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1 **Title**

2 First insights into the wood management for the production of lime given by the
3 anthracological study of a 19th century lime kiln from Martinique, Lesser Antilles

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18 **Abstract**

19 The colonial economy of Martinique, French West Indies, has long been based on sugar cane
20 exploitation, which started in the 17th century and decreased during the 19th century. Sugar
21 economy led to woodland exploitation for the production of fuel. In particular, this fuelwood
22 was needed for lime production, which was used for the purification of cane juice. As lime kilns
23 are numerous in Martinique, their functioning implied an intense wood exploitation. To date,
24 no archaeobotanical studies were conducted to assess how lime kiln workers used and
25 managed wood for the production of fuel. In this study, we analyzed 207 wood charcoals
26 fragments from a 19th century lime kiln at the Sucrierie plantation, Les Anses-d'Arlet,
27 Martinique. This led to the identification of 50 taxa, showing that wood collection was mainly
28 diffuse and unfocused. But the occurrence of taxa known as being used for fuelwood or
29 charcoal production suggests that lime kiln workers were looking for wood with good fuel
30 properties. Our results also show that the collection of wood was made locally, as revealed by
31 the presence of a xero- to mesophilic vegetation in the anthracological record, which is in
32 accordance with botanical and ethnological data. The presence of pioneer and heliophilic taxa
33 also suggest that the vegetation was already impacted by wood exploitation i.e., local forest
34 associations were largely disturbed by this time and secondary regrowth was conspicuous.
35 Nevertheless, the high proportion of small-gauge wood charcoals fragments (36%) and the
36 presence of edible taxa in the anthracological record suggest that saplings and pruning waste
37 may have been preferred to preserve useful and mature trees. This study allows for the first
38 time to assess which fuelwood was used by Antillean lime kiln workers during the colonial
39 Period which makes it possible to better understand one of the most widespread handicrafts
40 during the sugar exploitation in the Caribbean.

41 **Keywords**

42 Tropical Anthracology – Caribbean Archaeology – Colonial Landscape – Wood Charcoal –
43 Lime kiln – Fuelwood – Sugar Economy

1. Introduction

45 For several decades, the development of archaeology for the colonial period has led to an
46 interest in the plantation dwellings of the West Indies (Moussette and Waselkov 2013; Kelly
47 and Bérard 2014). In Martinique, the inventory of sugar refineries and distilleries (Mousnier
48 and Caille 1990) allowed several research themes to emerge: the habitat of slaves (Kelly 2004;
49 2013) the production of ceramics (England 1994; 1997; Amouric et al. 2007; Amouric 2010;
50 2011; 2012; 2013; 2015; Thiriot et al. 2012; Cloarec-Quillon et al. 2015) and that of lime (Vidal
51 et al. 2000; Verrand and Vidal 2004; Vaschalde et al. 2016; 2017; 2019b).

52 Currently, archaeobotany is developing thanks to Cultural Resources Management
53 archaeology, but no detailed study of wood charcoal from the colonial period has
54 ever been carried out in the Lesser Antilles. Yet, the economy of large plantations has impacted
55 the Caribbean forested landscape. As early as 1635, new settlers had to clear the land in order
56 to benefit from advantageous settlement conditions granted by the royal power (Blérald 1986,
57 p25). An export economy developed rapidly, first based on tobacco cultivation, then on sugar
58 cane (Doumenge and Monnier 1989). In 1670, large land estates appeared and enabled the
59 French West Indies to export sugar to Europe on a massive scale. The sugar plantation was
60 the basis of the colonial economy. It concentrates both the cultivation of cane, which implies
61 the acquisition of land, and the means to transform it into sugar (mill, lime kiln...). For nearly
62 two centuries, no innovation allowed production techniques to progress. The growth of the
63 sugar economy was based solely on the increase in the slave population, the multiplication of
64 plantations and the extension of cultivated lands (Blérald 1986, p27).

65 In the 18th century, sugarcane cultivation often occupied less than half of the surface area of
66 sugar estates (Blérald 1986, p27; Bégot 2008, p51; Bonnet 2008, p167), and a large part of
67 the estates were covered with woods and savannahs, which were essential for livestock and
68 firewood (Bégot 2008, p50). However, the lack of management of forest resources led to a
69 shortage of timber, which was then imported (Bégot 2008, p50). In the 19th century, profound
70 changes affected the sugar economy: the modernization of the means of production (adoption
71 of steam mills, shareholding), the abolition of slavery in 1848, and the competition from
72 European beet sugar. However, the areas cultivated with cane continued to increase thanks
73 to the development of the rum industry. Between 1855 and 1895, these areas increased by
74 28%, and Martinique became the first world exporter of rum (Blérald 1986, p60 and 74-79).
75 During World War I, the number of distilleries doubled, as the production of sugar and alcohol
76 was stopped in France because of the conflict. From the middle of the 20th century onwards,
77 many factories closed down, and the cultivated areas decreased.

78 Thus, between the end of the 17th and the 20th century, the slave sugar economy, then the
79 capitalist one, led to the clearing of large areas of land. Moreover, the supply of fuel was
80 indispensable to the West Indian economy. Before the arrival of industrial techniques and of
81 coal at the end of the 19th century, wood and bagasse were the only fuels available. Fire was
82 used to heat sugar boilers (Vidal 1994), potters' kilns that produced sugarloaves and molasses
83 pots (England 1994; 1997; Thiriot et al. 2012), as well as lime kilns. Many kilns provided the
84 lime necessary for the purification of cane juice. At the end of the 18th century, Martinique had
85 nearly 80 lime kilns (Verrand and Vidal 2004, p41). An archaeological inventory has allowed
86 to identify more than 130 of them on the island (Vaschalde et al. 2019b). The impact of this
87 activity on the vegetation has thus been significant, and may have required the development
88 of techniques for woodland management.

89 The colonial archives do not provide any clues on this woodland management, and only
90 anthracology is able to enlighten us. In 2014, an archaeological excavation was carried out on
91 a 19th lime kiln at the Sucrerie plantation, Les Anses-d'Arlet, and allowed the extraction of wood

92 charcoal. Anthracology in the tropics is challenging because of the scarcity of the studies
93 compared with those from temperate or Mediterranean environments; this makes comparisons
94 difficult. In the Neotropics, anthracological studies are most common in South America (e.g.,
95 Tardy et al. 2000; Scheel-Ybert 2001; Beauclair et al. 2009; Bianchini and Scheel-Ybert 2011;
96 Fernandes Caromano et al. 2013; Scheel-Ybert et al. 2014; Bachelet and Scheel-Ybert 2017;
97 Bodin et al. 2020) but are still rare in the Antilles (Newsom and Molengraaff 1999). To our
98 knowledge, the only anthracological study conducted in Martinique is that by Christophe Tardy
99 on the pre-Columbian site of Vivé (Tardy 2001). In this paper, we assess how lime kiln burners
100 managed woodland to produce charcoal for the functioning of a 19th century lime kiln, in the
101 context of the sugar cane exploitation in Martinique. Specifically, we ask these questions to
102 better understand the fuel economy:

- 103 1. Did craftspeople favor some kind of vegetation?
- 104 2. Did they collect wood locally?

105 To answer these questions, we identified wood charcoals found in the remains of the lime kiln.
106 This study, combining anthracology with an ethnoarchaeological approach, is the first one for
107 a Caribbean colonial site.

108 2. Material and methods

109 2.1 Regional setting

110 The study was undertaken in Les Anses-d'Arlet (14°29'26", 61°04'50"), in Martinique, a French
111 overseas department located in the Lesser Antilles (Fig. 1). The climate is tropical humid (Peel
112 et al. 2007) with a mean annual rainfall of 1300 mm and a mean annual temperature of 27°C
113 recorded in Les Anses-d'Arlet between 1951 and 1970 (Portécop 1979). The dry season
114 extends from January to April and the rainy season occurs between June and November. In
115 the South, the geological substratum is older and the topography lower than in the North-
116 Western part of the island where the *Montagne Pelée* stands. The climate is also drier in the
117 South (Portécop 1979). Martinique belongs to the Caribbean hotspot of biodiversity, which
118 hosts more than 11,000 species of native seed plants with a species endemism rate of about
119 72% (Myers et al. 2000; Conservation International 2020). The most recent update of the
120 floristic checklist counts about 3200 angiosperm species in Guadeloupe-Martinique (Fournet
121 and Sastre 2002). In 1994, Fiard reports 396 tree species of which 20% are endemic to the
122 Lesser Antilles. According to Portécop (1979), the flora of Martinique has a strong affinity with
123 that of Puerto Rico and, in a lesser extent, with that of the North of South America. In Les
124 Anses-d'Arlet area, the vegetation is xerophytic, with a *Tabebuia-Bursera* forest, a *Ceiba-Ficus*
125 sandy-clay facies and a *Lonchocarpus-Inga* riparian forest (Portécop 1979).

126 2.2 Historical context

127 During the second half of the 18th century, the Sucrierie plantation was one of the most
128 important sugar plantation in southwest Martinique. Around 1770, the map of Moreau du
129 Temple indicates that the domain was called "Lebrun" (Bégot et al. 1998). In 1783, the Delpech
130 family built a sugar factory, and in 1788, the plantation was bought by Jean-François Hayot
131 (1733-1788) (Bruneau-Latouche et al. 2002, p569; Elisabeth 2005, p1). During the 19th
132 century, the Hayot family established itself throughout southern Martinique and diversified its
133 economic activity (sugar, rum, pottery, building materials, etc.). It increased the extent of the
134 Sucrierie plantation, which reached 116 ha in 1788, 177 ha in 1820, and 284 ha in 1828
135 (Bruneau-Latouche et al. 2002, pp569-573; Ollivier and Vaschalde 2015). Starting in the 1840s
136 in Martinique, the creation of modern factories equipped with steam boilers disrupted the
137 operation of the Sucrierie plantation. Around 1845, Michel Hayot (1786-1852) put an end to the
138 pressing of sugar on the domain, and sent the cane to the new sugar factory at Pointe-Simon

139 (Fort-de-France). This factory was founded by Joseph Quenesson (1819-1890), which
140 bought the plantation in 1878 (Ollivier and Vaschalde 2015). After the closure of the factory,
141 Simon Hayot bought the Sucrierie plantation in 1899. Taking advantage of the development of
142 the rum industry, he set up a distillery in 1918 (Louis-Alexandre 1985). In 1926, the map of the
143 *Compagnie française aérienne* indicates that sugar cane plantations occupy large areas in the
144 plain around the house, and that the hills are forested. The distillery closed definitively in 1950
145 (Mousnier and Caille 1990; Flohic et al. 1998, p29).

146 2.3 Remains associated to the Sucrierie plantation

147 The plantation is organized around a hill overlooking the *Ravine des Œillets* and the village of
148 Les Anses-d'Arlet. The Sucrierie plantation is composed of a master's mansion probably
149 dating from 1760-1770 AD (Charlery 2004) installed on the hilltop, and of various buildings
150 related to its past economic activity. The only vestiges that can be linked to the sugar activity
151 of the plantation in the 18th-19th centuries are those of the sugar mill that has been identified
152 south of the ruins. The 20th century distillery, built on the sugar factory, stretches from east
153 to west on the northern piedmont of the hill. It consists of a large building, restored in 2011
154 and containing several vats or vat supports, a steam boiler and the mechanical installation
155 still in place, also restored. Other ruins are located to the north and west. In 2014, the
156 archaeological excavation uncovered walls of basalt rubble bound with lime mortar and
157 partially plastered (Fig. 2; MR 1002 and MR 1025). Dating from the second half of the 18th
158 century, their function remains unknown.

159

160 2.4 Lime kiln structure and functioning

161 The lime kiln is built to the North-East of the distillery. It is a circular building measuring
162 approximately 5 m in diameter for a preserved height of 2.20 m (Fig. 2). The external facing is
163 built in irregular apparatus of large basalt rubble bound with a lime mortar, the whole being
164 covered with a smooth lime plaster, like the walls previously described.

165 To the West is the mouth of the kiln, facing a ruined building that may have served as a "lime
166 hut". The mouth is composed of a basalt sill and refractory stone pedestals. The lintel topping
167 the whole has disappeared. The mouth is preceded by a large splay, which sheltered the
168 working area, partially filled by alternating layers of lime, containing fragments of charred coral
169 and wood mixed with ash, which testify to the activity of the kiln (US 1015). Inside the kiln, the
170 firing chamber has a diameter of 1.50 m at the base. It has the shape of an inverted truncated
171 cone. The floor consists of a paving laid on a bed of lime mortar and the walls are built with cut
172 refractory stones.

173 To the north of the kiln, a masonry ramp allowing access to the top in order to feed it with corals
174 has been identified despite the poor state of conservation.

175 The architecture of the structure indicates that it is a short-flame kiln (Vaschalde 2018, pp91-
176 97), a process that is very widespread in Martinique (Vidal et al. 2000; Verrand and Vidal 2004;
177 Vaschalde et al. 2016; 2017; 2019b). The raw material, composed of coral and shell fragments,
178 is charged by forming beds alternating with fuel (wood charcoals). At the end of each firing,
179 the lime is discharged through the mouth at the bottom of the kiln, and part of the charcoal is
180 spread on the floor of the work area.

181 2.5 Dating of the lime kiln

182 The dating of the lime kiln is based on stratigraphy, textual sources and artifacts found during
183 the excavation. After the walls MR 1002 and MR 1025 were levelled, the ground was backfilled

184 and the kiln's foundations were then dug. An inventory drawn up in 1820 does not mention the
185 lime kiln, indicating that it was built after that date. In 1878, the lime kiln appears in the deed
186 of sale of the estate to Joseph Quenesson (Ollivier and Vaschalde 2015). It can be assumed
187 that it was in good condition at this time. Thereafter, it is probable that Joseph Quenesson
188 did not have lime produced at the plantation anymore, since the canes were brought to the
189 factory of Pointe-Simon. Finally, the excavation of the work area uncovered two fragments of
190 glass bottle bottoms, dated to the mid-19th century. The lime kiln was therefore in operation in
191 the mid-19th century, and seems to have been abandoned after a few decades of use.

192 2.6 Charcoal sampling and identification

193 Sampling was done in a deposit of mixed charcoal, coral and stone fragments in front of the
194 opening of the kiln from a single layer, the stratigraphic unit 1015 (Fig. 2), which probably
195 corresponds to the last firing. The 2-liters deposit was collected in clods with a trowel to avoid
196 charcoal breaking. It was then water-sieved in 4 and 2 mm meshes to retrieve charcoal
197 fragments. Charcoal fragments were then dried away from the direct sunlight to prevent them
198 from bursting.

199 Only fragments > 4 mm were considered for anthracological analysis (Chabal et al. 1999;
200 Scheel-Ybert 2001). Below this size, the identification is harder because fewer anatomical
201 features are visible. This is especially true for the tropical material where there is a strong
202 anatomical homogeneity. Charcoals were observed under a reflected light microscope with
203 dark and bright field, at x100, x200, x500 and x1000 magnifications. In the absence of a
204 reference collection of charred wood from the Lesser Antilles at *the Institut des Sciences de*
205 *l'Evolution de Montpellier*, identification was performed with the help of the charcoal reference
206 collection from French Guiana (Scheel-Ybert 2016), as many taxa are common between the
207 two regions. Specific literature (Détienne and Jacquet 1983; Cirad 1990; Rollet et al. 2010)
208 and identification tools (InsideWood 2004-onwards; Bodin et al. 2019) were also used to
209 complement the comparisons with the reference collection. Many tropical woods are
210 characterized by a homogeneous anatomy, making them difficult to distinguish, especially
211 within the same family. Identification at the genus level is possible in the case of a monogeneric
212 family or when genera present distinguishable anatomical features. Similarly, identification at
213 the species level is only possible in the case of a monospecific genus or when species are
214 anatomically heterogeneous. Poor preservation of charcoal masking diagnostic features or the
215 presence of features common to several taxa led to the designation of morphological types
216 (e.g., type *Lonchocarpus* or Leguminosae type *Lonchocarpus*). A quasi-secured identification
217 is preceded by "cf." for *confer* (e.g., cf. *Spondias* or *Spondias cf. mombin*). When a taxon has
218 an anatomical affinity with another taxon but differs from it in major aspects, it is preceded by
219 the mention "aff." for *affinis*. Finally, when two species may match with the observed features,
220 they are both mentioned (e.g., *Spondias dulcis/mombin*). The nomenclature used follows that
221 of the Angiosperm Phylogeny Group (2016) and that of the Legume Phylogeny Working Group
222 (2017) for the Legume family.

223 3. Results

224 The anthracological analysis resulted in the identification of 183 charcoal fragments out of 207,
225 distributed in 50 taxa including 16 morphological types and 7 indeterminate (Fig. 3). Among
226 the 207 charcoal pieces, 24 were indeterminable due to a very poor preservation (e.g.,
227 vitrification) or because of a distorted anatomical structure (knots). The anthracological
228 assemblage contains an important proportion of Leguminosae (45%) distributed in 19 types of
229 which 6 are assigned to genera or species which have a close anatomy. Among the 207
230 analyzed charcoal fragments, 29% come from twigs and 6% come from knots.

231 **4. Discussion**

232 4.1 Palaeological significance: a firewood collected locally

233 The high number of types in our anthracological spectrum reflects the need of a specific
234 reference collection for study areas with peculiar vegetation composition: even if the reference
235 collection of charred woods from French Guiana helped through the identification process,
236 many taxa are endemic to the Lesser Antilles or simply do not occur in French Guiana.
237 However, building a reference collection is a long process which is not compatible with short
238 projects. This is an issue that was previously underlined during a pioneering research in New
239 Caledonia, another tropical region where anthracological studies are still scarce (Dotte-Sarout
240 2011). Hence, due to the high number of morphological types, the following interpretation relies
241 on a reduced list of taxa that may shed light on the collect of wood used as fuel for the lime
242 kiln. This short list already makes it possible to formulate hypotheses.

243 First, some taxa found in the anthracological assemblage may indicate that wood collection
244 was made in a xerophilic forest. These are *Spondias mombin*, cf. *Zygia latifolia*, an
245 Apocynaceae resembling *Plumeria* sp. and the types *Acacia macracantha* and *Senna*
246 *bicapsularis*. To this list can be added the types *Psidium guajava* and *Citharexylum* which have
247 xero-mesophilic affinities and *Coccoloba*/Sapindaceae which may also correspond to a
248 xerophilic facies (Rollet et al. 2010). It is noteworthy that the porknut *Acacia macracantha*,
249 which was the most abundant taxon in the charcoal assemblage, and the golden apple
250 *Spondias dulcis*, an introduced species from Oceania, are used as firewood and for the
251 production of charcoal (Rollet et al. 2010). Some species of the genera *Citharexylum*,
252 *Coccoloba* and *Plumeria* are also used as firewood and to produce charcoal in the French
253 West Indies, such as the fiddlewood *Citharexylum spinosum*, the seagrape *Coccoloba uvifera*
254 and the frangipani *Plumeria alba* (Rollet et al. 2010; ONF 2015).

255 There are also taxa corresponding to a mesophilic vegetation, which suggest that wood
256 collection was not restricted to the xerophilic forest. These are the breadfruit *Artocarpus altilis*,
257 the amarillon *Lonchocarpus* cf. *heptaphyllus*, which is used as firewood in the Lesser Antilles
258 (Rollet et al. 2010; ONF 2015) and Melastomatoideae. To these taxa can be added the type
259 *Cassipourea guianensis* and two *Inga* morphotypes.

260 Second, other taxa may indicate a pioneer and/or heliophilic vegetation such as *Spondias*
261 *dulcis/mombin*, Melastomatoideae, Salicaceae, cf. *Zygia latifolia*, *Coccoloba*/Sapindaceae and
262 the type *Acacia macracantha*. This suggests that the fuelwood was collected in a secondary
263 forest or in disturbed areas. Three morphological types found in the anthracological
264 assemblage might support the hypothesis of a collection from a secondary forest association.
265 These are the types *Citharexylum*, *Cordia* and *Psidium guajava*. The species of the genus
266 *Citharexylum* are heliophilic, the common guava *P. guajava* is a pioneer and some *Cordia*
267 species are short-lived pioneers, such as *C. alliodora* (Rollet et al. 2010). Interestingly, some
268 *Cordia* species are also used as firewood in the French Antilles, such as the white manjack *C.*
269 *sulcata* (Rollet et al. 2010; ONF 2015). The presence of pioneer and heliophilic taxa may be
270 the result of an intense landscape exploitation.

271 Third, the presence of possible riparian taxa, such as the amarillon *Lonchocarpus* cf.
272 *heptaphyllus*, cf. *Zygia latifolia*, *Spondias mombin* and the type *Senna bicapsularis*, may also
273 suggest that some woods were collected near water courses (Guppy 1917; Portécop 1979;
274 Rollet et al. 2010; ONF 2015).

275 Obviously, the uncertainty of some identifications (e.g., morphological types) requires caution
276 in interpreting their presence. Nevertheless, the presence of xero- to mesophilic, secondary
277 forest and riparian taxa in the anthracological record is coherent with the present-day flora

278 found near the Sucrerie plantation. This suggests that the craftspeople collected the firewood
279 in the vicinity of the plantation, and, given the high number of taxa represented in the
280 anthracological record (50 potential taxa) without any preferential collection of certain species
281 for fuel use. However, it is possible that the craftspeople favored woods with good fuel
282 properties, as suggested by the presence of several taxa known to be used as firewood or for
283 charcoal production.

284 The fact that the wood was collected in the near environment of the lime kiln is consistent with
285 ethnological data from another lime kiln site in Martinique. In Le Lamentin, near Fort-de-
286 France, a retired craftsman told that he used the wood of different mangrove tree species
287 (Vaschalde et al. 2019b). In the bay of Fort-de-France, the mangrove vegetation is abundant,
288 especially near Le Lamentin, which reinforces the idea of local supply. According to the
289 craftsmen of Le Lamentin, mangrove wood was appreciated by the lime kiln workers. In
290 Guadeloupe, this use is attested since the 19th century (Archives de Médecine Navale 1869).
291 In Les Anses-d'Arlet, the mangrove is absent, and no mangrove charcoal was found in the lime
292 kiln. As in Le Lamentin, artisans have harvested wood around the site, and have adapted their
293 practices to local taxa.

294 4.2 On the most abundant taxa: a reflect of the palaeoenvironment or a differential
295 preservation?

296 The most abundant taxa of the anthracological record are the type *Acacia macracantha*,
297 *Lonchocarpus cf. heptaphyllus* and the type *Psidium guajava* which count respectively for 14%,
298 10% and 8.2% of the total number of charcoal fragments, representing together 32.2% of the
299 anthracological record. As there is a large amount of other taxa represented, reaching a total
300 of 50, it is unlikely that these three taxa were preferred as fuelwood and specifically selected
301 by the craftspeople. The dominance of these taxa in the anthracological record may simply
302 reflect their abundance in the environment rather than a wood preference. Similar observations
303 have been made in Europe for potters and lime kiln workers from the historical period (Chabal
304 1997; Vaschalde 2018). Another explanation for their dominance could be a differential
305 preservation leading to an over-fragmentation of charcoals. Several studies have shown that
306 post-depositional processes affect charcoal preservation and can induce a bias in the
307 proportions between taxa (Lancelotti et al. 2010; Théry-Parisot et al. 2010; Chrzazvez et al.
308 2014; Dussol et al. 2017; Henry et al. 2020). To assess the likelihood of the hypothesis of a
309 differential preservation, we would need this kind of data for each of our taxa, which would
310 require time-consuming experiments. Furthermore, this would be applicable only for those
311 which have been securely identified, not for the morphological types. Testing this hypothesis
312 is therefore very difficult.

313 4.3 Collection of cultivated and/or edible species as fuelwood

314 As pointed above, the large amount of potential taxa (*i.e.* including the morphological types)
315 found in charcoals suggest that there was no selection of a specific taxon for fuel use. Even
316 edible species were collected: the breadfruit *Artocarpus altilis*, a species introduced in the late
317 18th century (Leakey 1977), and the hog plum or the golden apple (*Spondias mombin* or *S.*
318 *dulcis*), also both introduced – probably much earlier concerning the hog plum, by natural seed
319 dispersion (Guppy 1917). To these taxa might be added the common guava *Psidium guajava*.
320 The use of edible species as fuel for lime kilns in Martinique has already been reported by
321 Father Labat in the late 17th – early 18th century with the orange tree *Citrus* sp., introduced in
322 the 16th century (Labat 1724; Le Bellec and Le Bellec 2004), and more recently by Vidal *et al.*
323 (2000) with the mango tree *Mangifera indica*, introduced in the 18th century (Le Bellec and Le
324 Bellec 2004). Therefore, it is not surprising to find edible species in the wood used for the
325 functioning of lime kilns. The charcoal from the lime kilns can thus testify to the taxa exploited

326 and/or cultivated within an exploitation specialized in sugar production. In Europe, the
327 presence of exploited/cultivated taxa in anthracological assemblages results from the pruning
328 of fruit trees, as it is the case with vine for example (Ros and Vaschalde, in press). At the
329 Sucrierie plantation, pruning waste from *Spondias dulcis/mombin*, *Artocarpus altilis* and
330 *Psidium guajava* could thus have been harvested for fuel use.

331 4.4 On the presence of charcoals of twigs in the fuel

332 About 30% of the charcoal fragments came from twigs, as revealed by the non-parallel
333 arrangement of the rays in the transverse section. If we consider that the knots also come from
334 twigs or branches, this percentage reaches 36%. It is therefore likely that small-gauge wood
335 was favored by the craftspeople. Several reasons could explain this. First, the abundance of
336 small-gauge wood in the environment, such as in a semi-open forest with small trees and
337 shrubs as suggested by the presence of pioneer and heliophilic taxa (see above). This type of
338 vegetation would be in agreement with the intensive land exploitation by the sugar economy
339 of the 19th century. This has been observed with Mediterranean lime kilns fueled by wood from
340 the *garrigue* or the *maquis* (Vaschalde et al. 2008; 2019a; Vaschalde 2018). Second, this could
341 be due to wood management practices. The managers of the plantation could have wanted to
342 preserve the useful parts of the trees (trunks, main branches) by forbidding them to be cut
343 down. Artisans would have used only small branches, dead wood, or brushwood. This type of
344 practice is attested in the south of France during the modern period (Vaschalde 2018), and
345 would be in agreement with the recovery of supposed pruning waste from fruit trees found in
346 the lime kiln of the Sucrierie plantation.

347 5. Conclusion

348 The study of wood charcoals from the lime kiln of the Sucrierie plantation is one of the firsts
349 from the colonial period in the West Indies. It shows that the lime burners used wood harvested
350 from local vegetation composed of a great diversity of species. This vegetation was open to
351 semi-open, and appears to have been highly impacted by the exploitation of resources.
352 However, tree management practices may have been applied, explaining the important use of
353 small-gauge wood. This management would notably concern cultivated and/or exploited trees
354 and food crops in the plantation. Anthracology makes it thus possible to address issues that
355 cannot be dealt with on the basis of a study of the archives. Thanks to this archaeobotanical
356 approach, we get a better understanding on how lime burners managed woody vegetation
357 during the colonial period. Further research is however needed on this kind of activity in the
358 Antilles, and it is necessary to study a greater number and diversity of archaeological sites
359 from the colonial period to able comparisons between practices used in other islands of the
360 archipelago. Finally, it is also necessary to carry out floristic surveys of the current vegetation
361 around the sites in order to highlight the impact of the colonial sugar economy on the present-
362 day environment.

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370 **SB, CV** and **DO** wrote the manuscript. **CV** did fieldwork (charcoal extraction and sieving), **DO**
371 led the archaeological excavation and **SB** did charcoal identification.

372 7. References

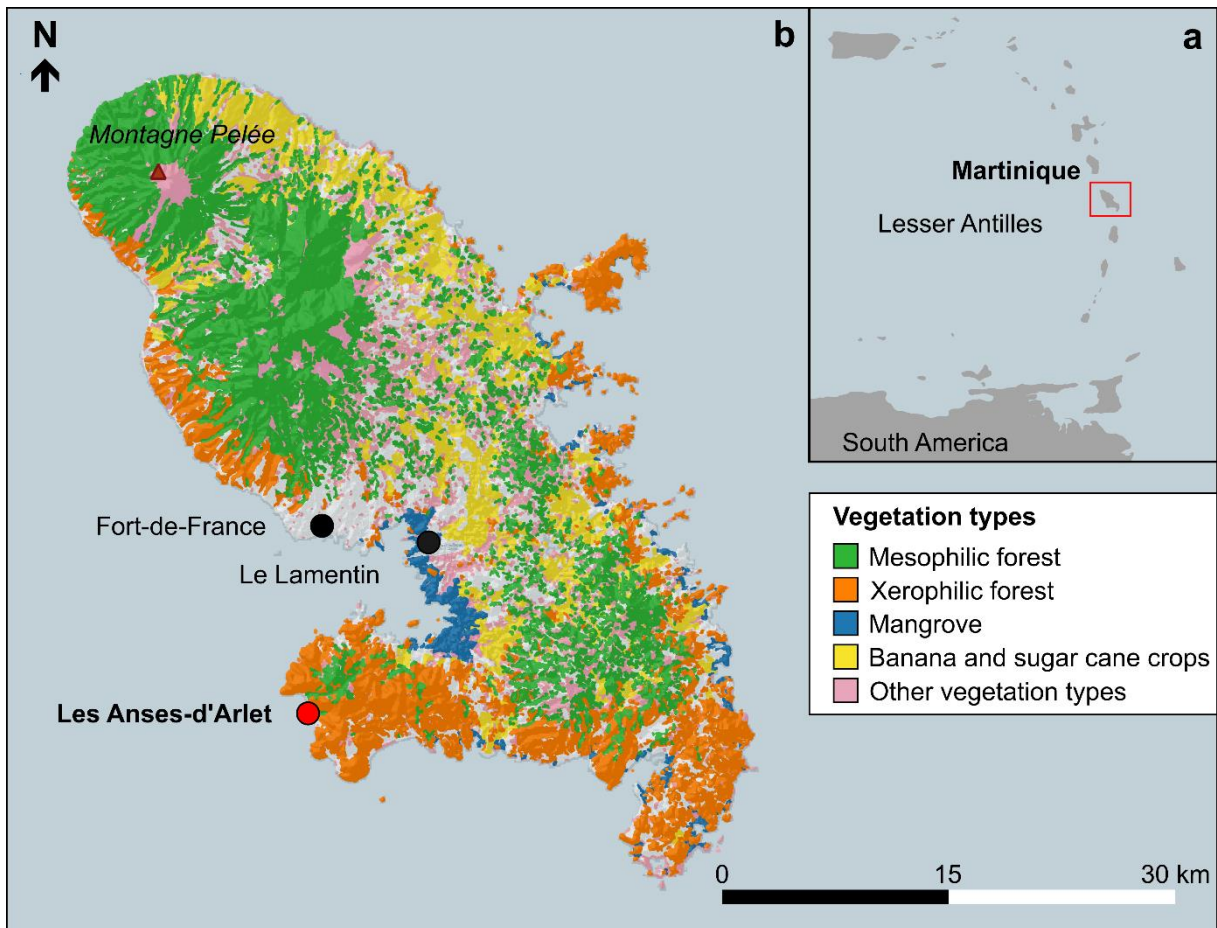
- 373 Amouric H (2010) Projet Collectif de Recherche Interrégional « Poteries des îles françaises
374 d'Amérique : XVIIe-XXe siècles. SRA Martinique, service des patrimoines de la Guadeloupe,
375 Aix-en-Provence
- 376 Amouric H (2011) Projet Collectif de Recherche Interrégional « Poteries des îles françaises
377 d'Amérique : XVIIe-XXe siècles. SRA Martinique, service des patrimoines de la Guadeloupe,
378 Aix-en-Provence
- 379 Amouric H (2012) Projet Collectif de Recherche Interrégional « Poteries des îles françaises
380 d'Amérique : XVIIe-XXe siècles. SRA Martinique, service des patrimoines de la Guadeloupe,
381 Aix-en-Provence
- 382 Amouric H (2013) Projet Collectif de Recherche Interrégional « Poteries des îles françaises
383 d'Amérique : XVIIe-XXe siècles. SRA Martinique, Aix-en-Provence
- 384 Amouric H (2015) Projet Collectif de Recherche Interrégional « Poteries des îles françaises
385 d'Amérique : XVIIe-XXe siècles. SRA Martinique, Aix-en-Provence
- 386 Amouric H, Guionova G, Vallauri L (2007) Projet collectif de Recherche Interrégional : Poteries des îles
387 françaises de l'Amérique, productions locales et importées, XVIIe-XXe siècles. SRA
388 MARTinique ; LA3M
- 389 APG (2016) An update of the Angiosperm Phylogeny Group classification for the orders and families
390 of flowering plants: APG IV. Bot J Linn Soc 181:1–20 . <https://doi.org/10.1111/boj.12385>
- 391 Archives de Médecine Navale (1869) Tome XII : étude sur l'eau thermo-minérale du puits artésien de
392 l'hôpital maritime de Rochefort, J.-B. Baillière. Librairies de l'Académie Impériale de
393 Médecine, Paris
- 394 Bachelet C, Scheel-Ybert R (2017) Landscape and firewood selection in the Santa Elina rock shelter
395 (Mato Grosso, Brazil) during the Holocene. Quaternary International 431:52–60 .
396 <https://doi.org/10.1016/j.quaint.2015.12.019>
- 397 Beauclair M, Scheel-Ybert R, Bianchini GF, Buarque A (2009) Fire and ritual: bark hearths in South-
398 American Tupiguarani mortuary rites. Journal of Archaeological Science 36:1409–1415
- 399 Bégot D (2008) Le planteur vigilant et l'atelier fortuné : Jean-Baptiste Poyen de Sainte-Marie et les
400 conseils d'un vieux planteur aux jeunes agriculteurs des colonies. In: La plantation coloniale
401 esclavagiste XVIIe-XIXe siècles. CTHS, Paris, Nancy, 2002, pp 47–88
- 402 Bégot D, Bousquet-Bressolier C, Pelletier M (1998) La Martinique de Moreau du Temple, 1770. La
403 carte des ingénieurs géographes. CTHS, Paris
- 404 Bianchini GF, Scheel-Ybert R (2011) Plants for life and death: evidence of use of plant resources in
405 funerary activities of shellmound builders through the anthracological analysis of
406 Jabuticabeira-II site (Santa Catarina, Brazil). 2
- 407 Blérald AP (1986) Histoire économique de la Guadeloupe et de la Martinique : du XVIIe siècle à nos
408 jours. KARTHALA Editions, Paris

- 409 Bodin SC, Molino J-F, Odonne G, Bremond L (2020) Unraveling pre-Columbian occupation patterns in
410 the tropical forests of French Guiana using an anthracological approach. *Veget Hist*
411 *Archaeobot.* <https://doi.org/10.1007/s00334-019-00767-w>
- 412 Bodin SC, Scheel-Ybert R, Beauchêne J, Molino J-F, Bremond L (2019) CharKey: An electronic
413 identification key for wood charcoals of French Guiana. *IAWA Journal* 40:75–91
- 414 Bonnet N (2008) Les production sucrière à Saint-Domingue dans la seconde moitié du XVIIIe siècle :
415 étude des comptes de deux habitations. In: *La plantation coloniale esclavagiste XVIIe-XIXe*
416 *siècles.* CTHS, Paris, Nancy, 2002, pp 165–185
- 417 Bruneau-Latouche E, Cordiez C, Cordiez P (2002) 209 anciennes familles subsistantes de la
418 Martinique : notices généalogiques, acquisitions, ventes, échanges, alliances et
419 descendance antérieurs à 1901. E. Bruneau-Latouche. [Livry-Gargan], Aix-en-Provence/Fort-
420 de-France/Paris
- 421 Chabal L (1997) Forêts et sociétés en Languedoc (Néolithique final, Antiquité tardive).
422 L'anthracologie, méthode et paléoécologie, Editions de la Maison des Sciences de l'Homme.
423 Editions de la Maison des Sciences de l'Homme, Paris
- 424 Chabal L, Fabre L, Terral JF, Théry-Parisot I (1999) L'anthracologie. In: Bourquin-Mignot C, Brochier J,
425 Chabal L, Crozat S, Fabre L, Guibal F, Marival P, Richard H, Terral JF, Théry-Parisot I (eds) *La*
426 *botanique.* Errance, Paris, pp 43–104
- 427 Charlery C (2004) Maisons de maître et habitations coloniales dans les anciens territoires français de
428 l'Amérique tropicale. In *Situ Revue des patrimoines.* <https://doi.org/10.4000/insitu.2362>
- 429 Chrzazvez J, Théry-Parisot I, Fiorucci G, Terral J-F, Thibaut B (2014) Impact of post-depositional
430 processes on charcoal fragmentation and archaeobotanical implications: experimental
431 approach combining charcoal analysis and biomechanics. *Journal of Archaeological Science*
432 44:30–42 . <https://doi.org/10.1016/j.jas.2014.01.006>
- 433 Cirad (1990) Bois des DOM-TOM. Tome 2 : Antilles françaises. Centre Technique Forestier Tropical,
434 Nogent-Sur-Marne
- 435 Cloarec-Quillon A, Ollivier D, Thiriou J (2015) Production locale de formes à sucre pour l'industrie
436 sucrière de la Martinique, l'exemple de la poterie Dalençon au Marin. Ankara : Koç University
437 VEKAM, Antalya, Turkey, pp 179–187
- 438 Conservation International (2020) Caribbean Islands - Species | CEPF. [https://www.cepf.net/our-](https://www.cepf.net/our-work/biodiversity-hotspots/caribbean-islands/species)
439 [work/biodiversity-hotspots/caribbean-islands/species.](https://www.cepf.net/our-work/biodiversity-hotspots/caribbean-islands/species) Accessed 24 Apr 2020
- 440 Détienne P, Jacquet P (1983) Atlas d'identification des bois de l'Amazonie et des régions voisines.
441 Centre Technique Forestier Tropical, Nogent-Sur-Marne
- 442 Dotte-Sarout E (2011) Evaluating methods and results for the application of anthracology to high
443 diversity and high endemism environments: Case study in the Tiwaka Valley, north-eastern
444 Grande Terre of New Caledonia. *SAGVNTVM Extra* 11:41–42
- 445 Doumenge F, Monnier Y (1989) Les Antilles françaises. PUF, Paris
- 446 Dussol L, Elliott M, Théry-Parisot I (2017) Experimental anthracology: Evaluating the role of
447 combustion processes in the representivity of archaeological charcoal records in tropical

- 448 forests, a case study from the Maya Lowlands. *Journal of Archaeological Science: Reports*
449 12:480–490 . <https://doi.org/10.1016/j.jasrep.2017.02.020>
- 450 Elisabeth L (2005) Avant-Propos. Emile Hayot et sa place dans l'histoire des livres de couleur. In: *Les*
451 *gens de couleur libres du Fort-Royal 1679-1823*. Société française d'histoire d'outre-mer,
452 Paris, pp 1–3
- 453 England S (1994) *Acculturation in the Creole context : a case study of La Poterie Martinique*. Thesis,
454 University of Cambridge
- 455 England S (1997) *Prospection des poteries historiques à la Martinique*. SRA Martinique
- 456 Fernandes Caromano C, Cascon LM, Neves EG, Scheel-Ybert R (2013) Revealing Fires and Rich Diets:
457 Macro- and Micro-archaeobotanical Analysis at the Hatahara Site, Central Amazonia. *Tipití:*
458 *Journal of the Society for the Anthropology of Lowland South America* 11:40–51
- 459 Fiard J (1994) *Les forêts du nord de la Montagne Pelée et des édifices volcaniques du Piton Mont*
460 *Conil et du Morne Sibérie (Martinique)*. PhD dissertation, Université Antilles-Guyane
- 461 Flohic J-L, et al. (1998) *Le patrimoine des communes de la Martinique*. Attique, Paris
- 462 Fournet J, Sastre C (2002) Progrès récents dans la connaissance de la flore de Guadeloupe et de
463 Martinique. *Acta Botanica Gallica* 149:481–500 .
464 <https://doi.org/10.1080/12538078.2002.10515977>
- 465 Guppy H (1917) *Plants, seeds, and currents in the West Indies and Azores; the results of*
466 *investigations carried out in those regions between 1906 and 1914*. Williams and Norgate,
467 London
- 468 Henry A, Coli VL, Valdeyron N, Théry-Parisot I (2020) Old taphonomy issues, new charcoal data for
469 Mesolithic contexts: Impact of fragment size and sampling context on the assemblages of
470 Escabasses cave (SW France). *Journal of Archaeological Science: Reports* 30:102232 .
471 <https://doi.org/10.1016/j.jasrep.2020.102232>
- 472 InsideWood (2004) Published on the Internet. <http://insidewood.lib.ncsu.edu/search>
- 473 Kelly K (2004) Historical Archaeology in the French Caribbean: An Introduction to a Special Volume of
474 the *Journal of Caribbean Archaeology*. *Journal of Caribbean Archaeology* 1:1–10
- 475 Kelly K (2013) La vie quotidienne des habitations sucrières aux Antilles : l'archéologie à la découverte
476 d'une histoire cachée. In *Situ Revue des patrimoines*. <https://doi.org/10.4000/insitu.10160>
- 477 Kelly K, Bérard B (2014) *Bitation, archéologie des habitations/plantations des Petites Antilles*.
478 Sidestone Press, Leiden
- 479 Labat J-B (1724) *Nouveau voyage aux isles de l'Amérique*. La Haye
- 480 Lancelotti C, Madella M, Ajithprasad P, Petrie CA (2010) Temperature, compression and
481 fragmentation: an experimental analysis to assess the impact of taphonomic processes on
482 charcoal preservation. *Archaeol Anthropol Sci* 2:307–320 . [https://doi.org/10.1007/s12520-](https://doi.org/10.1007/s12520-010-0046-8)
483 [010-0046-8](https://doi.org/10.1007/s12520-010-0046-8)
- 484 Le Bellec F, Le Bellec V (2004) *A la découverte des fruits des Antilles*. PLB Editions

- 485 Leakey C (1977) Breadfruit reconnaissance study in the Caribbean region. Centro Internacional de
486 Agricultura Tropical (CIAT), Inter-American Development Bank, Cali, Colombia
- 487 Louis-Alexandre M (1985) Les Anses d'Arlet, Habitation La Sucrierie. DAC Martinique
- 488 LPWG (2017) A new subfamily classification of the Leguminosae based on a taxonomically
489 comprehensive phylogeny. *Taxon* 66:44–77
- 490 Mousnier M, Caille Br (1990) Atlas historique du patrimoine sucrier de la Martinique (XVIIè-XXè s.).
491 L'Harmattan, Paris
- 492 Moussette M, Waselkov GA (2013) Archéologie de l'Amérique coloniale française. Lévesque éditeur,
493 Montréal
- 494 Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J (2000) Biodiversity hotspots for
495 conservation priorities. *Nature* 403:853–858 . <https://doi.org/10.1038/35002501>
- 496 Newsom L, Molengraaff J (1999) Paleoethnobotanical analysis. In: Hofman CL, Hoogland MLP (eds)
497 Archaeological investigations on St. Martin (Lesser Antilles): the sites of Norman Estate, Anse
498 des Pères and Hope Estate with a contribution to the "La Hueca problem." Faculty of
499 Archaeology, Leiden University, The Netherlands, p 329
- 500 Ollivier D, Vaschalde C (2015) Habitation La Sucrierie : Fouille du four à chaux. La Martinique, les
501 Anses-d'Arlet. LA3M-CNRS/Aix-Marseille Université
- 502 ONF (2015) Guide de reconnaissance des arbres de Guadeloupe. Office National des Forêts, Direction
503 Régionale de Guadeloupe
- 504 Peel MC, Finlayson BL, McMahon TA (2007) Updated world map of the Köppen-Geiger climate
505 classification. *Hydrology and Earth System Sciences Discussions* 4:439–473
- 506 Portécop J (1979) Phytogéographie, cartographie écologique et aménagement dans une île tropicale.
507 Le cas de la Martinique. Grenoble
- 508 Rollet B, Fiard J, Huc R (2010) Arbres des Petites Antilles. Tome 2 : Description des espèces. Office
509 National des Forêts, Basse-Terre (Guadeloupe)
- 510 Ros J, Vaschalde C (In press) De l'exploitation de la Vigne en Roussillon antique et médiéval : bilan
511 archéobotanique. In: Actes de la table-ronde de Madrid. Casa de Velazquez, Madrid
- 512 Scheel-Ybert R (2001) Man and Vegetation in Southeastern Brazil during the Late Holocene. *Journal*
513 *of Archaeological Science* 28:471–480 . <https://doi.org/10.1006/jasc.2000.0577>
- 514 Scheel-Ybert R (2016) Charcoal collections of the world. *IAWA Journal* 37:489–505 .
515 <https://doi.org/10.1163/22941932-20160148>
- 516 Scheel-Ybert R, Beauclair M, Buarque A (2014) The forest people: landscape and firewood use in the
517 Araruama region, southeastern Brazil, during the late Holocene. *Vegetation History and*
518 *Archaeobotany* 23:97–111 . <https://doi.org/10.1007/s00334-013-0397-z>
- 519 Tardy C (2001) Rapport anthracologique du site archéologique de Vivé (Martinique). In: Bérard B (ed)
520 Le Néolithique martiniquais dans son contexte antillais. Rapport de PCR, SRA Martinique,
521 Fort-de-France

- 522 Tardy C, Vernet JL, Servant M, Fournier M, Leprun J-C, Pessenda LC, Sifeddine A, Solari ME, Soubiès F,
523 Turcq B, Wengler L, Vacher S, Jérémie S, Ceccantini G, Cordeiro R, Scheel R (2000) Feux, sols
524 et écosystèmes forestiers tropicaux. In: Servant M, Servant Vildary S (eds) Dynamique à long
525 terme des écosystèmes forestiers intertropicaux. IRD, Paris, pp 343–348
- 526 Théry-Parisot I, Chabal L, Chrzavzez J (2010) Anthracology and taphonomy, from wood gathering to
527 charcoal analysis. A review of the taphonomic processes modifying charcoal assemblages, in
528 archaeological contexts. *Palaeogeography, Palaeoclimatology, Palaeoecology* 291:142–153 .
529 <https://doi.org/10.1016/j.palaeo.2009.09.016>
- 530 Thiriot J, Ollivier D, Rinalducci V (2012) Fouiller les encyclopédistes : transfert de modèles aux Antilles
531 françaises. In: Gonçalves MJ, Gómez Martínez S (eds). Câmara Municipal de Silves/Campo
532 Arqueológico de Mértola, Silves, Portugal, pp 560–572
- 533 Vaschalde C (2018) Fours à chaux et chaufourniers en France méditerranéenne du moyen âge à
534 l'époque moderne. Approche interdisciplinaire autour des techniques, des savoir-faire et des
535 artisans. Editions Mergoil, Drémil-Lafage
- 536 Vaschalde C, Bodin S, Chauvin A, Guionova G, Latournerie J, Ollivier D, Volpe T (2017) La
537 chaufournerie en Martinique. Prospection triennale (2017-2019). 2017 : la côte atlantique.
538 DAC Martinique
- 539 Vaschalde C, Duperron G, Doniga A (2019a) Le four à chaux FR1430 de Saint-Martin-le-Bas (Gruissan,
540 Aude) : éclairage interdisciplinaire sur la chaufournerie en pays narbonnais aux XIe-XIIIe
541 siècles. *Archéologie médiévale* 53–86
- 542 Vaschalde C, Durand A, Thiriot J, Figueiral I (2008) Charcoal analysis of lime kiln remains in Southern
543 France: an original process of mediaeval and modern traditional lime burning. Bruxelles,
544 Belgium, pp 251-258,
- 545 Vaschalde C, Latournerie J, Guionova G, Volpe T (2016) Fours à chaux et chaufourniers en
546 Martinique. Prospection dans la partie Sud de l'île (2015). DAC Martinique
- 547 Vaschalde C, Latournerie J, Ollivier D, Serra L (2019b) La chaufournerie en Martinique. Prospection
548 triennale (2017-2019). 2018 : de la baie de Fort-de-France au Prêcheur. DAC Martinique
- 549 Verrand L, Vidal N (2004) Les fours à chaux de Martinique. *Journal of Caribbean Archaeology*, Special
550 publication 1:29–46
- 551 Vidal N (1994) Le fonctionnement et l'évolution du système de chauffe des habitations-sucreries
552 traditionnelles, à la Martinique, entre le XVIIe et le début du XIXe siècle. *Caribena* 4:137–152
- 553 Vidal N, Verrand L, Guillaume M (2000) Tout autour du four. La fabrication artisanale de la chaux en
554 Martinique, structures et savoir-faire. In: Le sucre, de l'Antiquité à son destin antillais. CTHS,
555 Paris, Antilles-Guyane, p 187
- 556



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558 Caption Figure 1: a. Location of Martinique in the Lesser Antilles. b. Location of Les Anses-
 559 d'Arlet in Martinique, where the Sucrierie homestead and its lime kiln are situated, and main
 560 vegetation types of the island. Origin of the data: IGN OCS GE 2017, ESRI World Light Gray
 561 Base, DEM SRTM 1 and viewfinderpanoramas.org.

