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CHARCOAL AND MICROCHARCOAL :CONTINENTAL AND MARINE RECORDS
4th International Meeting of Anthracology, Brussels , 8-13 September 2008
Royal Belgian Institute of Natural Sciences

Article accepted by the scientific committee, in press

Charcoal analysis of lime kiln remains in Southern France: an original process of mediaeval and modern traditional lime burning.

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Abstract

In Europe, little is known of the traditional production of lime, in terms of fuel management and lay out of the fireplace. This is why charcoal analysis plays an important role when attempting to understand this activity. A new research program, at the basis of a PhD work, highlighted the weakness of data obtained previously, i.e. the lack of exhaustive charcoal sampling leading to partial information. As a result, a new sampling protocol, applied to the fireplaces used in lime kilns, has been established. Comprehensive results have been obtained for the first time, testifying to the potential existence of a specific Mediterranean technique using a high firing chamber. Systematic measurement of the diameter of charcoal fragments testifies to the use of small branches and twigs of local, readily available plant species.

Key-Words: limekiln with high firing chamber, Southern France, sampling strategy, charring, artisanal charcoal

Introduction

Limekilns have been used for a long time to transform limestone into lime, which had three main applications: mortar (in the construction of buildings), limewash (applied to outside walls of buildings) and compost (to improve soil fertility). We recall that the process of burning limestone releases quick lime (calcium oxide), which is chemically unstable in

normal atmospheric conditions. Combined with water it produces slaked lime (calcium hydroxide).

Despite the extensive use of this process through time, little is known of the traditional production of lime as reflected by the scant archaeological publications, which focus only on theoretic information provided by scholars and engineers (Biringuccio 1572, Fourcroy de Ramecourt 1766, Biston 1836, Magnier 1881). The structures identified and excavated have been ranked by Adam and Varène (1985).

A review of charcoal data concerning this type of structure clearly shows that sampling was not carried out exhaustively partly due to the lack of time during field work, partly due to the absence of a keen interest in this type of activity. As a result, data obtained in the numerous structures excavated, in France and elsewhere in Europe, can not be considered as totally representative of this activity.

According to published data, gallo-roman and medieval kilns from northern France appear to have been fed mainly with deciduous *Quercus* and /or *Fraxinus* (Solari 1990, Marguerie 2002, Blin *et al*, 1999).

Only once, were two phases of burning identified and sampled in a kiln (XIVth century), located at Colayrac-Saint-cirq (Ballarin *et al*. 2006, 136). Deciduous *Quercus*, *Corylus* and *Ulmus* were used during the first phase, while *Abies* replaced *Corylus* in the second phase.

Further south, more shrubby species, such as *Pistacia lentiscus* and Cistaceae, were also used (Devillers 1999, Chausserie-Laprée 2000). The use of shrubby garrigue plants has been also identified in other kilns (Thinon in Brochier, Livache 2003 and 2004; Fabre 2001 and Fabre in Ginouvez 2001)

Elsewhere in Europe, and despite the reduced number of charcoal fragments available, a diverse plant spectrum of plants has been identified. In England, *Fagus*, *Populus*, *Quercus*, *Crataegus*, *Corylus* and *Acer* were used in the roman kilns at Weekley (Jackson *et al*. 1973), while in Germany (Rhine valley) kilns were fed with *Populus* and *Salix* (Sölter, 1970,19). In Switzerland, fuel wood used in the kilns of la Combe Tenon and Pâturage aux Boeufs comprised *Abies*, *Sorbus*, *Corylus*, *Populus*, *Fagus* and *Pinus sylvestris* (Gerber *et al*. 2002). The taxonomic diversity identified suggests that no species was particularly targeted for this activity. Local availability appears to have been the main factor.

Quantitative data concerning wood diameter is usually not included in the studies referred to above. In some cases, such as Nespouls (Figueiral, unpublished report) this was clearly impossible to carry out due to the absence of complete branches. We know however, that both branches of small calibre (Fabre, 2001; Brochier, Livache 2003, 12; Poirier in Ballarin *et a*l., 2006, 137; Jackson *et al*.,1973) and bigger logs were used (Marguerie 2002)

Further information, concerning fuel used in kilns, is provided by ethnoarchaeology. In Morocco (at Moulay-Idris), the leaves of *Chamaerops humilis* ou *Hyphaene thebaica* were used to feed the fire (Herber, 1923, 421). Dry herbaceous plants and branches of small steppe shrubs were used in Tunisia (at Kairouen) (Adam, Varène 1985, 95), along with branches of dry rosemary recovered from distilling factories (Chehaibi *et al*. 2008). In Grece (at Nauplie), and as recently as 1980, kilns were feed with olive oilcake and almond shells (Adam, Varène 1985, 93).

A specific technique of converting limestone into lime

Recent research carried out in Southern France, has allowed us to identify an unusual technique used for lime burning. It is generally accepted that the earliest limekilns were straightforward pit-like structures, becoming more important constructions from the Middle Ages onwards. These funnel-shaped constructions were usually built into a slope / hillside, natural depressions, so that the natural ramp allowed both the feeding of the fire and the transport of limestone, tipped down into the crucible. Inside, an arched sole made of limestone, is separated from the kiln pot and heating chamber (Figure 1). The opening of the kiln, located at the bottom, creates a direct access to the heating chamber. After the burning, the sole is also converted into lime, thus disappearing from the archaeological record.

Recent archaeological evidence has been obtained in 2007, while digging at Le vallon de l'Homme Mort (Peynier, Provence) (Vaschalde 2008a) and in 2008, at quartier de Bel Homme (Peynier, Provence) (Figure 2). The interest of the first limekiln results from the location of the fire place, 2 m under the small entrance (50 x 60 cm), with no other airing system. This unusual design raises problems concerning both the entrance of oxygen and the shape of the arch, dependant on the location of the entrance. Contrary to what is usual, a very thick layer (1,30 m) of charred remains was preserved beside the entrance. The fireplace is very well preserved, protected by a layer of lime.

The second limekiln, presents the same features, with the addition of a small "banquette" (Vaschalde 2008b).

The characteristics of these two kilns have been compared with those from other structures excavated in southern France. The kiln from the earthenware factory Favier (XVIIth century, Montpellier) presents the same stratigraphy, with an accumulation of charcoal fragments near the entrance. This kiln also presented two piers, which formed some kind of chimney between the entrance and the heating chamber (Ginouvez 2001). This device was described by Thiriot (2006) following the excavation of another of these structures, located at Bollène (Vaucluse). This kiln had two small heating chambers, each with a fireplace. This example, in association with ethnographic data from the Mediterranean region, mainly Tunisia (Adam, Varène 1985, Chehaibi *et al*. 2008), provides the basis to our reconstruction of the kiln from Peynier (Figure 3) : two different arched areas on the top of the fire place establish the communication between the entrance and the small heating chamber.

In southern France, medieval and modern limekilns appear to run in a specific manner and have a characteristic lay out, with a deep pit and a kiln pot of small dimensions.

This type of kiln is not often described in the specialized literature. The first description dates back to 1766 (Fourcroy de Ramecour 1766). More recently, its use during the roman period is mentioned by Flach (1981), but no archaeological example is provided. And yet, this type of kiln appears to have been used in the whole of the Mediterranean world; well known examples include kilns from Rome (Sagui 1986), Kerkouane in Tunisia (Fantar 1984) and Moulay-Idris in Maroc (Herber 1923).

A specific fuel ?

Does this particular lime burning technique require special fuel management? The answer to this question requires a planned sampling strategy such as the one carried out at Le vallon de l'Homme Mort.

Charcoal was exhaustively sampled. Three different samples were analysed, revealing the different distribution of plant species (Figure 4) : high frequencies of *Quercus ilex* / *coccifera* (c. 80%) are observed in the first sample. Lower frequencies of this taxon are recorded in the second sample (50%) in association with *Quercus* (deciduous) / *Castanea* (c.

15%) and *Pinus halepensis* / *pinea* + *Pinus* sp. (15%). In the third sample, *Quercus ilex* / *coccifera* reaches 66%, while *Quercus* deciduous and pine attain 12 and 6% respectively.

The diameter of the charcoal fragments from these three samples varies between 1 and 14 mm, clearly showing that small twigs and branches were used as fuel wood. The measurements, carried out in 31% of the specimens, allowed the drawing of a calibration curve, which separates three different groups of specimens: those measuring c. 3mm, c. 7mm and c. 11mm. It is difficult to explain the identification of these three groups in the absence of the exact position of the samples in the kiln. It is likely, however, that this reflects only the natural morphology of the specimens thrown into the fire.

15% of the specimens analysed allowed us to establish the cutting season (Figure 5) : transition earlywood / latewood or beginning of latewood. It is therefore possible that the kiln was used during the beginning of the autumn.

The study of this structure shows that lime burning in kilns with high firing chamber (high kiln pot) uses fuel well adapted to this activity / structure design. Twigs and small branches, probably in bundles, produce the flames required to the success of this activity (Fourcroy de Ramecourt 1766, Biston 1836). Furthermore, results obtained clearly show that different samples must be taken in the charcoal layer, as significant variations concerning species identified, their frequencies and calibre, have been recorded.

This new data, concerning the fuel used and its relation with the firing technique, shed new light on information from kilns excavated previously, such as the one from Orgon (Provence), excavated by R. Gaday (2007). This kiln, dating back to the XVIIIth century, was greatly damaged, making it impossible to recognize the existence of a high kiln pot. A lateral accumulation of charcoal identifies the fireplace area. The analysis of the charcoal fragments (Figueiral, unpublished report) presents remarkable similarities with that of Peynier (Figure 6). Plant species used are characteristic of the surrounding 'garrigue' environment (evergreen *Quercus*, *Rosmarinus officinalis, Juniperus* and Fabaceae), with diameters varying between 2 and 13mm. Taxa frequencies also fluctuate in the different samples studied.

The similarity of the charcoal data and the lay out of the fireplace suggest that the kiln from Orgon, also was a limestone kiln with high pot, despite the absence of structural remains.

Towards a new sampling protocol

A new sampling protocol has been established while excavating the kiln 'la Marcouline' at Cassis (Provence) aiming at a better understanding of the links between kiln construction, lay out and fire control. This kiln, apparently dating back to the 19th century, also presents a high kiln pot; and as at Peynier, the fireplace was protected by a layer of carbonated lime, preventing post-depositional disturbance. This certainly influenced the outcome of the dig in itself and of the charcoal analysis data. The important numbers of indeterminable specimens result from the reduced dimensions of the charcoal fragments.

Excavation work, covering ¼ of the fireplace, was carried out following artificial layers, 5cm thick. Each sample was sieved (2mm mesh), and the whole of the sieve was scanned to recover de smallest twig fragments. Seven of these samples were subject to analysis.

This careful excavation and sampling was followed by micro-topography of the kiln, in order to identify the morphology / pattern of the fireplace. The precise location of the material studied was recorded. Three phases were recognized in its construction (Figure 7), testifying to the existence of a fire management.

At the bottom (first 10 cms) the charcoal assemblage is composed of small twigs/ branches (mean diameter = 2 mm); *Quercus ilex* / *coccifera* dominates with c. 70-80%. Abundant fragments of twigs, thorns and leaves identified as *Quercus coccifera*, *Rosmarinus* and *Lavandula* were recovered from the entire flot, suggesting the presence of a wick at the bottom of the fireplace to light the fire. When the fireplace collapsed, after the initial rapid blaze, the remains of the wick were deprived of oxygen and preserved from further damage.

In the middle layers, *Quercus* sp. still predominates (70%), but wood calibre is more important (mean 4-5 mm) and remains of leaves, thorns and small twigs are no longer present. These layers represent the "maturity" of the fire.

The topmost layer provided very different results. The first five centimetres were dominated by *Pinus halepensis* / *pinea* (72%); measurement of wood calibre was not viable. Furthermore, a single log (diameter = 120 mm) of pine lay on the top of the charcoals. It is difficult to explain its presence in this particular place. However, we believe it was of no consequence to the running and effectiveness of the fire.

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Conclusion

A survey of charcoal analysis work carried out in archaeological lime kilns emphasized the need of a sampling strategy applied to this type of structure. It is clear that data provided by a single sample only offer a partial image of the running of the fireplace. The new sampling protocol proposed allows us to recognize the different construction procedures and to understand how the fireplace was stoked. However, the success of this protocol depends on the good preservation of the fireplace, which only happens when this is sealed by a layer of carbonated lime.

Remains of a wick were found in the kiln from Cassis. This testifies to the importance of a thorough, exhaustive sampling and highlights how limited our knowledge is, concerning this activity. The presence of this wick provides evidence of an unusual way of starting the fire. At Peynier, the fire was located two meters under the kiln pot, and thus totally inaccessible.

In the long term, added improvements to our sampling strategy will hopefully provide precise three dimensional images of the fireplaces.

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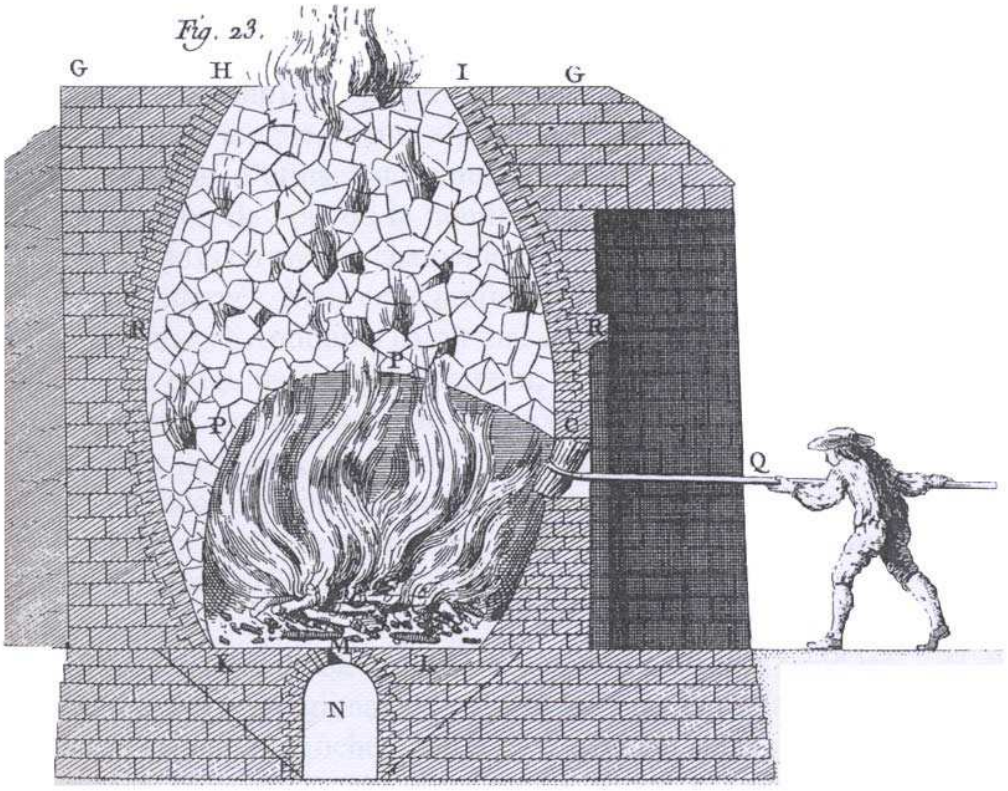
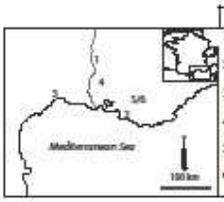


Fig. 1 Traditionnal lime kiln firing according to Fourcroy de Ramecourt 1766

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Site	Period	Archaeologists	Anthracologist	References
1 : Bollène - Saint-Blaise-de-Bauzon (Vaucluse)	XIIIth	J. Thiriot		Thiriot 2006
2 : Cassis - La Marcouline (Bouches-du-Rhône)	XIXth	Cl. Thomas, Chr. Vaschalde	Chr. Vaschalde	
3 : Montpellier - Faïencerie Favier (Hérault)	XVIIth	O. Ginouvez, J. Thiriot	L. Fabre	Ginouvez 2001, Fabre 2001
4 : Ongon - Le Défends (Bouches-du-Rhône)	XVIIth	R. Gaday	I. Figueiral	Gaday 2007, Figueiral 2008
5 : Peynier - vallon de l'Homme Mort (Bouches-du-Rhône)	XVIIth	Chr. Vaschalde	Chr. Vaschalde	Vaschalde 2008a
6 : Peynier - Bel Homme (Bouches-du-Rhône)	?	Chr. Vaschalde		Vaschalde 2008b

Figure 2 :Location of sites referred to in the text.

Fig. 2 Location of sites

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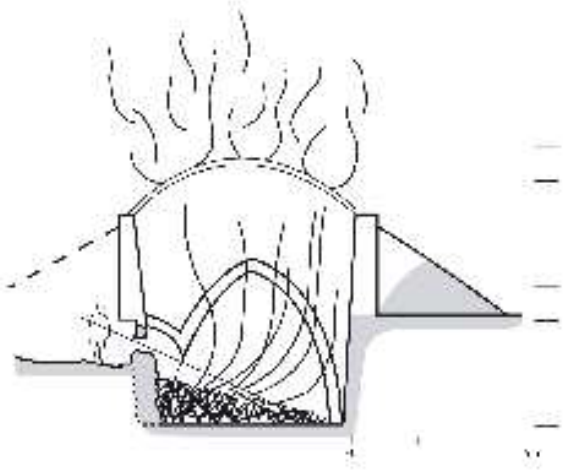


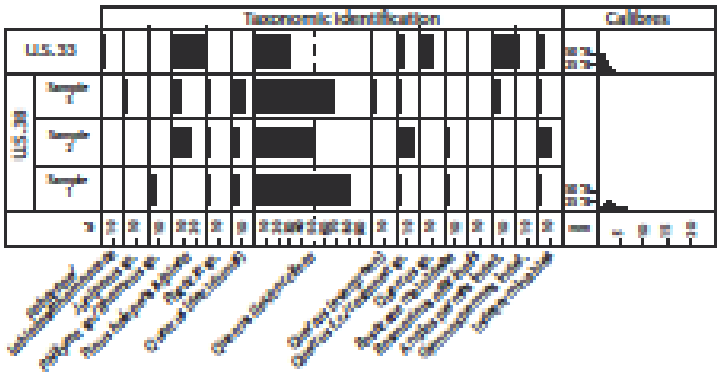
Figure 3 : Hypothetical reconstruction of the lime kiln from Vallon de l'Homme Mort (Peynier).

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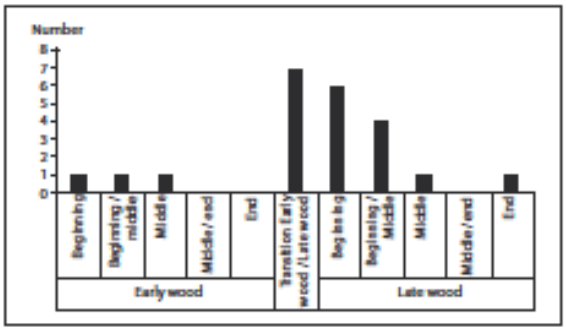


Fig. 5 Cutting season identified in complete branches (Peynier)

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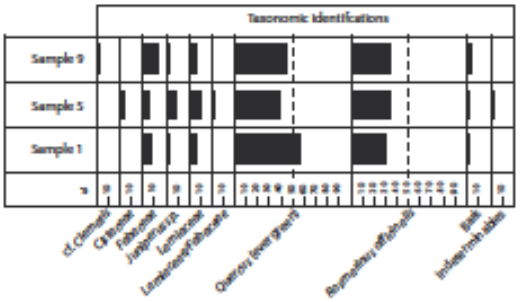


Fig. 6 Charcoal analysis diagram (Orgon) [Converti]

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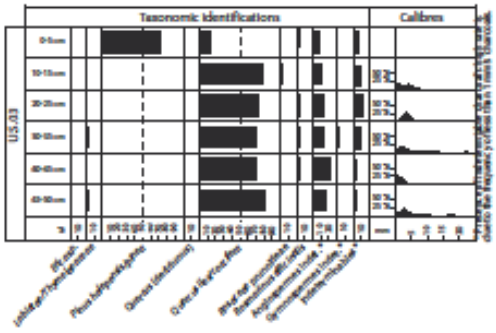


Fig. 7 Charcoal analysis diagram (Cassis)

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