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THE ORIGIN OF 18TH–19TH CENTURY TIN-GLAZED POTTERY FROM LORRAINE, FRANCE*

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Forty-eight tin-glazed ceramic fragments (faiences) from Lorraine, found in excavations or pertaining to objects in collections, were subjected to X-ray fluorescence analysis to determine the bulk, major, minor and trace element compositions. Sixteen superficially clay layers from the surroundings of Lunéville and Saint-Clément were also analysed. The faiences are, with four exceptions, MgO rich. The combination of stylistic and chemical arguments allowed the recognition of 28 objects that were attributable to the important faience manufactory of Jacques II Chambrette in Lunéville. This reference group was used to test the provenance of high-Mg faiences from private collections. The latter are not from the manufactory of Le Bois d'Épense/Les Islettes as commonly assumed, but most probably belong to Lunéville and Saint-Clément. According to archival sources, the potters mixed three clays for the pastes. Some prospected clays are MgO rich due to the presence of dolomite and other Mg-bearing minerals, but not as high as the faiences, a fact that can be explained by the sampling of de-carbonatized layers.

KEYWORDS: FAIENCE, TIN GLAZE, LORRAINE, LUNÉVILLE, SAINT-CLÉMENT, CHEMISTRY, MINERALOGY

INTRODUCTION

French faience

The origin of the tin-glaze technique can be traced to what today is Iraq (Caiger-Smith 1973; Soustiel 1985). Analyses by Mason and Tite (1997) and Mason (2004) threw much light on the development of Mesopotamian tin glazes, as summarized by Maggetti (2012) and Heimann and Maggetti (2014, ch. 13). French faience is a tin-glazed pottery; that is, a type of earthenware covered with a lead–alkali glaze to which tin oxide (cassiterite SnO_2) has been added as an opacifier. The first French tin-glazed earthenware was produced in Marseille (Fig. 1) at the beginning of the 13th century (Marchesi *et al*. 1997; Rosen 2001). In Marseille, local workshops created unglazed objects, or objects with a transparent lead glaze, both in a medieval tradition as well as a few tin-glazed pieces in a new, Islamic technique. This technology spread rapidly, locally but also throughout France, as shown by the production of enamelled wares at the beginning of the 13th century in Languedoc, probably in Montpellier (Leenhardt 1999, 152). During the first 300 years (from end of the 13th until the early 16th century), tin-glazed tiles were produced for a wealthy clientele (Rosen 2001), while Uzège, Languedoc and Montpellier

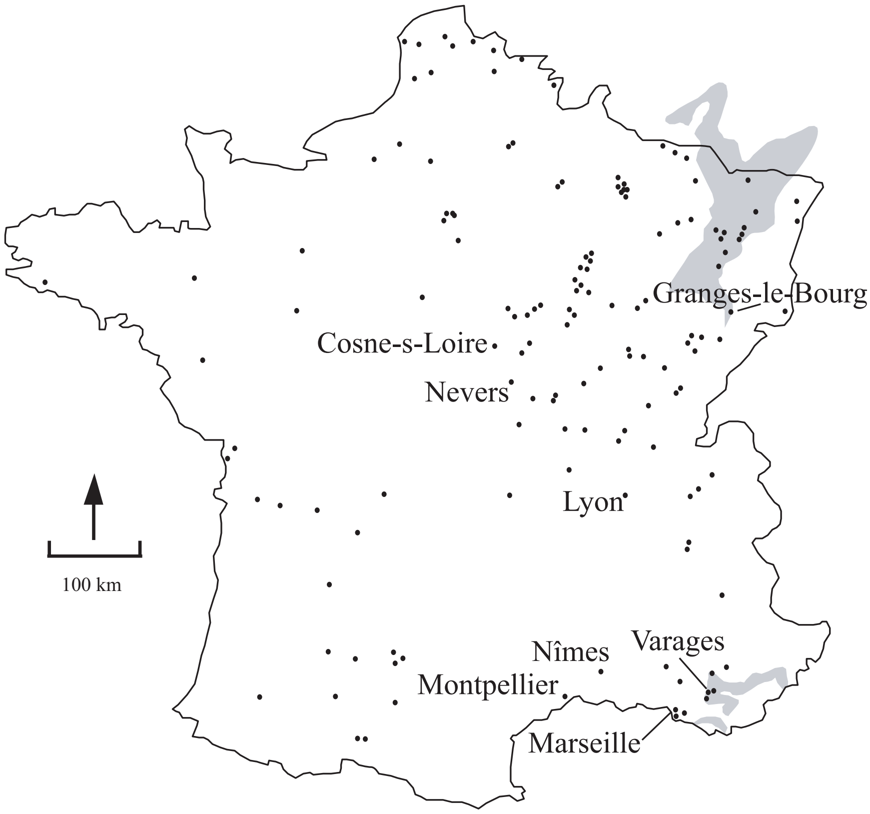

Figure 1 *A map showing 144 important French faience manufactories (dots) of the 17th to 19th centuries, redrawn from Rosen (2001). Manufactories referred to in the text are labelled. There were surely many more, as: (1) only the most important are represented here, (2) many towns had more than one manufactory and (3) not all are known or excavated. Triassic terrains are shown in grey (the small Triassic outcrops around the Massif Central are not represented).*

continued to produce lead-glazed ware (Vallauri 1999, 161). Italian potters moved to Lyon shortly after 1510, and several Italian tin-glaze pottery workshops opened before the end of the 16th century in Lyon, Nîmes, Montpellier, Nevers and Cosne-sur-Loire. These establishments were the starting point for the extraordinary expansion and success of French faience in the 17th and 18th centuries. Around the mid-16th century in and around Faenza (Italy), the biscuits were coated with a particularly thick pure white glaze. These *bianchi di Faenza* were so popular and commanding throughout Europe that to this day in France the name of the city has become the synonym for French tin-glazed pottery, *faïence*. In the time span from 1550 to 1600, Lyon's tin-glaze potters were called 'white earth potters' or 'vase makers in the style of Venice', and those from Nevers 'white crockery makers in the style of Venice' (Rosen 2001). The term *fayence* appeared for the first time at the beginning of the 16th century in Nevers (France), where the ceramist Jean-Baptiste Conrade was labelled 'sculpteur en terre de fayence' (sculptor of faience earth) (Rosen 2001). Archaeometric studies of French faiences are scarce (see the discussion in Maggetti 2012).

Faience production in Lorraine

History The earliest establishment in Lorraine is the manufactory founded in 1711, in Champigneulles, near Nancy (Fig. 2), by Jacques I Chambrette (1683–1751). He came from Dijon, and was the son of Jean, who had learned the trade in Nevers. His son Jacques II Chambrette, born in Dijon, (*c*.1705–58) started out as a faience merchant in Lunéville in 1722.

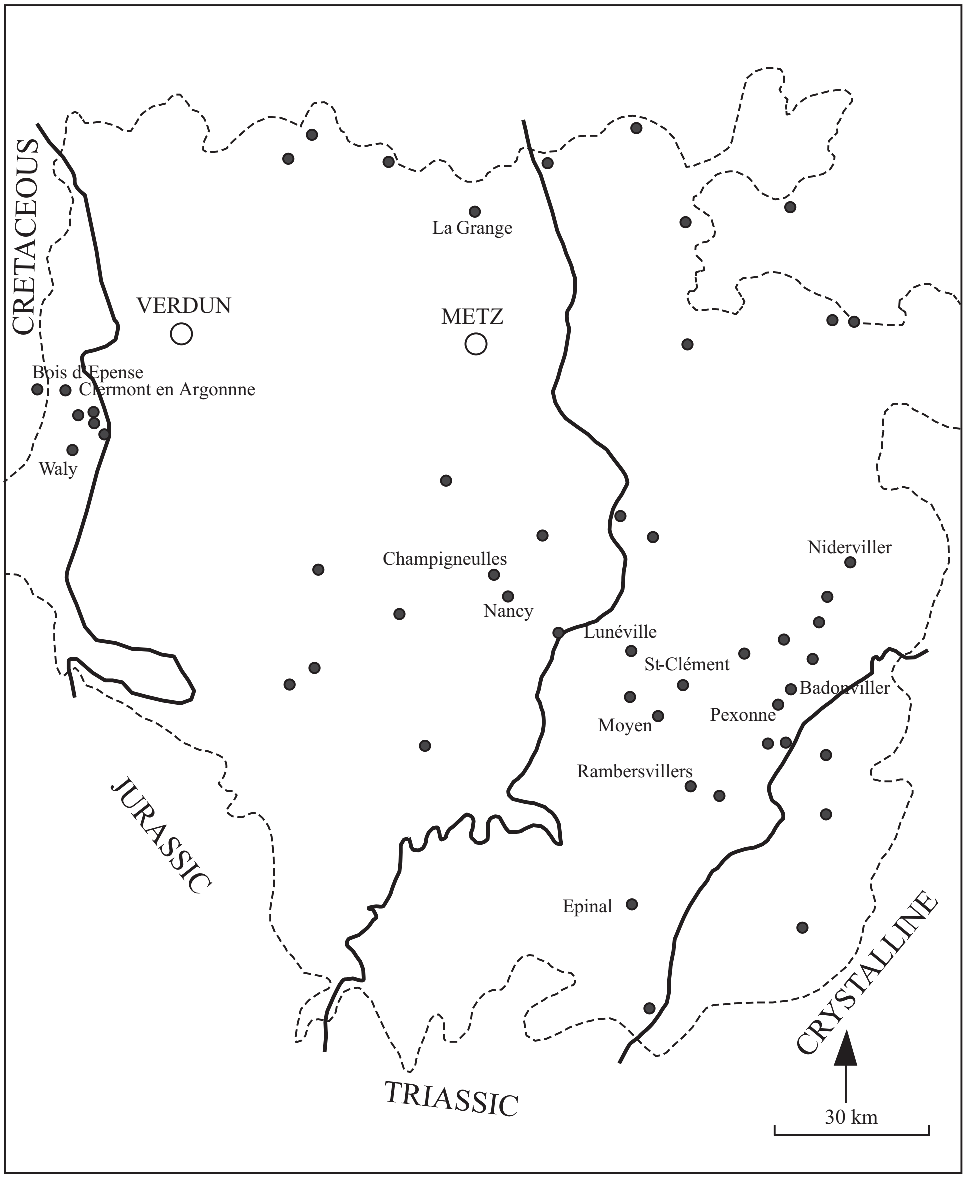

Figure 2 *Forty-six faience manufactories (dots) from Lorraine, according to Saint-Dié (1981, 166) with geological limits according to Carte géologique de France (1968). The most important manufactories are labelled. The circles show important towns.*

There, in around 1730, he set up his first manufactory, which was to produce continuously until 1973. He also created a certain number of other establishments in the area: a creamware (white earthenware) manufactory in Lunéville, where the first 'Terres de Lorraine' was produced as early as 1748, and Saint-Clément in 1757, situated in the nearby 'Three Bishoprics', as was that of Épinal, founded 2 years later (1759–1840). On the death of Jacques II Chambrette in 1758, it was said that the 'Royal Manufactory' of Lunéville had attained considerable economic importance, ruining the Dutch and English trade in Lorraine, and selling its products to Switzerland, Germany, the Low Countries, Italy and even Poland. Other faience manufactories were founded by his son Gabriel: Moyen (1763–83) and Rambervillers (1738–1866). Moreover, a dozen other manufactories, such as Waly, founded in 1708, could be found in the nearby region of Argonne, amongst which the most important was that of Le Bois d'Épense, the so-called 'Les Islettes' (1735–1848)—situated in the territory of the 'Five Big Farms', just on the other side of the border formed by the river Biesme—which employed up to almost 200 workers. The main difficulty is that the design, patterns and colours of the products of all these manufactories are very similar, which does not help to distinguish them from one another.

Production technique The Lunéville (Grandjean 1983) and Saint-Clément (Calame and Wéber 2008) manufacturers used the same techniques as those that were well established in other French manufactories (Deck 1887; Munier 1957; Montagnon 1987; Rosen 1995, 2009; Peiffer 2000; Bastian 2002–3; Maggetti 2007, 2012). According to de Dietrich (1799–1800, 3) and Grandjean (1983, 75), the Lunéville manufacturers mixed clays from Hériménil, Adoménil and Réhainvillier, three sites very close to the manufactory (Fig. 3). Braconnier (1883, 136) describes these clays as follows: '[the] Lunéville and Saint-Clément manufactories make use of the blue clays from the upper layer taken from Hériménil and Rehainviller, in the amount of 2.000 cubic metres a year'. This lithostratigraphic formation is the upper part of the *inferior iridescent marls* of the Middle to Lower Keuper, which pertain chronostratigraphically to the Middle and Upper/Late Trias (Ladinian to Carnian). The same author gives a detailed profile on 34.45 m (Braconnier 1883, 133), along with 28 chemical analyses (Braconnier 1883, 134). Table 1 shows the profile and the chemical analyses of the clay strata. The 6 m of blue clay are very poor in CaO (1.5 wt%) and lack MgO, contrary to the thick layer of the underlying grey dolomitic marls (9 m), with high CaO (24.6 wt%) and MgO (17.1 wt%) contents. Deliveries of clays from the Lunéville region to the Saint-Clément manufactory are already mentioned in the archives by around 1790 (Calame and Wéber 2008, 95). In Saint-Clément, three deposits very close to the manufactory were used, situated in the Middle Keuper and the Alluvium of the Meurthe river (Dubus and Pannequin 1999, 146; Calame and Wéber 2008, 92–6; see also Fig. 3). Not only the inferior Keuper clays, but largely all the clays of the whole Keuper series—that is, of the whole Upper/Late Trias—are dolomitic and gypsiferous (Braconnier 1883; Millot 1950; Ménillet 2005).

Goals for this study

Many ceramic production centres in 18th-century Lorraine simultaneously produced two types of pottery: (1) traditional tin-glazed earthenware (*faience*), made from local clays, and (2) white earthenware, made from imported white firing clays, blended with calcined flint and other ingredients. This synthetic (artificial) body was invented before 1750 in both England (*creamware* or *Queen's ware*) and France/Lorraine (*faïence fine* or *terre de pipe*; Maire 2008). The origin and technique of Lorraine calcareous white earthenwares were studied by Maggetti

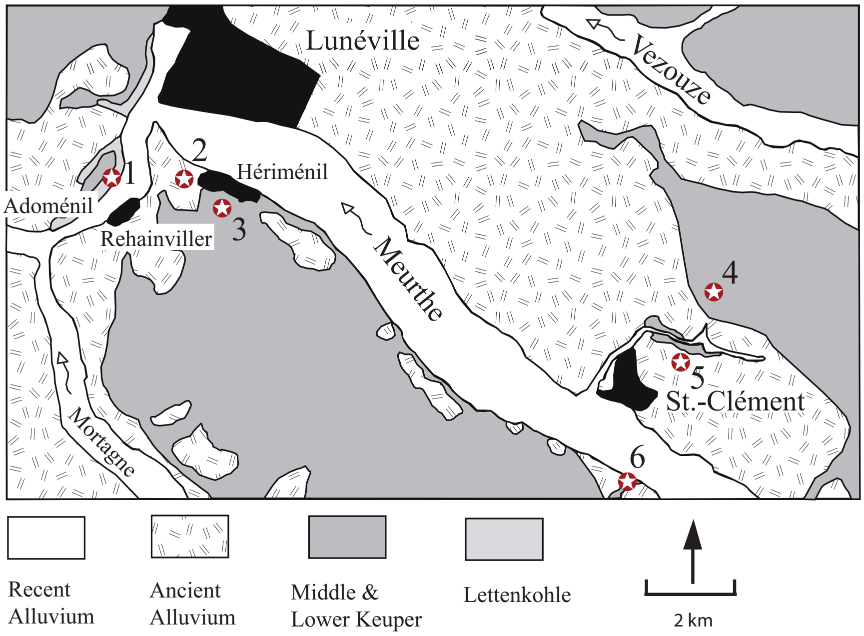

Figure 3 *A simplified geological map of the region around Lunéville and Saint-Clément, according to Hilly* et al. *(1997) and Ménillet* et al. *(2005). The stars show the sites of clay pits for the manufactories of Lunéville (1, Rehainviller; 2, Patis; 3, Hériménil: Grandjean 1983) and Saint-Clément (4, Le Trimoulot; 5, Les Eaux; 6, La Meurthe (assumed): Calame and Wéber 2008). The prospected clays are LNV 44–49 (1), LNV 42–43 (3), LNV 39–41 (4) and LNV 36–38 (5). LNV 31 and LNV 32 were collected outside the perimeter of this map.*

Table 1 *The top-down profile in the clays of Emberménil and Fraimbois (iridescent marls of the Lower Keuper), according to Braconnier (1883, 134). Braconnier's chemical analyses were recalculated without loss on ignition. Only the clay strata are presented*

Thickness (m)	*Type*	*SiO_2*	*Al_2O_3*	*Fe_2O_3*	*CaO*	*MgO*	*P_2O_5*	*SO_2*	*Sum*
6	Blue clay with some platelets of sandy limestone	60.7	36.4	0.9	1.5	0.0	0.1	0.3	100
9	Dolomitic grey marl	40.3	16.8	0.9	24.6	17.1	0.1	0.3	100
8	Clayey dolomites alternating with thin beds of clayey dolomitic sands								
3	Dolomitic marls with gypsum veins	41.4	26.1	1.7	15.5	14.2	0.1	0.9	100
0.4	Red and green clay with gypsum veins	48.2	27.4	0.5	12.1	11.4	0.0	0.4	100
4	Greyish–greenish clay with gypsum veins	17.5	8.4	0.9	32.0	4.2	0.1	37.0	100
3.3	Grey, sandy and dolomitic clay								
0.3	Yellowish dolomite								
0.15	Grey and dolomitic sand								
0.3	Yellow and dolomitic clayey sand								

et al. (2011). In this paper, similar research was undertaken for the first ceramic type, with two objectives: (1) to determine whether the faience from Lorraine is actually rich in magnesium; and (2) to see if it is possible to distinguish the products of different manufactories in Lorraine, by attempting first of all to identify chemically the faience produced by Jacques II Chambrette and his successors in their Lunéville manufactory, the most important in Lorraine, and hence to define in this manner a chemical reference group. It is also necessary to find an answer to the question as to whether it is possible to differentiate chemically between objects made in Lunéville and in Saint-Clément, the two manufactories being separated only by a mere 12 km, and using the same raw materials. The archaeometric aspects of these problems are addressed in this paper, whereas the art-history arguments were extensively discussed in Rosen and Maggetti (2012).

EXPERIMENTAL

Objects and sampling strategy

A total of 64 objects were studied. Forty-eight belong to ceramic pieces from different archaeological, museum and private collections (Table 2) and 16 are clays (Table 3).

Ceramics A first set of 28 objects—16 from the archaeological excavations at the former *Maison de plaisance* of Frescaty (Masquilier *et al*. 1998; Masquilier 2002; Masquilier and Copret 2005), stored in Scy-Chazelles, eight from the collections of the Castle of Lunéville, and four from other excavations or private collections (Autun, excavations of St Nazaire, 2003; Château de la Grange: Stiller 1986; Dijon, excavations of the Tivoli rampart, 1985)—was established in order to define a 'Lunéville' reference group, as all these objects are believed to have originated in the Lunéville manufactory of Jacques II Chambrette. Only pieces with the least possible damage were sampled in the Lunéville castle collection, which suffered great damage in the blaze of 2 January 2003. The second set comprises 20 objects, which are currently assumed (Saint-Dié 1981) to have their origin not in Lunéville, but in another manufactory such as Le Bois d'Épense/Les Islettes. It consists of 18 intact objects from private collections and two surface findings in the manufactory of Le Bois d'Épense. Images of BEI 181 and 185–188, LNV 34 and 50 and TBL 5 are given in Figure 4; images of the other ceramic objects were published in Rosen and Maggetti (2012).

Clays The places where the clays were collected were selected following the indications of Braconnier (1883), Grandjean (1983) and Calame and Wéber (2008) (see Fig. 3). The wooded hill (Bois du Haut Colas) along the right bank of the Meurthe river, south of the motorway at the level of the houses called 'La Guinguette', shows evident signs of extraction of clays, which could easily be shipped to the manufactories.

Sample preparation

Ceramics Samples of 2.7–13.6 g were obtained by cutting the objects with a saw, then ground in a tungsten carbide mill after careful removal of the possibly contaminated surface: 2 g of powder was obtained by drilling under the base of the terrine LNV 33. If available, subsamples from broken objects were used for scanning electron microscopic analyses.

Table 2 *The descriptions of the 48 ceramic fragments*

Sample number	*Form*	*Technique*	*Decoration*	*Date*	*Stylistic attribution*	*Provenance*
Reference group						
LNV 1	Plate with moulded rim	Hard firing; polychrome decoration with red	Flowers with red rim, ill. in Rosen and Maggetti (2012, annex 1)	*c.*1750–60	Lunéville	Excavation Autun 60, St Nazaire church
LNV 2	Plant pot	Hard firing; blue camaïeu	Lambrequins, ill. in Rosen and Maggetti (2012, annex 1)	*c.*1740–50	Lorraine?	Excavation La Grange castle, Thionville
LNV 3	Plant pot	Hard firing; blue camaïeu	Coat of arms of Gomé de la Grange/Marneau (1691–1757), ill. in Rosen and Maggetti (2012, fig. 2-4)	1691–1757	La Grange?	Excavations Frescaty; Scy-Chazelles/1102
LNV 4	Plant pot	Hard firing; blue camaïeu	Coat of arms of Montmorency-Laval, (1761–91), ill. in Rosen and Maggetti (2012, fig. 2-44)	1761–91	Lunéville?	Excavations Frescaty; Scy-Chazelles/1102
LNV 5	Plant pot	Hard firing; blue camaïeu	Coat of arms of Cambout de Coislin (1711-1732), ill. in Rosen et Maggetti (2012, fig. 2-4)	1711–32	Champigneulles?	Excavations Frescaty; Scy-Chazelles/1102
LNV 6	Plate	Hard firing; manganese camaïeu	Coat of arms of Mgr de St Simon, border decoration with lattice pattern (1732–60), ill. in Rosen and Maggetti (2012, annex 1)	1732–60	Lunéville	Excavations Frescaty; Scy-Chazelles, 1543/89
LNV 7	Fiddle-shaped bidet	Hard firing; polychrome decoration	Manganese carnation and butterfly, ill. in Rosen and Maggetti (2012, annex 1)	*c.*1750	Lunéville	Excavations Frescaty; Scy-Chazelles, 1101/01
LNV 8	Barber’s bowl	Hard firing; blue camaïeu	Basket with flowers, border decoration with lattice pattern, ill. in Rosen and Maggetti (2012, annex 1)	*c.*1750	Lunéville	Excavations Frescaty; Scy-Chazelles, 5543/90
LNV 9	Chamber pot	Hard firing; blue camaïeu	Lambrequins, ill. in Rosen and Maggetti (2012, fig. 2-5)		?	Excavations Frescaty; Scy-Chazelles, 1100/(1)
LNV 10	Base of plant pot	Hard firing; polychrome decoration	Blue and green triangles, ill. in Rosen and Maggetti (2012, annex 1)	*c.*1750	Lunéville	Excavations Frescaty; Scy-Chazelles, 1100/(2)
LNV 11	Dish	Hard firing; polychrome decoration	Yellow and manganese flowers with green and blue leaves, ill. in Rosen and Maggetti (2012, annex 1)	*c.*1750	?	Excavations Frescaty; Scy-Chazelles, 1112/01
LNV 12	Plate	Hard firing with black writing	‘Office frescaty’ written in black, border decoration with blue lattice pattern, ill. in Rosen and Maggetti (2012, fig. 2-43)	*c.*1750	Lunéville	Excavations Frescaty; Scy-Chazelles, 1069/203
LNV 13	Plate	Enamel firing; polychrome decoration	‘Early type’ rose, ill. in Rosen and Maggetti (2012, annex 1)	*c.*1760	Lunéville?	Excavations Frescaty; Scy-Chazelles, 1101/04
LNV 16	Plate	Enamel firing; polychrome decoration	Large rose, ill. in Rosen and Maggetti (2012, annex 1)	*c.*1760–80	Lunéville?	Excavations Frescaty; Scy-Chazelles, 1101/04
LNV 17	Plate	Enamel firing; polychrome decoration	Bunch of flowers with carnation, ill. in Rosen and Maggetti (2012, annex 1)	*c.*1760–1780	Lunéville?	Excavations Frescaty; Scy-Chazelles, 1101/07
LNV 18	Plate	Enamel firing; polychrome decoration	Butterfly, ill. in Rosen and Maggetti (2012, annex 1)	*c.*1760–80	Lunéville?	Excavations Frescaty; Scy-Chazelles, 1101/02
LNV 19	Plate	Enamel firing; polychrome decoration	Insect with folded wings, ill. in Rosen and Maggetti (2012, annex 1)	*c.*1760–80	Lunéville?	Excavations Frescaty; Scy-Chazelles, 1101/03
LNV 20	Plate	Enamel firing; polychrome decoration	Chinese character with Chinese foliage, ill. in Rosen and Maggetti (2012, annex 1)	*c.*1770–80	Lunéville?	Excavations Frescaty; Scy-Chazelles, 1101/21

Table 2 *(Continued)*

Sample number	*Form*	*Technique*	*Decoration*	*Date*	*Stylistic attribution*	*Provenance*
LNV 21	Drug jar	Hard firing; polychrome decoration	Embossed green leaves, ill. in Guillemé-Brulon (1999, 95) and Bastian and Bastian (2009, 100)	*c.*1755–60	Lunéville?	Lunéville castle museum
LNV 22	Parsley pot	Hard firing; polychrome decoration	Chinese decoration and flowers, ill. in Mitteilungsblatt KFS (1995, no. 30/31, pl. VI), Guillemé-Brulon (1999, 89) and Rosen and Maggetti (2012, fig. 2-26)	*c.*1750	Lunéville	Lunéville castle museum
LNV 23	Bust of Roman soldier	Hard firing; polychrome decoration	'Au naturel' decoration, marble base, ill. in Céramique lorraine (1990, 51), Guillemé-Brulon (1999, 84) and Rosen and Maggetti (2012, fig. 2-10)	*c.*1750	Lunéville?	Lunéville castle museum
LNV 24	Drug jar with masks in relief	Hard firing; polychrome decoration	Theriaca jar, bunch of flowers with a bow, ill. in Céramique lorraine (1990, 54), Guillemé-Brulon (1999, 90) and Rosen and Maggetti (2012, fig. 2-19)	*c.*1760	Lunéville	Lunéville castle museum
LNV 25	Statue of Duke Stanislas' dwarf	Hard firing; polychrome decoration	'Au naturel' decoration, ill. in Fay-Hallé and Lahaussois (1986, 187), Céramique lorraine (1990, 21) and Rosen and Maggetti (2012, figs 1-1, 2-8 and 2-9)	1756 (mark 'NP')	Lunéville	Lunéville castle museum
LNV 26	Double bottle cooler	Enamel firing; polychrome decoration	Flowers in relief, ill. in Céramique lorraine (1990, 93)	*c.*1770	Niderviller	Lunéville castle museum
LNV 27	Plant pot	Enamel firing; polychrome decoration	Chinese decoration, ill. in Faïences de lorraine (1720–1840, 1997, 122, no. 92)	*c.*1770–80	Lorraine?	Lunéville castle museum
LNV 28	Drug jar	Polychrome decoration	Rose and foliage, ill. in Rosen and Maggetti (2012, annex 1)	*c.*1760–80	Lunéville	Lunéville castle museum
LNV 29	Jug	Hard firing; polychrome decoration with red	Bunch of flowers with bow, ill. in Rosen and Maggetti (2012, annex 1)	*c.*1760–80	Lunéville?	Excavation rempart Tivoli 1985, Dijon, Musée de la vie bourguignonne
LNV 30	Fragment of plate	Hard firing	White enamelling, ill. in Rosen and Maggetti (2012, fig. 2-6)	*c.*1760–80	Lunéville	Private collection, formerly Scy-Chazelles
Test objects						
BEI 115	Circular dish with five lobes	Enamel firing; polychrome decoration	Ill. in Rosen and Maggetti (2012, fig. 3-7)	Late 18th century	Saint-Clément	Private collection
BEI 117	Circular plate	Enamel firing; polychrome decoration	Woman with parasol, diameter 230 mm, ill. in Catalogue (2007, 107, no. 35) and Rosen and Maggetti (2012, fig. 3-8)	Early 19th century	Le Bois d'Epense	Private collection
BEI 118	Circular plate with eight lobes; diameter 230 mm; Chinese decoration	Enamel firing; polychrome decoration	Chinese decoration, diameter 230 mm, ill. in Rosen and Maggetti (2012, fig. 3-3)	Early 19th century	Le Bois d'Epense	Private collection
BEI 119	Circular plate with eight lobes	Enamel firing; polychrome decoration	Peacock, diameter 230 mm, ill. in Rosen and Maggetti (2012, fig. 3-6)	Early 19th century	Le Bois d'Epense	Private collection

BEI 164	Circular plate with eight lobes	Enamel firing; polychrome decoration	Three fleurs de lys under a crown between two laurel branches with bow, diameter 227 mm, ill. in Catalogue (2007, 89, fig. 76) and Rosen and Maggetti (2012, fig. 3-9)	Early 19th century	Le Bois d'Epense	Private collection
BEI 165	Inkstand	Enamel firing; polychrome decoration	Flower and Chinese decoration, length 197 mm, total height 660 mm, width 116 mm, ill. in Rosen and Maggetti (2012, fig. 3-4)	Early 19th century	Le Bois d'Epense	Private collection
BEI 166	Small bulb pot	Enamel firing; polychrome decoration	Flower and Chinese decoration, ill. in Rosen and Maggetti (2012, fig. 3-5)	Early 19th century	Le Bois d'Epense	Private collection
BEI 167	Circular plate with eight lobes	Enamel firing; polychrome decoration	Rooster on gate, border decoration with three double cherries, diameter 221 mm, ill. in Rosen and Maggetti (2012, fig. 3-2)	Late 18th century	Saint-Clément	Private collection
BEI 168	Circular plate with eight lobes	Enamel firing; polychrome decoration	Napoleon eagle and flashes of lightening, jagged pink border decoration, diameter 235 mm, ill. in Catalogue (2007, 88, fig. 75) and Rosen and Maggetti (2012, fig. 3-10)	Early 19th century	Le Bois d'Epense	Private collection
BEI 173	Fragments of a plate	Enamel firing; polychrome decoration	Rooster and flashes of lightening, ill. in Catalogue (2007, 97, fig. 96)	Around 1830–1831	Le Bois d'Epense	Private collection, surface findings, manufactory of Le Bois d'Epense
BEI 181	Fragments of a plate	Enamel firing; polychrome decoration	Chinese people and Chinese decoration	Early 19th century	Le Bois d'Epense	Private collection, surface findings, manufactory of Le Bois d'Epense
BEI 185	Flowerholder	Enamel firing; polychrome decoration	Seated Chinese figure	Late 18th century	Lunéville	Private collection
BEI 186	Flowerholder	Enamel firing; polychrome decoration	Seated Chinese figure	Early 19th century	Le Bois d'Epense	Private collection
BEI 187	Circular plate with eight lobes	Enamel firing; polychrome decoration	Seated Chinese figure	Late 18th century	Lunéville	Private collection
BEI 188	Circular plate with eight lobes	Hard firing; polychrome decoration	Revolutionary inscription 'La liberté ou la mort'	Late 18th century	Waly	Private collection
LNV 33	Covered vegetable dish	Hard firing; polychrome decoration	Rouen-style flowers, ill. in Rosen and Maggetti (2012, fig. 2-16)	Late 18th century, mark '2'	Lunéville?	Private collection
LNV 34	Dish with six lobes	Enamel firing; polychrome decoration	Purple rose with three small flowers on the rim	Late 18th century, marks 'M.R.' and 'h/2'	Lunéville?	Private collection
LNV 50	Circular plate	Enamel firing; polychrome decoration	Three 'fleur de lys' under a crown	Early 19th century	Lunéville area?	Private collection
MRL 483	Plate	Enamel firing; polychrome decoration	Flowers, ill. in Rosen and Maggetti (2012, figs 3-11 and 3-12)	*c.*1770–80, marks 'MR' and 'S/2'	Lunéville area?	Private collection
TBL5	Lid of chocolate pot	Enamel firing; polychrome decoration	Flowers with apple-shaped finial	*c.*1760–80	Lunéville?	Private collection

Table 3 *Descriptions of the 16 clay samples*

Sample number	*Type and age*	*Literature*	*Provenance*
LNV 31	Middle Triassic, Ladinian (Lower Keuper, Lettenkohle)		'Noires Terres', ~0.8 km south of the village of Lamath, ploughed field, Sheet 3416 Bayon 1:25 000, GPS coordinates 311 600/5377 540
LNV 32	Upper Triassic, Carnian/Norian (Middle Keuper, *marnes irisées* or iridescent marls)		'La Mazière', ~0.7 km south-east of the village of Méhoncourt, ploughed field, Sheet 3416 Bayon 0:25 000, GPS coordinates 307 600/5375 500
LNV 36	Ancient alluvial clays	Calame and Wéber (2008, 94, no. 5)	'Les Eaux', 1 km east of the village of Laronxe, Sheet 3516 Lunéville 1:25 000, GPS coordinates 324 300/5378 850
LNV 37	Ancient alluvial clays	Calame and Wéber (2008, 94, no. 5)	'Les Eaux', 1 km east of the village of Laronxe, Sheet 3516 Lunéville 1:25 000, GPS coordinates 324 300/5378 850
LNV 38	Ancient alluvial clays		'Les Eaux', 1 km east of the village of Laronxe, Sheet 3516 Lunéville 1:25 000, GPS coordinates 324 300/5378 850
LNV 39	Upper Triassic, Carnian/Norian (Middle Keuper, *marnes irisées* or iridescent marls)	Calame and Wéber (2008, 94, no. 4)	'Le Trimoulot', ~2 km north-east of the village of Laronxe, Sheet 3516 Lunéville 1:25 000, GPS coordinates 324 650/5379 750
LNV 40	Upper Triassic, Carnian/Norian (Middle Keuper, *marnes irisées* or iridescent marls)	Calame and Wéber (2008, 94, no. 4)	'Le Trimoulot', ~2 km north-east of the village of Laronxe, Sheet 3516 Lunéville 1:25 000, GPS coordinates 324 650/5379 750
LNV 41	Upper Triassic, Carnian/Norian (Middle Keuper, *marnes irisées* or iridescent marls)	Calame and Wéber (2008, 94, no. 4)	'Le Trimoulot', ~2 km north-east of the village of Laronxe, Sheet 3516 Lunéville 1:25 000, GPS coordinates 324 800/5379 600
LNV 42	Upper Triassic, Carnian/Norian (Middle Keuper, *marnes irisées* or iridescent marls)		1.5 km south of the village of Hériménil, Sheet 3516 Lunéville 1:25 000, GPS coordinates 315 900/5380 830
LNV 43	Upper Triassic, Carnian/Norian (Middle Keuper, *marnes irisées* or iridescent marls)		1.5 km south of the village of Hériménil, Sheet 3516 Lunéville 1:25 000, GPS coordinates 316 180/5381 000
LNV 44	Middle Triassic, Ladinian (Lower Keuper, Lettenkohle)		'Poirier de Justice', ~1 km north of the castle Adoménil, Sheet 3416 Bayon 1:25 000, GPS coordinates 312 990/5382 850
LNV 45	Upper Triassic, Carnian/Norian (Middle Keuper, *marnes irisées* or iridescent marls)		'Poirier de Justice', ~1 km north of the castle Adoménil, Sheet 3416 Bayon 1:25 000, GPS coordinates 313 040/5382 820
LNV 46	Upper Triassic, Carnian/Norian (Middle Keuper, *marnes irisées* or iridescent marls)		'Poirier de Justice', ~1 km north of the castle Adoménil, Sheet 3416 Bayon 1:25 000, GPS coordinates 312 950/5382 950
LNV 47	Upper Triassic, Carnian/Norian (Middle Keuper, *marnes irisées* or iridescent marls)		'Poirier de Justice', ~1 km north of the castle Adoménil, Sheet 3416 Bayon 1:25 000, GPS coordinates 312 820/5382 000
LNV 48	Upper Triassic, Carnian/Norian (Middle Keuper, *marnes irisées* or iridescent marls)		'Poirier de Justice', ~1 km north of the castle Adoménil, Sheet 3416 Bayon 1:25 000, GPS coordinates 312 820/5382 000
LNV 49	Middle Triassic, Ladinian (Lower Keuper, Lettenkohle)		'Bois du Haut-Colas', ~1.7 km north of the castle Adoménil, Sheet 3416 Bayon 1:25 000, GPS coordinates 313 100/5383 550

Figure 4 *Illustrations of as yet unpublished sampled pieces from collections. The signature on the reverse side of LNV 34 is also shown.*

Figure 4 *Continued.*

Clays In the field, about 1.5 kg per sample was collected at a depth of 20–30 cm. From each sample, 30–180 g was dispersed in water and sieved through the 250 mesh sieve. The analyses were carried out exclusively using the sieved part.

Analytical methods

Two methods (X-ray fluorescence and X-ray diffractometric analyses) are detailed in Maggetti *et al*. (2011). The total for LNV 25 was only 92.99 wt%. Repeated measurements with different tablets did not improve this result. One tablet was therefore measured with the UNIQUANT method, but no element could be detected that could have caused the difference. The very low total is therefore most probably due to the very high Pb content, which exceeds the Pb calibration curve. BEI 173 was analysed at the CNRS Centre de Recherches Pétrographiques et Géochimiques, Spectrochimie, Service d'Analyses des Roches et des Minéraux, of Vandoeuvre-Nancy. An amount of 500 mg was fused with $LiBO_2$ and dissolved in HNO_3. Major elements were measured with ICP–AES and the others with ICP–MS. The results (CNRS An. No.: CRPG # 0903698) were checked against international geostandards. MRL 483 was analysed by XRF in the former Laboratoire de Céramologie, Lyon, France, then under the direction of M. Picon. Lyon's results can be compared to those obtained in the Fribourg laboratory, as shown by inter-laboratory measurements (Galetti 1994).

Statistics The statistical treatment of the chemical analyses was obtained using the program SPSS 16. The analyses shown in Figures 7, 8 and 9 below were performed with log data of 14 variables—SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O, K_2O, Ba, Cr, Ni, Rb, Sr and Zr—and additionnally with Y and Zn for Figure 10. Cluster analyses were carried out as follows: the Ward method, *z*-scores and squared Euclidean distances.

RESULTS

Ceramic bodies

Macroscopic aspects The body of the MgO-rich samples is very characteristic, making it look like a cork sheet. The pores are surrounded by a yellow halo and the reddish paste includes red circles. In the MgO-poor samples, these red inclusions are missing and the colour of the matrix is clearer.

Bulk compositions The majority of the analysed sherds are Mg rich (MgO > 5.5 wt%), with four Mg-poorer exceptions (LNV 3, 5 and 9, and TBL 5), see Figure 5. LNV 18 and LNV 19 are chemically very similar—they most probably belong to the same object or the same batch (Table 4). LNV 6, LNV 8, LNV 9 and LNV 29 are rich in P_2O_5 (Fig. 6 (a)). Most of the sherds have lead concentrations > 500 ppm (Table 4), TBL 5 is very rich in chromium and nickel, and MRL 483 has the highest Ni value (Fig. 6 (b)), LNV 4 and LNV 7 are rich in copper (Fig. 6 (c)), LNV 25 is very rich in yttrium and four samples show Zn values > 150 ppm (Fig. 6 (d)).

Clays

Bulk compositions The MgO contents of the clays show a wide scatter and are lower than those for many ceramic bodies (Fig. 5). The *ancient alluvial* clays and *iridescent marls* north-east of Saint-Clément and south of Hériménil are non-calcareous, with very low magnesium concentrations. In contrast, the *Lettenkohle* and *iridescent marls* from Lamath, Méhoncourt and site 1 are much richer in magnesium (up to 8.6 wt% MgO).

Mineral associations The X-ray diffraction study was focused on the detection of carbonates and sulphates, and not on the determination of the exact nature of the clay minerals. According to this, the samples can be classified as follows:
(a) Illite + quartz + plagioclase + kalifeldspar: LNV 32 and 36–43.
(b) Illite + quartz + plagioclase + kalifeldspar + dolomite: LNV 31.
(c) Illite + quartz + plagioclase + kalifeldspar + calcite + dolomite: LNV 44–49.

DISCUSSION

Chemical contamination

Phosphorus Burial contamination is to be expected for samples LNV 2–20 and 29, all unearthed by excavations. Compared with the other specimens, their chemical composition is seemingly not

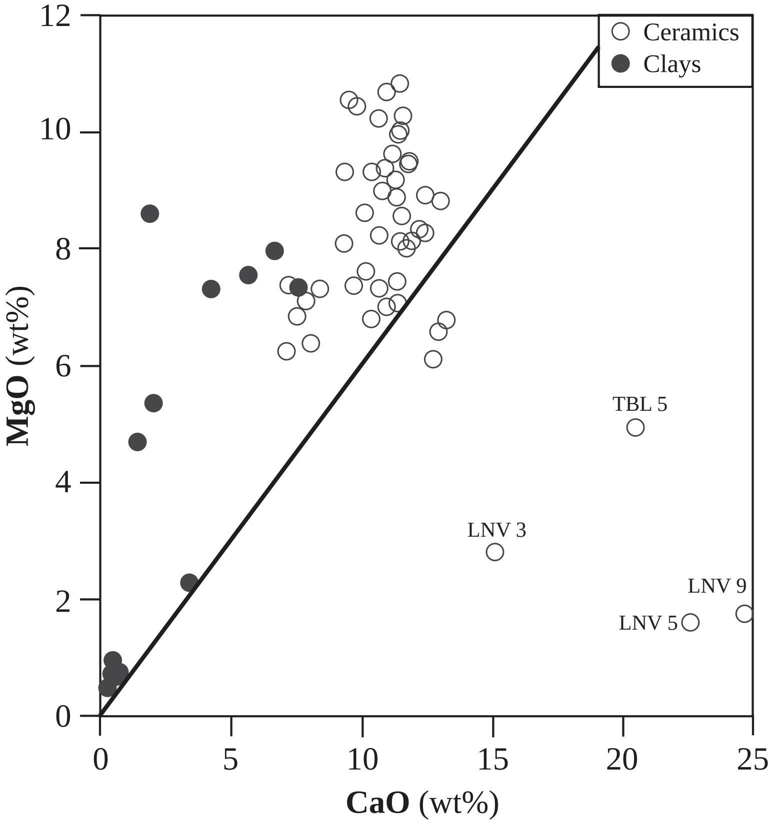

Figure 5 *The MgO–CaO correlation diagram of 48 faiences and 16 clays. The solid line is the dolomite line.*

affected by such processes, with the exception of phosphorus. LNV 6, 8, 9 and 29 have P_2O_5 concentrations significantly higher than the maximum concentrations found in the studied clays (Fig. 6 (a)). This is interpreted as contamination through migrating P-rich solutions (Collomb and Maggetti 1996, and literature therein).

Lead The local clays contain less than 60 ppm of Pb. Each of the analysed faiences shows a much higher concentration, in some cases exceeding the percentage range. This can be due to: (1) insufficient removal of the lead glaze before milling; (2) infiltration into the porous body by the lead-rich watery suspension obtained during the removal of the lead glaze; (3) infiltration of the porous biscuit body by the watery glaze supension during glazing; (4) infiltration of the porous biscuit body by the fused glaze during firing; (5) contamination of the porous biscuit body by Pb vapours during firing; and (6) contamination by lead-rich melts or vapours during the Lunéville Castle blaze of 2 January 2003. We exclude the first hypothesis, as the removal was carefully made. With respect to the other four possibilities, it is impossible to discern if one or more effects are responsible for these contaminations.

Zinc The zinc values for three body samples, which endured the Lunéville Castle blaze of 2 January 2003, exceed the maximum of 160 ppm for 454 clays and shales from all over the world,

Table 4 *The bulk compositions of the specimens analysed by XRF (oxides and LOI in wt%, elements in ppm; Fe_2O_3 = total Fe as Fe_2O_3)*

Sample number	*SiO_2*	*TiO_2*	*Al_2O_3*	*Fe_2O_3*	*MnO*	*MgO*	*CaO*	*Na_2O*	*K_2O*	*P_2O_5*	*Ba*	*Cr*	*Cu*	*Nb*	*Ni*	*Pb*	*Rb*	*Sr*	*Y*	*Zn*	*Zr*	*Sum*	*LOI*
LNV 1	54.45	0.73	15.07	5.14	0.08	8.11	11.97	1.18	3.33	0.27	389	82	69	17	43	4 212	124	164	27	69	201	100.87	0.60
LNV 2	61.21	0.62	13.98	4.12	0.08	7.08	7.89	1.14	3.84	0.21	408	63	21	16	37	2 189	124	147	28	84	203	100.53	0.35
LNV 3	54.64	0.91	18.13	5.02	0.10	2.78	15.13	0.92	2.77	0.20	414	103	24	18	48	218	120	484	31	92	213	100.80	5.58
LNV 4	57.16	0.66	13.97	5.00	0.07	7.58	10.20	1.03	3.75	0.17	388	77	438	15	41	1 489	129	185	21	55	181	99.99	1.95
LNV 5	48.51	0.91	18.07	5.59	0.05	1.57	22.61	0.87	2.05	0.29	344	73	15	18	52	464	87	464	31	83	197	100.72	10.03
LNV 6	56.61	0.64	13.19	4.97	0.09	6.08	12.72	1.19	3.30	1.13	483	51	70	15	27	8 503	114	275	30	63	232	100.93	1.16
LNV 7	55.02	0.67	14.19	4.99	0.09	8.11	11.54	0.98	3.32	0.16	388	77	438	15	41	1 489	129	185	21	55	181	99.25	4.30
LNV 8	54.59	0.66	14.42	5.11	0.07	6.76	13.25	1.34	2.83	1.14	407	77	67	13	38	5 736	92	208	28	80	190	100.89	1.39
LNV 9	46.22	0.87	17.53	5.43	0.06	1.73	24.74	1.19	0.99	0.66	285	108	123	18	49	7 783	34	245	37	97	198	100.32	6.66
LNV 10	55.47	0.71	14.83	5.04	0.07	8.22	10.70	1.07	3.55	0.20	351	77	82	16	46	2 149	128	171	25	59	189	100.19	1.89
LNV 11	54.29	0.73	14.85	5.08	0.09	8.00	11.84	1.26	3.20	0.18	339	96	59	16	54	4 814	114	160	31	65	198	100.12	0.60
LNV 12	54.86	0.68	14.76	5.35	0.06	8.88	11.40	1.65	2.36	0.23	357	94	37	14	48	4 090	108	163	27	62	179	100.76	0.72
LNV 13	55.78	0.70	14.94	5.20	0.08	7.40	11.39	1.08	3.68	0.19	352	89	50	17	48	2 292	135	169	26	62	196	100.81	2.15
LNV 16	55.51	0.71	15.23	4.73	0.05	7.30	10.66	1.24	3.41	0.19	416	54	76	18	39	8 807	144	109	40	72	246	100.06	0.53
LNV 17	54.09	0.67	14.58	5.14	0.07	8.29	12.25	1.26	3.09	0.23	381	77	54	16	44	3 915	120	173	26	60	183	100.18	0.83
LNV 18	52.16	0.73	17.09	6.06	0.08	6.98	11.00	1.44	4.27	0.24	430	70	59	15	41	6 447	142	131	32	93	154	100.86	0.89
LNV 19	52.16	0.71	16.82	5.88	0.08	6.79	10.39	1.39	4.47	0.25	415	65	61	15	44	12 015	123	125	36	92	162	100.29	1.04
LNV 20	51.20	0.74	16.88	6.08	0.10	8.58	10.19	1.46	3.98	0.24	470	81	70	18	43	14 009	125	127	41	91	167	100.99	0.82
LNV 21	53.97	0.67	14.94	5.41	0.07	10.46	9.75	1.25	3.39	0.16	318	91	69	18	48	5 108	120	155	28	56	175	100.72	0.40
LNV 22	60.36	0.73	14.45	4.52	0.07	7.38	7.30	1.15	3.60	0.13	296	81	38	17	46	2 363	140	178	29	266	234	100.07	0.49
LNV 23	56.18	0.77	13.90	4.83	0.05	6.23	7.12	1.06	4.76	0.36	295	87	78	18	67	37 512	87	102	60	60	240	99.13	0.54
LNV 24	58.58	0.69	14.18	4.48	0.07	8.05	9.34	1.01	3.39	0.13	417	86	46	16	46	6 641	108	159	32	117	207	100.72	0.67
LNV 25	48.88	0.71	12.05	4.16	0.05	5.69	6.36	1.09	4.15	0.34	235	66	140	14	52	94 098	112	51	123	406	336	92.99	1.29
LNV 26	55.01	0.79	15.97	6.21	0.22	7.30	8.44	1.38	4.24	0.12	421	78	25	18	45	6 453	143	106	41	192	224	100.47	0.42
LNV 27	54.16	0.70	16.34	4.22	0.07	6.60	12.95	0.93	2.48	0.16	406	86	46	21	42	18 184	148	211	44	127	233	100.57	0.61
LNV 28	50.79	0.72	16.79	6.33	0.12	10.50	9.63	1.08	4.02	0.16	453	82	88	17	48	5 403	121	132	31	100	134	100.82	0.47
LNV 29	51.12	0.70	15.18	5.39	0.06	8.83	13.07	1.37	3.13	0.65	441	79	59	16	47	9 326	106	178	33	97	177	100.56	1.06
LNV 30	52.90	0.69	15.55	5.89	0.07	8.54	11.64	1.97	2.41	0.28	388	83	24	15	47	4 934	119	195	29	89	167	100.57	0.75
BEI 115	50.95	0.68	15.41	6.25	0.08	10.22	10.65	1.08	3.59	0.15	374	100	24	17	59	4 448	128	168	40	87	157	99.62	0.87
BEI 117	51.78	0.68	15.76	5.95	0.09	8.25	12.37	1.33	3.29	0.17	418	73	78	14	46	9 752	95	140	37	132	161	100.76	1.36
BEI 118	51.37	0.70	15.05	6.11	0.07	9.92	11.51	1.19	3.32	0.16	369	86	82	16	57	14 127	80	172	42	103	182	100.94	0.50
BEI 119	50.82	0.67	14.73	5.79	0.07	10.67	10.98	1.06	3.37	0.17	363	91	32	12	54	7 067	116	169	44	72	167	99.15	1.08

Table 4 *(Continued)*

Sample number	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	*MnO*	*MgO*	*CaO*	Na_2O	K_2O	P_2O_5	*Ba*	*Cr*	*Cu*	*Nb*	*Ni*	*Pb*	*Rb*	*Sr*	*Y*	*Zn*	*Zr*	*Sum*	*LOI*
BEI 164	53.37	0.69	14.80	5.83	0.08	9.16	11.35	1.11	3.35	0.16	385	91	121	16	56	8 816	91	172	35	138	194	100.92	0.81
BEI 165	51.50	0.68	14.55	5.55	0.08	10.78	11.47	1.17	3.66	0.22	365	117	55	15	56	5 180	124	179	30	109	169	100.32	1.90
BEI 166	51.60	0.67	14.58	6.13	0.07	9.44	11.77	0.46	3.79	0.16	414	89	42	10	55	2 312	142	176	34	336	244	99.05	1.91
BEI 167	52.20	0.70	15.43	5.87	0.07	9.59	11.20	1.23	3.09	0.15	352	87	118	16	59	11 466	83	155	39	111	178	100.81	1.48
BEI 168	50.90	0.69	15.54	6.43	0.09	9.38	10.91	1.09	3.41	0.19	365	100	54	14	63	4 945	118	163	40	73	160	99.24	0.68
BEI 173	61.12	0.54	12.03	3.79	0.05	7.05	11.35	0.97	2.32	0.17	381	79	60	11	47	14 125	95	178	21	59	210	100.81	1.83
BEI 181	60.07	0.58	13.60	5.27	0.08	7.36	9.77	1.10	2.32	0.15	363	103	97	14	59	5 284	81	228	38	103	210	100.96	5.86
BEI 185	51.24	0.65	14.37	4.96	0.07	9.52	11.77	1.77	3.27	0.16	363	80	51	14	52	10 590	74	163	17	97	143	98.95	2.03
BEI 186	51.08	0.68	14.91	5.96	0.07	8.88	12.64	0.42	3.84	0.17	399	86	42	13	55	1 991	133	157	26	114	147	98.99	4.37
BEI 187	50.85	0.64	14.56	5.53	0.07	10.15	11.56	1.25	3.98	0.15	425	84	39	13	52	2 582	134	161	22	85	136	99.12	2.07
BEI 188	50.80	0.68	14.93	5.67	0.08	10.25	11.59	0.92	2.91	0.14	329	93	88	14	57	13 327	84	166	46	86	171	99.41	1.09
LNV 33	56.14	0.80	15.06	5.45	0.06	6.41	8.15	1.09	5.35	0.41	331	104	56	14	71	2 052	160	123	23	71	145	99.24	8.02
LNV 34	55.40	0.61	13.94	5.31	0.13	9.32	9.41	0.88	3.68	0.16	388	74	59	13	49	4 986	109	120	36	60	167	99.46	1.74
LNV 50	52.65	0.69	14.61	5.78	0.07	8.97	10.93	0.65	3.61	0.15	366	94	108	16	54	8 520	105	162	41	76	188	99.11	1.13
MRL 483	55.91	0.61	14.24	5.01	0.08	9.32	10.59	0.82	3.12	0.18	353	62			108		104	137		53	201	99.88	
TBL 5	49.05	0.60	13.58	5.12	0.12	4.93	20.54	2.08	2.18	0.18	353	248	79	13	97	10 939	68	370	36	94	158	99.61	1.20
LNV 31	68.57	0.82	14.06	5.70	0.18	4.69	1.43	0.37	3.58	0.18	450	90	30	18	52	36	146	130	33	72	221	99.74	9.35
LNV 32	59.95	0.76	17.14	6.61	0.12	8.60	1.94	0.24	3.92	0.18	530	97	36	17	53	41	163	139	31	118	169	99.60	10.09
LNV 36	79.36	0.72	10.59	2.91	0.11	0.76	0.48	1.18	3.58	0.26	566	83	10	18	20	56	165	118	31	61	534	100.12	4.61
LNV 37	80.21	0.71	9.86	2.51	0.09	0.65	0.56	1.13	3.51	0.20	615	70	6	18	16	51	156	126	33	55	614	99.60	7.14
LNV 38	77.89	0.79	11.28	2.84	0.05	0.73	0.76	1.05	3.37	0.19	590	70	10	17	22	53	154	141	31	67	496	99.12	9.57
LNV 39	83.95	0.92	8.76	1.92	0.04	0.45	0.30	1.02	2.45	0.09	420	68	1	21	15	29	108	101	35	40	560	100.05	4.61
LNV 40	83.27	0.97	9.13	2.30	0.04	0.51	0.29	1.02	2.30	0.07	395	76	3	22	16	31	103	98	36	38	544	100.04	4.04
LNV 41	79.70	0.96	10.77	3.39	0.08	0.75	0.46	1.12	2.52	0.12	476	81	8	22	26	29	121	98	39	56	524	100.02	5.14
LNV 42	76.98	0.89	12.10	5.10	0.07	0.95	0.50	0.62	2.33	0.09	399	84	59	18	29	28	119	86	38	51	444	99.76	4.88
LNV 43	80.83	0.87	10.03	3.83	0.09	0.72	0.38	0.73	2.29	0.16	376	84	13	19	22	32	106	84	37	51	492	100.07	4.64
LNV 44	54.15	0.79	17.51	6.94	0.13	7.95	6.67	0.32	4.45	0.15	418	110	36	16	63	35	166	343	30	86	149	99.21	12.09
LNV 45	59.80	0.74	15.09	5.89	0.15	7.56	5.68	0.60	4.03	0.19	479	91	31	16	52	33	150	408	30	78	187	99.89	12.50
LNV 46	60.30	0.78	15.50	6.15	0.17	7.32	4.25	0.45	4.18	0.23	485	97	85	17	57	44	153	222	32	84	187	99.47	12.19
LNV 47	57.89	0.75	15.02	5.99	0.17	7.37	7.57	0.50	3.89	0.13	500	86	29	15	54	37	143	359	31	67	181	99.42	12.39
LNV 48	64.92	0.83	15.39	6.06	0.18	5.34	2.03	0.60	4.02	0.12	566	104	27	18	52	37	155	157	34	67	240	99.65	7.76
LNV 49	71.04	0.77	13.00	4.56	0.08	2.30	3.42	0.90	3.41	0.20	500	82	21	17	39	41	156	344	35	86	346	99.85	11.31

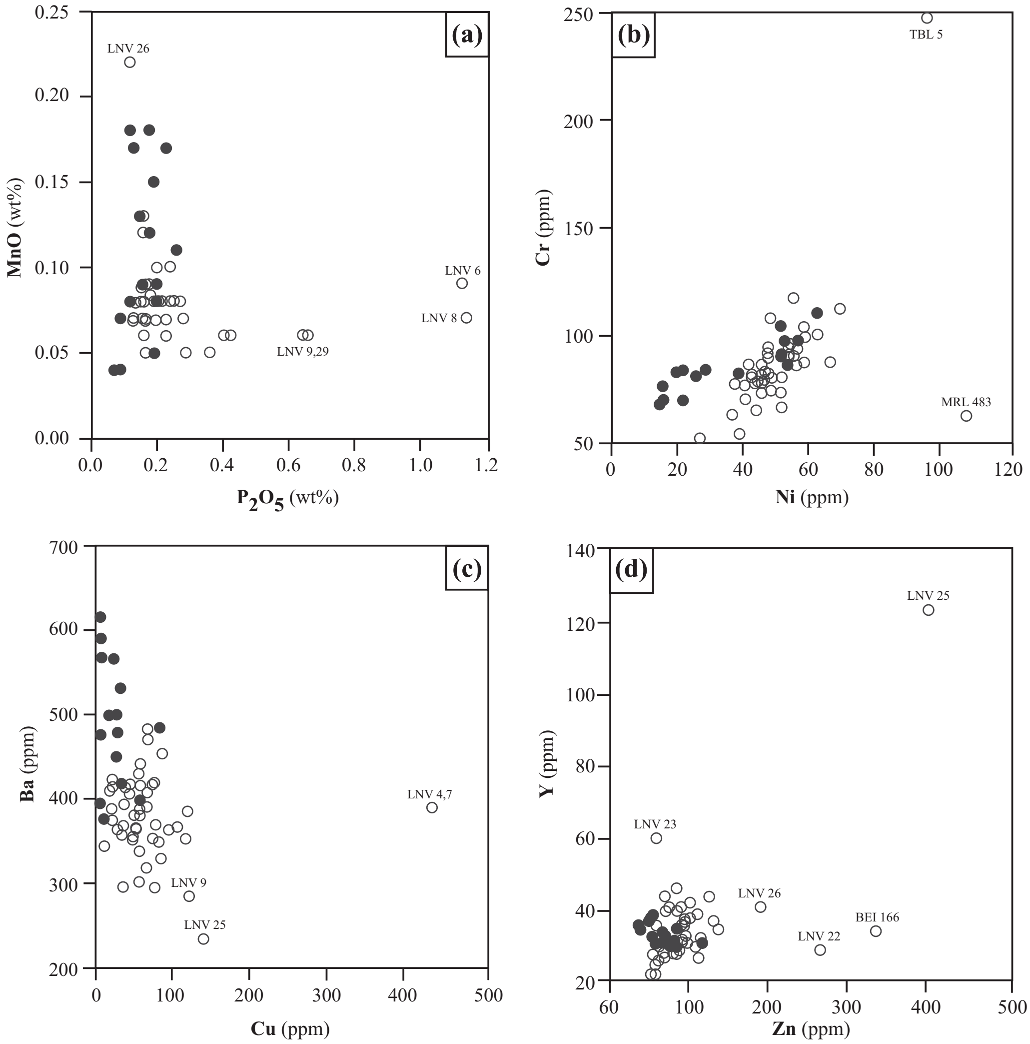

Figure 6 *The body (bulk) compositions for 48 faiences and 16 clays displayed on bivariate plots of selected oxides and elements. Symbols as in Figure 5.*

low in bituminous and carbonaceous matter (Brehler and Wedepohl 1969), and of 120 ppm for the studied local clays (Fig. 6 (d)). The higher concentrations very probably reflect chemical contamination during the blaze by zinc vapours, coming out of melting metallic objects, as also inferred for Cyfflé's figurines and white earthenware bodies that suffered in the same blaze (Maggetti *et al*. 2010, 2011). The high Zn content (336 ppm) in sample BEI 166, from a private collection, apparently contradicts such contamination processes and cannot be explained yet.

Copper, chromium and nickel Samples LNV 4 and 7 have high Cu contents, which could be due to burial contamination. But the high Cr and Ni concentrations of TBL 5 and MRL 483 must be of a primary origin, as neither sample was in the soil or affected by the castle fire.

Yttrium This element is very high in LNV 25, the sample with the strongest impact of the castle fire, as it looks like bloated lava. Were the Y concentrations affected by the castle fire?

Barium This element is considered by many authors as highly mobile. In the present case, the *ancient alluvial* clays have concentrations >500 ppm, and most of the *iridescent clays* <500 ppm, as do the studied ceramics (Fig. 6 (c)). Barium mobility can therefore be dismissed, especially when considering the similar Ba values of the collection objects, which did not suffer burial contamination.

Raw materials

As expected, the *ancient alluvial clays* are all MgO poor and show no dolomite in their X-ray diffractograms. Both *Lettenkohle* samples have MgO concentrations between 2.3 and 4.7 wt% and contain dolomite, whereas five *iridescent marls* are MgO poor (no dolomite) and five are MgO rich (with dolomite). This could theoretically be explained by an incorrect mapping of the outcrops, where the first five samples were taken, as *iridescent marls* and not as *ancient alluvial clays*. However, if the geological map is correct, one has to consider that superficial strata of such marls could have been de-carbonatized by meteoric waters, as assumed for the raw materials from Granges-le-Bourg, where the original MgO (and CaO) concentrations were only found at a depth of 0.6–0.7 m (Maggetti *et al*. 2009a; Maggetti 2013). For the present research, no construction pit could be made available to sample as in the case of Granges-le-Bourg. Such an explanation is supported by Table 1, which shows low CaO and MgO in the uppermost *blue clay*. Further, not all MgO is fixed in the dolomite phase, as revealed by Figure 5, or as an example LNV 32, with insufficient CaO (1.94 wt%) to combine all MgO (8.6 wt%) into this mineral. It is therefore likely that the excess MgO is present in another discrete phase such as smectite.

Provenance

In this discussion, oxides and chemical elements showing possible effects of contamination (Cu, Pb, P_2O_5, Y, Zn) or minimal concentrations (MnO, Nb) are not taken into account. The analyses were recalculated accordingly.

Towards a Lunéville (manufactory of Jaques II Chambrette) reference group The 25 MgO-rich analyses were submitted to a cluster analysis (Fig. 7). The problem is to know how to interpret this diagram, and where to cut the arborescence to define the groups (Picon 1984, 1993). It could be cut at an amalgamation distance of 22, yielding one large group and another very small one, with only two faiences, LNV 23 and 25, which actually form a separate group, as revealed by the multivariate analysis, because their chemical composition differs from that of the other samples. It can be argued that these two pieces should have been discarded, considering their high Pb concentration, due to glaze contamination during the castle fire. But as they represent a specific ceramic type, the 'flameware' ('terre à feu'), that is less rich in Ca, Mg, Sr and Al, giving them a red body, both were integrated in the multivariate statistic study. Their exclusion from the statistical analyses has very little effect on the classification of the remaining samples. The manufacturers have therefore used another recipe to prepare the paste of these two objects. As the Lunéville origin of the 'Bébé' dwarf (LNV 25) was never questioned, we can attribute a similar origin to the second piece of this group, the 'Roman soldier' (LNV 23). The remaining large group could be subdivided at a distance of 10, which would give

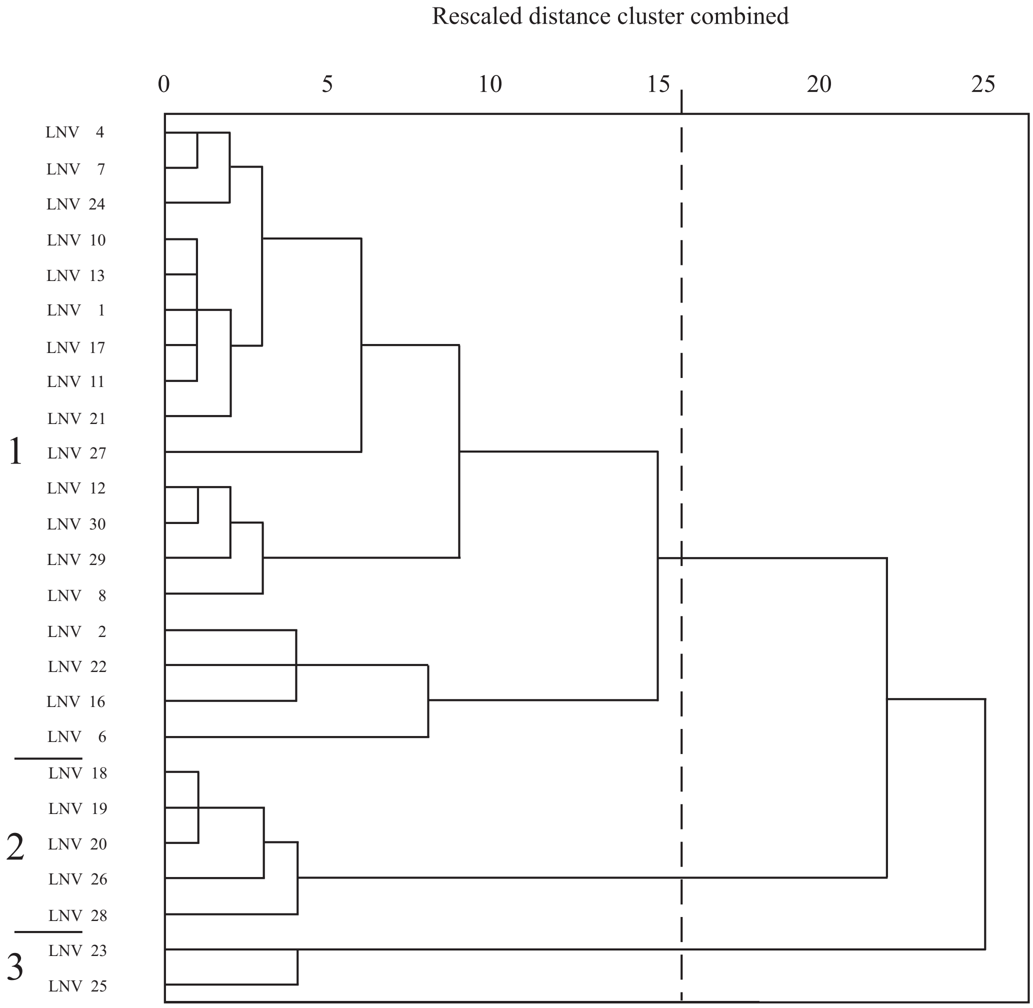

Figure 7 *The grouping of 25 MgO-rich specimens of assumed Lunéville origin by cluster analysis. The dashed line represents the cutting line of the tree, used for the definition of three groups.*

three additional subgroups, or at a distance of 17 (dotted line), with two new subgroups. The second solution was adopted, because the pieces, which are traditionally attributed to Lunéville (LNV 1, 6, 23 and 24), are found in the same large subgroup. We would then have a first large subgroup, including 18 pieces (LNV 1, 2, 4, 6, 7, 8, 10, 11, 12, 13, 16, 17, 21, 22, 24, 27, 29 and 30), all with a Lunéville origin. The second group (LNV 18, 19, 20, 26 and 28), exclusively with a third firing decoration (on-glaze painting), is different from the first one because of its high aluminium (13–15 wt% versus > 16 wt%) and potassium (2.5–4.0 wt% versus > 4 wt%) oxide contents.

Three hypotheses must be discussed to explain the chemical differences between these two groups. The first includes chemical contaminations, which could have occurred during burial (for the objects coming from Autun, Dijon, Frescaty and La Grange) or during the blaze (for those coming from Lunéville Castle). The calculation has already taken this possibility into account by suppressing the oxides and chemical elements, the mobility of which when buried is well known, such as manganese or phosphorus, or elements that become mobile in fire, such as lead and zinc. The other oxides or chemical elements must have been stable, as it would be most surprising for two processes of such a different nature to have had the same chemical impact on the objects. According to the second hypothesis, group 2 definitely consists of Lunéville products, but as the result of a third recipe. Why, then, were there three recipes? Are the reasons technical, or does the reason lie in a change in the places of extraction of the raw materials? A third hypothesis remains, according to which groups 1 and 2 come from two manufactories with chemically different faience pastes.

Attributing LNV 26 and implicitly all of group 2 to the Niderviller manufactory seems to favour such a possibility. This suggested attribution rests on the fact that another identical object kept in the Musée des Arts décoratifs of Strasbourg, similar to the one analysed, bears on the reverse the mark *N*, attributed to Niderviller (Céramique lorraine 1990, 93). The same mark *N* is found on two other objects, a plate with six bracketed lobes with a third-firing purple rose pattern (Nevers, Société académique du Nivernais, inv. 15x7), and a similarly shaped plate with a third-firing decoration of initials and flowers, belonging to King Stanislas Leszczynski's dinner service, where the manganese *N* appears along with the mention *Niderviller* (Céramique lorraine 1990, 71).

As groups 1 and 2 form a larger group if a distance of amalgamation of approximately 22 is selected—which is indeed very big—group 2 could be assumed to have a Lunéville origin. In this case, one must consider the possibility that Lunéville sold biscuit or white faience, which was later to be decorated in Niderviller—which is always possible, even if it remains exceptional (Revert and Noël 1995)—and abandon the hypothesis of a similar Lunéville origin for the three bottle coolers.

To conclude, the 25 magnesium analyses from the manufactory of Jacques II Chambrette in Lunéville comprise three chemical subgroups, quite probably bearing witness to the use of three different pastes in the same manufactory. The first (Lunéville paste A) would correspond to group 1 in the dendrogram, which—if we go further—contains many marked faiences identified as coming from the Jacques II Chambrette manufactory; the second (Lunéville paste B) would correspond to group 2, third-firing decorated faiences, corresponding to the Loyal directorship (1772–86), some time after Chambrette's death; and the last one (Lunéville paste C), corresponding to group 3, that of the 'flameware'. The 23 analyses (pastes A and B) form the new referential 'faiences from the Jacques II Chambrette manufactory in Lunéville', with very high chemical variations.

This referential is quite distinct from the other French faience referentials published to date, as the latter are poor in magnesium, except for the Granges-le-Bourg (Franche-Comté: Maggetti *et al.* 2009a,b; Maggetti 2013) and Varages (South of France: Schmitt 1990) products. The Lunéville faiences are for the most part richer in magnesium and barium, but poorer in aluminium, iron, potassium and rubidium than those from Granges-le-Bourg.

A hierarchical cluster analysis or a factor analysis separates both perfectly, with the exception of the faience GLB 18, the biscuit GLB 76 and the misfired faience GLB 77, the three plotting at the margins of the Lunéville samples, in the mini-group of LNV 18, 19, 20 and 28 (Fig. 8). This chemical difference is geologically meaningful, since the manufactory of Granges-le-Bourg used older raw materials—that is, gypsiferous dolomitic marls from the Middle Anisian (Middle Trias, Middle Muschelkalk)—as did the potters at Lunéville, even if three faiences from Granges-le-Bourg are chemically very close to those from Lunéville. The MgO contents of the five Varages

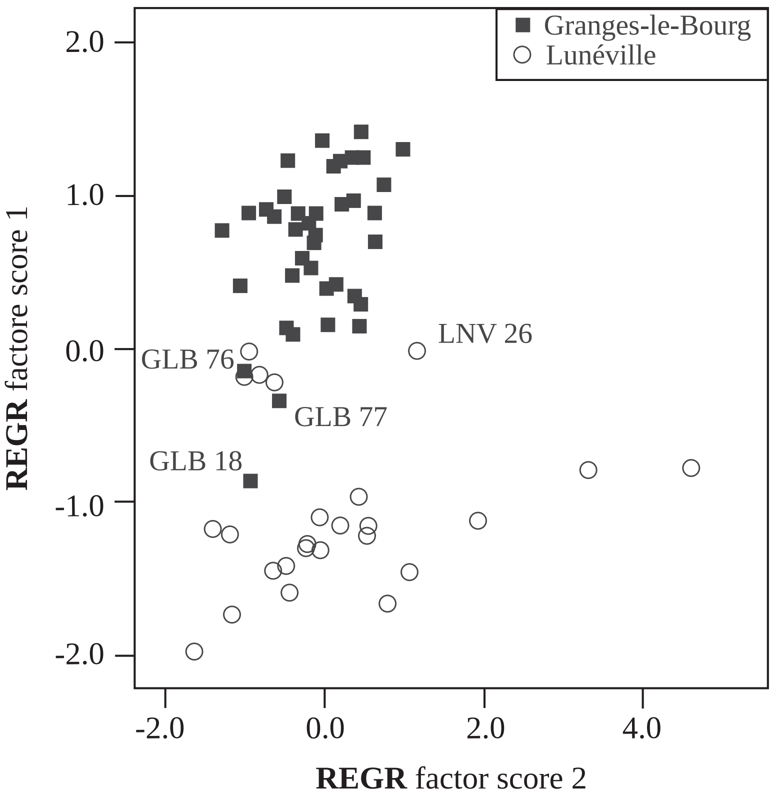

Figure 8 *Differentiation of the faiences of Jacques II Chambrette's Lunéville reference group (n = 25) from those of Granges-le-Bourg (n = 38; Maggetti* et al. *2009a) by a factor analysis.*

faiences analysed by Schmitt (1990), with more than 11 wt% MgO, are clearly distinct from the Lunéville referential (MgO < 11 wt%).

The origin of the test objects Most of these objects have always been attributed to the manufactory of Le Bois d'Épense/Les Islettes (see Table 2; see also Saint-Dié 1981). But their high MgO content makes them very different from the non-magnesian pastes of this manufactory (unpublished analyses). They must therefore come from a Lorraine manufactory using magnesian pastes, such as Lunéville or Saint-Clément. The dendrogram of the cluster analysis (Fig. 9) shows divergences with Figure 7. Indeed, the objects made with pastes A and B no longer form a group, but cluster into smaller groups, despite the fact that the same method and parameters were used. Clearly, the introduction of new samples upset the nice classification. If a line is drawn at a very low amalgamation distance, around 4.4, 13 groups are obtained, which must be interpreted by using stylistic and chemical criteria simultaneously. Group 1 contains BEI 115, currently attributed to Saint-Clément. We can thus infer that the other objects in this group, among which two 'Chinamen with the big finger' (BEI 119 and 169) share the same origin. Consequently, BEI 187 must be attributed to Saint-Clément rather than to Lunéville. LNV 21, a Chambrette paste A faience, belongs to this group because of its high aluminium content. Group 2 also contains a 'Chinaman with the big finger' (BEI 166), which attributes the three objects concerned to the

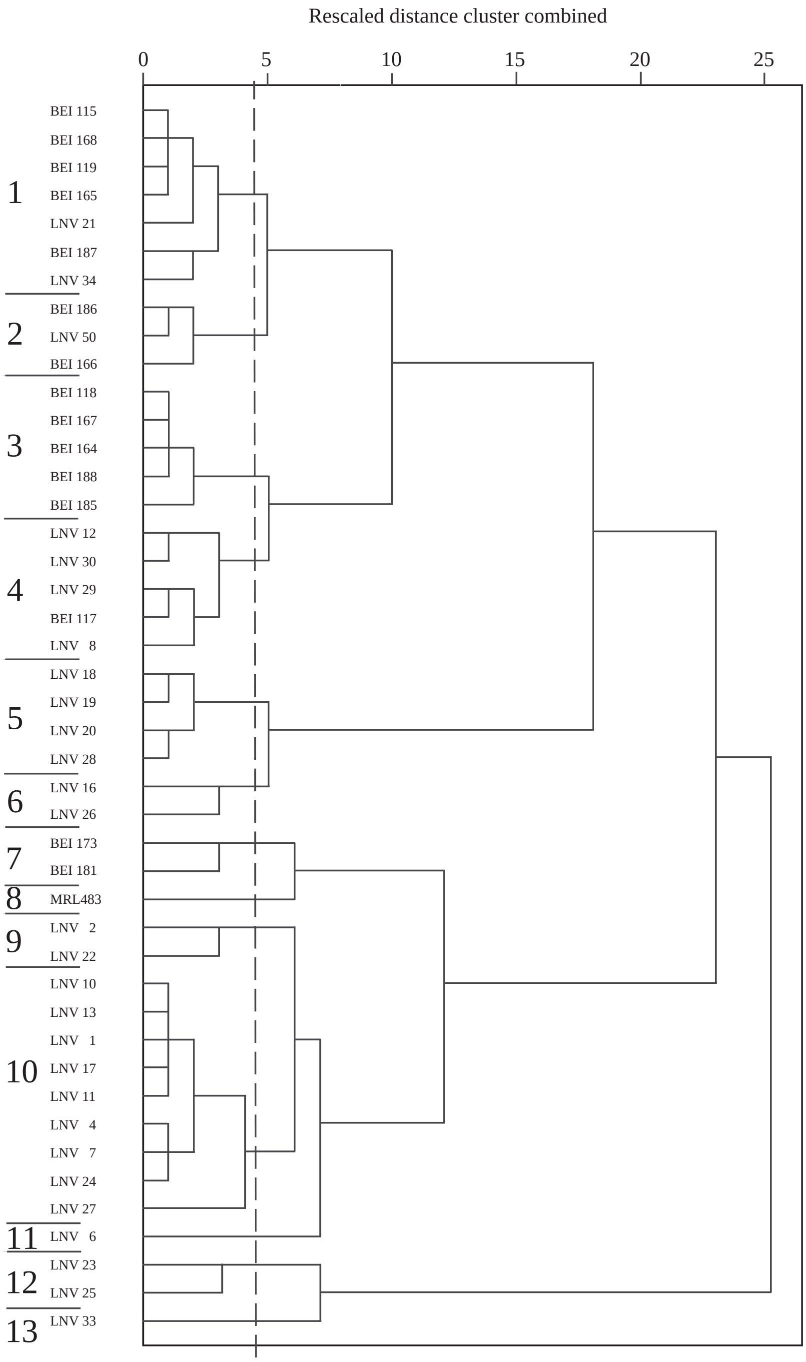

Figure 9 *The grouping of all MgO-rich samples by a cluster analysis.*

Saint-Clément manufactory. The objects in group 3 also quite probably come from Saint-Clément, because it includes BEI 167 (for which the Saint-Clément origin has never been in doubt: Saint-Dié 1985), and another 'Chinaman with the big finger' (BEI 118). It follows that BEI 185 and 188 must be attributed to Saint-Clément rather than to Lunéville or Waly. Group 4 contains objects with in-glaze decoration from the Chambrette manufactory (paste A), as well as the plate BEI 117. Groups 5 and 6 include objects from Lunéville (paste B) and LNV 16 (paste A). The three test objects from groups 7 and 8 form a larger group with an amalgamation distance of 13 with the paste A Chambrette faiences of groups 9, 10 and 11, which go together in a coherent group with an amalgamation distance of 8. The 'flameware' (groups 12 and 13) clearly classifies separately, and clusters at a distance of amalgamation of 8.

In conclusion, the test objects can be attributed as follows:

Lunéville: BEI 117, 173 and 181, LNV 33 and MRL 483.

Saint-Clément: BEI 115, 118, 119, 164, 165, 166, 167, 168, 185, 186, 187 and 188 and LNV 34 and 50.

It is quite puzzling to find BEI 185 and 188 in the Saint-Clément group, as the current attribution of BEI 185 would rather be in favour of Lunéville, given its shape and the colours of its decoration. On the other hand, BEI 188—often attributed to Waly without the slightest hint of any proof—has not been attributed convincingly so far, being sometimes given to Lunéville and even, more recently, to Badonviller, which is only 29 km away from Saint-Clément.

The result of this cluster analysis clearly shows the chemical similarities of the two types of pottery production. This is not so surprising, as both manufactories used the same raw materials. According to archival sources (Calame and Wéber 2008), Saint-Clément even used clays or ready-made pastes from Lunéville, a highly probable procedure, especially at the beginning of production at Saint-Clément. Furthermore, it cannot be excluded that both manufactories exchanged biscuits and white wares if needed, as they were under the same family direction.

The origin of the four non-magnesian objects Three garden vases from the Frescaty Castle (LNV 3, 5 and 9) contain very little magnesium, but do not belong to the Bois d'Épense referential, as shown by the factor analysis (Fig. 10). LNV 3, which bears the coat of arms of the counsellor Gomé de la Grange and his wife Marneau, could well come from the La Grange manufactory near Thionville founded by this counsellor, and situated on non-magnesian strata (Fig. 2). LNV 5, with the arms of Monseigneur du Cambout de Coislin (1711–32), who built the Frescaty Castle, could originate from the Champigneulles manufactory, also situated outside the Lorraine Trias (the Toarcian blue marl from the marlpit 4 km north of Nancy contains 11% calcite, but no dolomite, according to Millot 1950), which was in operation before Lunéville, having been founded soon after 1730. On the other hand, the origin of LNV 9 and TBL 5 remains open, although a Triassic Lorraine origin can be excluded.

CONCLUSIONS

The present study has shown the wealth in MgO of faiences stylistically attributed to the manufactories of Lunéville and Saint-Clément, wealth due to the fact that both establishments used dolomitic clays from the Trias. It can be deduced that the products from the 25 Lorraine manufactories, which were situated, as Lunéville and Saint-Clément were, on a Triassic subsoil (Fig. 2), should also have a magnesian nature. These are the manufactories at Badonviller, Bertrambois, Château-Salins, Cirey, Domèvre, Epinal, Frauenberg, Frémonville, Gerbéviller,

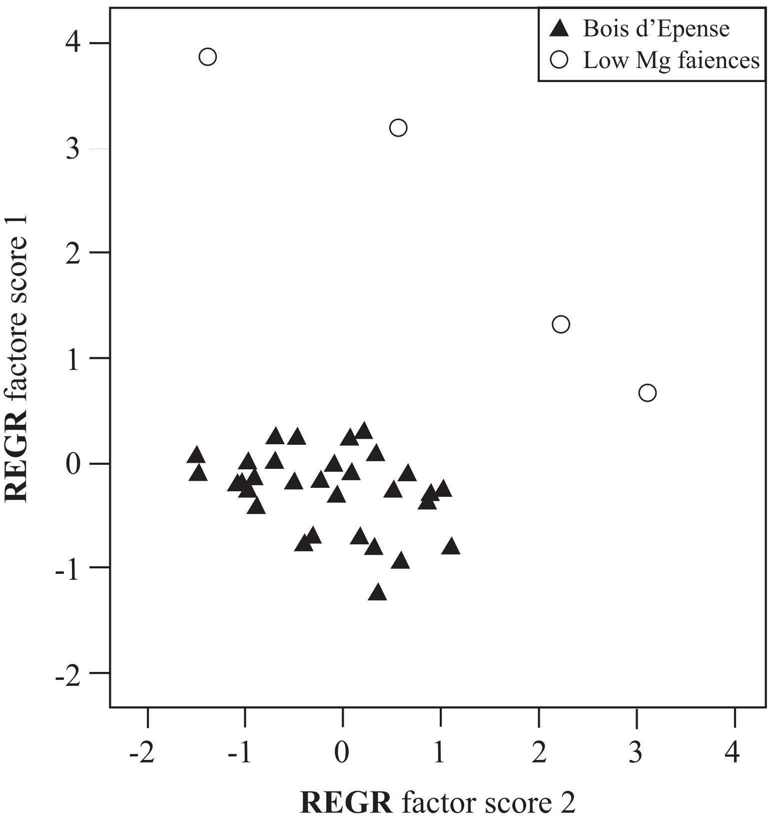

Figure 10 *Differentiation of the four Mg-poor faiences from those of Le Bois d'Épense (unpublished analyses, n = 31) by a factor analysis.*

Jeanménil, La Trouche, Mettlach, Moyen, Niderviller, Pexonne, Plombières, Raon L'Etape, Ramberviller, Saint-Avold, Saint-Nicolas, Saint-Quirin-Halmoz, Sarrguemines, Sierck, Vaudrevange and Vic. Three further manufactories could be added to this list: Gérardmer, Saint-Dié and Senones, situated on crystalline bedrocks, and which could also have used imported magnesian clays. The identification of two chemical groups answers the second question. Either the analyses pertain to a large Lunéville group, produced in the Jacques II Chambrette manufactory, with three chemical subgroups, probably reflecting the use of three different pastes in the same manufactory, or to a second lesser group, whose objects were made at Saint-Clément in the early 19th century. It seems possible to differentiate the faiences of these two manufactories chemically, despite the fact that they used the same raw materials. The way in which these materials were processed, and the proportion of the clays, must have been different from one manufactory to the other, ultimately amounting to different chemical body compositions. These results open up promising and fascinating directions for research. However, the great scattering of the analyses calls for prudence: it is necessary to undertake other analyses of objects with a reliable provenance in order to better determine the chemical variability of the 27 Lorraine manufactories known today.

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