Palissy ceramics: elemental analysis and origin of clays

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ABSTRACT Bernard Palissy (1510-1590) had a large contribution in the development of ceramics in France. Palissy's fame was triggered in the 19th century after the discovery of ceramic fragments on the site of the present-day "Jardin des Tuileries" in Paris. Excavations from 1984 to 1992 uncovered his production workshop, with thousands of fragments. They are being analysed in order to determine the origin of the clay bodies of Palissy objects. Both the structure and chemistry of the clays have been studied by petrographic observations and elemental analysis. Various types of clays have been used by Palissy throughout his works. Groups are defined and tentatively linked to typical clay products from the Renaissance times in northern France.

1. Introduction

Bernard Palissy (1510-1590) is the best known ceramic artist from the French Renaissance. In addition to his ceramics, he has produced a number of written documents such as *Recepte Véritable* ... and *Discours Admirables*. His ceramic production can be estimated from the thousands of fragments from earthenware, glaze and plaster objects found during excavations made during the 19th and the 20th centuries. Accidental findings during the second half of the 19th century led to the discovery of Palissy's workshop east of the Tuileries Palace. This promoted a large number of investigations on his life and his production. At the end of the 20th century, detailed investigations have been performed on the underground structures of the site of the laboratory of the C2RMF (Dufay et al., 1987). This led to the discovery of the innovative kiln of Palissy (Dufay et al., 1987) as well as several thousand objects, opening new opportunities to understand the technology involved in his ceramic production. Palissy started ceramic production around 1540 when he settled in Saintes in southwest France. Thirty years later, he was living in Paris as a renowned artist producing ceramic art objects for the King and for aristocrats. As a consequence of religious persecution, he left Paris in 1572 and lived in Sedan, where he then spent a large fraction of the remainder of his life. The extent of his ceramic production during that period is not clearly established.

Based in particular on his writings, Palissy is known for having performed numerous experiments on ceramic processing. However, it is clear that he was aware of the know-how of his time. He lived at the same time as Masséot Abaquesne in Rouen who mastered the production of tin glazes. He made reference to the work of Girolamo Della Robbia (1488 birth in Florence — in France after 1517 — 1566 death in Paris). Palissy also knew the production of Saint Porchaire. He specifically attempted to reproduce, in his ceramic work, all the colour variations that can be found in Nature. Most of the fragments of ceramic and plaster objects which have been excavated are linked to the production of architectural parts (tiles, bricks, grotto elements), rustic figurines ("rustiques figulines") representing shells, plants and animals to be incorporated into grottoes, rustic basins or platters, silverware-like ceramics (spoons, cups, ornament, medals) and, finally, technical parts (moulds, cases, "albarelli", name for small drug jars, etc.) typical of a ceramist's workshop (Dufay et al., 1987).

Some data have been obtained on the composition of Palissy ceramics by Munier (1949), Tite (1996) and Perrin (2001). The newly found objects have opened an immense field of investigation to provide a better knowledge of Palissy's production, his fabrication processes and of his links to other Renaissance ceramists. There are questions related to his technical achievements in Saintes before going to Paris. The extent of Palissy's production that exists now is not well known because of the large number of imitators active throughout the centuries (Amico, 1987). In this paper, we present preliminary results to answer a few questions based on the analysis of about 70 ceramic bodies taken from objects found in Palissy's workshop.

2. Methodology

Specimens were chosen from the thousands of shards found recently during the excavations in the Louvre. The selection aimed at being representative of the different types of objects. Some of them were altered by the long burial, but this should not affect the analysis of ceramic bodies constituting the bulk of the objects. Three main classes are based on the colour of the bodies (Munier, 1949); they are named for the clays used, which are red clay, beige clay and extra white clay. In some cases, different clays are mixed to give pastes with coloured veins.

The ceramic pastes have been systematically analysed by the CRPG (CNRS UPR 2300 in Nancy) using ICP-AES and ICP-MS. The first technique gives the major elements and the second gives the trace elements; 55 elements were measured including rare earths. Small amounts of powder (about 0,5 g) are necessary; they were obtained by drilling holes in the objects.

Petrographic slabs could be cut only from shards in order to identify the minerals and the structure of the bodies (temper, clay mixing, etc.).

3 Results

Examination of the objects reveals that Palissy chose clays according to a variety of criteria, such as colours or other physical properties. Indeed, there are many examples of thick clay layers or of mixed clays giving spectacular colour effects with the help of transparent glazes. The mixed clay bodies are made of millimetre size multilayers with sharp interfaces (Figs. 1 to 3). Each layer corresponds the red or beige clays described below, with additions of manganese oxide and cobalt ore to obtain darker colours. Small objects, such as medals or dinnerware, are made with extra-white fine clays. Moreover, it is common to find fragments of objects made of two kinds of clays. For instance, the glazed decorative sides of grotto elements are lightly coloured (white or beige); they are supported by a walled structure of red clays, the two having been sintered in a single step. The chemical compositions of the ceramic bodies are SiO_2 55-60%, Al_2O_3 30-40%, Fe_2O_3 1% for extra white clays, SiO_2 65-75%, Al_2O_3 15-25%, Fe_2O_3 1-5% for beige clays and SiO_2 60-70%, Al_2O_3 20-25%, Fe_2O_3 8-9% for red clays.

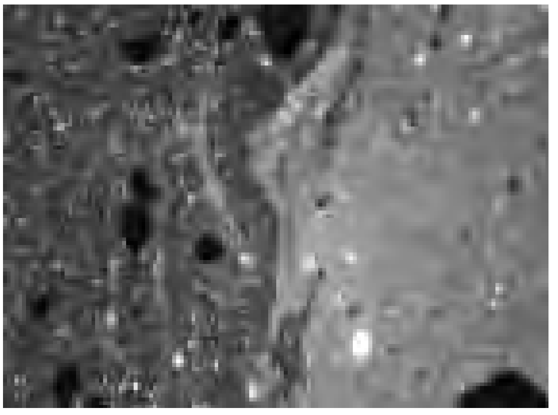

FIG. 1 – Petrographic image (4,7 x 3,4 mm² view) between crossed polars of a thin section from the group i) in Table 2; triangular brick EP 81 (lab 25772). A zone made with beige and red clays is shown. The compositions are SiO_2 62.2%, Al_2O_3 28.2%, Fe_2O_3 4,9% for the beige part (right) and SiO_2 60.6%, Al_2O_3 25,5%, Fe_2O_3 8,83% for red part (left). The black dots are iron rich nodules. A small quantity of fine quartz grains is present.

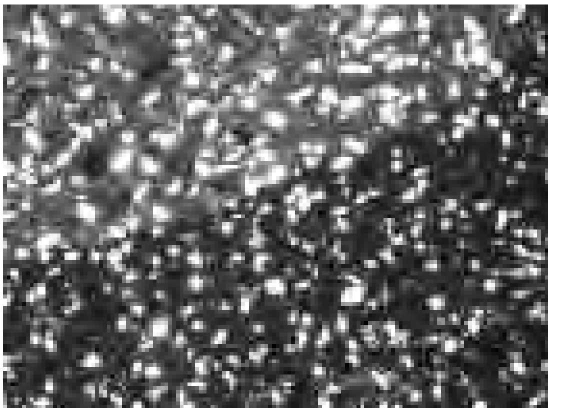

FIG. 2 – Petrographic image (4,7 x 3,4 mm² view) for the group v) in Table 2; brick EP 259 (lab 25768). The composition of the beige part is SiO_2 75,3%, Al_2O_3 16,6%, Fe_2O_3 4,7%.

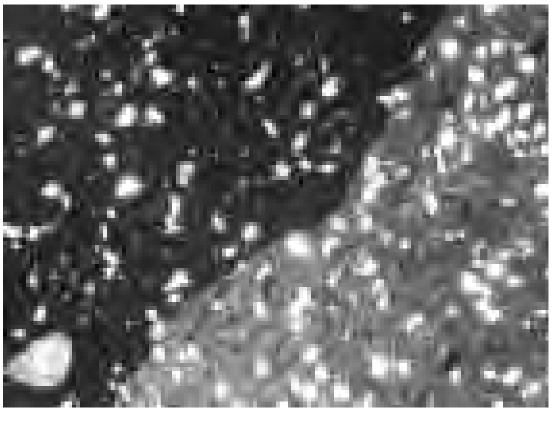

FIG. 3 – Petrographic image (4,7 x 3,4 mm² view) for the group ii) in Table 2; floor tile EP 946 (lab 25835). The compositions are SiO_2 68,4%, Al_2O_3 23,8%, Fe_2O_3 3,74% for the beige part and SiO_2 65,5%, Al_2O_3 21,9%, Fe_2O_3 8,3% for red part. A large quantity of coarse quartz grains is present.

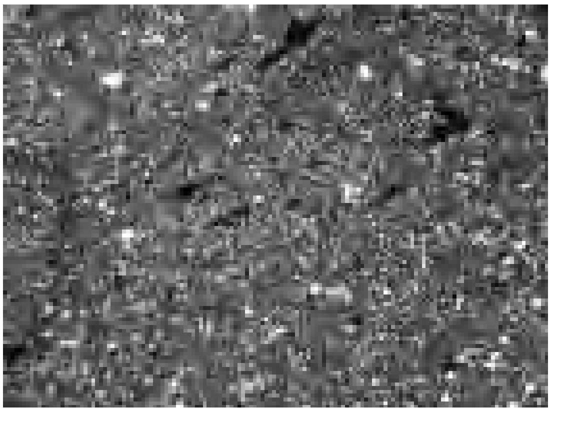

FIG. 4 – Petrographic image (4,7 x 3,4 mm² view) for the group vi) in Table 2; albarello 21456 (lab 25831). The albarelli were used for experimentation; they were probably produced for that purpose by potters close to Palissy. The composition is SiO_2 75,9%, Al_2O_3 19,2%, Fe_2O_3 1,3% .

3.1 Red clays

The ceramic bodies consist of a dominant clay matrix tempered by quartz grains having a restricted size distribution. Three groups have been identified based on the chemical compositions (Table 1). The first group includes 6 objects with 4 bricks. The second group is homogeneous (9 floor tiles and two tableware objects) with intermediate SiO_2 concentrations. The third group includes 4 objects (brick, dinnerware, grotto element and floor tile). The red clay is sometimes used as thick layers or inlays to produce ornamental colours. Trace element concentrations suggest that all the objects used the same original clay with different preparations, quartz temper being added in various amounts. This can explain the SiO_2/Al_2O_3 data of Table 1.

TABLE 1

Average chemical compositions for a number of ceramics made of red clays, including X ray fluorescence data (Perrin, 2001).

Type	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2
Brick	60,5 ± 1,1	25,5 ± 0,6	8,7 ± 0,9	1,1 ± 0,4	0,6 ± 0	0,2	1,6 ± 0,1	1,7 ± 0,1
Tiles	65,7 ± 1,1	21,6 ± 0,5	8,3 ± 0,6	0,58 ± 0,2	1,1 ± 0,4	0,3	0,9 ± 0,2	1,5 ± 0,1
inlays	69,7 ± 1,2	18,0 ± 0,4	7,8 ± 0,6	0,9 ± 0,5	0,6 ± 0,1	0,4	1,2 ± 0,1	1,3 ± 0,1

3.2 Beige clays

The largest number of samples comes from beige clay ceramics. The compositions reported in Table 2 correspond to six groups, viz. i) 2 bricks, ii) 11 tiles and spacers used in kilns, iii) 4 bricks and moulds, iv) 14 ornaments, moulds, tableware and tiles, v) 3 bricks and vi) 10 rustic fragments, albarelli and tableware. The colour varies from ivory to pink depending on the iron concentration. Petrographic observations are necessary to characterize the various groups. The 2 bricks (group i) have low quartz content (Fig. 1), hence the low SiO_2 concentration (Table 2), in contrast to the 3 bricks (Fig. 2) that have a SiO_2 concentration of 75,3%. The 11 tiles and spacers (group ii) have compositions that are not far from the following two groups in Table 2; iron, sodium and potassium concentrations allow us to distinguish them. Their microstructure reveals coarse quartz grains (Fig. 3) showing occasional agglomerates of iron-rich clays. Finally, the 10 rustic fragments, albarelli and tableware have a fine microstructure typical of screened raw materials (Fig. 4). The large amount of quartz is consistent with the high SiO_2 concentration (Table 2). Fine grained materials were necessary for the moulding of details on the rustic ornaments (animals, shells, plants) typical of the Palissy production.

TABLE 2

Average chemical compositions for ceramics made of beige clays.

Type	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5
i) triangular bricks	61,9 ± 0,4	28,5 ± 0,4	4,9	0,8	0,7	0,1	0,9	2,1	0,1
ii) spacers, tiles	68,5 ± 0,8	23,3 ± 0,8	3,9 ± 0,6	0,5 ± 0,1	1,1 ± 0,4	0,1	0,8	1,6 ± 0,1	0,1
iii) bricks, moulds	69,1 ± 1,4	24,4 ± 1,2	1,8 ± 0,2	0,4 ± 0,1	0,6 ± 0,2	0,3	1,9 ± 0,1	1,4 ± 0,1	0,1
iv) ornament, mould, tableware, tiles	70,7 ± 2,3	24,4 ± 2,5	1,6 ± 0,4	0,2 ± 0,1	0,8 ± 0,2	0,1 ± 0,1	0,4 ± 0,1	1,8 ± 0,1	0,1
v) bricks	75,3 ± 0,5	16,5 ± 0,1	4,7 ± 0,5	0,5	0,6	0,1	0,9	1,2	0,1
vi) rustic, albarello, tableware	77,6 ± 1,3	17,1 ± 1,4	1,3 ± 0,1	0,2	0,7 ± 0,3	0,1	0,9 ± 0,1	1,7 ± 0,1	0,3 ± 0,3

3.3 Extra white clays

Alumina-rich clays have also been used by Palissy (Table 3) for the production of specific objects such as medals moulded from metallic counterparts. Low density materials are obtained. Chemical compositions do not permit us to distinguish groups of objects (Table 3). Petrographic observations show very fine microstructures (e.g. for EP 1644) and cases with coarse microstructures with quartz or flint grains larger than 20 µm.

TABLE 3
Chemical compositions of ceramics made of extra white clays.

Type	Invent. #	SiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5
Salt-cellar	EP2139A	63,23	29,86	2,45	tr	0,53	0,78	0,14	1,17	1,52	0,32
"St Porchaire"	EP1769	63,86	30,83	1,15	tr	0,38	1,04	0,28	1,39	0,91	0,16
Medal	EP1609	62,87	34,16	0,69	tr	0,38	0,36	0,08	0,85	0,61	tr
grotto wall	21235	62,10	35,24	0,68	tr	0,44	0,41	0,13	0,50	0,47	0,03
Small salt-cellar	EP2136	61,74	35,81	0,61	0,02	0,35	0,36	0,09	0,55	0,43	0,03
medal	EP1644	57,43	40,38	0,45	0,02	0,27	0,29	0,07	0,64	0,41	0,02
Grotto wall	21225	56,07	39,87	1,37	tr	0,29	0,28	0,12	1,02	0,92	0,04

4 Discussion and conclusions

Previous analytical data have been obtained on the fragments discovered in the 19th century. Tite (1986) found compositions comparable with those of Table 3 for three white body ceramics. The data of Perrin (2001) were obtained with the X ray fluorescence facility of the C2RMF; they are included in the present data (Table 1). Munier (1949) studied the three coloured bodies and gave the chemical compositions for four fragments: for red clays SiO_2 72.14%, Al_2O_3 18.79%, Fe_2O_3 6.84%; for beige clays SiO_2 69.89%, Al_2O_3 24.64%, Fe_2O_3 2.82%; and two results for extra-white clays SiO_2 58.62%, Al_2O_3 36.91%, Fe_2O_3 1.64% and SiO_2 59.28%, Al_2O_3 35.35%, Fe_2O_3 1.65%. In the latter case, the values are in agreement with those of Table 3. For the beige clays, the composition is analogous to those of groups ii), iii) and iv) of Table 2. The red clays of Table 1 have a lower SiO_2 content and a higher Fe_2O_3 content than the red clay of Munier (1949). The data of Tables 1 and 2 have been obtained by averaging the concentrations obtained for many objects. Trace element compositions suggest the same origin for clays in each class. The compositional variations would then result from different processing of the raw materials, in particular to control the shrinkage during drying or firing which is critical to obtain the multi-layered bodies (Figs. 1 to 3) so frequent in Palissy works.

Palissy produced large quantities of ceramics in Saintes and in Paris, where thousands of objects have been found in recent excavations. The origin of the clays used to make these objects is still an open question. Munier (1949) suggested that the red clay comes from Villebon, near Orsay, 25 km south of Paris; indeed, its composition is close to those of tiles and inlays in Table 1. For the beige clays, the situation is still unclear; Munier (1949) deduced from his single analysis an origin near Paris (Arcueil or Ivry sur Seine). Based on the large data set summarized in Table 2, a new study is in progress to determine the origin of beige clays by comparing the Palissy productions with those of various workshops active in the Paris area in the 15th-16th centuries (Ravoire and Bouquillon, 2004, in preparation). The extra-white clays do not seem to exist around Paris. Even the white clays from Beauvaisis are not suitable to make the Palissy extra-white bodies. Their compositions (Table 3) are compatible with clays from southwest France, as suggested by Munier (1949) and Tite (1986). A firm conclusion requires a detailed study of the clays which is in progress; clays from various deposits around Paris have been collected and are being analysed (Ravoire and Bouquillon, 2004, in preparation).

In his publications, Palissy describes the considerable efforts that he made to understand the behaviour of raw materials, but he does not give any clear indication about the way he found to control them. The objects that have been discovered show great sophistication in their processing (Figs. 1 to 3) which has to be the consequence of Palissy's investigations, mostly in Saintes. Considering the ceramics found in Paris, it seems that Palissy started with raw materials of the same origin. He modified their properties by adding various amounts of quartz of different particle sizes (Figs. 1 to 4). It is known that such addition decreases the plasticity of the paste, limits the shrinkage during drying and firing, and gives a thermal expansion close to that of glazes (Hamer et al., 1997, p. 271). This is especially important to achieve perfect glazing on "rustiques figulines" (snakes, frogs, etc.) after several firings. The addition of fine grained quartz (less than 25 µm) does not give the same properties; such fine particles could act as flux if the firing temperature is high enough (Hamer et al., 1997, p. 159, 304). Palissy seems to have understood many such phenomena concerning ceramic processing during the course of his research on pottery fabrication. Studies in progress should allow us to confirm this conclusion and give detailed insights on his contributions to various aspects of the technology.

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REFERENCE LIST

AMICO, L. N. (1987) - Les céramiques rustiques authentiques de Bernard Palissy. *Revue de l'Art*. Paris. 75, p. 61-69.

DUFAY, B.; DE KISCH, Y.; POULAIN, D.; ROUMEGOUX, Y.; TROMBETTA, P.-J. (1987) - L'atelier parisien de Bernard Palissy. *Revue de l'Art*. Paris. 75, p. 33-60.

HAMER, F.; HAMER, J. (1997) - *The Potter's dictionary of materials and techniques*. 4th edition. London: A&C Black, 2004.

MUNIER, P. (1949) - Contribution à l'étude des céramiques de B. Palissy. *Bulletin de la Société Française de Céramique*. Paris. 3, p. 26-46.

PALISSY, B. (1563) - *Recepte veritable par laquelle tous les hommes de la France pourront apprendre à multiplier et augmenter leurs thresors*. La Rochelle: Bathélémy Berton.

PALISSY, B. (1580) - *Discours admirables de la nature des eaux et fontaines*. Paris: Martin le Jeune.

PERRIN, I. (2001) - *Les techniques céramiques de Bernard Palissy*. Thèse Université Paris IV. Villeneuve d'Ascq: Editions Presses Universitaires du Septentrion.

TITE, M. S. (1996) - Comparative study of the production technology for "Saint Porchaire" and related European ceramics. In BARBOUR, D.; STURMAN, S., eds. - *Saint Porchaire ceramics*. Hannover; London: University Press of New England (National Gallery of Washington, Studies in the history of art 52. Monograph series II), p. 99-105.