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Local production and long-distance procurement of beads and pendants with high mineralogical diversity in an early Saladoid settlement of Guadeloupe (French West Indies)

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Abstract

The preventive excavation of an archaeological site located at the Gare Maritime of Basse-Terre (Guadeloupe, French West Indies) revealed a series of stone artifacts including finished beads and pendants, as well as pieces representing several stages of the *chaîne opératoire*. This work is an integrated study of the mineralogy and typo-technology of these objects. The artifacts have been recovered from layers interpreted as midden deposits of an early Saladoid coastal settlement dated to 250 – 400 A.D. Non-invasive analyses by Raman spectroscopy have shown that the 50 artifacts belong to 13 different gemstones which are, in decreasing order of frequency: serpentine, amethyst, turquoise, sudoite, rock crystal, calcite, feldspar, diorite, jasper, aventurine, chlorite, paragonite and nephrite. All these materials' mineralogy, and in particular the great diversity of the so called "green rocks", could only be reliably determined through an analytical characterization. The diversity of

34 lithic materials used and abandoned in the Gare Maritime site dump is the largest known to
35 date in the Caribbean archipelago. The presence of seven objects in turquoise is particularly
36 noteworthy in view of its rarity in the other known sites in the region. The *chaîne opératoire*
37 for each of these raw materials could be approached for the first time in the Caribbean area
38 by emancipating ourselves from the “greenstone” category, which has been too often used
39 in the past because of the lack of reliable mineralogical identification. These results make it
40 possible to integrate the Gare Maritime site into the group of Saladoid sites which have
41 delivered a large set of ornamental elements. On the one hand, the various shapes of
42 artifacts fit the regional cultural pattern, both for beads and pendants shapes, the latter being
43 mainly stylized frogs. On the other hand, the use of 13 semi-precious stones in the lapidary
44 production is exceptional for the region and confirms the use at this period of many exotic
45 raw materials. The provenance of these materials, although difficult to pinpoint properly due
46 to the incomplete mapping of regional resources, documents a mixture of regional and even
47 distant (continental) origins, thus strengthening the idea of a pan-Caribbean network for the
48 exchange of raw materials for lapidary art.

49

50 **Keywords**

51 Caribbean archaeology; Beads technology; Raman spectroscopy; Stone beads; Lapidary
52 art; Raw materials; Gemstones

53

54 **Highlights**

- 55 - An early saladoid archaeological site in Guadeloupe yielded 50 lapidary artifacts
- 56 - Thirteen different raw materials were identified through Raman spectroscopy
- 57 - The *chaînes opératoires* for each material has been documented
- 58 - Raman spectroscopy was mandatory to identify eight different *greenstone* gems
- 59 - The highlighted use of exotic gemstones fits the Saladoid pan-Caribbean network
60 model

61

62 **1. INTRODUCTION**

63 The Saladoid series, also considered as the Saladoid phenomenon, is the first series of
64 the Ceramic Age in the Antilles (Rouse, 1992). It develops inland and coastlands in South
65 America, probably since 2500 BC (Berard, 2013; Rouse and Cruxent, 1963) and expands
66 towards the Antilles from 500 BC until ca. 1000 AD, depending on the islands. These
67 migrating groups replaces and probably acculturate mutually with the former preceramic
68 occupants of the Antilles. Their subsistence is based on horticulture associated with hunting,

69 fishing and foraging, while their material production is based on highly decorated ceramic,
70 a simple lithic industry and polished axes produced from rocks and shells. The coastal and
71 maritime area of dispersion of this culture embraces the Northeastern coast of South
72 America and the whole of the Antilles as far north as Puerto Rico (Berard, 2013; Bonnissent,
73 2010; Hofman et al., 2007; Rouse, 1992).

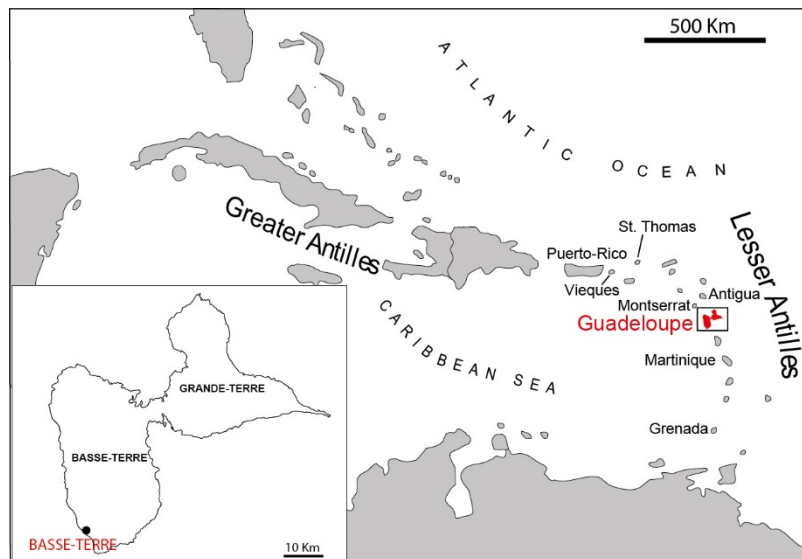
74 Several Saladoid archaeological sites have yielded mineral beads and pendants in the
75 Lesser Antilles during the past decades (Bullen and Bullen, 1972; Cody, 1991; Crock and
76 Bartone, 1998; Fewkes, 1903; Gent and de Mille, 2003; Harris, 1980; Haviser, 1991; Henocq
77 et al., 1995; Mattioni, 1979; Murphy et al., 2000; Watters and Scaglione, 1994) and these
78 special artifacts have been the basis of numerous hypothesis regarding diffusion networks
79 and sociopolitical organization. Indeed, the diffusion of these artifacts made in "exotic"
80 material among the West Indies during the Saladoid period (500 BC-1000 AD) has been
81 one of the bases for the idea of a pan-Caribbean network (Cody, 1993; Hofman et al., 2007;
82 Knippenberg, 2007; Rodriguez, 1993; Rodriguez Ramos, 2010; Watters, 1997). The
83 lapidary production, estimated as highly valuable for several reasons such as rarity of
84 suitable raw material, time and technological investment to produce them, has also been
85 used for reflection on the "big man collectivities" vs. "complex tribe" models (Boomert, 1999;
86 Righter, 2003).

87 Exotic provenance of most of the West Indian lapidary artifacts is frequently underlined,
88 but with poor arguments on the exact provenance of their raw material which is generally
89 related to an incomplete mineralogical description (Cody, 1993; Crock and Bartone, 1998;
90 Righter, 2003; Roobol and Lee, 1976). The only mineralogical study being the one by
91 Murphy *et al.* (2000) for three sites in Antigua. Stylistic observation and ethnographical
92 observations have also entered the discussion, pointing to different geographical
93 provenance (Boomert, 1987; Narganes Storde, 1995; Rodriguez Ramos, 2011) but with no
94 formal evidence. Among the sites yielding mineral beads, some of them are also considered
95 as lapidary sites dedicated to the transformation of one material, like Pearls (Grenada) for
96 the amethyst (Cody, 1991), Trants (Montserrat) or sites from Antigua for the cornelian
97 (Murphy et al., 2000; Watters and Scaglione, 1994). As Roobol & Lee (1976) already pointed
98 out, precise greenstone attribution "could provide an estimate of inter-island trade or
99 migration within the Greater Antilles", this statement obviously also stands for Lesser
100 Antilles. Recent geological discoveries have renewed the knowledge on the geographical
101 distribution of natural occurrences of some symbolically used minerals/rocks and especially
102 jadeitite (Cárdenas-Párraga et al., 2010; García-Casco et al., 2009; Harlow et al., 2006;
103 Rodriguez Ramos, 2011; Schertl et al., 2012). It offers the opportunity of some more precise
104 artifact provenance definition.

105 In this context, the excavation of the Gare Maritime Saladoid site in Basse-Terre
106 (Guadeloupe, French West Indies), during preventive archeological excavation, yielded a
107 large collection of beads and pendants. It gives us the opportunity of an exhaustive
108 mineralogical and technological study in order to document their *chaîne opératoire*. This
109 knowledge, indeed, lacks for Guadeloupe, a large territory of the Leeward Islands, which
110 had not previously yielded lapidary site and for which the beads and pendants are known
111 only by the impressive discoveries at Morel (Durand and Petitjean Roget, 1991; Hamy,
112 1884) or of recent excavations in Basse-Terre (Bonnissent and Romon, 2004; Etrich,
113 2003a). The precise mineralogical identification of the Gare Maritime collection was reached
114 thanks to a non-invasive analytical approach based on Raman spectroscopy. Applying an
115 integrative technological study and an accurate mineralogical characterization to this new
116 collection is thus of great interest to improve both our knowledge about the *chaîne opératoire*
117 of beads and pendants and the diffusion of exotic minerals in the Lesser Antilles during the
118 early Saladoid.

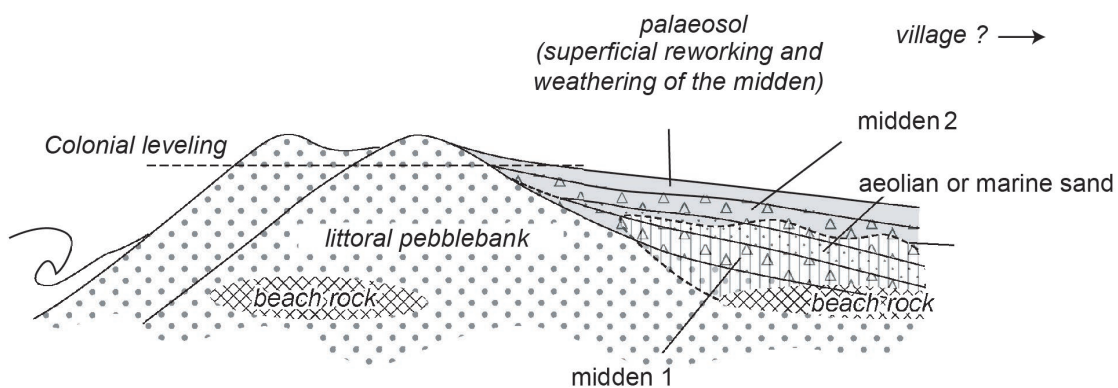
119 **2. ARCHAEOLOGICAL CONTEXT**

120 The archaeological site of Gare Maritime is located in the present-day commercial
121 harbor of Basse-Terre city, the regional capital of Guadeloupe (Fig. 1). Nowadays it is ca.
122 one hundred meters from the actual harbor dock, but during pre-Columbian times it was
123 located just behind the littoral pebble bank and on a river bank (Fig. 2). Although its
124 stratigraphy is separated into several units, the geoarchaeological, lithic and ceramic studies
125 converge towards a rather long but single occupation of the site (Romon et al., 2013). The
126 multiple layers are interpreted as a Huecan Saladoid (or Huecoid depending of the authors)
127 midden separated in two main stratigraphic units by a very short event of sand deposition,
128 possibly related to a violent storm. The excavation corresponds to a small part of the site,
129 only represented by its coastal zone. The settlement area was presumably located further
130 inland, and could be preserved under a modern square. The pre-Columbian occupation is
131 well dated to 250-400 cal. A.D. with several radiocarbon dates related to the different
132 stratigraphic units, only the very top layer being slightly more recent (Romon et al., 2013).
133 This study concerns the 50 mineral artifacts which have been recovered during the manual
134 excavation of 28 m² of the pre-Columbian layers.



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Figure 1. Map of the regional and local position of the archaeological site of Gare Maritime, in Basse-Terre city. The islands hosting the archaeological sites mentioned in the text are also indicated.



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Figure 2. Interpretative section of the Gare Maritime site representative of the Pre-columbian period (modified after Bertran P. in Romon, 2013).

143 3. MATERIALS AND METHODS

144 All the fifty mineral artifacts related to beads or pendants production recovered from
145 the site have been studied in this work (Table 1, Fig. 3). They come from different layers
146 and most of them have been recovered thanks to the systematic wet sieving with a 3 mm
147 mesh of the full amount of sediment manually excavated during the archaeological
148 operation.

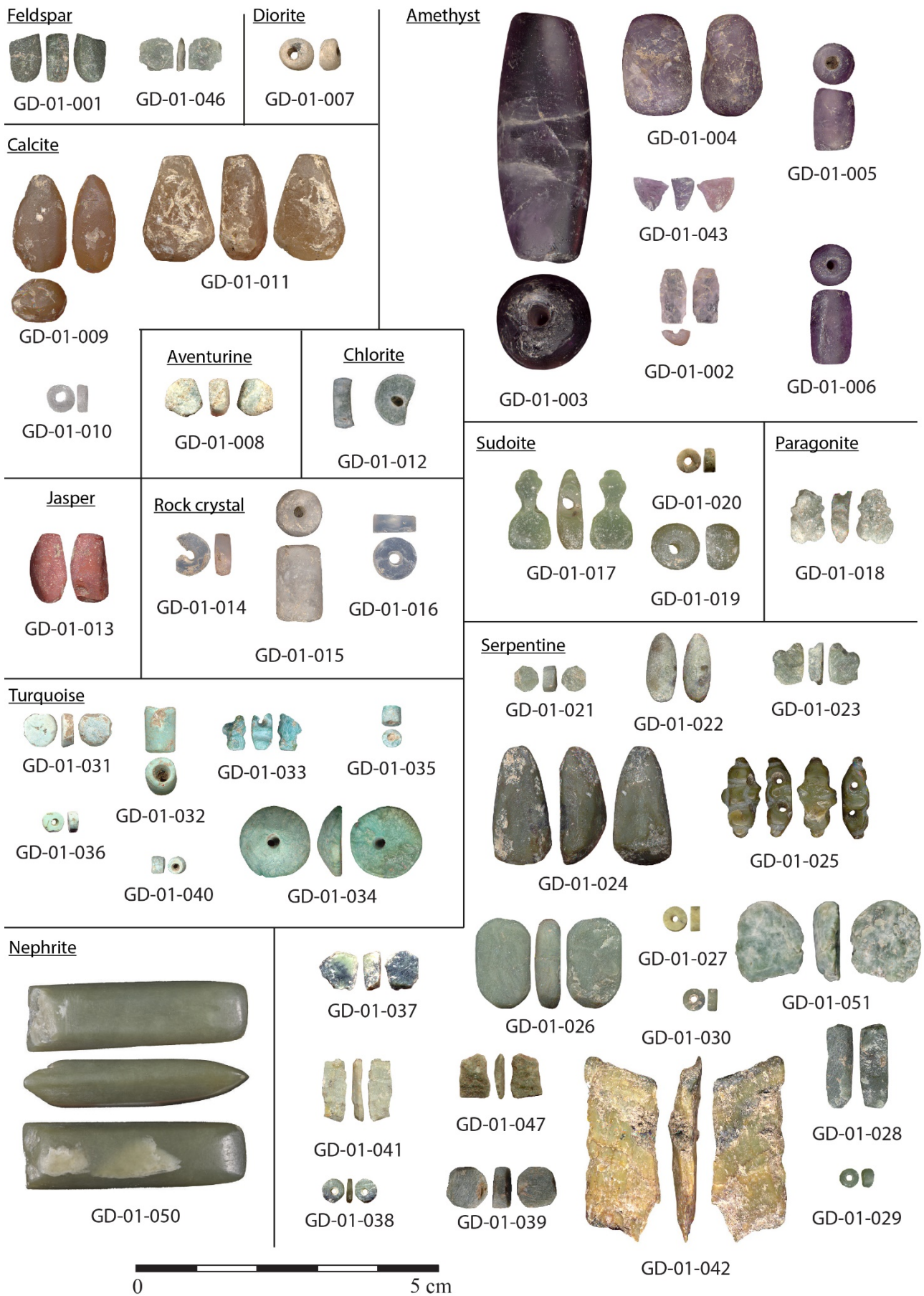
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Artefact reference number	Bead length	Bead diameter	Perforation diameter	Weight	Perforation type	Final object	State	Gemological name	Identified minerals
	Pendant height	Pendant width	Pendant/blank thickness						
	(mm)	(mm)	(mm)		(g)				
GD-01-001	7,3	5,9	4,2	0,28	-	Tablet	Raw material	Feldspar	Albite + Paragonite
GD-01-002	9,1	4,2	1,8	0,12	Drilled from both ends	Long tubular bead	Finished / broken	Amethyst	Quartz
GD-01-003	41,7	16	2 - 3	15,96	Drilled from both ends	Long barrel bead	Finished	Amethyst	Quartz
GD-01-004	17	11,5	10,5	3,06	-	Tubular	Blank	Amethyst	Quartz
GD-01-005	10,4	7	2	0,78	Drilled from both ends	Long barrel bead	Finished	Amethyst	Quartz
GD-01-006	12,4	7	2	1	Drilled from both ends	Long tubular bead with convex ends	Finished	Amethyst	Quartz
GD-01-007	3,7	5,6	1,8	0,16	Drilled from both ends	Short barrel bead	Finished	Diorite	Anorthite + Diopside
GD-01-008	3	6	-	0,19	-	Polygonal	Blank	Aventurine	Quartz + Muscovite + Surfacic calcite
GD-01-009	16,3	9,2	7,5	1,52	-	Droplet bead/pendant?	Blank	Calcite	Calcite
GD-01-010	2	4,6	1,8	0,05	Double cone	Discoid tubular bead	Finished	Calcite	Calcite
GD-01-011	18	12	7	2,26	-	Droplet bead/pendant?	Blank	Calcite	Calcite
GD-01-012	3,2	8,3	-	0,29	Drilled from both ends	Discoid barrel bead	Finished / broken	Chlorite	Clinochlore
GD-01-013	11,7	5,9	5,7	0,51	-	Barrel	Blank	Cornelian	Quartz + Moganite + Hematite
GD-01-014	2,8	6,9	2	0,15	Chamfered	Discoid barrel bead	Finished / broken	Rock crystal	Quartz
GD-01-015	12,9	7,7	2	1,32	Drilled from both ends	Long tubular bead	Finished	Rock crystal	Quartz
GD-01-016	3	7,1	1,8	0,27	Chamfered	Discoid tubular bead	Finished	Rock crystal	Quartz
GD-01-017	13,9	7,2	4,2	0,48	Double cone + Plain	Pendant	Finished	Sudoite	Sudoite
GD-01-018	9	6	3,1	0,25	Drilled from both ends	Pendant	Finished / broken	Paragonite	Paragonite
GD-01-019	6,2	7,9	2	0,5	Drilled from both ends	Short barrel bead, wedge-shaped	Finished	Sudoite	Sudoite + Gypsum + Clinochlore
GD-01-020	2,1	4,2	1,5	0,06	Drilled from both ends	Short tubular bead	Finished	Sudoite	Sudoite + Gypsum + Clinochlore
GD-01-021	2,1	4	-	0,06	-	Polygonal	Blank	Serpentine	Antigorite

GD-01-022	11	4,3	-	0,33	-	Droplet bead/pendant?	Blank	Serpentine	Antigorite + Magnetite inclusions
GD-01-023	6,1	5,8	2,4	0,13	-	Polygonal	Blank	Serpentine	Antigorite + Microcharcoals
GD-01-024	19,9	9,7	6, 2	1,55	-	Droplet bead/pendant?	Blank	Serpentine	Antigorite
GD-01-025	13,4	6,5	4,5	0,39	Double cone	Pendant	Finished	Serpentine	Antigorite
GD-01-026	15	9,2	4,5	1	-	Oval	Blank	Serpentine	Antigorite + Hematite
GD-01-027	2	4	1	0,05	Drilled from both ends	Short tubular bead	Finished	Serpentine	Antigorite
GD-01-028	13,9	4,8	4	0,46	-	Tubular	Blank	Serpentine	Antigorite + Magnetite inclusions
GD-01-029	1,7	3,2	1	0,02	Drilled from both ends	Short tubular bead, wedge-shaped	Finished	Serpentine	Antigorite
GD-01-030	1,6	3,7	0,9	0,04	Drilled from both ends	Discoid tubular bead, wedge-shaped	Finished	Serpentine	Antigorite
GD-01-031	2,1	5,7	-	0,13	-	Discoid	Blank	Turquoise	Turquoise + Gypsum + Labradorite + Charcoal
GD-01-032	7,7	5,3	2,1	0,31	Drilled from both ends	Long tubular bead	Finished	Turquoise	Turquoise
GD-01-033	"6	"3,9	3,6	0,11	Double cone	Pendant	Finished / broken	Turquoise	Turquoise
GD-01-034	4,2	12	1,9	0,76	Drilled from both ends	Discoid plano-convex bead	Finished	Turquoise	Turquoise
GD-01-035	2,9	3,1	1,4	0,05	Drilled from both ends	Short tubular bead	Finished	Turquoise	Turquoise
GD-01-036	1,7	3,7	1	0,03	Drilled from both ends	Discoid tubular bead	Finished	Turquoise	Turquoise + Gypsum
GD-01-037	2,9	6,5	2,9	0,18	-	Polygonal	Blank	Serpentine	Antigorite + Clinocllore
GD-01-038	1,1	4,2	0,9	0,1	Drilled from both ends	Discoid	Blank	Serpentine	Antigorite
GD-01-039	2,9	7	-	0,22	-	Discoid	Blank	Serpentine	Antigorite
GD-01-040	2	2,8	1	0,02	Drilled from both ends	Short barrel bead	Finished	Turquoise	Turquoise + Magnetite inclusions
GD-01-041	10,4	4	1,4	0,08	-	Chip	Raw material	Serpentine	Antigorite + Charcoal + Surfacic iron/manganese oxide
GD-01-042	30	12	5	2,08	-	Chip	Raw material	Serpentine	Antigorite + Magnetite inclusions + Surfacic calcite
GD-01-043	5,7	5,1	3,7	0,09	-	Chip	Raw material	Amethyst	Quartz
GD-01-046	5,4	5,6	1,5	0,05	-	Chip	Raw material	Feldspar	Albite + Quartz + Titanite
GD-01-047	"7,5	"5	2	0,09	-	Chip	Raw material	Serpentine	Antigorite

GD-01-050	36,4	11,3	7,9	6,35	-	Pendant?	Finished / broken?	Nephrite	Actinolite
GD-01-051	4,3	11,4	-	0,74	-	Fragment	Finished / broken?	Serpentine	Antigorite
GD-01-056	-	-	-	0,1	-	Chip	Raw material	Amethyst	Quartz
GD-01-057	-	-	-	0,1	-	Chip	Raw material	Amethyst	Quartz
GD-01-058	-	-	-	0,1	-	Chip	Raw material	Amethyst	Quartz

Table 1. Summary of the typological measurements, technical facts and the mineralogical characterization of the studied lapidary artifacts.



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Figure 3. Photographic documentation of the 47 main mineral artifacts related to lapidary production recovered from the Gare Maritime site. Three tiny amethyst chips are not represented. The classification by raw material types is achieved thanks to the Raman spectroscopy characterization (see table 1).

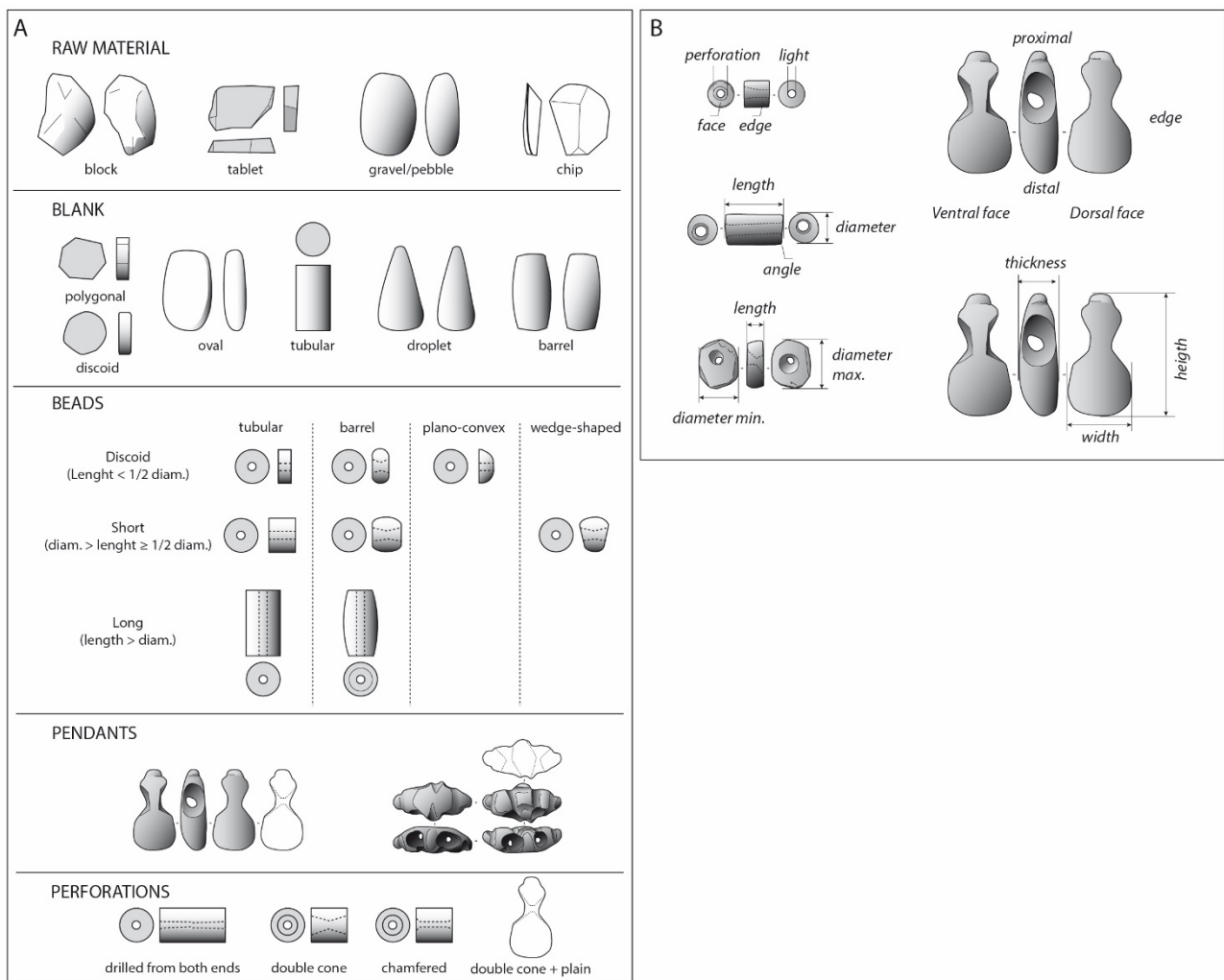
157 The artifacts were typologically classified according to the terminology exposed in Figure
158 4a. Technological description and artifacts measurements were performed on the basis of
159 the terminology and the characteristic dimensions presented in Figure 4b. Terminology is
160 adapted from both Beck (1928) and Carter and Helmer (2015).

161 A first material classification was proposed via macroscopic observations, underlining
162 a highly diverse raw material selection calling for a more detailed mineralogical
163 determination. Especially 26 artifacts were classified as “*greenstones*”, a category related
164 to an aspect rather than a rock type which can be linked to a specific geological source. It is
165 therefore mandatory to analytically define the nature of raw materials in order to specify their
166 geographic distribution and, when possible, their geographic origin.

167 Every object has been analyzed via Raman spectroscopy with a confocal Raman
168 microspectrometer SENTERRA (Bruker Optics) equipped with 532 nm excitation line.
169 Spectra were recorded between 100 and 1555 cm^{-1} with a resolution of 3-5 cm^{-1} . Some
170 pieces were also analyzed with a confocal Raman microspectrometer HR800 (Horiba Jobin
171 Yvon) using the 488 nm emission of a Ar^+ Laser, a 600 lines/mm grating giving a spectral
172 resolution of about 3 cm^{-1} . For all measurements a 50x objective was used and spectra were
173 collected on several locations for each artifact to explore the heterogeneity of the materials.
174 All spectra were baseline corrected to subtract the fluorescence background.

175 Mineral identification was achieved mainly by comparison with the Ruff database
176 (Lafuente et al., 2015) completed by some specific publications, and a strict mineralogical
177 denomination was used according to the International Mineralogical Association list (Nickel
178 and Nichols, 2009). Rock names for polymineralic artifacts and/or gemological appellations
179 were also indicated to be consistent with names commonly used in archaeology.

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Figure 4. Terminology used for the beads and pendants typological description (A) and characterization (B).

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184 4. RESULTS

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The mineralogical analysis of the Gare Maritime beads and pendants allowed us to confirm most of the macroscopic determination, and, as initially assumed, to refine the mineralogical composition of the *greenstones* (Table 1). Quartz and amethyst artifacts were obviously correctly determined macroscopically and thus confirmed by analysis, as well as calcite beads.

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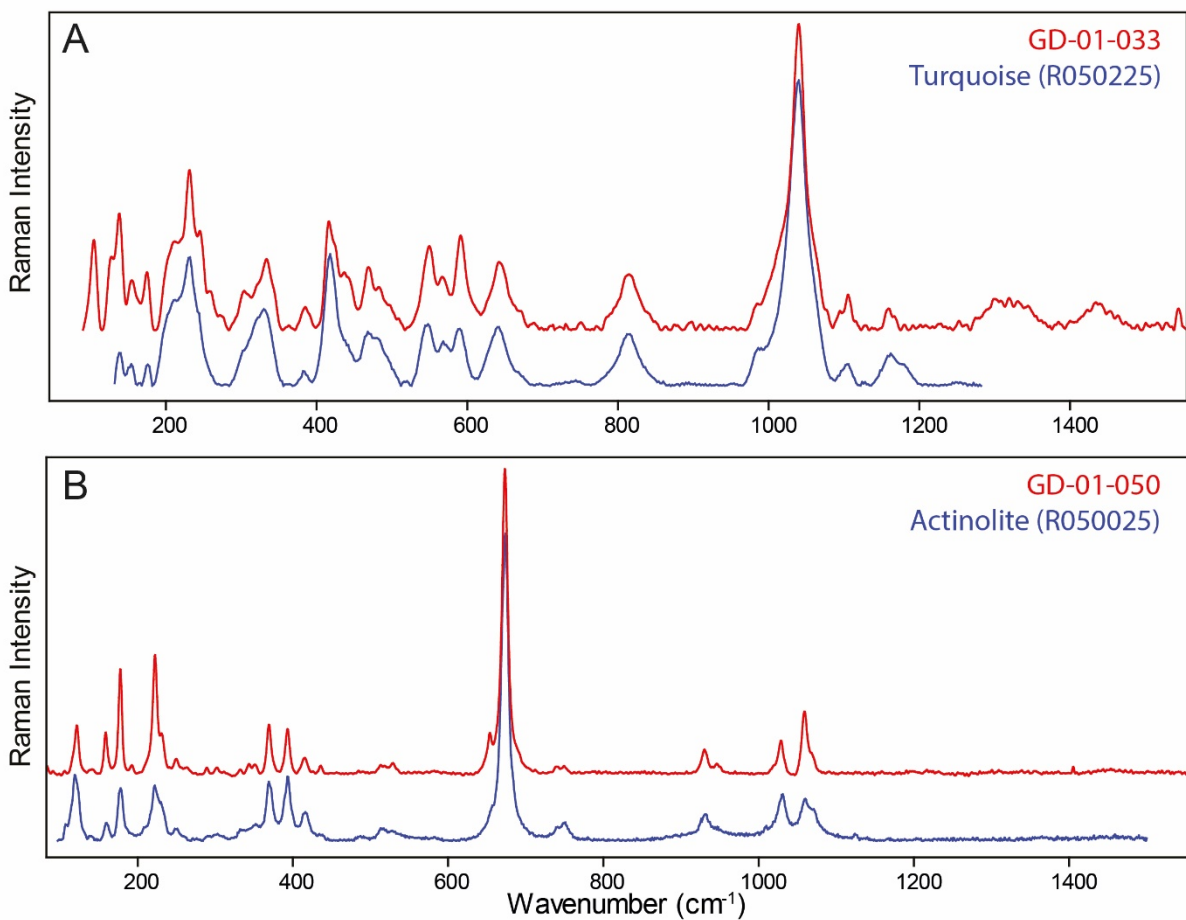
The major intake of Raman spectroscopy is clearly the mineralogical or petrographic attribution of the so called *greenstones* to eight different kinds of rocks or minerals (Table 1). The remarkable amount of turquoise (7 artifacts) was confirmed (Fig. 5A), each of the light green-blue object having been correctly identified with the naked eye.

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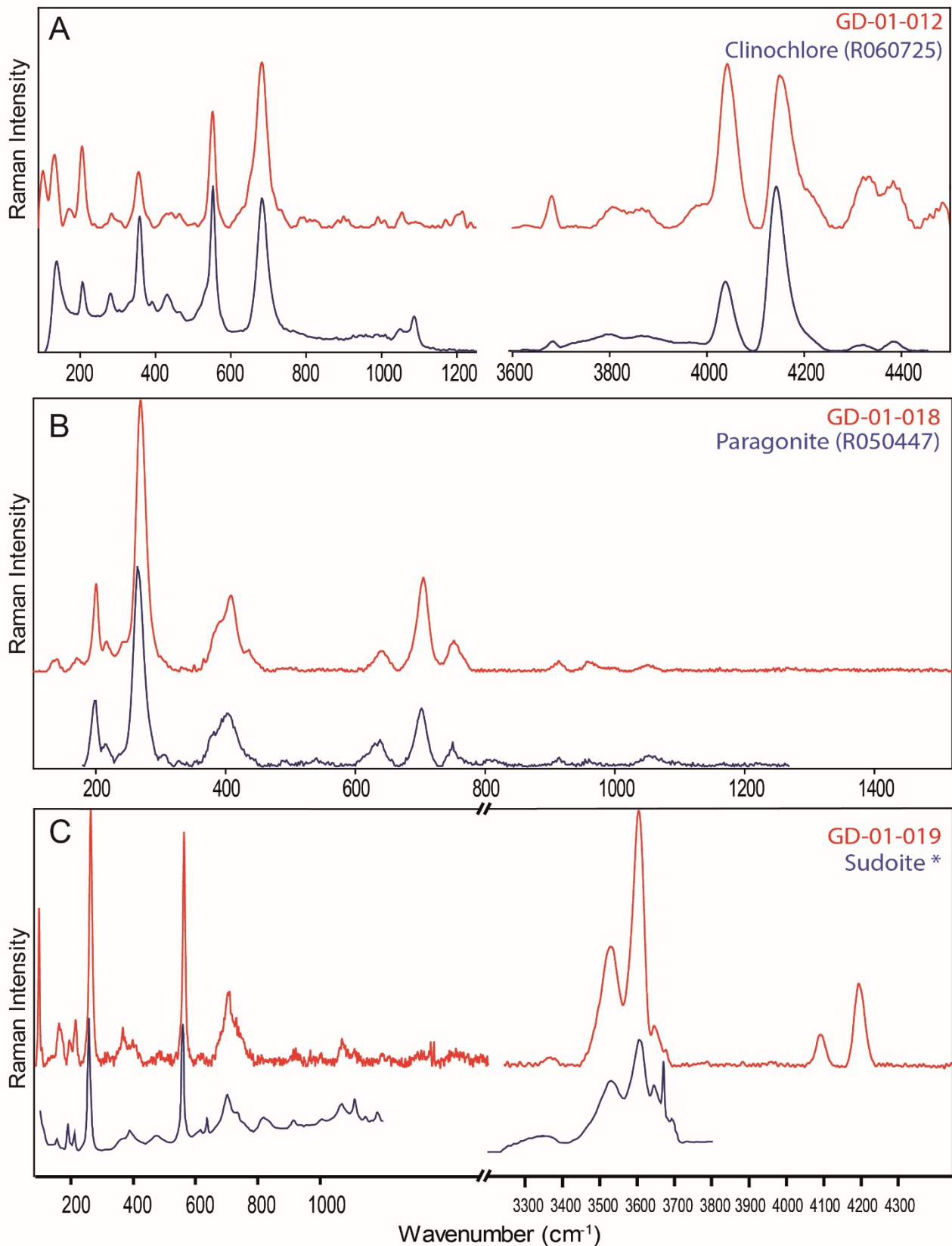
One blank (GD-01-008) was identified as the gem aventurine since it is green and composed of quartz and muscovite. Two greenish chips (GD-01-001 and GD-01-046) were identified as albite and albite + muscovite. A miniature celt shaped artifact is made of nephrite jade, the gemological/archaeological term for the rock composed primarily of the

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198 amphibole actinolite (Fig. 5B). One broken discoid bead is made of clinocllore (Fig. 6A) and
199 would be called chlorite as a gem. One frog-shaped pendant presenting clearly visible
200 cleavage planes was identified as paragonite (Fig. 6B). Another frog-shaped pendant (GD-
201 01-017), one sub-spherical (GD-01-019) and one discoid (GD-01-020) bead, were
202 unexpectedly characterized as sudoite (Fig. 6C). Finally, seventeen of these *greenstones*
203 were classified as serpentine rock, the main mineralogical component of which being
204 antigorite (Fig. 7). Its straightforward identification by Raman spectroscopy is achieved by
205 the presence of the specific band at 1045 cm^{-1} and the shape and position of the O-H
206 stretching bands at 3670 and 3697 cm^{-1} (Groppo et al., 2006; Petriglieri et al., 2015; Rinaudo
207 et al., 2003) observed in every serpentine artifact analyzed in this study.



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209 Figure 5. Representative Raman spectra of a turquoise artifact (GD-01-033) compared to a Ruff database
210 turquoise reference (A) and of the celt-shaped pendant GD-01-050 compared with actinolite (B).



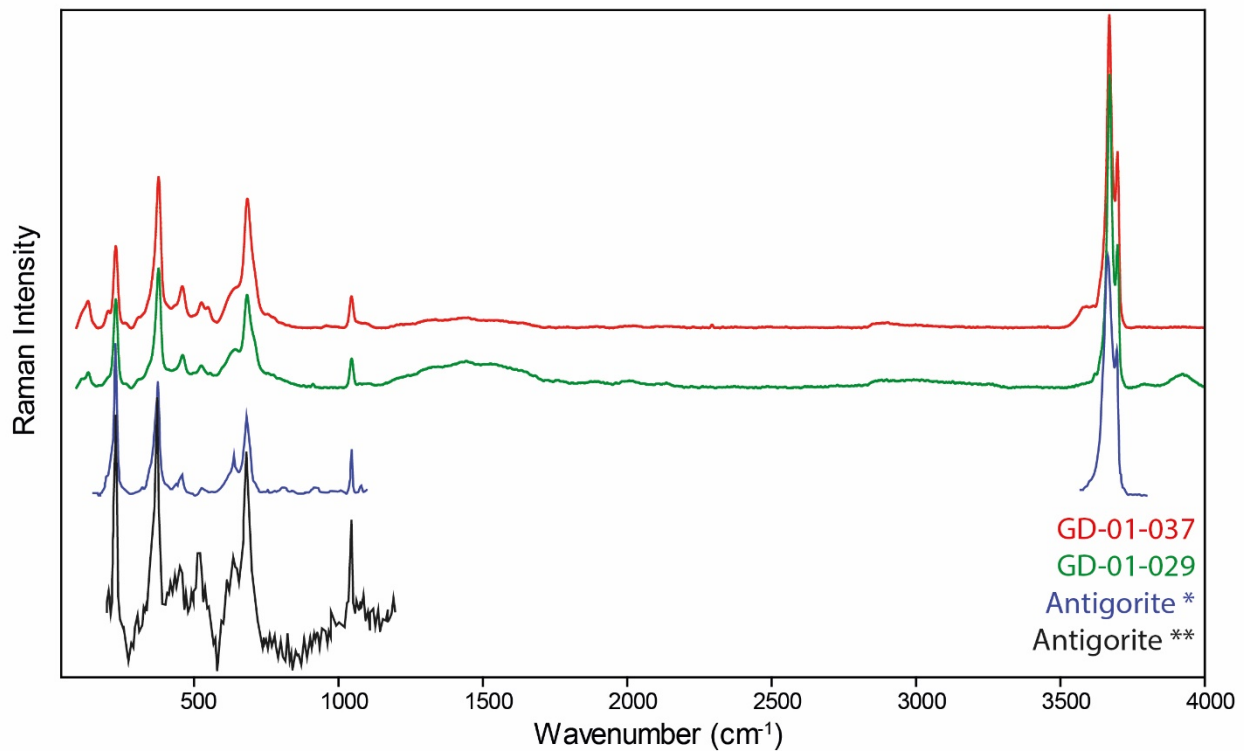
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Figure 6. Spectroscopic identification for some of the greenstones. Raman spectra of the discoid bead GD-01-012 compared with clinochlore (A), the frog-shaped pendant GD-01-018 compared with Paragonite, (B) and the sub-spherical bead GD-01-019 compared with sudoite (C) (* Reynard et al., 2015).



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Figure 7. Raman spectra of two representative serpentine beads compared with antigorite spectra from literature (* Petriglieri et al. 2015, ** Rinaudo et al. 2006).

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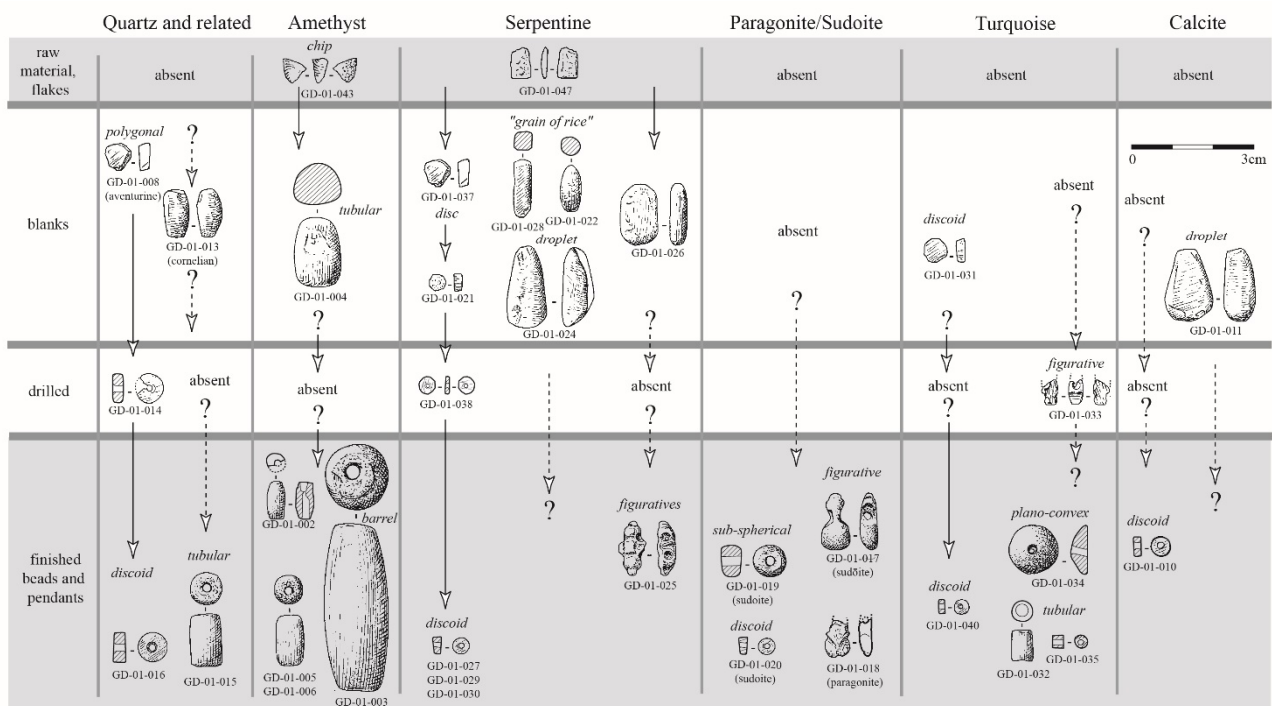
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In Gare Maritime's site, relations between the raw material and typology can be inferred from this quite large set of objects (Fig. 3 and 8, Table 1). The minerals represented by few artifacts mostly show their use for different types of lapidary products. For example, turquoise is used for discoid, tubular, plano-convex beads and small pendants. Serpentine is used for beads and pendants, as well as sudoite and probably calcite if the droplet blanks are meant to become pendants. The only consistency underlined in the corpus is the use of quartz (as rock crystal or amethyst) only for beads and particularly tubular beads. This is in opposition to the other two common materials, serpentine and turquoise, which have been used for beads and pendants. The other rare materials (albite, anorthite, clinocllore, carnelian, quartz + muscovite) are only used for beads, with the exception of nephrite which is only used for a very specific artifact which could be a pendant. As regards to the color of the material, the only connection with shape is the consistency in using the various green materials to produce the frog pendants.

Although we have a truncated view of the production, linked to the partial excavation of the dump and the site, and a modest collection of 50 pieces, it is possible to estimate the ornaments that can result from an on-site processing and those that could be imported as finished or semi-finished products (Fig. 8).



229 Figure 8: *Chaîne opératoire* for the different minerals as represented in the Gare Maritime corpus. "Absent"
 230 notices the absence of this step in the series discovered during the excavation. This excavation being partial,
 231 questions remain about the actual absence of these products.

232 For rock crystal, there are no elements showing that the raw material was imported
 233 unprocessed. For amethyst, three small chips show that the raw material has been cut onsite
 234 although the corresponding preforms are missing. Only a partially polished cylindrical blank
 235 has been discovered. Production based on amethyst seems to be limited to tubular and
 236 barrel beads.

237 Serpentine is the most represented mineral, from raw material to finished products.
 238 All the steps of shaping small discoid beads are represented. It is more difficult to interpret
 239 the cylindrical preforms in terms of their becoming, as they could be used for tubular or
 240 barrel-shaped beads, which are absent from the series, as well as for figurative pendants,
 241 or to produce several discoid beads. The oval plate GD-01-026 could provide a good support
 242 for a frog pendant for example. However, there are no intermediate processing steps for
 243 these ornaments and it cannot be excluded that the artifact GD-01-025 has been imported
 244 in finished form. No element of the sudoite artifacts production chain is present in the series,
 245 only finished ornaments, beads and pendants, indicate that they were probably imported as
 246 such.

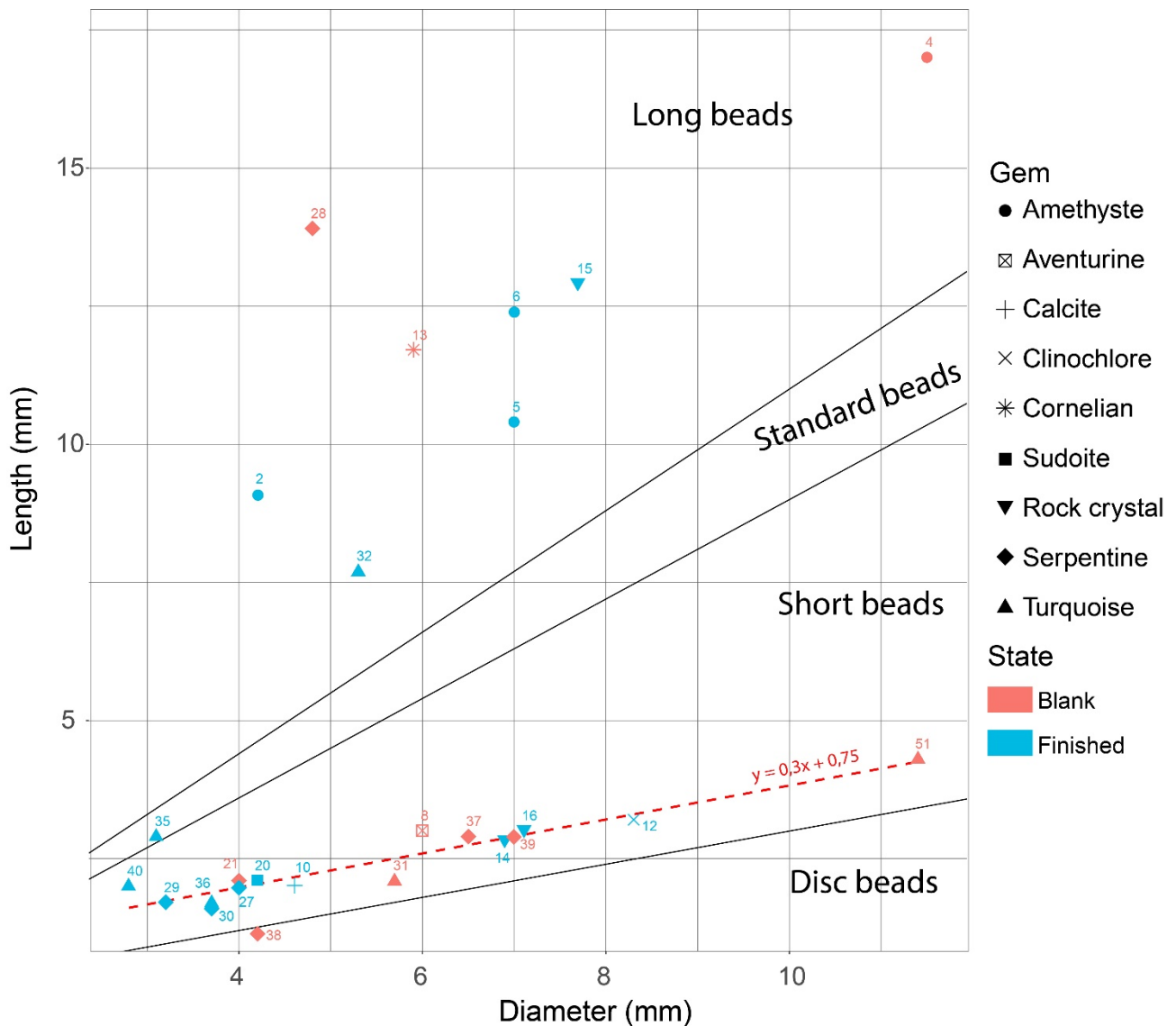
247 Although it has only seven pieces, the turquoise set offers quite an exceptional series
 248 for the Lesser Antilles. It is absent in the form of raw material, but a discoid preform with
 249 polished faces and still faceted edges shows that the first stages of these beads were made
 250 at the site. The other pieces include finished shapes, with the exception of a fragment of a

251 pendeloque, which may have been broken during its manufacture.

252 Calcite ornament is curiously little represented, since this raw material may have a
253 local origin (in Grande-Terre). Only two drop-shaped blanks, of which we do not know what
254 type of ornament it was intended for, and a finished discoid bead, are formed in this material.

255 Blanks, unfinished objects, broken objects are present for aventurine, jasper,
256 serpentine, turquoise and paragonite, suggesting that all these minerals have been worked,
257 at least partially, on site. But most materials do not display the “raw material” and “reduction
258 chips” stages. We could therefore hypothesize that preforms could have been the stage at
259 which the Saladoids would have acquired most of these exotic minerals.

260 The details of each object's *chaîne opératoire* are difficult to infer from the Gare
261 Maritime corpus, because most are finished and only document the last stages of the
262 manufacturing process while some blanks do not seem to be connected to finished objects.
263 The exception concerns discoid beads for which the full process can be studied by
264 combining clues from the different gemstones. They are shaped from small chips (Fig. 8).
265 Blanks are obtained by polishing both faces and edges to shape it from polygon into discoid,
266 which diameter ranges between 5.5 and 6.5 mm. The blank is then given to its final thickness
267 prior to perforation, as visible by the different sizes of blanks opposed to the homogeneous
268 size of the finished objects (Fig. 9). A final polishing step, giving the luster, is probably the
269 final step to make the finished bead after drilling. One can notice that the only bead falling
270 in the “disc bead” category of Beck (1928) is a blank (Fig. 9). This bead is still not perfectly
271 rounded and still not polished, as scratches are visible on its surface. The final steps would
272 have probably made it smaller in diameter and would thus fall as a finished object into the
273 “short bead” category. Only rock crystal beads and the chlorite artifact are bigger in size
274 than those made from other material. Despite this bigger size of some artifacts, it is
275 noteworthy that the proportions of the discoid tubular beads are very homogeneous, as
276 showed by the regression line calculated on their dimensions (Fig. 9).

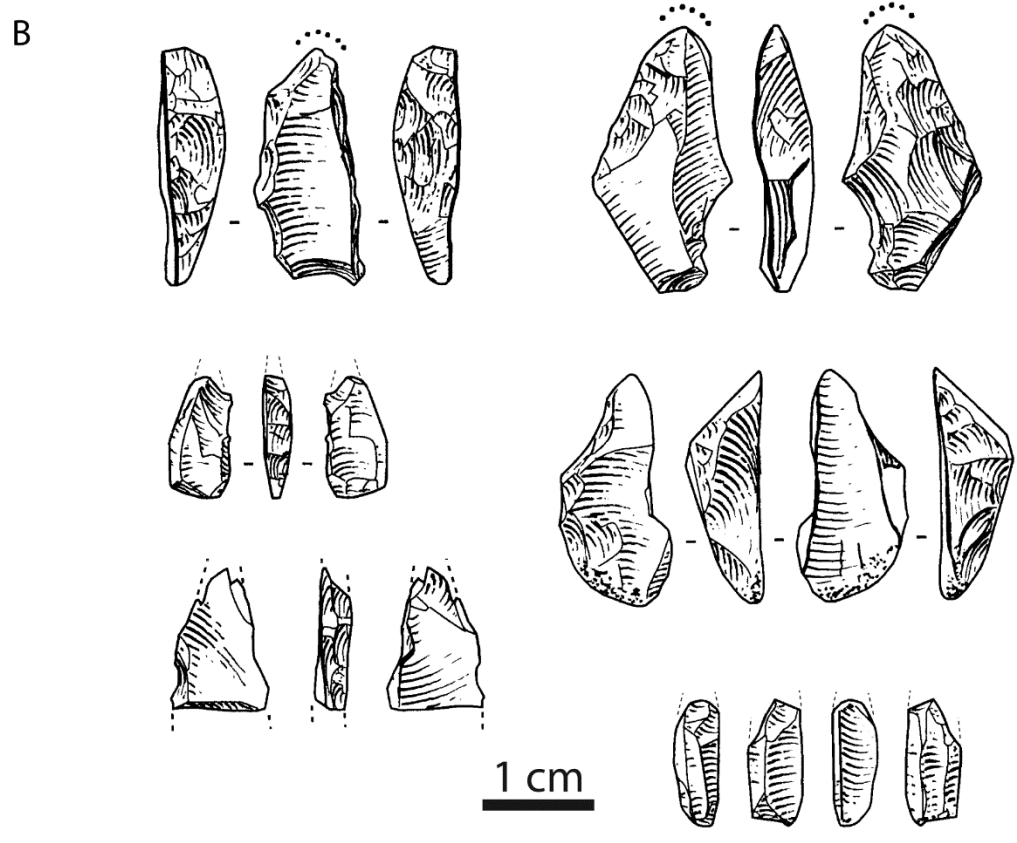


277
 278 Figure 9: Dimension pattern for cylindrical and barrel beads from Gare Maritime. Limits between the different
 279 types of beads are from Beck (1928). Only Bead GD-01-003 (excessively bigger than the others) is not
 280 presented in this graph. The regression line is calculated on the basis of the discoid and short beads from
 281 table 1.

282 The specific equipment used for the manufacturing of beads is difficult to identify.
 283 Gare Maritime site delivered several pebbles used as hammers and some stone polishers
 284 which were able to participate in the manufacture of ornaments. Three polishers with groove,
 285 made of volcanic rock, were likely used for calibrating small discoid or tubular beads,
 286 polished in a row on a link or on the unit (Fig. 10a). At Gare Maritime site, six drills made of
 287 flint have been discovered (Fig. 10b). They could have been used to start a first hole, but
 288 another technique was necessary to drill small diameter holes, sometimes several
 289 centimeters long, in very hard materials. Hence these flint tools were probably more suitable
 290 for soft materials such as shell; also knowing that more than over a thousand shell beads
 291 have been recovered during the excavation (Romon et al., 2013)



10 cm



292
293
294

Figure 10. Tools that can be part of the beads production *chaîne opératoire* at Gare Maritime site. A – Polishers with groove, made of volcanic rock. B – Flint drills.

295 5. DISCUSSION

296 Gare Maritime site has proved to be one of the richest excavated West Indian site for
297 beads and pendants and especially one which displays a great diversity of raw materials.
298 Indeed, 50 artifacts from 13 different raw materials have been recovered during the manual
299 excavation of 28 m² of pre-Columbian layers. One has to keep in mind that it is not a surface
300 collection and even if it seems limited, it is one of the largest excavations of this kind of
301 production place. It could be argued, however, that this is probably a limited production case,
302 reduced to the needs of the local population only and not surplus production for export as
303 has been shown at Golden Grove (Mones 2007).

304 With regard to the occupation of the site, neither geological observations, nor the
305 complete study of the archaeological material, nor radiometric dating has allowed chrono-
306 cultural differentiation between the different layers. The analysis of the set of beads and
307 pendants itself does not support any stratigraphic differentiation either. Mineralogical
308 species, shapes, states of production, are dispersed homogeneously through the
309 archaeological levels of the midden. The full amount of symbolic items has therefore to be
310 considered as a single set.

311

312 *5.1 Raw materials, their distribution and their potential origin*

313 The accurate mineralogical determination by Raman spectroscopy applied to the
314 complete set of artifacts allowed, on the one hand, to confirm part of the macroscopic
315 observation and, on the other hand, to precisely define the mineralogy of *greenstones*. The
316 kinds of minerals used for the production of symbolic items at Gare Maritime are in adequacy
317 with those mentioned for the other lapidary sites of the Lesser Antilles for this period. Indeed,
318 use of rock crystal, amethyst, carnelian, diorite, serpentine and nephrite, is already known
319 from the major lapidary sites like: Tecla, Sorcé, Tutu, Royall, Elliot, PA-15, Trants, Vivé and
320 Golden Grove (tabl. 2). Regarding the raw material represented, the specificity of Gare
321 Maritime lies in the more common use of turquoise, here for the production of seven artifacts
322 while only one is known in Royall (Murphy et al., 2000), two in Pearls (Cody, 1991), one in
323 Manzanilla (Trinidad) (Nieweg and Dorst, 2001), and a relatively small amount in Sorcé and
324 Tecla (Narganes Storde, 1995) and Prosperity (St. Croix, USVI) (Hardy, 2010). If the high
325 concentration of a mineral can be seen as a specialization of the site like it is supposed for:
326 Pearls (for amethyst), Trants (for cornelian) and Golden Grove (for diorite) (Cody, 1991;
327 Crock and Bartone, 1998; Mones, 2007); Gare Maritime could be interpreted as a turquoise
328 specialized site. However, over-interpretation should be avoided as seven artifacts among
329 50, dispersed in several cubic meters of a midden, make it difficult to attribute a turquoise'

330 workshop status to the site.

331 The diversity and the exogenous origin of the materials used for the lapidary
332 production of Gare Maritime raise the question of their provenance, with diversified
333 inferences according to each material. Diorite can be supposed to come from Tobago, where
334 it is well known both geologically and archaeologically (Mones, 2007; Snoke, 2001). The
335 kind of very big and dark amethyst recovered (especially GD-01-003) is geologically rare
336 and its origin is unknown despite some allusions to amethyst present in Martinique. Indeed,
337 contrary to Cody (1993) and Hofman et al. (2007), we cannot confirm the presence in
338 Martinique of amethyst crystals large enough to make the numerous beads found in the
339 saladoid sites around the West Indies when reading the literature cited for this statement in
340 these two papers, which are respectively Pinchon (1967) and Westercamp and Tazieff
341 (1980). The first one wrote: "*Amethyst, when it is constituted by big crystals deeply colored,*
342 *is appreciated by stone cutters; [...] unfortunately, this is not the case of our Martinican*
343 *source which is simply a geological curiosity*" (proposed translation from French). The
344 second citation, which is the booklet of the geological map of Martinique, only mention
345 amethyst in the list of hydrothermal minerals present on the island, and not at all as dark
346 purple crystals of 4 to 5 centimeters of length.. The distinctive hue of the bead GD-01-003
347 makes it certainly special and it should be noted that this very dark purple color was also
348 mentioned at the Pearls site among lighter colors (Cody, 1991), and that this specific color
349 and this size of minerals does exist in Brazil (Epstein, 1988).

350 Concerning nephrite, the case is even more complex, since literature is contradictory.
351 Cody (1993), based on old citations that we could not find for reading, mentions Mount
352 Roraima and other localities in Brazil. Despite this, no recent work can confirm this: Harlow
353 et al. (2006) and O'Donoghue (2006) stand for a complete lack of evidence of nephrite in
354 Mesoamerica and South America, while Meirelles & Costa (2012) seem to locate nephrite
355 in Brazil as a common fact.

356 Finally, turquoise items provenance is still difficult to establish. The only well
357 documented sources of this mineral are the numerous mines located in the South West of
358 the USA that provided the green mineral for Mesoamerican and North American pre-
359 Hispanic people (Harbottle and Weigand, 1992). Other sources are known in South America
360 (Evans, 1913; Evans and Southward, 1914; López et al., 2018) and could have been related
361 to the presence of turquoise in the North of the continent and further in the West Indies. One
362 last hypothesis for the origin of the turquoise artifacts recovered in the West Indies could be
363 the existence of such a mineral source in the Greater Antilles. The jadeite example recently
364 proved the possibility of discovering unknown sources of archaeologically valuable minerals

365 in this region (Cárdenas-Párraga et al., 2010; García-Casco et al., 2009; Harlow et al., 2006;
366 Rodriguez Ramos, 2011; Schertl et al., 2012). Recent works based on isotope
367 measurements to discriminate geological sources (Hull et al., 2014; Othmane et al., 2015;
368 Thibodeau et al., 2015) in North America may in the future be applied to West Indian
369 archaeological turquoise to trace their origin.

370 Since most materials are coming from outside Guadeloupe and even outside Lesser
371 Antilles, this raises the question of a single origin or multiple origins, even quite distant, for
372 these products. Amethyst of the size and color of the bead GD-01-003 or even the quite
373 large amount of large beads made of this gem points towards a Brazilian origin. Other
374 minerals could also come from this region. Several minerals are products of low grade
375 metamorphism, such as antigorite, sudoite, paragonite and chlorite. This type of
376 metamorphism is found in the Greater Antilles as a product of the subduction activity in the
377 region, but a detailed regional inventory of the availability of these lithic resources for
378 prehistoric man is still to be carried out to propose provenances. Since most of the gems
379 have their origin outside Guadeloupe and we can assume that their origin is not unique, the
380 assumption of a large diffusion system involving South America and the Antilles is the most
381 logical for us.

382 *5.2 Typo-technologies, manufacturing and regional connections*

383 Comparisons can also be made with other sites in the Lesser Antilles regarding the
384 shapes of Gare Maritime's beads and pendants. Indeed, cylindrical, discoid, barrel-shaped
385 and spherical beads are known from most of the archaeological sites previously listed. At
386 Gare Maritime the diversity of shapes is the greatest for the quartz and amethyst artifacts
387 with the complete range of shapes found in the Lesser Antilles, despite the very high
388 hardness of these materials. Some cylindrical or barrel beads (GD-01-003, GD-01-005, GD-
389 01-006 and GD-01-015) made of amethyst are nearly identical to those found in the burials
390 of Morel in Guadeloupe (Durand and Petitjean Roget, 1991), and Vivé in Martinique
391 (Mattioni, 1979); or in other contexts like in the Guadeloupean sites of: 24 rue Schoelcher
392 (Etrich, 2003a), Allée Dumanoir (Etrich, 2003b, 2002), Anse Ste Marguerite (unpublished);
393 the West Indian sites of: Pearls (Cody, 1991), Elliot (Murphy et al., 2000) and other parts of
394 the Morel site (Delpuech, 1995; Hambourg, 1999) or the continental site of Midden
395 Ramdutt's field in Guyana (Roth, 1944).

396
397 Regarding the manufacturing, it is difficult to imagine how Amerindian people
398 managed to drill such long beads of amethyst with their technology, an issue that has been
399 already raised before. The only answer that one can find is in old texts about the Amazonian

400 bead makers, like Vincent Roth (Roth, 1944) that cannot recall if Wallace or Bates told him
401 that drilling a bead "took the spare time of three generation", and specify the technique used:
402 "with nothing harder than the mid-rib of leaf of the ite palm". It is noteworthy that Walter
403 Edmund Roth, his father, wrote, in 1924, quoting Wallace (1889), that it took two lives and
404 not three. We thus have probably only one primary source writing about quartz bead makers
405 in the Amazonian Basin that is Wallace (Wallace, 1889) who wrote: « *I now saw several of the*
406 *men with their most peculiar and valued ornament a cylindrical, opaque, white stone, looking like*
407 *marble, but which is really quartz imperfectly crystallized. These stones are from four to eight inches*
408 *long, and about an inch in diameter. They are ground round, and flat at the ends, a work of great*
409 *labour, and are each pierced with a hole at one end, through which a string is inserted, to suspend*
410 *it round the neck. It appears almost incredible that they should make this hole in so hard a substance*
411 *without any iron instrument for the purpose. What they are said to use is the pointed flexible leaf-*
412 *shoot of the large wild plantain, triturating with fine sand and a little water; and I have no doubt it is,*
413 *as it is said to be, a labour of years. Yet it must take a much longer time to pierce that which the*
414 *Tushaiia wears as the symbol of his authority, for it is generally of the largest size, and is worn*
415 *transversely across the breast, for which purpose the hole is bored lengthways from one end to the*
416 *other, an operation which I was informed sometimes occupies two lives.*». Some very rare drills or
417 fragments of drills, related to hard stone drilling, have been mentioned in a few sites, as it is
418 the case (but unfortunately without any representation of them) in Pearls as a "drill bit [made
419 of] hard stone" (Cody, 1991) or in PA-15 with "small trapezoidal chert flakes [that] may be
420 drill bits" (Gent and de Mille, 2003). Cody (1991) and Crock & Bartone (1998) also note the
421 presence of partially drilled quartz beads, the latter mentioning that the bottom of the hole
422 presents a remnant cone, leading them to think that a hollow drill must have been used.
423 Regarding the Gare Maritime's artifacts that could be related to manufacturing tools (fig. 10),
424 as previously discussed, they are mainly represented by polishers and the flint drills
425 identified cannot be at the origin of fine and long bead's holes. The lack of precise
426 information for the drills of Pearls and PA-15 unfortunately prevent us to think they are
427 different from the ones from Gare Maritime. The documentation of drilling technologies will
428 need further studies, regarding for example use wear studies of artifacts and putative tools,
429 or complementary investigation based on experimental archaeology.

430 The plano-convex bead made in turquoise (GD-01-034) is only similar (typology and
431 raw material), to our knowledge, to the *adornos plano-convexo* found in Sorcé (Narganes
432 Storde, 1995) among a thousand beads and pendants recovered during its excavation. In
433 this site, this specific type of artifacts always exhibits a greenish color even if they are made
434 of diverse materials. They are there interpreted as eyes of disappeared wooden or cotton
435 sculptures. It could also be similar in shape to the turquoise bead of Royall's site (Murphy et

436 al. 2010 fig. 10).

437 All the pendants found in Gare Maritime are frog-shaped pendants of small size (the
438 so called "segmented frog" (Cody, 1993)), all made in green colored material. For two of
439 them (GD-01-017 and GD-01-018), as for the amethyst beads, the shape is very close to a
440 frog pendant found in another vicinity site (Cathédrale de Basse-Terre (Bonnissent and
441 Romon, 2004)) and the mineralogy is identical (Queffelec et al. unpublished data). But
442 similar objects have also been found in other islands of the Lesser Antilles, Greater Antilles
443 and even Costa Rica (Cody, 1993; Rodriguez Ramos, 2010).

444 Beyond the variety of shapes and materials excavated from the Gare Maritime site that
445 fits perfectly in the diversity of the lapidary sites or adornments-rich sites of the Lesser
446 Antilles, the Gare Maritime stone artifacts also enter in the range of the Early Ceramic Age
447 "shiny personal ornaments" period as Rodriguez-Ramos calls it (Rodriguez Ramos, 2011).
448 This tradition, connected to a north-south West Indian trade route with materials and ideas
449 coming from South America, or even, depending on the authors, a Pan-Caribbean network
450 involving also Mesoamerica, is said to disappear to be replaced by productions on more
451 local materials (Knippenberg, 2007; Rodriguez Ramos, 2010, 2007). The dating of the Gare
452 Maritime site (250 – 400 cal. AD), indeed, corresponds to the model of a lapidary crafting
453 using exotic materials during the first five centuries of our era by adding a new point on the
454 map and on the timeline. Indeed, Gare Maritime presents a large diversity of materials
455 coming from outside the Guadeloupe Island (jasper, diorite, serpentine and sudoite) and
456 even some other from outside the Lesser Antilles (amethyst, nephrite, turquoise) with
457 perhaps for the latter a South American origin.

458

Island	Contexte	Amethyst			Rock crystal			Cornelian			Chalcedony			Serpentine			Nephrite			Calcite			Turquoise			Diorite			Other
		R/C	B	F	R/C	B	F	R/C	B	F	R/C	B	F	R/C	B	F	R/C	B	F	R/C	B	F	R/C	B	F	R/C	B	F	
Puerto Rico	Excavations			X	X		X			X			X		X		X		X			X		X		X		aventurine, marble, malachite	
Vieques	Excavations			X	X		X			X			X		X		X		X			X		X		X		aventurine, marble, malachite	
St. Thomas	Excavation (midden)			X			X								greenstone		greenstone				X							green chert	
Antigua	Excavations + surface				X	X	X	X	X	X	X	X			X				X	X	X			X			X	jasper, limestone, tuff, barite	
Antigua	Excavations + surface	X			X		X	X	X	X	X			X			X	X	X	X	X					X	X	limestone, tuff, barite	
Antigua	Excavations					X	X						X	X		X	X		X	X					X	X			
Montserrat	Excavations + surface			X	X		X	X	X					greenstone		greenstone										X		feldspar	
Guadeloupe	Excavation (midden)	X	X	X			X						X	X	X			X	X		X	X				X	jasper, aventurine, feldspar, chlorite, sudoite, paragonite		
Martinique	Excavation (burial)			X				X					greenstone		greenstone														
Grenada	Excavations	X	X	X	X	X	X				X	X										X							
Tobago	Excavations																							X	X	X			

459 Table 2. Presence / absence of the most common minerals found in the lapidary sites identified in the Lesser Antilles or the bead-rich sites of the region. R/C: Raw
460 material / reduction Chip; B: bead or pendant Blank; F: Finished bead or pendant. Sites are listed from north to south (see fig. 1).

461

462 **CONCLUSION**

463 The site of Gare Maritime (250 – 400 cal. AD) yielded a collection of 50 lapidary artifacts
464 ranging from the raw material to the finished object. Beyond illustrating the development of
465 the lapidary art in the Caribbean basin, the presence of a wide variety of exogenous raw
466 materials testifies to long-distance diffusions networks. Such a collection, recently
467 excavated, for this specific prehistoric period in Guadeloupe offers primary documentation
468 for studying the entire *chaîne opératoire* of these valuable goods.

469 Raman spectroscopy was mandatory in non-invasively identifying the precise
470 mineralogical composition of all these objects, especially the 33 so-called *greenstones*. For
471 this color class, eight different kinds of rocks or minerals have been identified, which are:
472 aventurine, chlorite, feldspar, nephrite, paragonite, serpentine, sudoite and turquoise.
473 Beyond that, five other kinds of rocks or minerals (amethyst, calcite, jasper, rock crystal and
474 diorite) were identified in the collection.

475 Due to the lack of accurate and reliable geological resource documentation about the
476 lithic resources in the West Indies, for the moment it is not possible to attribute a precise
477 geographical provenance for the identified raw materials. Moreover for some of the mineral
478 identified, as amethyst, nephrite and turquoise, a more distant source on the continent
479 (Mesoamerica or South-America) must be investigated. At this stage, the results obtained
480 contribute to define the distribution areas of raw materials and specific typologies that
481 already contribute to the debate of cultural diffusions.

482 The *chaînes opératoires* for the different materials have been approached, despite
483 some raw materials poorly represented in the studied collection. Some materials are
484 processed on site (amethyst, aventurine, jasper, feldspar, calcite, serpentine and turquoise),
485 while others (chlorite, diorite, nephrite, paragonite, rock crystal and sudoite) seems to be
486 brought on site already finished. Pendants are made only of green materials, while very hard
487 material such as rock crystal and amethyst are used only for bead production.

488 Style and material analysis allow to confirm the extension of a homogeneous production
489 with some objects found very similar to nearby and remote archaeological sites. The main
490 minerals, also, are represented in most of the studied sites in the area. The geographical
491 and chronological position of the Gare Maritime site fit the model of a lapidary production of
492 beads and pendants in exotic minerals during the end of the Saladoid period.

493 Further accumulation of data and the methodology implemented in this work applied to
494 future archaeological collections will provide an advanced description of the *chaîne*
495 *opératoire* for these prestigious artifacts.

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505

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