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

## 1. Introduction

The Saladoid series, also considered as the Saladoid phenomenon, is the first series of the Ceramic Age in the Antilles (Rouse, 1992). It develops inland and coastlands in South America, probably since 2500 BC (Berard, 2013; Rouse and Cruxent, 1963) and expands towards the Antilles from 500 BC until ca. 1000 AD, depending on the islands. Theses migrating groups replaces and probably acculturate mutually with the former preceramic occupants of the Antilles. Their subsistence is based on horticulture associated with hunting, fishing and foraging, while their material production is based on highly decorated ceramic, a simple lithic industry and polished axes produced from rocks and shells. The coastal and maritime area of dispersion of this culture embraces the Northeastern coast of South America and the whole of the Antilles as far north as Puerto Rico (Berard, 2013; Bonnissent, 2010; Hofman et al., 2007; Rouse, 1992).

Several Saladoid archaeological sites have yielded mineral beads and pendants in the Lesser Antilles during the past decades (Bullen and

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

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

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

## 2. Archaeological context

The archaeological site of Gare Maritime is located in the present-day commercial harbor of Basse-Terre city, the regional capital of Guadeloupe (Fig. 1). Nowadays it is ca. one hundred meters from the actual harbor dock, but during pre-Columbian times it was located just behind the littoral pebble bank and on a river bank (Fig. 2). Although its stratigraphy is separated into several units, the geoarchaeological, lithic and ceramic studies converge towards a rather long but single occupation of the site (Romon et al., 2013). The multiple layers are interpreted as a Huecan Saladoid (or Huecoid depending of the authors) midden separated in two main stratigraphic units by a very short event

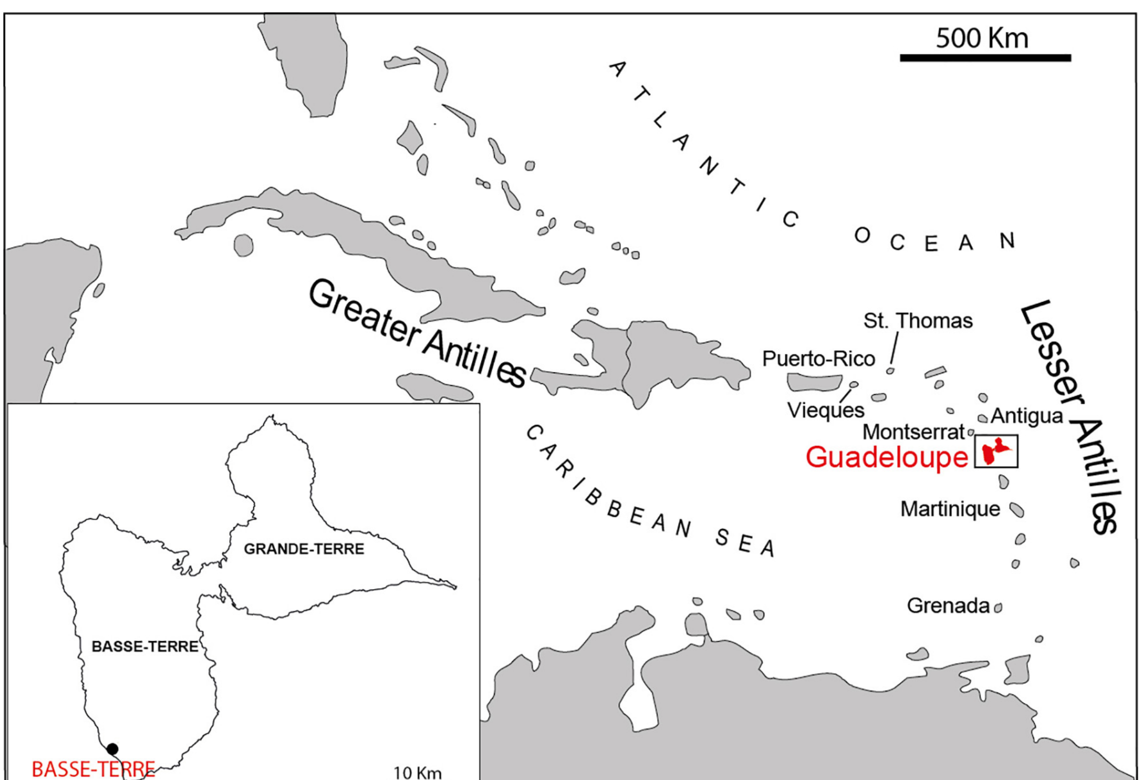


**Fig. 1.** Map of the regional and local position of the archaeological site of Gare Maritime, in Basse-Terre city. The islands hosting the archaeological sites mentioned in the text are also indicated.

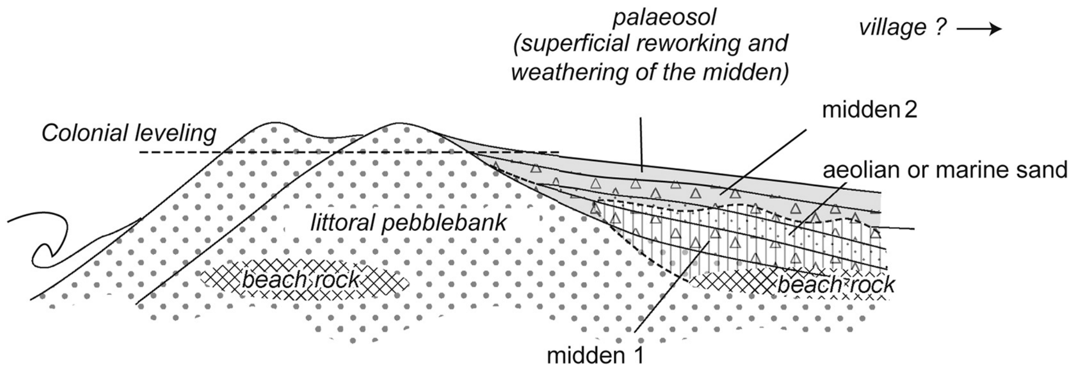


**Fig. 2.** Interpretative section of the Gare Maritime site representative of the Pre-Columbian period (modified after Bertran P. in Romon et al., 2013).

of sand deposition, possibly related to a violent storm. The excavation corresponds to a small part of the site, only represented by its coastal zone. The settlement area was presumably located further inland, and could be preserved under a modern square. The pre-Columbian occupation is well dated to 250–400 cal. A.D. with several radiocarbon dates related to the different stratigraphic units, only the very top layer being slightly more recent (Romon et al., 2013). This study concerns the 50 mineral artifacts which have been recovered during the manual excavation of 28 $m^2$ of the pre-Columbian layers.

## 3. Materials and methods

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

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

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

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

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

## 4. Results

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.

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.

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

In Gare Maritime's site, relations between the raw material and typology can be inferred from this quite large set of objects (Figs. 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, clinochlore, 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

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

| Artifact 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 + clinochlore |
| GD-01-038 | 1.1 | 4.2 | 0.9 | 0.1 | Drilled from both ends | Discoid | Blank | Serpentine | Antigorite |

(*continued on next page*)

**Table 1** (*continued*)

| Artifact 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-01-039 | 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 |

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).

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

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

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

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

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

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

The specific equipment used for the manufacturing of beads is difficult to identify. Gare Maritime site delivered several pebbles used as hammers and some stone polishers which were able to participate in the manufacture of ornaments. Three polishers with groove, made of volcanic rock, were likely used for calibrating small discoid or tubular

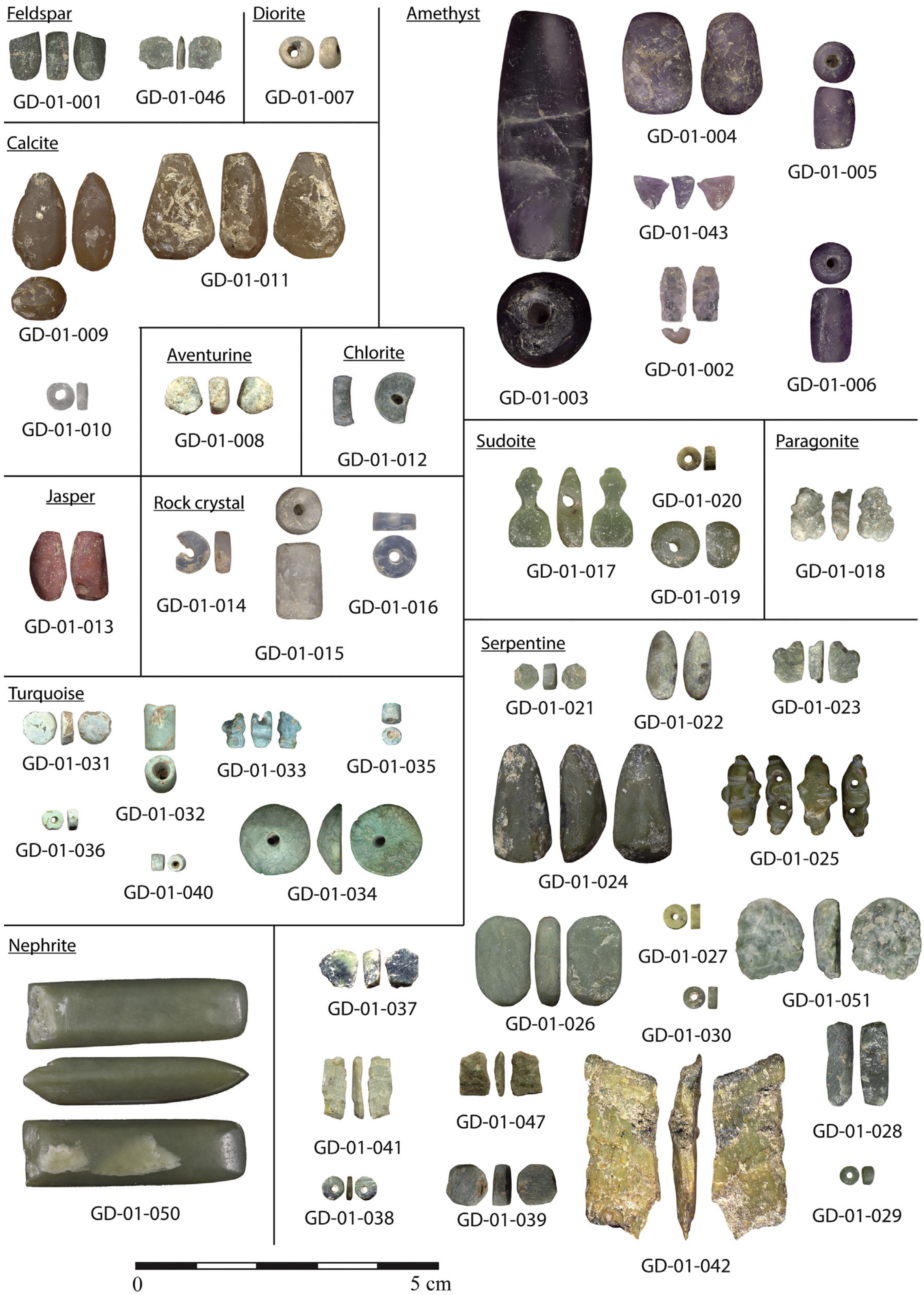


**Fig. 3.** Photographic documentation of the 47 main mineral artifacts related to lapidary production recovered from the Gare Maritime site. Three tiny amethyst chips are not represented. The classification by raw material types is achieved thanks to the Raman spectroscopy characterization (see Table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

beads, polished in a row on a link or on the unit (Fig. 10a). At Gare Maritime site, six drills made of flint have been discovered (Fig. 10b). They could have been used to start a first hole, but another technique was necessary to drill small diameter holes, sometimes several centimeters long, in very hard materials. Hence these flint tools were probably more suitable for soft materials such as shell; also knowing that more that over a thousand shell beads have been recovered during the excavation (Romon et al., 2013).

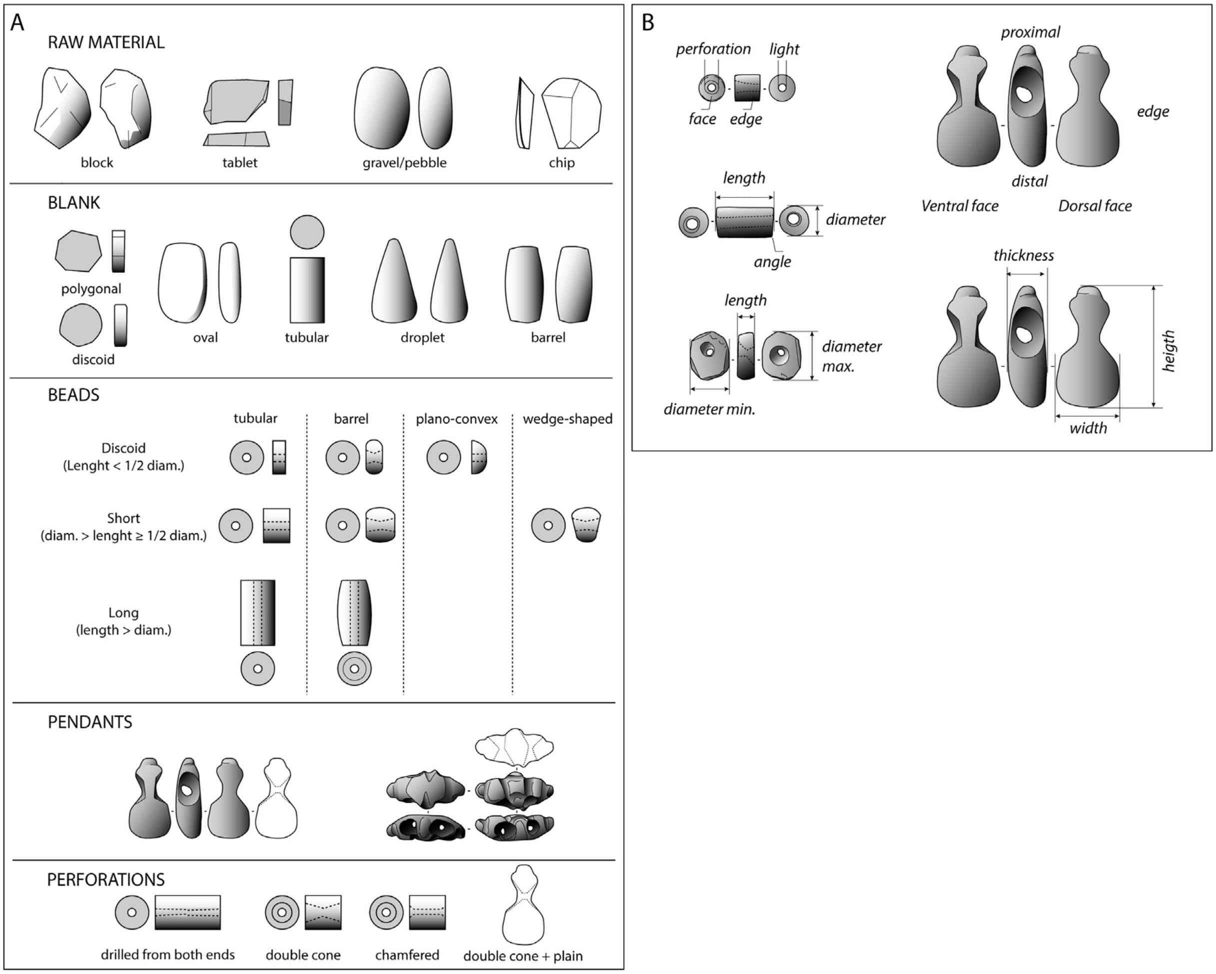


**Fig. 4.** Terminology used for the beads and pendants typological description (A) and characterization (B).

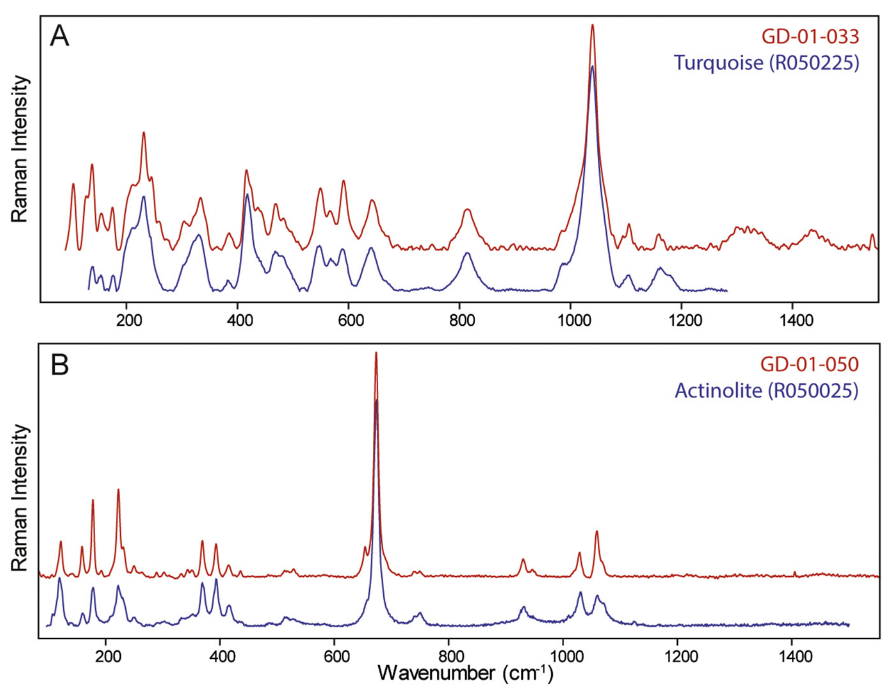


**Fig. 5.** Representative Raman spectra of a turquoise artifact (GD-01-033) compared to a Rruff database turquoise reference (A) and of the celt-shaped pendant GD-01-050 compared with actinolite (B).

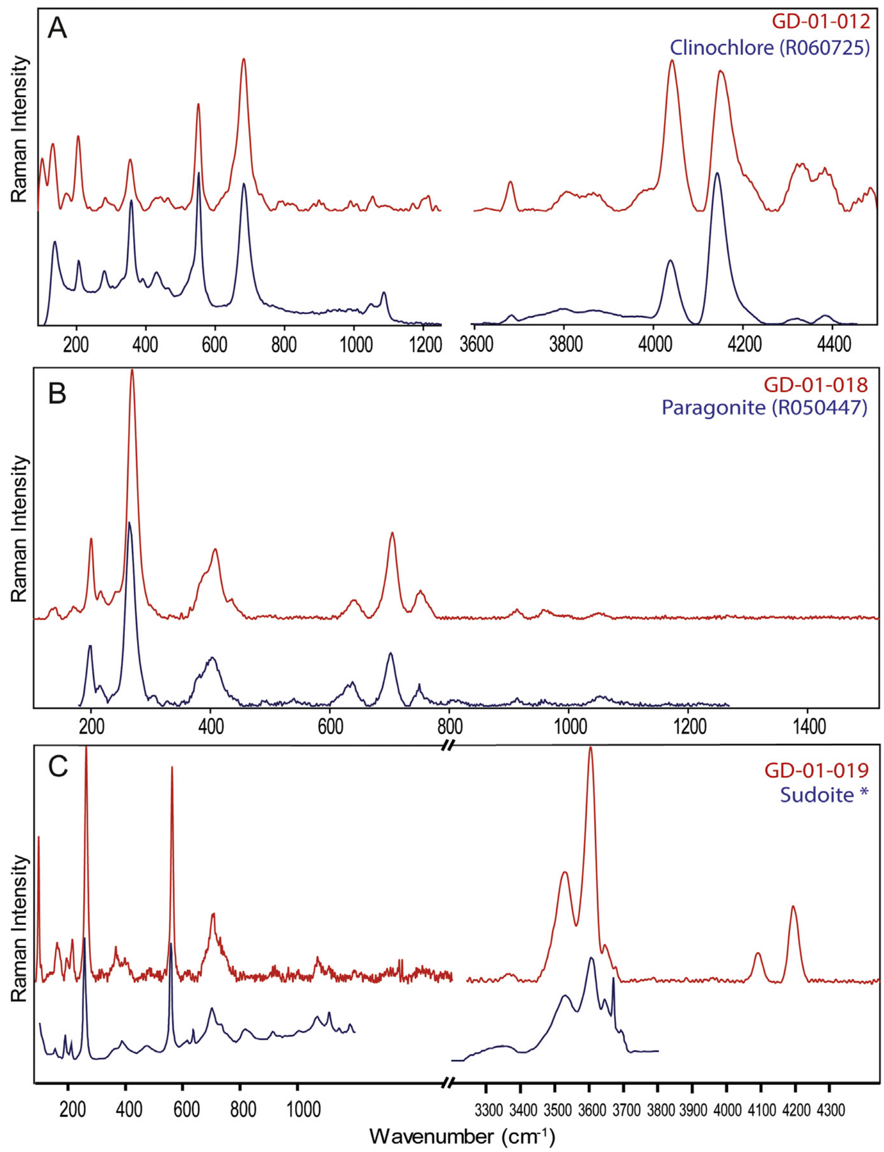


**Fig. 6.** Spectroscopic identification for some of the greenstones. Raman spectra of the discoid bead GD-01-012 compared with clinochlore (A), the frog-shaped pendant GD-01-018 compared with Paragonite, (B) and the sub-spherical bead GD-01-019 compared with sudoite (C) (*Reynard et al., 2015).

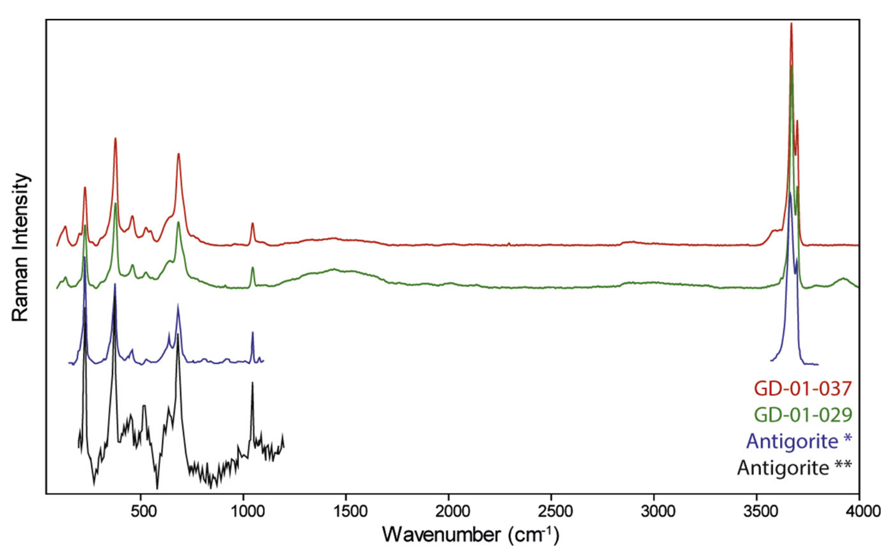


**Fig. 7.** Raman spectra of two representative serpentine beads compared with antigorite spectra from literature (*Petriglieri et al., 2015, **Rinaudo et al., 2003).

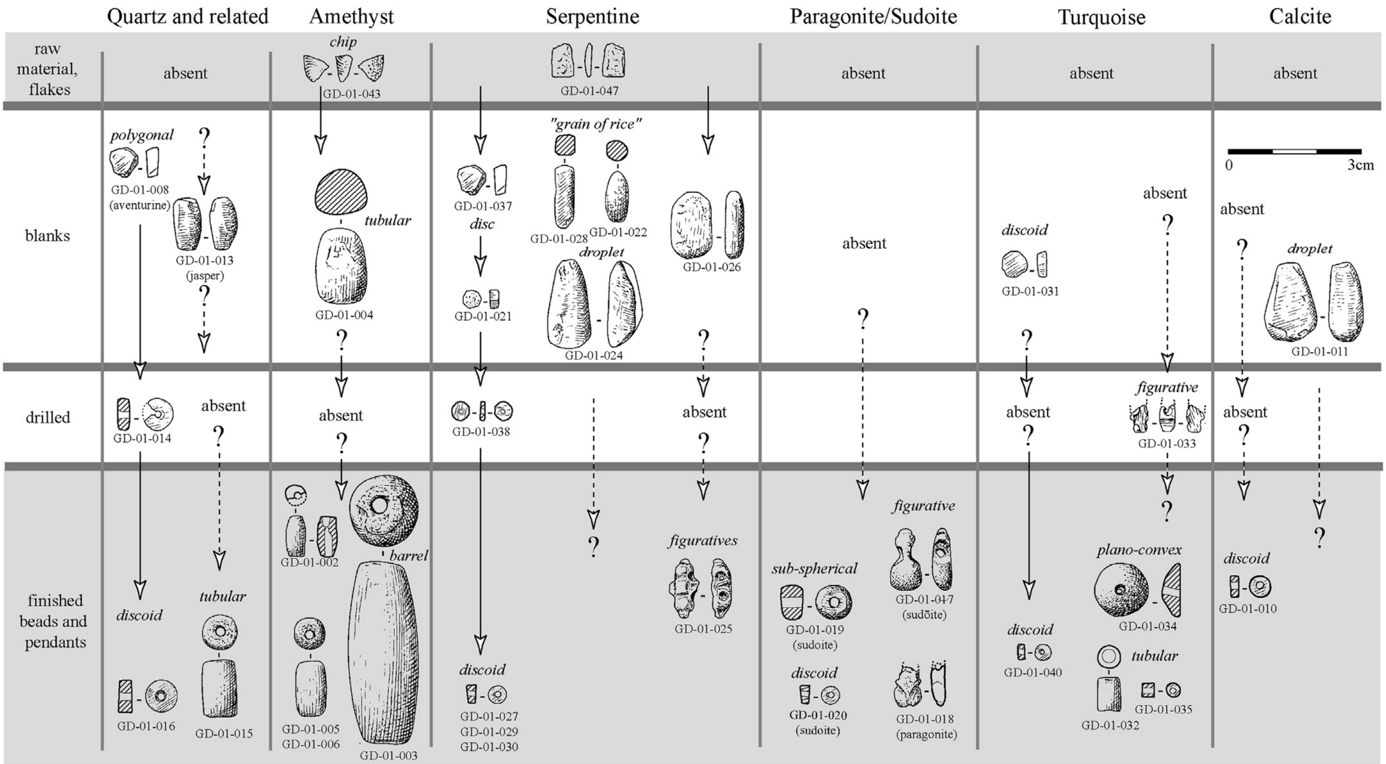


**Fig. 8.** *Chaîne opératoire* for the different minerals as represented in the Gare Maritime corpus. “Absent” notices the absence of this step in the series discovered during the excavation. This excavation being partial, questions remain about the actual absence of these products.

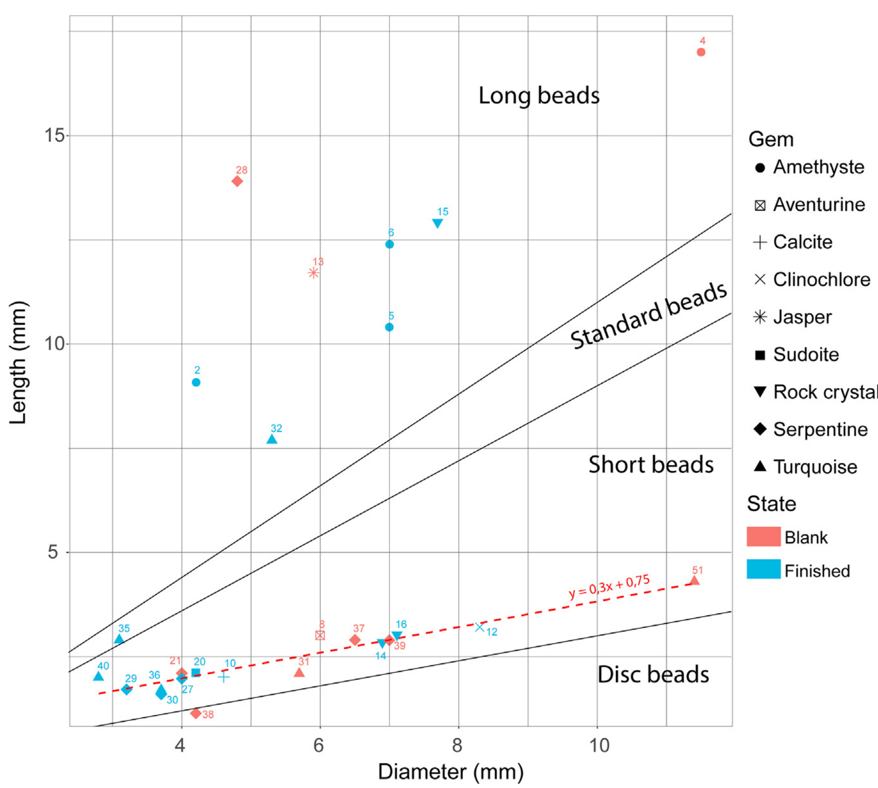


**Fig. 9.** Dimension pattern for cylindrical and barrel beads from Gare Maritime. Limits between the different types of beads are from Beck (1928). Only Bead GD-01-003 (excessively bigger than the others) is not presented in this graph. The regression line is calculated on the basis of the discoid and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

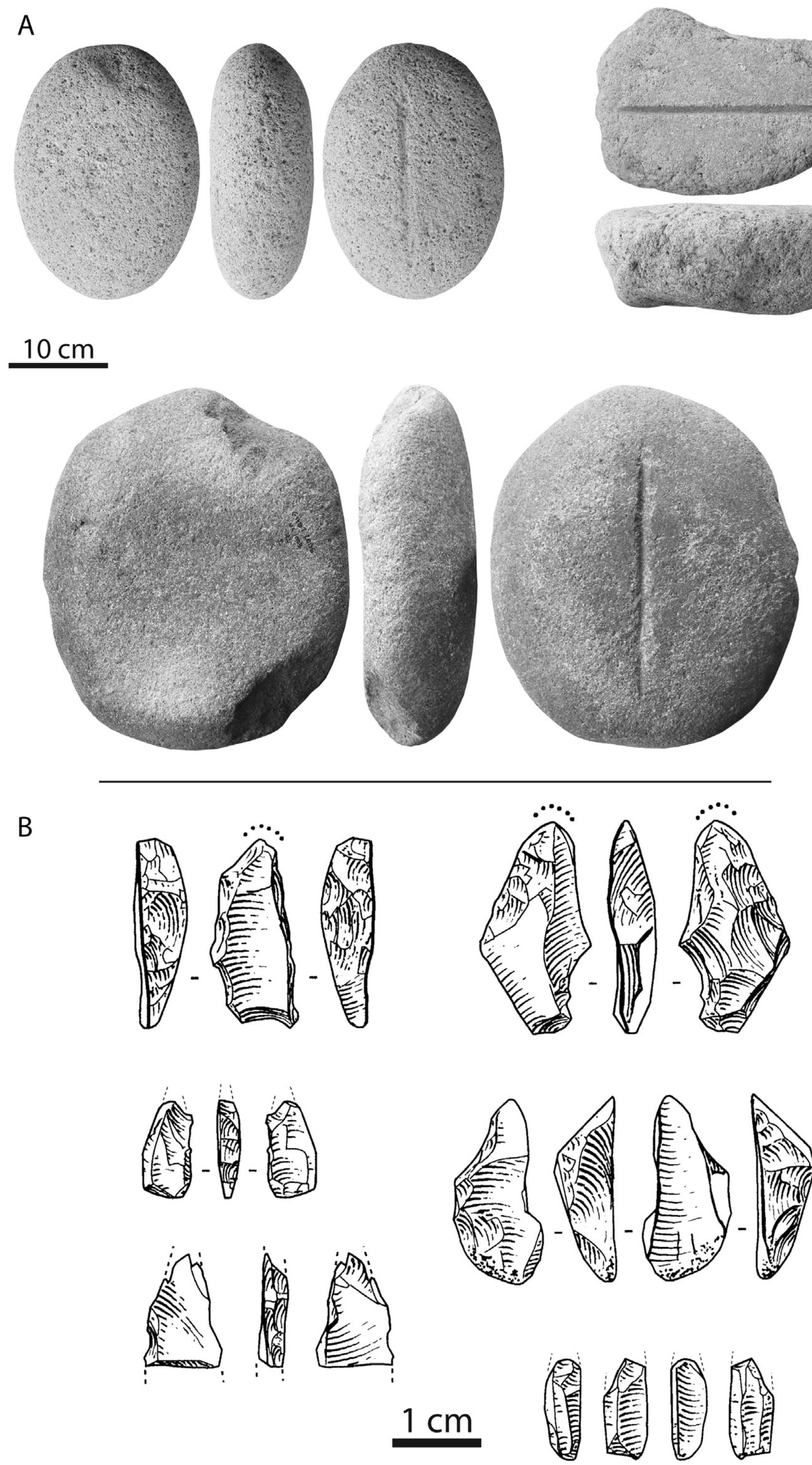


**Fig. 10.** Tools that can be part of the beads production *chaîne opératoire* at Gare Maritime site. A – Polishers with groove, made of volcanic rock. B – Flint drills.

## 5. Discussion

Gare Maritime site has proved to be one of the richest excavated West Indian site for beads and pendants and especially one which displays a great diversity of raw materials. Indeed, 50 artifacts from 13 different raw materials have been recovered during the manual excavation of 28 $m^2$ of pre-Columbian layers. One has to keep in mind that it is not a surface collection and even if it seems limited, it is one of the largest excavations of this kind of production place. It could be argued, however, that this is probably a limited production case, reduced to the needs of the local population only and not surplus production for export as has been shown at Golden Grove (Mones, 2007).

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

### 5.1. Raw materials, their distribution and their potential origin

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

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

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

Finally, turquoise items provenance is still difficult to establish. The only well documented sources of this mineral are the numerous mines located in the South West of the USA that provided the green mineral for Mesoamerican and North American pre-Hispanic people (Harbottle and Weigand, 1992). Other sources are known in South America (Evans, 1913; Evans and Southward, 1914; López et al., 2018) and could have been related to the presence of turquoise in the North of the continent and further in the West Indies. One last hypothesis for the origin of the turquoise artifacts recovered in the West Indies could be the existence of such a mineral source in the Greater Antilles. The jadeite example recently proved the possibility of discovering unknown sources of archaeologically valuable minerals in this region (Cárdenas-Párraga et al., 2010; García-Casco et al., 2009; Harlow et al., 2006; Rodriguez Ramos, 2011; Schertl et al., 2012). Recent works based on isotope measurements to discriminate geological sources (Hull et al., 2014; Othmane et al., 2015; Thibodeau et al., 2015) in North America may in the future be applied to West Indian archaeological turquoise to trace their origin.

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

### 5.2. Typo-technologies, manufacturing and regional connections

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

Regarding the manufacturing, it is difficult to imagine how Amerindian people managed to drill such long beads of amethyst with their technology, an issue that has been already raised before. The only answer that one can find is in old texts about the Amazonian bead makers, like Vincent Roth (Roth, 1944) that cannot recall if Wallace or Bates told him that drilling a bead "took the spare time of three generation", and specify the technique used: "with nothing harder than the mid-rib of leaf of the ite palm". It is noteworthy that Walter Edmund Roth, his father, wrote, in 1924, quoting Wallace (1889), that it took two lives and not three. We thus have probably only one primary source writing about quartz bead makers in the Amazonian Basin that is Wallace (Wallace, 1889) who wrote: "*I now saw several of the men with their most peculiar and valued ornament a cylindrical, opaque, white stone, looking like marble, but which is really quartz imperfectly crystallized. These stones are from four to eight inches long, and about an inch in diameter. They are ground round, and flat at the ends, a work of great labour, and are each pierced with a hole at one end, through which a string is inserted, to suspend it round the neck. It appears almost incredible that they should make this hole in so hard a substance without any iron instrument for the purpose. What they are said to use is the pointed flexible leaf-shoot of the large wild plantain, triturating with fine sand and a little water; and I have no doubt it*

**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 material/reduction chip; B: bead or pendant blank; F: finished bead or pendant. Sites are listed from north to south (see Fig. 1).

| Site | Island | Context | 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 | |
| Tecla | Puerto Rico | Excavations | | | X | X | | X | | | X | | | X | X | | X | X | | X | X | | X | | | X | X | | X | Aventurine, marble, malachite |
| Sorcé | Vieques | Excavations | | | X | X | | X | | | X | | | X | X | | X | X | | X | X | | X | | | X | X | | X | Aventurine, marble, malachite |
| Tutu | St. Thomas | Excavation (midden) | | | X | | X | | | | | | | | Greenstone | | | Greenstone | | | | | X | | | | | | | Green chert |
| Royall | Antigua | Excavations + surface | | | | X | X | X | X | X | X | X | X | X | | | X | | | | X | X | X | | | X | | | X | Jasper, limestone, tuff, barite |
| Elliot | Antigua | Excavations + surface | X | | | X | | X | X | | X | X | X | | | | X | | | X | X | X | X | | | | | | X | Limestone, tuff, barite |
| PA-15 | Antigua | Excavations | | | | | X | X | | | | | | | | X | X | | X | X | | X | X | | | | | X | X | |
| Trants | Montserrat | Excavations + surface | | | X | X | | X | X | X | X | | | | Greenstone | | | Greenstone | | | | | | | | | | | X | Feldspar |
| Gare Maritime | Guadeloupe | Excavation (midden) | X | X | X | | X | | | | | | | | X | X | X | | | X | | X | X | | X | X | | | X | Jasper, aventurine, feldspar, chlorite, sudoite, paragonite |
| Vivé | Martinique | Excavation (burial) | | | X | | | | X | | | | | | Greenstone | | | Greenstone | | | | | | | | | | | | |
| Pearls | Grenada | Excavations | X | X | X | X | X | X | | | | | X | X | | | | | | | | | | | | X | | | | |
| Golden Grove | Tobago | Excavations | | | | | | | | | | | | | | | | | | | | | | | | | X | X | X | |

*is, as it is said to be, a labour of years. Yet it must take a much longer time to pierce that which the Tushaiia wears as the symbol of his authority, for it is generally of the largest size, and is worn transversely across the breast, for which purpose the hole is bored lengthways from one end to the other, an operation which I was informed sometimes occupies two lives.*". Some very rare drills or fragments of drills, related to hard stone drilling, have been mentioned in a few sites, as it is the case (but unfortunately without any representation of them) in Pearls as a "drill bit [made of] hard stone" (Cody, 1991) or in PA-15 with "small trapezoidal chert flakes [that] may be drill bits" (Gent and de Mille, 2003). Cody (1991) and Crock and Bartone (1998) also note the presence of partially drilled quartz beads, the latter mentioning that the bottom of the hole presents a remnant cone, leading them to think that a hollow drill must have been used. Regarding the Gare Maritime's artifacts that could be related to manufacturing tools (Fig. 10), as previously discussed, they are mainly represented by polishers and the flint drills identified cannot be at the origin of fine and long bead's holes. The lack of precise information for the drills of Pearls and PA-15 unfortunately prevent us to think they are different from the ones from Gare Maritime. The documentation of drilling technologies will need further studies, regarding for example use wear studies of artifacts and putative tools, or complementary investigation based on experimental archaeology.

The plano-convex bead made in turquoise (GD-01-034) is only similar (typology and raw material), to our knowledge, to the *adornos plano-convexo* found in Sorcé (Narganes Storde, 1995) among a thousand beads and pendants recovered during its excavation. In this site, this specific type of artifacts always exhibits a greenish color even if they are made of diverse materials. They are there interpreted as eyes of disappeared wooden or cotton sculptures. It could also be similar in shape to the turquoise bead of Royall's site (Murphy et al., 2000, Fig. 10).

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

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

## 6. Conclusion

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

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

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

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

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

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

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