

## [Supplementary material]

### **Birch-bark tar in the Roman world: the persistence of an ancient craft tradition?**

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#### **S1. Description and context of discovery of the Roman hinges investigated**

Roman hinges are composite objects comprising an empty, cylindrical bone piece frequently made of a sawed-off section from a long and tubular bone (a cattle - *Bos Taurus* metatarsus). Two models can be distinguished: a small one with one regular hole (type A XI, 2; Béal 1983: 102) and a long one with two regular holes, one above the other, pierced on one face (type A XI, 1; Béal 1983: 102). The other pieces that compose hinges are a wooden cylinder conforming to the internal cavity of the bone and wooden pegs (Fremersdorf 1940). The centre of the bone is plugged with the wooden cylinder. Each piece is held to the next by a system of tenons and mortise located at its ends. The cylinders may be adjusted together to produce hinges which are able to twist on the same axis but in different directions. The wooden pegs are fitted inside the holes of the cylindrical bone and alternately, inside the holes bored into the edge of the box or cupboard and into the lid (or door). Some hinges come from ancient excavations and their contexts of discovery are unknown (Lyon, Besançon). Others were found in urban contexts, sometimes in handcraft areas (Autun, rue des Pierres; Fréjus, les Poiriers). Several examples were found in sanctuary areas (Vendeuil-Caply), rooms of domus (Amiens, Palais des Sports), in dumps (Amiens, îlot de la Boucherie and Garage Citroën), gutters (Nice, Cimiez), in pit fillings (Reims, rue Maucroix) or in various embankments (Amiens, îlot de la Boucherie; Narbonne, clos de la Lombarde; Fréjus, îlot Camelin).

#### **S2. Details of the methodology employed in the chemical analysis**

*DI-MS analyses*

A micro-grain, typically the size of a pinhead or even smaller, was placed in a Pyrex vial on the probe that was introduced into the ionisation chamber of the mass spectrometer. The probe was heated from 50°C to 325°C at a rate of 40°C min<sup>-1</sup> which allows the thermal desorption of the organic molecules present in the sample. Mass spectra were recorded in the electron ionisation mode at 70 eV on a Shimadzu QP210 ultra equipped with a quadrupole. The mass range was scanned from  $m/z$  50 to 950. The source temperature was fixed at 200°C. To avoid any memory effect, a blank was acquired between the analyses of successive samples with an empty Pyrex glass.

### *GC-MS analyses*

The samples were extracted with dichloromethane (HPLC grade) and dried under a gentle stream of nitrogen at 40°C. Trimethylsilation was performed with 50µL of BSTFA with 1% TMCS, 1µL of pyridin and 1µL of CH<sub>2</sub>Cl<sub>2</sub> dichloromethane for 30 min at 70°C. After evaporation of the derivatising agent to dryness, the sample was re-dissolved in 100µL of dichloromethane.

One µL of the solution obtained was then injected into the split/splitless injector (splitless mode) on a GC-MS apparatus Shimadzu GC2010 plus QP2010 ultra. The temperature of the injector was fixed at 300°C. The gas chromatograph was equipped with a DB-5HT column (15m length, 0.32mm i.d., 0.1µm film thickness). Helium was used as carrier gas. Gas flow at the head of the column was of 3mL min<sup>-1</sup>. The temperature of the gas chromatograph oven was programmed as follows: 50°C for 1 min, 20°C min<sup>-1</sup> to 150°C, 4°C min<sup>-1</sup> to 350°C, 10 min at 350°C.

Mass spectra were recorded in the electron ionisation mode at 70eV. The source was held at 200°C and the transfer line at 280°C. The mass range was scanned from  $m/z$  50 to 800 in 0.25 s.

### **S3. Textual analysis and textual databases exploited**

The research focused on the following Latin terms occurring in texts from Classical Antiquity to the Middle Ages: the lemmas *betulla*, *bitumen*, *cera*, *gluten*, *pix* and *resina* (Table S1).

*Betulla* is the Latin word used by Pliny the Elder to refer to the birch tree. The other terms (*bitumen*, *cera*, *gluten*, *pix* and *resina*) belong to the same lexical field. They are often used as synonyms for a viscous, sticky and combustible substance, whether or not of plant origin

**Table S1. Summary of the Latin text databases investigated and occurrences of search words. Numbers in parenthesis correspond to the occurrence related to birch.**

lemmas	<i>Betulla</i> (birch)	<i>Bitumen</i>	<i>Cera</i>	<i>Gluten</i>	<i>Pix</i>	<i>Resina</i>
LLT (Library of Latin Texts)	3	410	1685	117	720	474
PL (Patrologia Latina)	1	319	1412	155	450	207
MGH (Monumenta Germaniae Historica)	0	73	389	49	140	21
CBMA (Corpus Burgundiae Medii Aevi - Corpus of medieval Burgundy)	0	0	0	0	1	0
Chartae Galliae	0	0	0	0	0	0
Original charters prior to 1121	0	0	0	0	0	0
Charters from 1121 to 1220	0	0	0	0	0	0

In Old French texts, research was focused on the terms *boul* for birch, and *brai* and *glu* for viscous and sticky substances of vegetal origin, sometimes obtained from birch, sometimes produced by other plants. In Modern French, *brai de bouleau* means “birch-bark tar”. Coming from Scandinavia (*braeda* - cf. *FEW*). One should note that the word *brai* first appeared in areas where the substance thus mentioned could help caulking ships), the word *brai* was used in Normandy, and from there went to England (after the Norman Conquest of England) and then to France. As for the word *glu* (glue), it is quite frequent in Old French texts where it refers to sticky substances of vegetal origin, mostly holly, and it often appears as a means to capture birds (cf. *DMF*, *GD*, *FEW*). Although it appeared in Old French texts at the end of the twelfth century (cf. *TLFi*), we chose not to include the word *goudron* (from the Arabic *qatran*), since it is generally used for fossil substances. For the same reason, we did not consider the word *bitume*. In the *DMF*, the only occurrences quoted appear in translations from ancient technical texts (one of a Hippocrates’ medical treatise, the other of a Vegetius’ military treatise). Moreover, another occurrence which is not in the *DMF* (it can be read in Regnaud le Queux’ *Baratre infernal*, c. 1480: see *La Vision de Tondale. Les versions françaises de Jean de Vignay*, David Aubert, Regnaud le Queux, éd. Mattia Cavagna, Paris, Champion, 2008 (Classiques français du Moyen Âge, 159): 296–97), which is meant to explain the viscosity of Hell’s “ground” through a comparison with bitumen and which is not to be read in the Latin text which usually inspires Regnaud (the anonymous *Speculum*

*morale*), is however glossed with a reference to Ovide’s *Metamorphoses* (liber IX), where *bitumen* means the well-known mineral product of earth. So, all medieval occurrences of *bitume* refer to antic uses, and none relates to birch tar. As for the words *poix* and *resine*, they relate to resinous plants which are not birch, while *cire* mainly means “beeswax”.

The main online dictionaries and reference lexicons, based on a corpus of Old French texts, were consulted. For each word, these resources propose information related to definition and etymology and provide occurrences of the word with mention of the written sources and the portion of the text containing the term of interest (Table S2).

**Table S2. Summary of the French medieval text databases queried and occurrences of search words.**

	<i>Boul</i> ( <i>birch</i> )	<i>Brai</i>	<i>Bitume</i>	<i>Cire</i>	<i>Glu</i>	<i>Goudron</i>	<i>Poix</i>	<i>Resine</i>
AND	1	1	2	30	7	–	–	–
CREALSCIENCE	0	0	–	–	–	–	–	–
DMF	7	3	2	84	31	6	12	4
GDC	10	0	5	25	5	10	8	7

The characteristics of each database queried are provided below. It is noteworthy that some of the terms of interest had other meanings completely unrelated to this research. The context in which each word was detected helped isolating the meanings relevant to this investigation. Finally, dictionaries of Gaulish language were consulted to assess the origin of the terms related to birch (Delamarre 2001; Lambert 2003; Walter & Avenas 2017).

### Latin text databases

*Library of Latin Texts, Brepolis, Brepols Publishers Online (LTT-O)*

(<http://www.brepols.net/Pages/BrowseBySeries.aspx?TreeSeries=LLT-O>)

This database is composed of two series. The *LLT-A* series contains 78 million Latin words collected in more than 3800 texts from 1200 authors, from Classical antiquity to the twentieth century. *LLT Series B* is a supplement to Series A, operational since 2009. “In total, the present version of the *LLT-B* includes 901 works in addition to 5804 diplomatic charters: it is now possible to search more than 36.4 million forms, drawn from more than 900 works that

are attributed to approximately 450 authors” (<https://about.brepolis.net/library-of-latin-texts-series-b/>).

*Patrologia Latina* (PL) is the electronic version of the collection of the same title published by Jacques-Paul Migne in the nineteenth century. The PL includes Latin works spanning a millennium, from Tertullian (d. AD 230) to Pope Innocent III (d. AD 1216), but also includes works from AD 1216 onwards

(<http://www.mlat.uzh.ch/MLS/xanfang.php?corpus=2&lang=0>).

*Monumenta Germaniae Historica* (MGH)

MGH concern the medieval history of Germany and Europe, including Church history. The database eMGH includes the series falls into five main divisions, *Antiquitates*, *Diplomata*, *Epistolae*, *Leges* and *Scriptores*, with an additional smaller division of *Necrologia*. Many subsidiary series have also been established, including a series of more compact (*Scriptores in usum scholarum*) and special studies (MGH Schriften)

(<https://about.brepolis.net/monumenta-germaniae-historicae-emgh/>).

*CBMA « Corpus de la Bourgogne du Moyen Âge » (Corpus of medieval Burgundy)*

(<http://www.cbma-project.eu/>)

This textual database of the Burgundian region is composed of nearly 29 000 charters and more than 30 manuscripts.

*TELMA platform [Electronic processing of manuscripts and archives] from the IRHT*

(Institut de Recherche et d’Histoire des Textes) (<http://www.cn-telma.fr/>)

Telma is a service and distribution platform for electronic publishing of corpus of ancient sources. It offers approximately ten text databases, including:

- Chartae Galliae (<http://www.cn-telma.fr/publication/chartae-galliae>)
- Original charters prior to AD 1121 (<http://www.cn-telma.fr//originaux/index/>)
- Charters from AD 1121 to 1220 (<http://www.cn-telma.fr//originaux2/index/>)

*Chartae Galliae* is a database devoted to writings related to France until the end of the thirteenth century. It was set up within the framework of the ANR (French National Research Agency) Espachar project (*Les espaces de la charte : les caractéristiques régionales et des réseaux d’influence dans l’établissement des actes*). Still active, it is regularly complemented with the integration of the twelfth century Cistercian charters (within the framework of the ANR Charcis programme). The database currently contains nearly 40 000 medieval charters of France.

The database *Original charters prior to AD 1121* provides the original texts, and soon photographic reproductions, of all the original charters prior to 1121 preserved in France. It consists of more than 5000 charters.

The database *Charters from AD 1121 to 1220* is a complement to the previous one (original charters prior to 1121) that has been constituted by adding the corpus of charters of the following century, currently preserved in Lorraine, *i.e.* more than 700 charters to date.

### **French medieval text databases**

#### *CREALSCIENCE*

This database (<https://crealscience.github.io/Dictionnaire/>) results from an ANR (French National Research Agency) project started in 2010 (<http://www.agence-nationale-recherche.fr/Projet-ANR-10-CREA-0007>). The Crealscience project (Genesis of a scientific language: the case of medieval French) is focused on the genesis of French as a scientific language in Medieval times (Ducos & Salvador 2011). Within the framework of this project, a dictionary of Medieval Scientific French (DFMS) is being produced (oral communication I. Vedrenne). The letters A, B, C, should be published soon.

#### *Dictionary of Middle French (Dictionnaire du Moyen Français (DMF))*

(<http://www.atilf.fr/dmf/>)

This is an electronic dictionary on the French language of the Middle Ages (AD 1300–1500), initiated in 1981, developed within the ATILF laboratory in Nancy, and still evolving.

This dictionary currently proposes 65 720 entries, 470 125 citations. The text corpus of the DMF consists partly of the FRANTEXT database (220 full texts) and about 500 other ‘partial’ texts.

#### *Dictionary of Old French language and all its dialects from the 9th to the 15th century by Frédéric Godefroy (GD)*

It is completed by the GDC (complement au Godefroy).

(<https://classiques-garnier.com/godefroy-dictionnaire-de-l-ancienne-langue-francaise.html>).

This dictionary is the essential element of the lexicography of Old French. It provides an invaluable source of information with more than 160 000 entries, and approximately 370 000 extracts from authors from Middle Ages. The dictionary relies on several sources including printed sources, manuscripts, charters and documents of archives, of the ninth to fifteenth centuries AD.

*Anglo-Norman Dictionary Online (AND)*

(<http://www.anglo-norman.net/gate/index.shtml?session=SNWK28160T1532684621>)

The Anglo-Norman language corresponds to the language in use in England following the Norman Conquest from AD 1066 until the middle of the fifteenth century. This online dictionary is a continuation of the second edition of the dictionary edited by Louise W. Stone and William Rothwell. Entries A to F are based on the text from the paper version of this second edition. For letters G to L, the paper version was abandoned in favour of the online version. The M–Z entries are based on the text from the first edition of the dictionary and will be gradually replaced as the new electronic version progresses.

To date, for the letters A to E, there are 10 600 nouns, and more than 26 000 entries, as well as 155 000 citations.

*Französisches Etymologisches Wörterbuch (FEW), by Walther von Wartburg* (continued under the direction of Jean-Pierre Chambon and Jean-Paul Chauveau),

Bonn/Leipzig/Berlin/Paris/Bâle /Tübingen, 1928-... (<https://apps.atilf.fr/lecteurFEW/>)

This is an etymological and historical dictionary of the Galloroman language (French and dialects of oïl, francoprovençal, occitan, gascon). The *FEW* aims to provide the most complete possible picture of the Galloroman lexicon from a genetic perspective, with analysis of phonetic, morphological and semantic changes, and precise references to sources. This work, begun by Walther von Wartburg between 1910 and 1940, is today continued by the ATILF group [*Analyse et Traitement Informatique de la Langue Française*] in Nancy (France). The general index of the dictionary consists of 25 fascicles and more than 16 700 pages. A selective index was published in 2003 under the direction of Eva Buchi. Accessible online, it contains 2370 pages and 275 295 forms deemed representative of the 25 volumes of the *FEW*, or about one-twentieth of the total.

*Trésor de la Langue Française informatisé (TLFi)* (<http://atilf.atilf.fr/tlf.htm>)

This is the computerised version of the *Trésor de la Langue Française*, a dictionary of the nineteenth and twentieth centuries in 16 volumes and one supplement, listing 100 000 words with their history, their definition (270 000 definitions) and examples presenting the words in their context (430 000 examples of occurrences).

*Base textuelle FRANTEXT de l'Atilf (FRANTEXT)* (<http://www.frantext.fr>)

This is a database including 5350 references and 251 000 000 words. Initiated and developed within the ATILF laboratory in Nancy, *Frantext* is has been online since 1998 and is still evolving. The texts studied date from ninth to twenty-first century, 325 are in medieval French. Each word is given in context.

#### **S4. Translations**

*Pliny the Elder, Natural History, Book XVI, translated from the Latin by H. Rackham (1938).*

XXX.

The service-tree delights in cold places, but even more the birch. The latter is a Gallic tree, of a remarkable white colour and slenderness, a cause of terror as supplying the magistrates' rods of office; it is also easily bent to make hoops and likewise the ribs of small baskets, and the Gauls extract from it bitumen by boiling. These trees are accompanied into the same regions by the may also, the most auspicious tree for supplying wedding torches, because according to the account of Masurius it was used for that purpose by the shepherds who carried off the Sabine women; but at the present time the hornbeam and the hazel are most usually employed for torches.

LXIX.

Cato attributes to the willow the third place in the estimation of the countryside, and puts it before the cultivation of the olive and before corn or meadowland and this is not because other kinds of withes are lacking, inasmuch as the broom, the poplar, the elm, the blood-red cornel, the birch, the reed when split and the leaves of the reed, as in Liguria, and the vine itself and brambles after the thorns have been cut off serve as ties, and also the hazel when twisted and it is surprising that any wood should make stronger ties after being bruised by twisting; nevertheless it is the willow that has the properties specially required for this purpose.

LXXVII.

The trees that have the coldest wood of all are all that grow in water; but the most flexible, and consequently the most suitable for making shields, are those in which an incision draws together at once and closes up its own wound, and



which consequently is more obstinate in allowing steel to penetrate; this class contains the vine, *agnus castus*, willow, lime, birch, elder, and both kinds of poplar. Of these woods the lightest and consequently the most useful are the *agnus castus* and the willow; but they are all suited for making baskets and things consisting of flexible wicker-work. Also they are shiny and hard, and easy to use in carvings. Plane has flexibility, but of a moist kind, like alder; a drier flexibility belongs to elm, ash, mulberry, and cherry, but it is heavier. Elm retains its toughness most stoutly, and is in consequence the most useful wood for the hinges and frames of doors, because it is not liable to warp, only it should be put the other way up, so that the top of the tree is towards the lower hinge and the root above.

## Figures

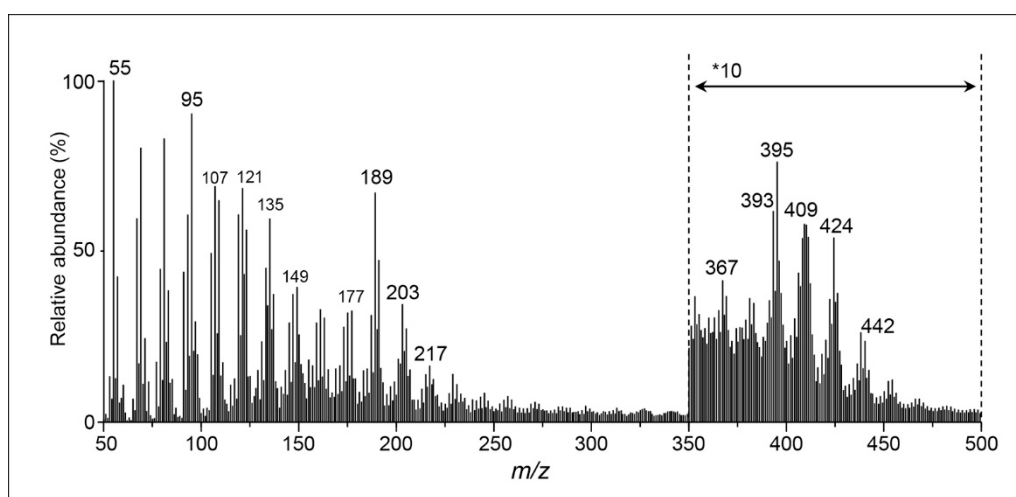


Figure S1. Mass spectrum of sample MR6253, obtained by DI-MS, typical of birch-bark tar. The spectrum corresponds to the sum of the spectra between 4 and 7 min on the desorption curve after subtraction of the background between 1 and 1.5 min. The region of the spectrum from  $m/z$  350 to 500 is magnified ( $\times 10$ ).

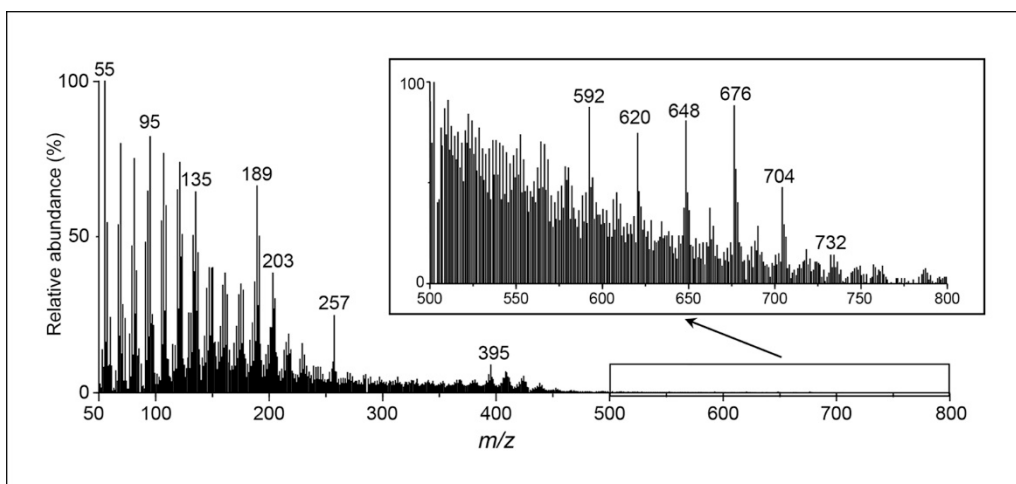


Figure S2. Mass spectrum of sample MR6261, obtained by DI-MS, characteristic of a mixture of birch-bark tar and beeswax. The spectrum corresponds to the sum of the spectra between 5 and 6 min on the desorption curve after subtraction of the background between 1 and 1.5min. The detail of the spectrum (topright) shows the peaks characteristic of the molecular ions of beeswax palmitate esters.

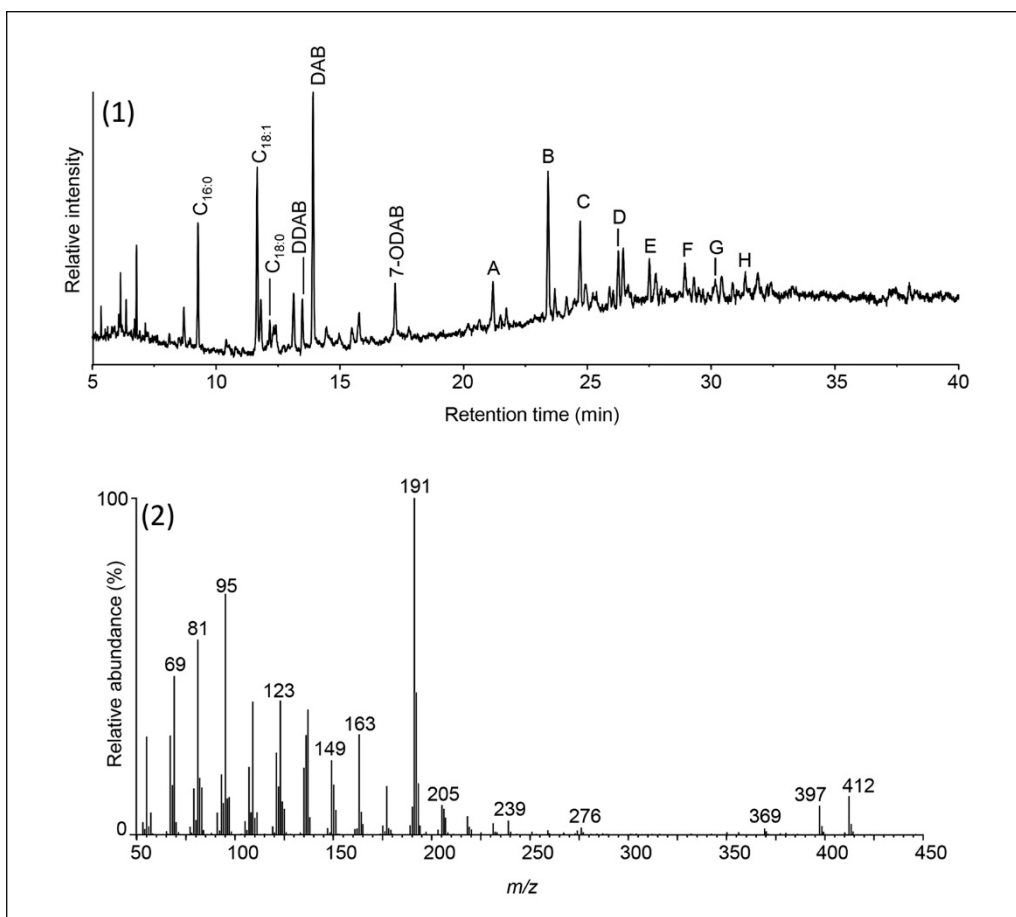


Figure S3. Chromatogram (1) obtained by GC-MS analysis of sample MR6248 showing the presence of fatty acids, diterpenoid markers and a series of hopanes

*components (A to H). DDAB: dehydro-dehydroabietic acid. DAB: dehydroabietic acid. 7-ODAB: 7-oxo-dehydroabietic acid. The components labeled A to H present a base peak at m/z 191 in mass spectrometry, with molecular weight of 370 (A), 398 (B), 412 (C), 426 (D), 440 (E), 454 (F), 468 (G) and 482 (H) corresponding to hopane components with respectively 27, 29, 30, 31, 32, 33, 34 and 35 carbon atoms. The mass spectrum of compound C is compatible with that of 17 $\alpha$ -hopane published in 1974 by Kimble et al., as shown on the second part of this figure (2).*

**Table S3. List of samples investigated in this study and indication of the materials identified (bbt: birch-bark tar. FA: fatty acids. PR: pine resin. BW: beeswax). ND: not documented. AE: ancient excavations.**

<b>Town</b>	<b>Archaeological site</b>	<b>Complementary archaeological information</b>	<b>Chronology</b>	<b>Lab number</b>	<b>Type of object</b>	<b>Analyses carried out</b>	<b>Materials identified</b>
Amiens	AIB	36	AD 60–70	MR6288	Hinge part	DI-MS	bbt
		38	<i>c.</i> AD 70	MR6289	Hinge part	DI-MS	bbt
		139	10/190–10/250 AD	MR6290	Hinge part	DI-MS & GC-MS	bbt
	Garage Citroën	600	AD 140– 180/200	MR6286	Hinge part	DI-MS & GC-MS	bbt
		667	AD 40–100	MR6287	Token	DI-MS & GC-MS	bbt
	PDS	303	AD 125–130	MR6283	Hinge part	DI-MS & GC-MS	bbt
		650	AD 100/110– 125/130	MR6284	Hinge part	DI-MS & GC-MS	bbt
		900	AD 125– 130	MR6285	Hinge part	DI-MS & GC-MS	bbt

Augst	Augusta Raurica	Région 1, Insula 22, 1964-1603	Mid-first to mid-second century AD	MR6269	Hinge part	DI-MS	bbt
		Région 1, Insula 24, 1959-5193	Mid-first to mid-second century AD	MR6265	Hinge part	DI-MS	bbt
		Région 1, Insula 25, 1977-10977	1st century AD	MR6263	Hinge part	DI-MS	bbt
		Région 1, Insula 29, 1961-13747	Mid-first to mid-second century AD	MR6266	Hinge part	DI-MS	bbt
		Région 1, Insula 30, 1962-10895	Mid-first to mid-second century AD	MR6264	Hinge part	DI-MS	bbt
		Région 1, Insula 30, 1959-12118	Mid-first to mid-second century AD	MR6267	Hinge part	DI-MS	bbt
		Région 1, Insula 50, 1982-12385	First–Fourth centuries AD	MR6270	Hinge part	DI-MS	bbt
		Région 17, D, 1973-14151	First century AD	MR6268	Hinge part	DI-MS	bbt

		Région 2, E, 1985-83552	First century AD	MR6262	Hinge part	DI-MS	bbt
Autun	Rue des Pierres	EVI - 62	Gallo-Roman times	MR6256	Hinge part	DI-MS	bbt
Besançon	Museum collection	41501 - 2013.0.1628	Gallo-Roman times	MR6274	Hinge part	DI-MS	Hydrocarbons
		40831- 852.15.52	Gallo-Roman times	MR6275	Hinge part	GC-MS	FA + bbt
		44424 - A.2005.6.135	Gallo-Roman times	MR6276	Hinge part	GC-MS	bbt
		41502 - 2013.0.1629/South Gaul	Gallo-Roman times	MR6277	Hinge part	DI-MS	bbt
Chartres	Cœur de ville	C191-5024-1	Gallo-Roman times	MR6271	Hinge part	DI-MS & GC-MS	bbt
		C191-5047-2	Gallo-Roman times	MR6272	Hinge part	DI-MS & GC-MS	bbt
		C 190-5282-3	Gallo-Roman times	MR6273	Cylinder part	GC-MS	bbt
Fréjus	Îlot Camelin	1041	First century AD	MR6252	Hinge part	DI-MS & GC-MS	bbt

		3633	ND	MR6254	Hinge part	DI-MS & GC-MS	bbt
		3630	ND	MR6255	Hinge part	DI-MS	191 - bitumen
	Les Aiguières	n°527	Augustus: 60/70 AD	MR6250	Hinge part	DI-MS & GC-MS	bbt
	Les Poiriers	300482	400–550 AD	MR6251	Hinge part	DI-MS & GC-MS	bbt
Lyon	ND, AE	136-608	Gallo-Roman times	136-608	Hinge part	DI-MS	bbt
		143-615	Gallo-Roman times	143-615	Hinge part	DI-MS	bbt
		144-616	Gallo-Roman times	144-616	Hinge part	DI-MS	bbt
	Verbe incarné	170-771-6-56	Gallo-Roman times	MR6245	Hinge part	DI-MS	Insufficient material
		Carré L6 dernier sol 2e état, 81-1-8- -8	Gallo-Roman times	MR6244	Hinge part	DI-MS	bbt
		ZA5 carré 9 citerbe, 80-1-6-40	Gallo-Roman times	MR6246	Hinge part	DI-MS	bbt

Narbonne	Clos de la Lombarde	10007	Gallo-Roman times	MR6253	Decorative plaque	DI-MS & GC-MS	bbt
Nice	Cimiez	Cimiez sud caniveau décumanus I	Gallo-Roman times	MR6257	Hinge part	GC-MS	bbt
		Transfert Masséna	Gallo-Roman times	MR6258	Hinge part	DI-MS & GC-MS	FA+PR + bitumen
Poitiers	Jardins du Pyugarreau	5045	First half of the second century AD	MR6259	Hinge part	Not analysed	Insufficient material
Reims	Bd Henrot	OI 742, US 518	Third century AD	MR6281	Hinge part	DI-MS & GC-MS	bbt
		OI 1035, US 1334	Third century AD	MR6282	Hinge part	DI-MS	bbt
	Rue Maucroix	OI 789, US 1070	Third century AD	MR6278	Hinge part	DI-MS	bbt
		OI 1043, US 398	Third century AD	MR6279	Hinge part	DI-MS	bbt
		OI 153, US 158	No context	MR6280	Hinge part	DI-MS	bbt
Rom	Le Parc 2011	125/10	Gallo-Roman times	MR6261	Hinge part	DI-MS	bbt + BW



	ND, AE	83S8 DEP	Gallo-Roman times	MR6293	Hinge part	DI-MS & GC-MS	bbt
		R3 S1 1006	Gallo-Roman times	MR6294	Hinge part	DI-MS	bbt
		R4?? 2003	Gallo-Roman times	MR6295	Hinge part	Not analysed	Insufficient material
Saintes	Rue Daubonneau	359/3001	First–Second century AD	MR6260	Hinge part	DI-MS & GC-MS	bbt
Vendeuil Caply	2013	2002 - 11	AD 180– 220/230	MR6291	Hinge part	DI-MS & GC-MS	bbt
		2050 - 60	AD 180– 220/230	MR6292	Hinge part	DI-MS & GC-MS	bbt
Saint- Maximin- la-Sainte- Baume	Rue Colbert	ND	Medieval: twelfth– fifteenth centuries AD	MR6296 MR6297	Die Die	GC-MS GC-MS	FA BW

**Table S4. List of sites from Early Iron Age to Roman period in which birch-bark tar was chemically identified. NI: not indicated.**

<b>Number on map</b>	<b>Site name</b>	<b>Reference</b>	<b>Archaeological context</b>	<b>Site location</b>	<b>Type of object / material</b>	<b>Date</b>	<b>Period</b>	<b>Number of samples investigated</b>	<b>Materials identified</b>
12	Cuciurpula	Rageot <i>et al.</i> (2016)	Early Iron Age village	Site located at an altitude of 1000m, in the south-central part of Corsica, on the Punta di Cuciurpula	Free lumps and residues on ceramic vessels	Ninth–sixth centuries BC (phases 0 to 2)	Early Iron Age	Two free lumps and seven visible organic residues sampled on ceramic vessels	Birch-bark tar and other materials (pine resin, beeswax)
11	Vetulonia, graveyard of Colle Baronico	Morandi <i>et al.</i> 2018	Graveyard	Northern Tuscany, Italy (42°51'034"N 10°58'016"E, 335m asl)	Tin-band decorated funerary urn	c. ninth–eighth centuries BC	Early Iron Age (Villanova culture)	Four micro-samples of a black organic substance decorating the urn	Birch-bark tar
2	Argancy	Regert & Rolando (2002)	Chariot burial	Argancy, Moselle, France	Organic residue in a chape of a sword		Early Iron Age	One sample	Birch-bark tar

1	Le Clos des Lilas	Langlois <i>et al.</i> (2005)	Hallstatt necropolis	Eterville, France	Organic residue on a fibula	End of sixth century–beginning of fifth century BC	Early Iron Age	One sample	Birch-bark tar
3	Eckwersheim	Courel <i>et al.</i> (2018: 72)	Hallstatt necropolis, tomb 6008	Eckwersheim, NE France	“Adhesive used to stick two bronze half-spheres to form a pendant”	625–550 BC	Early Iron Age (Hallstatt D1)	One sample	Birch-bark tar
4	Heuneburg	Rotländer (1986)	Hallstatt settlement	Herbertingen-Hundersingen, SO Germany	Residues on ceramic vessels	600–450 BC	Early Iron Age (Hallstatt D)	One sample	Birch-bark tar
5	Hochberg	Hayek <i>et al.</i> (1990: 2042, 1991: 155)		Lower Austria	“Ancient glued joint on a pottery (grave gift)”		Early Iron Age (R. H. C/D)	One sample	Birch-bark tar

7	Stillfried	Hayek <i>et al.</i> (1990: 2042, 1991: 155)		Lower Austria	“Contents of pottery bowl”		Early Iron Age (R. H. C/D)	One sample	Birch-bark tar
8	Odenburg Burgstall	Sauter (1967)		Hungary	Material used to repair ceramic vessels		Early Iron Age (Hallstatt)	Five samples	Possibly birch-bark tar (result based on IR analysis)
9	Kaptol-Gradci	Doracic <i>et al.</i> (2012)		Croatia	Reparation of ceramic vessels		Early Iron Age		Birch-bark tar
10	Belogradets	Ribechini <i>et al.</i> (2011)		Belogradets, Bulgaria	Samples from the golden sheath of a Thracian dagger	Eighth–seventh centuries BC	Thraco-cimmerian period	Five samples	Birch-bark tar
12	Cuciurpula	Rageot <i>et al.</i> (2016)	Early Iron Age village	Site located at an altitude of 1000m, in the south-central part of Corsica, on the	Free lumps and residues on ceramic vessels	Beginning of the sixth century BC (phase 3)	Early Iron Age	Three free lumps and 24 visible organic residues sampled on ceramic vessels	Birch-bark tar and other materials (pine resin, beeswax)

				Punta di Cuciurpula					
6	Langenlebarn	Sauter <i>et al.</i> (2002)	Tomb in a tumulus	District of Tulln, Lower Austria	Adhesive used to fix clay figurines	c. 600 BC	Early Iron Age (Hallstatt)	One sample	Birch-bark tar
13	Wetwang	Stacey (2004)	Chariot burial	East Yorkshire, England	Adhesive in the harness fittings	400–100 BC	Late Iron Age	Two samples	Birch-bark tar, possibly mixed with conifer product
15	Les Vairies	Sicard (2017)	Gallic rural settlement	Saint-Sauveur-des-Landes, Ile-et-Vilaine, France	Five tar loaves	170–10 BC			Birch-bark tar (unpublished analytical data)
14	Orval	Langlois & Regert (2007)	Chariot burial	Coutances, Manche, France	Adhesive used to fix a coral decor on parts of the harness fittings	Third–first centuries BC	Late Iron Age (La Tène)	Five samples analysed, four with birch-bark tar	Birch-bark tar
17	Vincelles	Poplin (1971)		Vincelles, Yonne, France	Adhesive used to repair a pottery		Late Iron Age (La Tène)		Birch-bark tar (unpublished analytical data)

18	Lavansaari	Reunanen <i>et al.</i> (1993)	Funerary context	Island of Lavansaari (russ. Mostnyi ostrov), eastern part of Gulf of Finland	Samples from wooden containers holding burnt bones of the deceased	1900–2200 BP	Pre-Roman Iron Age	Two samples	Birch-bark tar
16	Grand Aunay	Regert <i>et al.</i> (2003)	Enclosures and ditches	Yvré-l'Évêque, 5 km from Le Mans, Sarthe, France	Free lumps and residues on ceramic vessels	Third–first centuries BC	Late Iron Age (La Tène)	Eight lumps and organic residues on ceramic vessels	Birch-bark tar
19	West Cotton	Charters <i>et al.</i> (1993)		West Cotton, Northamptonshire, GB	Roman Ecton jar was recovered repaired by birch-bark tar		Roman period of Great Britain	One sample	Birch-bark tar
20	Catterick	Dudd & Evershed (1999)		Yorkshire, Great Britain	“Contents of a small, enamelled vessel”	Roman sediments	Roman period of Great Britain		Birch-bark tar
21	Naintré	Ribechini <i>et al.</i> (2011)		A few km from Poitiers (France)	Wooden spindle	Second half of the third	Gallo-roman period	One adhesive, a brownish-black material, used to fix	Birch-bark tar

						century AD		together two pieces of an archaeological spindle	
22	Albersto	Bergström (2004)		Province of Södermanland, eastern Sweden	One tar loaf, weight: 204g.	First century AD	Roman Iron Age	One sample	Mixture of birch-bark tar and animal fat
23	Vellensby	Karg <i>et al.</i> (2014)	A woman's grave	Island of Bornholm, Denmark	Two chewing gum-like objects with dental impressions		Late Roman Iron Age	One of the chewing gums	Birch-bark tar (low amount) and plant oil
24	NI (not shown on Figure 6)	Nordby (2009)	Grave contexts	Norway	Brownish-black ring of varying size in the sediment (linked with lath-walled wooden or bark containers)	c. 500 BC–AD 570	Norwegian Early Iron Age	Thirty-seven caulking remains	Birch-bark tar

**Table S5. List of sites from Early Iron Age to Roman period in which conifer products were chemically identified. NI: not indicated.**

<b>Number on map</b>	<b>Site name</b>	<b>Reference</b>	<b>Archaeological context</b>	<b>Site location</b>	<b>Type of object / material</b>	<b>Date</b>	<b>Period</b>	<b>Number of samples investigated</b>	<b>Materials identified</b>
A	Put Blanc	Connan <i>et al.</i> (2002)	Sublacustrin site	Sanguinet Pond, Landes, France	Vase 99-14 with carbonised residue	750–400 BC	Early Iron Age	One sample	Conifer pitch
H	La Castellina	Garnier (2003)	Etruscan site	La Castellina, Lazio, Italy	Etruscan amphorae coating	700–300 BC	Etruscan		Mixture of pine tar/resin and beeswax
B	Archaic Greek shipwreck- Jules Verne VII	Connan (2002)	Waterlogged site	Marseille, France	Ship caulking	Sixth century BC	Archaic Greek		Mixture of conifer tar and beeswax
C	Cassidaigne shipwreck	Garnier (2003)	Waterlogged site	Provence coast, France	Coating	Sixth century BC	NI		Pine resin
D	La Palud II shipwreck	Garnier (2003)	Waterlogged site	Provence coast, France	Greek amphorae coating	Sixth century BC	Archaic Greek		Pine tar



E	Pointe Lequin 1A shipwreck	Garnier (2003)	Waterlogged site	Provence coast, France	Greek amphorae coating	Sixth century BC	Archaic Greek		Pine tar
F	Pisa San Rossore	Garnier (2003)	Ancient harbour	Pisa, Tuscany, Italy	Amphorae coating	400–200 BC	Etruscan		Pine tar
J	Roman amphora from Vis	Jerković <i>et al.</i> (2012)	Waterlogged site	Adriatic sea, near Vis Island, Croatia	Greco-Italian amphora type Benoit Republicane-II/Lamboglia coating	Middle of the second century BC	Roman Republic	One sample	Pine resin/tar
I	Chiusi	Colombini <i>et al.</i> (2009: 1490)	Etruscan necropolis	Chiusi, Tuscany, Italy	<i>Unguentarium</i> content	Second half of Second century BC	Etruscan	One sample (“some contents of the <i>unguentarium</i> , approximately 10mg”)	Mixture of plant oil, pine resin and <i>pistaccia</i> resin
G	Bouvier shipwreck	Garnier (2003)	Waterlogged site	Porto Vecchio, Corsica, France	Dressel 21-22 amphorae coating	75–60 BC	Roman Republic		Pine tar

F	Pisa San Rossore	Colombini <i>et al.</i> (2003)	Ancient harbour	Pisa, Tuscany, Italy	Waterproofing, caulking and painting materials of Roman ships	First century BC–second century AD	Etruscan and Roman ages	10 samples	Pine resin and tar
K	Monte Poro	Izzo <i>et al.</i> (2013)	Subaqueous contexts	Monte Poro, Calabria, Italy	Dressel 1 amphorae coating	First century BC	Roman Republic	NI	<i>Pinaceae</i> resin and tar
O	London, Regis House	Stern <i>et al.</i> (2008)	NI	London, United Kingdom	Amphorae coating	AD 0–200	Romano-British	Seven samples	Pine resin
U	Chalon/Saône shipwreck	Connan & Nissenbaum (2003)	Waterlogged site	Chalon/Saône, Bourgogne-Franche-Comté, France	Ship caulking	AD 0–200	Gallo-Roman	NI	Conifer tar
M	Carlisle	Stern <i>et al.</i> (2008)	Various sites	Cumbria, United Kingdom	Camulodunum 186 and Gauloise flat-based amphorae	NI	Romano-British	Five residues of different amphorae	Pine resin

T	Melun-Vernin	Garnier (2003)	NI	Melun, Île-de-France, France	Gallo-Roman amphorae coating	AD 50–100	Gallo-Roman		Pine tar
W	Sud Perduto II shipwreck	Garnier (2003)	Waterlogged site	Bonifacio, Corsica, France	Dressel 28 amphorae coating	AD 75–100	Roman period		Pine tar
X	Villa B	Ribechini <i>et al.</i> (2008)	Roman villa	Oplontis, Naples, Italy	Glass unguentaria	First century BC–first century AD	Roman period	Seven samples	<i>Pinaceae</i> resin + beeswax and another wax
S	Rouen	Garnier (2003)	NI	Rouen, Normandy, France	Gallo-Roman amphorae coating	AD 100–300	Gallo-Roman		Pine tar
L	Sommaränge, Fullerö, Highway E4	Hjulström <i>et al.</i> (2006)	Dark coloured circles	Uppland, Sweden	Free lamp in small funnel-shaped pits	AD 240–540	Late Roman Iron Age	Thirteen from funnel-shaped pits	Pine tar
R	Guernsey	Connan <i>et al.</i> (2002)	Gallo-roman shipwreck	Island of Guernsey, United Kingdom	Piece of pitch	c. AD 280	Roman period	One sample	Pine tar

Y	Eastern cemetery of Thessaloniki	Papageorgopoulou <i>et al.</i> (2009)	Funeral	Thessaloniki, Greece	Embalming	c. AD 300	Roman period	One sample from the compact-particle material	Conifer and <i>pistacia</i> resins
N	Northview Hospital	Brettell <i>et al.</i> (2015)	Burials	Purton, Wiltshire, UK	Debris associated with skeletal elements	Late third–fourth century AD	Late Roman period	Four samples	Pinaceae derivative + <i>Pistacia</i> spp.
Q	Poundbury Camp	Brettell <i>et al.</i> (2015)	Burials	Dorchester, Dorset, UK	Residues associated with plaster or textiles	Fourth century AD	Late Roman period	13 samples	<i>Pinaceae</i> derivative
P	280 Bishopsgate, site K	Brettell <i>et al.</i> (2015)	Burials	Around London, UK	Samples within lead coffin	Mid-Fourth c. AD	Late Roman period	10 samples	<i>Pinaceae</i> derivative
V	Sanguinet	Connan <i>et al.</i> (2002)	Sublacustrin site	Sanguinet, Landes, France	Production residue	AD 400–600	Gallo-Roman	One sample	Conifer tar

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