the conservation of resources or cheaper iron from the provinces – to name a few possible reasons.[8] Subsequently, the island turned into a resort with luxurious villas during the Roman Imperial era.[9] Populonia's iron production struggled and ceased in the 1st century AD. Poets of the late antiquity can only write about Elba's former legendary wealth of iron.[10]

A hiatus in iron production lasted until the 11th century AD, when the Masters of Pisa reactivated iron exploitation on Elba.[11] Seasonal smelting took place in inland locations until the end of the 14th century AD.[12] After an internal government conspiracy, Pisa

lost the only active mine of Rio to the new Masters of Piombino, who could hardly defend their iron against pirates and opponents. Although the rulers over Elba changed continuously between the 16th and 19th century – Medici, Neapolitan/Spanish, English, Napoleon, and the Grand Duchy of Tuscany – Rio's raw ore was still traded.[13] From 1853, travellers' and mineralogists' reports about old waste dumps and large, ancient slag heaps[14] promoted the exploitation of Elba's iron mines with up-to-date methods. Unfortunately, centuries-old findings from Rialbano to Capo Calamita (fig. 2) were overprinted without any archaeological documentation.[15] As Italy proclaimed autarky in iron supply in the interwar years, ancient iron-rich slags from Elba, Populonia, and Poggio Butelli were mined and re-smelted. Most archaeological evidence was destroyed without any record.[16] After World War II, Elba's iron industry declined, and tourism became the most important sector. With the closing of the last mine in 1981,[17] Elba lost its long-lasting importance as the ironworks of Italy. However, the imprint of mining and smelting activities has remained in the landscape.

In this paper, we discuss the chronology and topography of iron mining and smelting on Elba using archival material and new 14C-dates to establish several spatio-temporally distinct phases of iron production in antiquity.

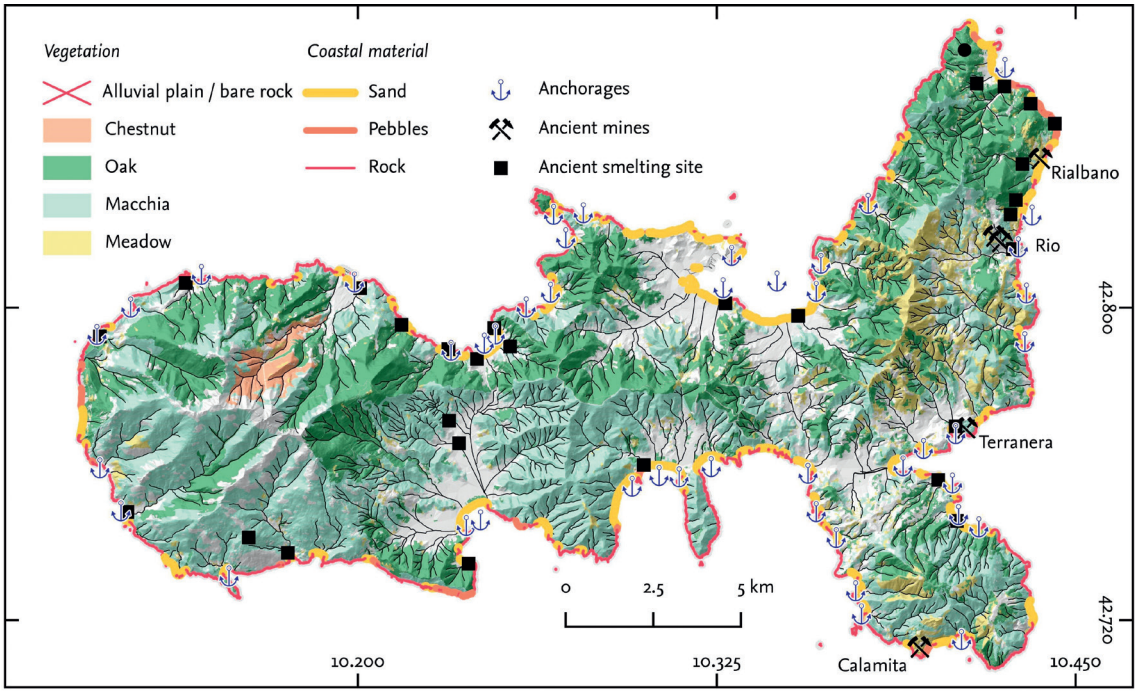

Fig. 2: Map of Elba with ancient smelting sites, beach characteristics, historical anchorages, present forest cover, and creeks.

Iron Mining on Elba: its Beginnings and Locations

If a society (e.g. Etruscan or Roman) wishes to achieve economic progress over the *longue durée* by mining, ore deposits must fulfill certain requirements.[18] Elba's iron ore deposits favour this development:

- Quality ore: Analyses showed predominately high-quality hematite mineralization with an iron content of c. 73% in the northern part (Rialbano, Rio, and Terranera; fig. 2).[19] The magnetite ores of the Calamita Mine in the southeast have also relatively high iron contents (approximately 52%).[20]
- Accessibility: All mines are located directly on the coast, which promotes sea-based transportation of large quantities of ore with lower costs than inland transport. Due to the geological setting of eastern Elba, all ancient deposits could be exploited by open-pit mining.[21]
- Sustainability: Long-term and permanent use of Elban ore deposits was secured. This is not only proved by the ancient topos of the 'inexhaustibility' of the mines,[22] but also by their exploitation in the Middle Ages and modern times.

The onset of mining on Elba is mainly dated by indirect evidence. Even today, it is claimed without any evidence that iron mining began in the 10th century BC.[23] The scarce occurrence of early iron in northern Etruria from the same time[24] makes it clear that this date is too early. Indirect evidence of early iron mining on Elba in the 8th century BC[25] has been taken from a hematite fragment found in the *Scarico Gosetti* on Pithecusae/Ischia.[26] However, its validity can be doubted for several reasons: (I) The fragment was found in a secondary, non-stratified context with finds ranging from the Late Bronze Age to the 2nd century BC.[27] (II) The Elban origin of the ore was declared by macroscopical analysis and thus the result should be handled carefully without supplementary analysis.[28] (III) Even if the small ore fragment is of Elban provenance and dates to the 8th century BC, it can be assumed that such sized material was used just for jewelry production,[29] which did not require large-scale mining on Elba.

Another issue besides dating is the exact location of ancient pits. However, old reports and occasional maps[30] from the beginning of the modern mining era (1853) have assisted in some re-localisations. For instance, in 1862, W. Jervis reported on the Rialbano mining district (fig. 3a):

> "An ancient excavation is seen above the present one, on the sea cliff, and a line of similar ones is reached on ascending the hill. […] the abundance of *gettate* [i.e. overburden] all around prove the agency of man."[31]

This corresponds well to a sketch of the Grattarino mine, in which ancient overburden is documented left and right of a deeply engraved mining hollow.[32] As no medieval phase is known, this mine may be considered of ancient date.[33] Ancient open pit mining was also documented for the Terranera mine (fig. 3c).[34] Here, the overburden overlaid the

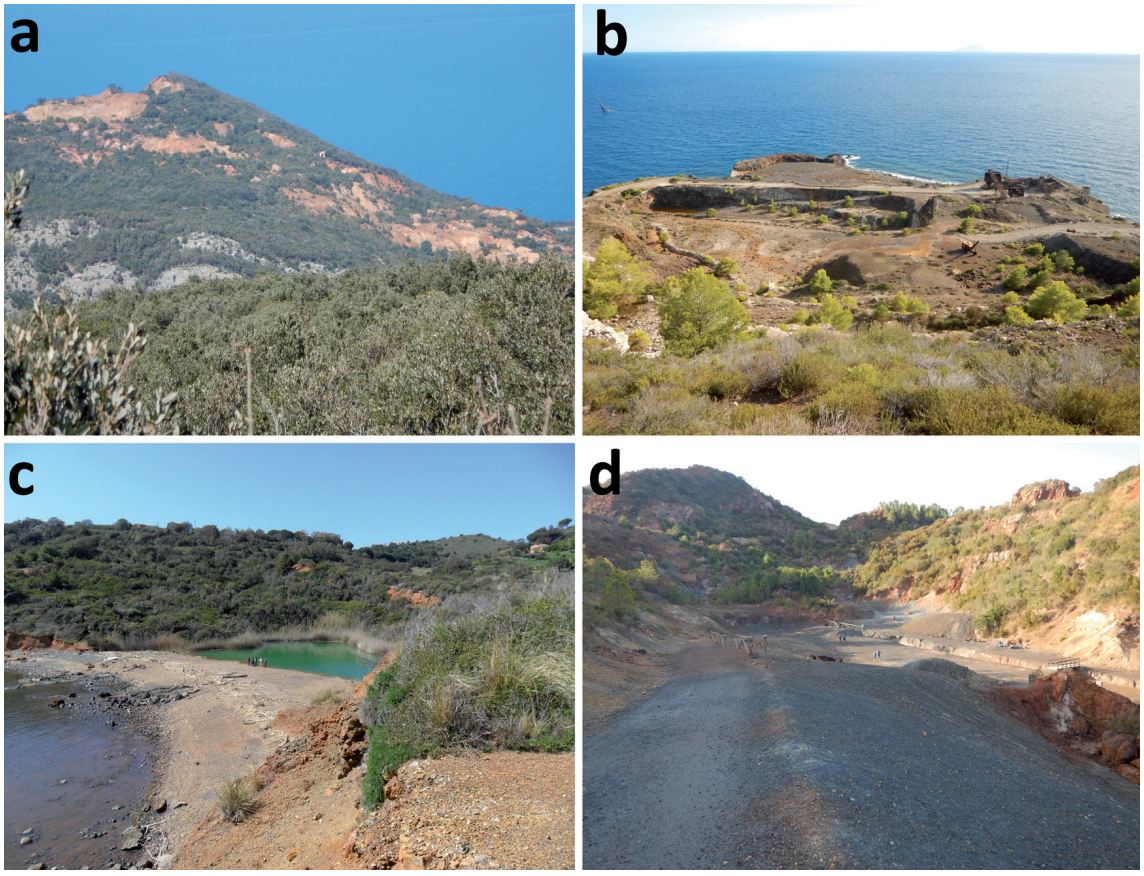

Fig. 3: Ancient mines of Elba with modern overprint; a: Rialbano – b: Vallone stope at Capo Calamita – c: Terranera – d: Bacino stope at Rio.

ore body and reached into the sea; during its removal (since 1880), fragments of ancient glass, copper sheets, terracotta, and copper nails were discovered.[35] An earlier planned exploitation in the Spanish period (18th century) apparently never took place due to the bribe of the Neapolitan prime minister.[36] A further sign of (small-scale) mining in antiquity is the reported overburden in the Vallone pit at Capo Calamita (fig. 3b); a wedge of bronze with traces of attrition suggests ancient mining on site.[37]

It is even possible to locate ancient mines in the long-living mining district of Rio[38] (fig. 3d). The mineralogist A. Krantz visited the mine three times – in 1835, 1839, and 1840 – before industrial exploitation started in 1853. Krantz published a geological map with areas of overburden that he distinguished between *gettate antiche* (ancient waste dumps; fig. 4, nos. I, II, XI) and *gettate vecchie* (old waste dumps; fig. 4, nos. XXI, XXIII).[39] Rusty mining tools of probable ancient origin were sometimes found in the *gettate antiche* and the possible sole ancient gallery called *'grotta romana'*.[40] Although this does not allow exact dating, it is clear that the Rio pits were active during antiquity. Further, a silver coin hoard – the final coin is dated to 74 BC – was discovered in 1902

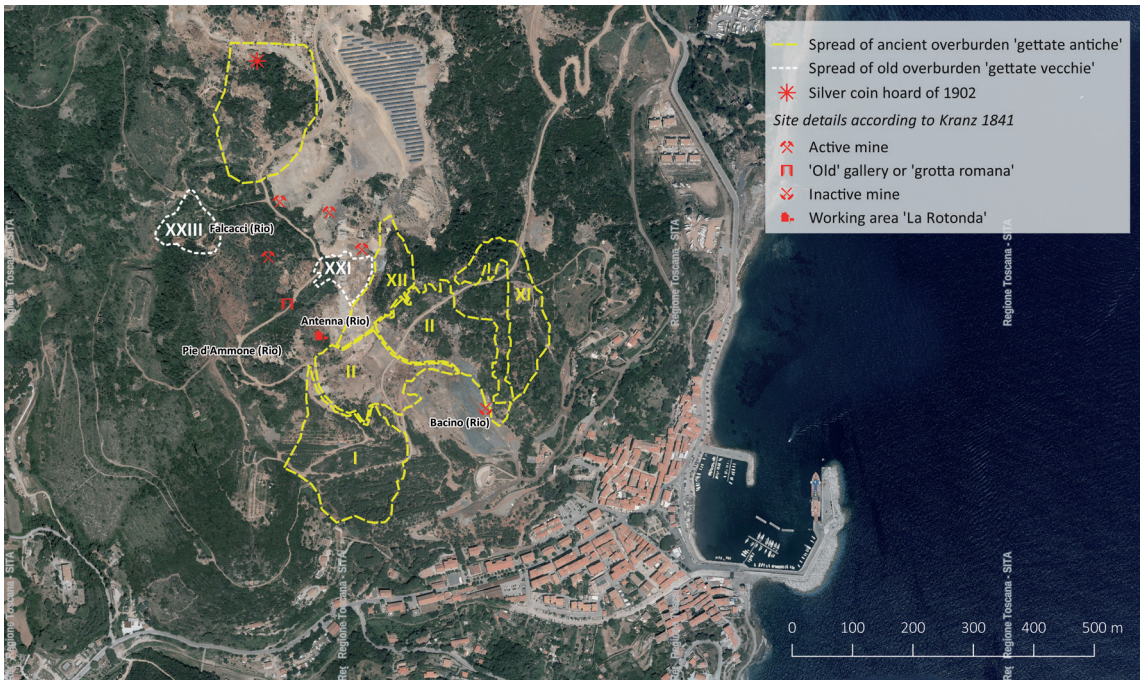

Fig. 4: Location of ancient and old overburden according to Krantz 1841 on modern satellite image.

in the northernmost overburden at Pozzo Fondi (Fig 4., without no.)[41] which points to mining around this date. From the location of the ancient overburden, we conclude that mining took place in the Bacino and Antenna stopes.

The best evidence for early iron mining on Elba was gained indirectly from dated contexts with finds of Elban iron ore. Ore fragments from 6th–5th century BC contexts in Genoa, Aléria, and Fonteblanda are often attributed to Elba without geochemical provenance analyses.[42] Iron ores from smelting sites in Pisa, San Piero a Grado (next to Pisa), and especially in Populonia and Follonica have proven Elban provenance and date to the 6th century BC (fig. 1b).[43] Iron objects of this time were only sparingly found in two grave contexts in the western area on Elba.[44] Simultaneously, the main settlement areas moved from west to east, closer to the mines,[45] which were probably controlled by Populonia. Hence, the 6th century BC can be considered as the beginning *initial phase*[46] of iron mining on Elba and of iron metallurgy on the Tuscan mainland.

Iron Smelting: Extended Chronology and State of the Art

In contrast to the occurrence of smelting sites along the Tuscan coast in the 6th and 5th century BC, the chronological evidence of iron smelting on Elba Island – collected by surveys and a few excavations by V. Mellini, R. Sabbadini, J. Nihlén[47], and A. Corretti[48] –

points to a delayed onset of smelting with the beginning of the Roman Republican period (3rd century BC).[49] An exception is the suggested chronology of the San Bennato site opposite Populonia. According to archaeomagnetic dating, the excavated smelting furnaces were already in use in the middle of the 5th century BC.[50] However, recent recalibrations point to a huge dating uncertainty (5th–1st century BC), indicating the archaeological dating of this context to the 3rd century BC might be more reliable.[51]

New radiocarbon dates from Elban sites may point to the onset of iron smelting in the 4th century BC. In Patresi in western Elba, a beach section containing a charcoal and iron slag layer (fig. 5, no. 4) was sampled and a charcoal fragment was dated to 360–150 or 140–110 BC at 95% confidence (fig. 6).[52] The earlier dating in the late 4th (or late 3rd) century BC may be possible as the upper slag layer (no. 2) – separated by a sterile stratum (no. 3) – contains fragments of Dressel 1 amphorae. Another late 4th century BC date was obtained from an in-slag charcoal sample from the Magazzini site in central Elba (figs. 1c. 6).[53] Iron slag of the 4th century BC was found at the hilltop settlement of Monte Fabbrello, which controlled the Magazzini area.[54] Smithing slags from the hilltop

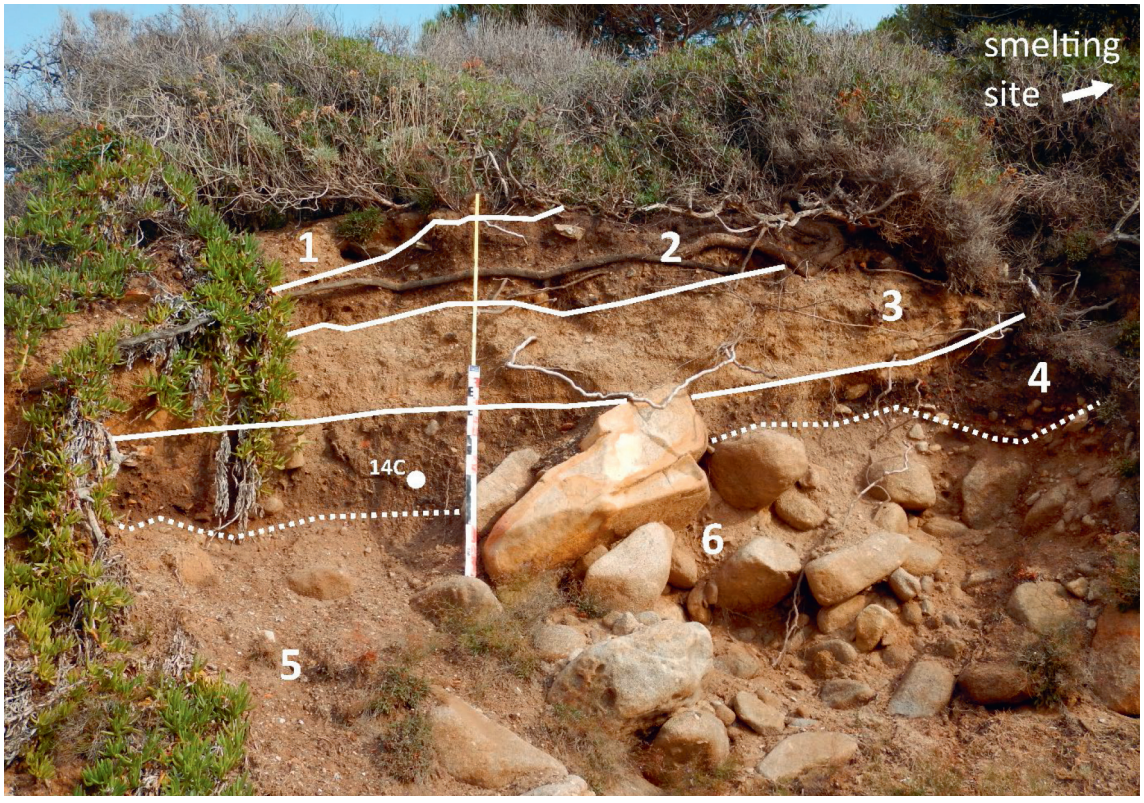

Fig. 5: Sampled beach section next to the Patresi site; 1: sterile layer – 2: slag-rich layer with Dressel 1 amphora fragments – 3: sterile layer – 4: slag-layer containing charcoal particles with spot marking the 14C-sample – 5: eroded beach section – 6: rocky layer. The profile is c. 2 m high.

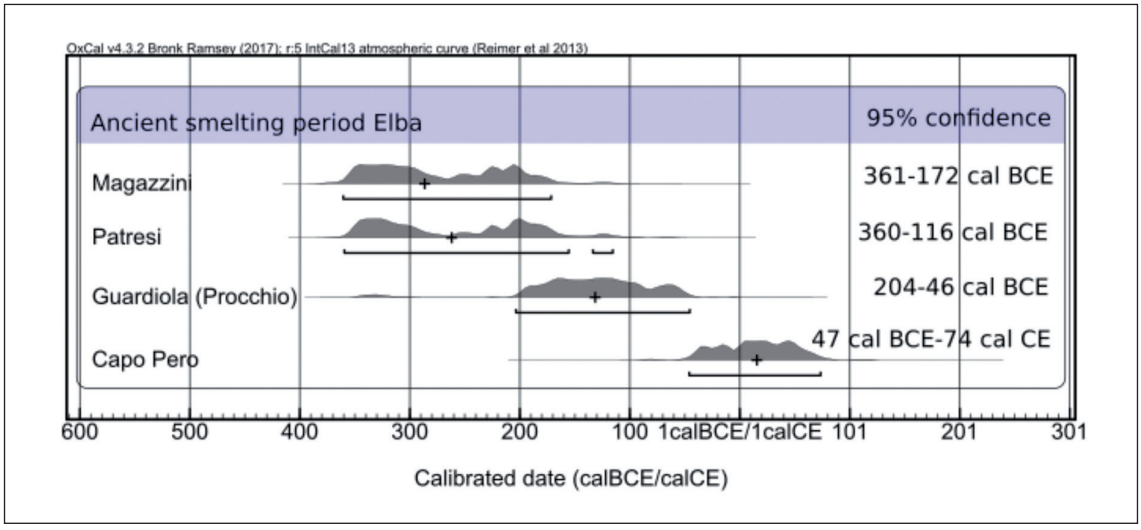

Fig. 6: Probability density functions of radiocarbon dates obtained from smelting deposits (Patresi, Guardiola, and Capo Pero), and in-slag charcoal (Magazzini).

settlement of Castiglione di San Martino – so far, the singular evidence for smithing on Elba – predate the Roman occupation.[55] Considering these dates[56], it seems possible that smelting was conducted along Elba's northern coast in the late Etruscan period.[57] An onset of smelting on Elba is reasonable in the light of the historic and economic context of Etruria. Facing threats from Celts, Syracusans, and Romans, the Etruscan city-states were in severe distress in the 4th century BC.[58] Hence, it seems only logical that there was a need to produce more of the strategically important iron using all of Elba's resources.[59]

This development towards the total exploitation of the island's resources for iron production was intensified after the Roman conquest, thus entering an *industrial phase*. Smelting sites were installed in most large bays with good landing facilities (sandy beaches) and anchorages (figs. 2. 7a). Fresh water supply came from nearby creeks (fig. 7b) and well accessible hinterlands provided further forest resources (fig. 7c).[60] For instance, smelting sites were clustered around the large Procchio bay, an area that benefited from dense vegetation on the north-exposed slopes of the Monte Capanne massif and the central Elba hills with good conditions for anchoring and landing ships (fig. 2; 7a. d). A radiocarbon date obtained at Guardiola confirmed the contemporary existance of one of these sites in the Roman heyday of smelting on Elba (2nd century BC; fig. 6).[61]

The end of iron smelting on Elba is commonly dated to the middle of the 1st century BC. However, a 14C-date obtained from Capo Pero in eastern Elba – close to the Rialbano mine – may suggest an extension of this chronology.[62] We sampled a charcoal-rich layer below a large solid slag conglomeration from the middle of the beach section. The date (50 BC–80 AD) merely points to activity at this site in the Early Roman Imperial

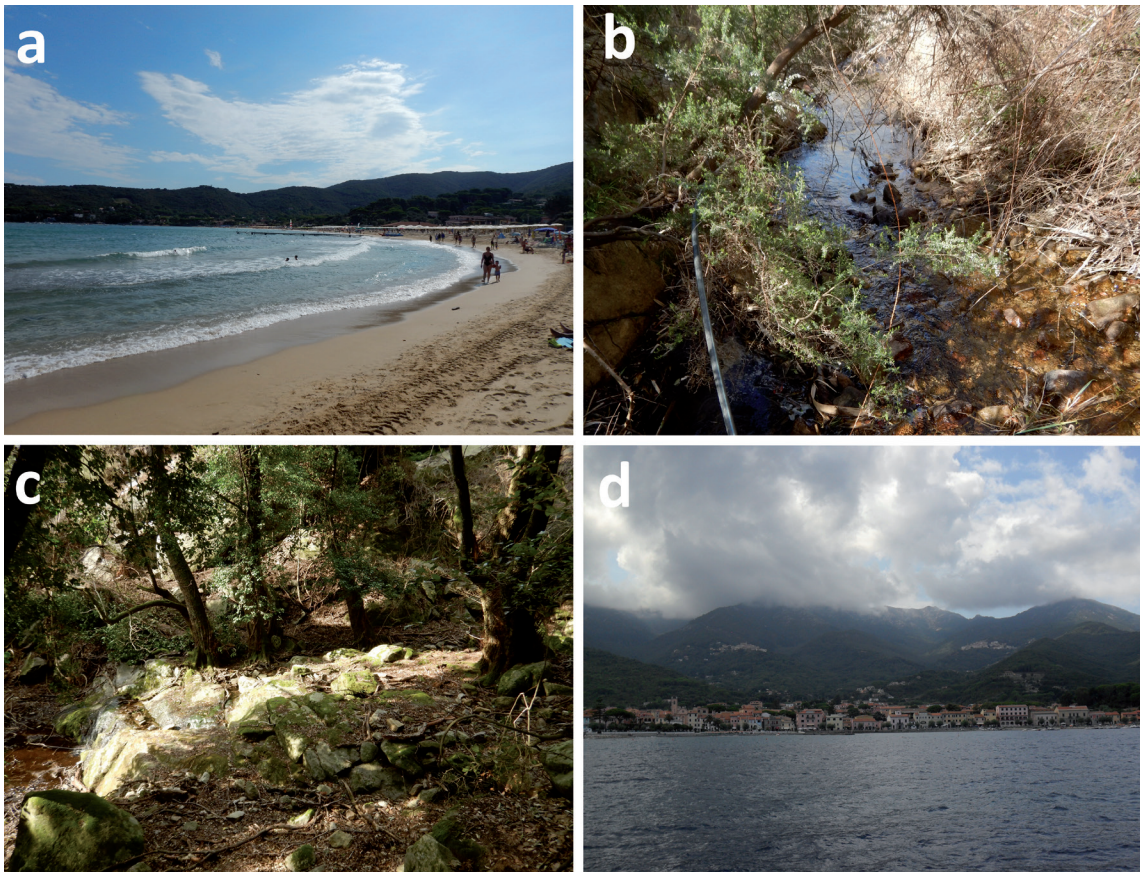

Fig. 7: Natural characteristics of Elba favouring the installation of smelting sites in antiquity; a: long beach of Procchio bay, suitable for landing – b: water-rich creek of the Pomonte valley – c: oaks in the upper Pomonte valley – d: thickly wooded slopes of the Monte Capanne massif above Marciana Marina.

period and therefore beyond the presumptive end of Elban iron smelting. Smelting at Capo Pero was concurrent to the occupation of villas on Elba and was perhaps part of their economy.[63] Furthermore, several smelting sites in the east and west of the island revealed evidence – including fragments of lamps, *terra sigillata,* amphorae, and coins – that attest to ongoing smelting on Elba in the 1st century AD.[64] Although iron smelting and mining continued, its intensity subsided gradually in the Roman Imperial period. New iron deposits in *Gallia, Noricum,* and *Hispania Tarraconensis* (fig. 1a) may have weakened the iron economy of Elba and Populonia, leading to a regional *phase of collapse.* The whole ferrous metallurgy seems to have declined in *Etruria mineraria* in the 1st century AD.[65] For Populonia, only one single forge of the 2nd century AD is known[66] and evidence for iron processing on Elba is completely lacking. Sporadical iron mining at least lasted into the late 2nd century AD, when a ship, sunken in the waters before the Guardiola smelting site, still carried hematite from Rio (fig. 1c).[67] After the 2nd century

AD, mining of Elban iron paused until exploitation began again in the Middle Ages (12th–14th centuries AD).

Conclusions

The history of the mining landscape on Elba during antiquity can be divided into different phases. An *anterior phase* can be seen in the possible exploitation of copper outcrops on the island, parallel to the copper smelting phase at Populonia (9th–8th century BC).[68] As the iron deposits on Elba were recognized, the metallurgical industry in Populonia turned from copper to iron in the 7th century BC.[69] The *initial phase* of ferrous metallurgy then began in the 6th century BC under Etruscan rule; iron mining occured on Elba, whereas smelting was conducted only on the Italian mainland. Both raw ore and raw iron were traded along the Tyrrhenian coast and even via Spina to the Adriatic region.[70] During the 4th century BC, pressure on Etruria grew and the demand for iron increased, which favored the onset of iron smelting sites on Elba. This development led to the beginning of the *industrial phase* (3rd–1st century BC) under Roman rule, when smelting sites spread all over the island to exploit Elba's secondary resources. Large-scale transports of Elban ore to the smelting sites at Follonica bay continued.[71] The *phase of collapse* (late 1st century BC–2nd century AD) is characterised by the decrease and finally the end of iron smelting on Elba in the 1st century AD, although sporadical iron mining on the island continued into the 2nd century AD. Current knowledge suggests a long hiatus for several centuries until iron working on Elba resumed its activity under Pisan rule.[72]

Notes

[1] Corretti 2017, 449–451; Chiarantini et al. 2018, 13 f.

[2] Shepherd 1993, 143; Sperl 1993, 73; Berveglieri – Valentini 2001, 50.

[3] Chiarantini – Benvenuti 2009, 207–209.

[4] Zifferero 2017, 425–427.

[5] Diod. Sic. 11.88.4–5; Zecchini 2001, 139–145; Corretti 2017, 453 f.

[6] Corretti 2017, 454 f.

[7] On the presumed lack of fuel due to smelting, see Becker et al. 2020; Becker et al. 2021.

[8] Cambi 2009, 226 f.; Camporeale 2013.

[9] Corretti – Firmati 2011, 240.

[10] Corretti – Taddei 2001, 260; Corretti 2017, 457.

[11] Vanagolli 2012, 18.

[12] Corretti 1991.

[13] Mori 1960–1961, 176–178.

[14] Some slag heaps had more than 10,000 tons; Nihlén – Ejlers 1958, 25.
[15] Corretti 2017, 446 f.
[16] Pistolesi 2013.
[17] Vanagolli 2012, 67–70.
[18] On the requirements see Stöllner 2003, 420–422; Stöllner 2014, 135 f.
[19] Sperl 1993, 74. Tanelli et al. 2001, 243 tab. 2 nos. 1–2 & 4.
[20] Mori 1960–1961, 184.
[21] Benvenuti 1997, 40 tab. 2. On the geological and metallogenic framework, Tanelli et al. 2001, 240–245.
[22] Serv. Aen. 10.174; Corretti 2004, 281–283.
[23] Shepherd 1993, 143 for northern Etruria; Berveglieri – Valentini 2001, 50. 52 stating that even smelting started around 1000 BC (!).
[24] Delpino 1989–1990, 9 nos. 7–9 (one small corroded disc and iron patinas on two bronze objects); Giardino 2005, 498 f.
[25] Snodgrass 1971, 46; Ridgway 1992, 91; Turfa 2018, 648.
[26] The small piece of iron ore (2.5 × 2.5 × 1.4 cm) was found in the acropolis dump at the East side in 1965 and analysed by G. Marinelli, who claims his provenance from the Elban mine of Rio; see Buchner 1969, 97 f.; Buchner 1985, 46. The ore fragment from Scarico Gosetti and the analysis of iron slags from the necropolis of S. Montano (Ischia) were mixed up early on; cf. Snodgrass 1971, 43 n. 36.
[27] Buchner 1969, 98; Buchner 1975, 64; Corretti – Benvenuti 2001, 134 f.
[28] Bakhuizen – Kreulen 1976, 66 f. n. 83; Treister 1996, 36 f.
[29] Sperl 1993, 73.
[30] Thus, one discovers also lentil- and kidney-like shaped ore bodies, surrounded by 'old' and new overburden on the *Carta geologica dell'Isola d'Elba* of Lotti et al. (Roma 1885).
[31] Jervis 1862, 45.
[32] Scott 1895, 150 section IV.
[33] Written sources from the 12th century AD to the modern mining era onwards mention only Rio as an active iron mine; see Vanagolli 2012, 19–52. Occasionally a Roman date is mentioned without giving any reasons for it; see Capacci 1911, 414; Mori 1960–1961, 181.
[34] Scott 1895, 155 section XII.
[35] Orlandi – Pezzotta 1996, 53.
[36] Tanelli et al. 2001, 243 tab. 2 no. 4 vs. Ninci 1815, 160 n. (A).
[37] Scott 1895, 157 with 156 section XIV showing mining hollows; Capacci 1911, 414. Monaco – Mellini 1965, 90 n. 114. 92 fig. 9; the wedge weighs about 0.65 kg and was found by V. Mellini in 1879. Today it is in the Museo Archeologico in Portoferraio.
[38] Tanelli et al. 2001, 243 tab. 2 no. 2.
[39] Krantz 1841, 409–417. 424 with pl. 12.
[40] Buzzegoli 1762, 17 f.; Pini 1777, 61–63; Corretti 2017, 447.
[41] Capacci 1911, 414; Backendorf 1998, 105.
[42] Milanese 1987, 307 f. Jehasse – Jehasse 1985, 99–101. Ciampoltrini – Firmati 2002, 31–33.
[43] Suitable geochemical markers for hematite from Elba are high contents in tin and tungsten; see Benvenuti et al. 2013, 488–501; Corretti 2017, 451.

[44] One fibula at Masso d'Aquila, dating to the 1st half of the 6th century BC (Maggiani 2006, 441 note 6), and fibulae, a lance, and a corroded iron block at Monte Catino, dating to the early 6th century BC (Zecchini 2001, 85–88).
[45] Corretti 2017, 453 with 450 fig. 26.1.
[46] Phases according to Stöllner 2003; Stöllner 2014.
[47] J. Nihlén prolonged his research on Elba for two more years until 1961. Among his unpublished materials is a map of Elba with an additional 21 smelting furnaces found in 1960, incorporated here in Fig. 1c.
[48] Monaco – Mellini 1965, 47–90; Sabbadini 1919, 853–856; Nihlén 1958–1959, 1. 3. 18; Corretti 1988, 9–27.
[49] Becker et al. 2020.
[50] Firmati et al. 2006, 304.
[51] An earlier date than the 3rd century BC would be quite possible; for the problematic San Bennato site, see Becker et al. 2020.
[52] Poz-77808 (Patresi): 2170 ± 30 BP, 360–290 and 230–170 cal BC at 68.2% and 360–150 and 140–110 cal BC at 95.4% confidence. OxCal v. 4.3.2: Bronk Ramsey 2009; Bronk Ramsey 2017; IntCal13: Reimer et al. 2013.
[53] Poz-88893 (Magazzini): 2185 ± 30 BP, 360–280 and 240–190 cal BC at 68.2% or 370–170 cal BC at 95.4% confidence.
[54] Pagliantini 2014, cat. S.157.
[55] Corretti 2016, 215 f.; for the phases see Fabiani 2016.
[56] An Etruscan Py 4 amphora handle at San Giovanni is probably connected with iron smelting on site in the 4th century BC; Corretti et al. 2014, 191.
[57] The connecting element between these sites and the mining zone in the east is the sea route from Populonia to Corsica (fig. 1b); see Toscanelli 1933, 100; Arnaud 2006, 75 f.
[58] Maggiani 2017, 553 f.
[59] It is noticeable that Populonia booms in the 4th century BC, while other Etruscan cities suffer; see Fedeli 1983, 180; Camporeale 1985, 31.
[60] Corretti 1988, 25 f.
[61] Poz-77809 (Guardiola): 2110 ± 30 BP, 180–90 cal BC at 68.2% and 203–45 cal BC at 95.4% confidence; cf. Corretti 1988, 12 n. 40.
[62] Poz-77810 (Capo Pero): 1985 ± 30 BP, 40–30 cal BC and 20 cal BC–60 cal AD at 68.3% and 50 cal BC–80 cal AD at 95.4% confidence.
[63] Marzano 2007, 72.
[64] Becker et al. 2020.
[65] Fedeli 1983, 181; Corretti – Taddei 2001, 260.
[66] Acconcia – Cambi 2009, 178.
[67] Brambilla 2003, CD-ROM, image gallery XI; Personal communication by V. Serneels, Sept. 2018; for the dating of the wreck see Zecchini 2001, 209–219.
[68] Corretti 2017, 450–452; Chiarantini et al. 2018, 12.
[69] Corretti 2017, 452.
[70] Zuffa 1974, 160–164.

[71] Cucini Tizzoni – Tizzoni 1992, 51 f.
[72] Vanagolli 2012, 18.

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Fig. 1: F. Becker, 2018; data according to Nihlén 1958–1959; map Nihlén 1960; Corretti 1991; Pagliantini 2014; own observations; hillshade: Regione Toscana 2014. – Fig. 2: F. Becker, 2017; data according to Regione Toscana 2014. – Fig. 3: R. A. Eser, 2015–2017. – Fig. 4: R. A. Eser, 2018; satellite image: Regione Toscana 2014. – Fig. 5: R. A. Eser, 2017. – Fig. 6: F. Becker, 2018. – Fig. 7: R. A. Eser, 2015–2017.

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