Nouveautés Lychnologiques
Lychnological News

LychnoServices

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LychnoServices

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Sommaire

Avant-propos

C'est à l'occasion du 1er congrès archéologique international d'étude sur le luminaire antique et de l'exposition « Lumière ! L'éclairage dans l'antiquité » organisée au Musée romain de Nyon que paraît « Nouveautés lychnologiques », un volume propre à favoriser la diffusion des connaissances et la confrontation des idées, mais offrant aussi aux spécialistes l'opportunité de soumettre à la critique de leurs pairs non seulement les résultats de leurs recherches mais encore de nouvelles manières d'interroger et de comprendre. La variété et la richesse des contributions illustrent l'intérêt et le renouveau des études relatives aux lampes, une discipline à part entière, certes, mais qui ne saurait se suffire à elle-même : il convient plus que jamais de se garder d'une spécialisation outrancière qui se ferait au préjudice d'une vue d'ensemble aussi large que possible. Si les études ponctuelles, mais précises, constituent un préalable nécessaire à toute synthèse, elles ne sauraient demeurer une fin en soi. La science lychnologique, à l'instar de la céramologie, de la numismatique, de l'archéo-botanique ou de la paléo-trichologie, reste indissociable de l'archéologie : à partir de vestiges matériels, aussi modestes soient-ils, il convient essentiellement de saisir l'homme dans sa complexité et sa relation avec l'univers. Dans cette quête, longue et difficile, parfois désespérée, il importe d'améliorer sans cesse les outils de détermination et d'interprétation, de veiller à la multiplicité et à la diversité des approches, qu'il s'agisse d'analyses de laboratoire, d'études typologiques, chrono-quantitatives, technologiques, iconographiques ou économiques, sans oublier les dimensions culturelles et anthropologiques et tout en restant à l'écoute d'autres spécialistes. C'est dans cette perspective que les auteurs du présent volume ont voulu placer leurs travaux et qu'il conviendra de situer les études à venir. La réflexion sur l'homme à partir des objets matériels et de leur contexte ne saurait se limiter à un simple exercice, aussi brillant soit-il : elle resterait totalement vaine si elle ne servait à allumer et à entretenir, goutte à goutte, notre propre lampe…

Genève, le 22 septembre 2003

Prof. Daniel Paunier

Éditorial

Décidément, l'année 2003 a été placée sous le signe des lampes et de la lumière. L'hiver nous quittait sur deux belles expositions sur ce thème, organisées par les collègues des musées de Veszprem (Hongrie) et de Jena (Allemagne).

Puis, au printemps, le 15 mai précisément, ce fut l'inauguration de l'exposition « LVMIERE ! L'éclairage dans l'Antiquité » au Musée romain de Nyon (Suisse).

Autour de cette exposition, le Musée romain et sa conservatrice Véronique Rey-Vodoz, avec l'aide du Professeur Daniel Paunier, ont accepté de soutenir le 1er Congrès international d'étude sur le luminaire antique, placé sous le haut patronage de M. Charles Kleiber, secrétaire d'Etat à la Science et à la Recherche.

Ce congrès, qui a réuni plus de quatre-vingt spécialistes en la matière de vingt-deux nationalités, a vu la fondation de l'Association Lychnologique Internationale.

En marge du congrès, LychnoServices, créé par Samuel Crettenand et Laurent Chrzanovski, se propose de mettre en valeur le patrimoine luminaire antique sous toutes ses formes, de la préhistoire au Moyen-âge, au moyen de quatre vecteurs d'information (site internet, publications, outils pédagogiques et bases de données scientifiques).

Nouveautés Lychnologiques / *Lychnological News* a donc remis au goût du jour le terme (ou plutôt le néologisme) "lychnologique", déjà proposé par les participants de la table ronde "*Les lampes de terre cuite en Méditerranée des origines à Justinien*", organisée par le C.N.R.S. (Centre National de la Recherche Scientifique) à Lyon, du 7 au 11 décembre 1981 (et publiée en 1987 à Paris sous la direction T. Oziol).

Ce volume propose au lecteur – spécialiste ou simple amateur – vingt et un articles de tous horizons (Allemagne, Belgique, Canada, Espagne, France, Israël, Italie, Liban, Palestine, Suède), présentant des lampes, presque toutes inédites, issues de fouilles ou de musées.

Par ailleurs, la thématique des premières lampes est traitée avec soin par Sophie A. De Beaune, et un article d'archéologie expérimentale de Christian-Heinrich Wunderlich complète ce recueil.

Nous vous souhaitons la plus agréable des lectures.

LychnoServices, Laurent Chrzanovski - octobre 2003

Editorial

Lamps and lighting are definitely the prevailing themes of the year 2003. Winter ended with two wonderful exhibitions dedicated to this topic, exhibitions organized by colleagues of the museums of Veszprém in Hungary and of Jena in Germany. Then spring, and more precisely May 15th, saw the inauguration of the exhibition "LVMIERE! L'éclairage dans l'Antiquité" at the Roman Museum of Nyon (Switzerland).

Around this exhibition, the Roman Museum and its curator Ms Véronique Rey-Vodoz, in cooperation with Professor Daniel Paunier, have accepted to support the 1st International Study Congress on Ancient Lighting Devices, placed under the high patronage of Mr. Charles Kleiber, Secretary of State for Science and Research.

The congress, held from September 29th to October 4th, gathered experts in this field from tweny-two different countries. During the event, the International Lychnological Association (ILA) was officially founded.

In connection with the congress, LychnoServices, created by Samuel Crettenand and Laurent Chrzanovski, offers to highlight the heritage of ancient lighting devices in all its forms, from Prehistory to the Middle Ages, through four means of information (website, publications, educational tools and scientific databases).

Nouveautés Lychnologiques / *Lychnological News* has brought up to date the term (or rather the neologism) "lychnological", which was already suggested by the participants in the round table entitled "*Les lampes en terre cuite en Méditerranée des origines à Justinien*", organized by the CNRS[1] (National Centre for Scientific Research) in Lyon, from December 7th to 11th 1981 (and published in Paris in 1987 under T. Oziol's supervision).

This volume offers readers – specialists or amateurs – twenty-one papers from various countries (Belgium, Canada, France, Germany, Israel, Italy, Lebanon, Palestine, Spain, Sweden), featuring lamps coming from excavations or museums, most of them previously unpublished.

Moreover, some special topics have been included in the book: Ms Sophie A. De Beaune carefully details the theme of the first lamps and Mr. Christian-Heinrich Wunderlich delivers an interesting article of experimental archaeology.

We wish you pleasant reading.

LychnoServices, Laurent Chrzanovski - october 2003

Articles

Light and Economy
An Essay about the Economy of Prehistoric and Ancient Lamps

Christian-Heinrich Wunderlich

Introduction

A lot of research work has been done on this topic so far. In classical archaeology, Roman Bildlampen provide important information for the dating of lamps. However, this field of research finds no application in central European prehistory, simply because of a lack of finds. The purpose of this essay will not be to compare the design of different types of lamps and to classify them (e.g. according to different pictures on the discus of ancient Roman Bildlampen). Design includes more than just the decoration of objects. Design stands for the dialogue between aesthetics and functionality. The aspect of functionality has not been appreciated enough yet, neither with ancient Roman lamps, nor with prehistoric lamps or those we believe to be lamps.

What is this essay is about ?

The purpose of this essay will be to discuss problems related to artificial lighting in terms of efficiency and functionality. Light is one of the essential factors of human life. Light plays a central role in religion, mythology and psychology, from a metaphorical point of view ('I am the Light of the World') as well as from a practical point of view (light in liturgies, lighting of our work place, light therapy in psychiatry).

We will learn, that 'lux' and 'luxuria' are not a coincidental play on words – both terms are closely linked to each other. We will talk about light and economy, and we will think about why there are hardly any lamps to be found in one of the richest archaeological repositories of central Europe.

This work is written by a chemist who works in the field of archaeology, and not by an archaeologist. For this reason, readers will understand why I will not be going into every archaeological detail.

Lux and Luxury, Light and Economy - Lighting Technology of Prehistory, Antiquity and the Middle Ages from an Economical Point of View

Dark Ages ?

As we enter our office, we have an instinctive movement towards the wall, on the left hand side of the door: the light switch, the neon light flickers. Work can start. Bringing light in the dark is one of man's elementary effort. We can hardly think of any work or leisure activities without light.

On the occasion of "The Night of Museums", the author was looking for prehistoric lighting equipment in the repository of the State Office for Archaeology Sachsen - Anhalt (Halle, Eastern Germany).

The result of the research was surprising and would make nearly impossible to speak of "Prehistoric Lighting in Middle Germany" as announced in the programme.

Although Sachsen - Anhalt is one of the richest regions in middle Europe as far as prehistoric cultures are concerned, there was hardly any object found that clearly could be clearly categorised among "lamps" until to the Upper Middle Ages. It is as if lamps only appeared since the beginning of the *Renaissance* and even then, they were regarded as "everyday crockery".

Does that mean that the people of Middle Germany were sitting in the dark, condemned to inactivity during long winter nights, while about 400 km away from there, in the Roman Cologne, there was "light culture" and people were doing all kind of activities by the light of oil lamps ?

In contrast to the situation in Middle Germany, we

have the Mediterranean area and the temporary Roman acculturated areas in Middle Europe with their countless lamps. Indeed, lamps are to be found in huge amounts there, at all stages of development and with a broad variety of *décor* and design.

This assumption, however, is based on the lack of occurrences of well-defined lamps among the finds on the one hand, on the other hand it is based on the existence of found material we clearly define as "lamp" (e.g. Firmalampe, Bildlampe).

Restrictively it must be said that, apart from a few exceptions which will be introduced later, no clearly-defined lamp has been found so far. However, lamps could be hidden among the major part of ceramics. As a matter of fact, almost all kinds of domestic pottery can be easily converted into lamps. Fill a bowl with grease or oil, put a wick inside and the primitive but fully functional lamp is ready.

An example from my private home may prove this:

On the other hand, objects undisputably regarded as lamps can also be used for other purposes. Most of objects called lamps lack the typical traces of smoke which one would like to see as a proof for the function "lamp".

Here is another example of my private home:

Of course the Bildlampe "Loeschcke Ib" is perfect as a milk jar, and conversely, the jar can be used as a lamp…

The absence of archaeological finds can also considerably help to explain the phenomena of historical culture. The aim of this lecture is to give a closer look at these phenomena.

Form and Function

or: How do I recognise a lamp in the repository of the museum ?

One would hardly assume, though, that people living in Middle Europe in prehistoric times simply used normal "everyday crockery" for their lighting. It is also unlikely that the "lack of lamps" arises from our inability to detect lighting equipment among the rich amount of finds. Furthermore, it seems most probable that the lamps of the ancient Mediterranean world had other functionss than just illumination.

As a provisional explanation the following theses may be put forward:

Thesis 1:

As far as economic reasons are concerned, lamps require specific constructions, which are different from the design of the rest of domestic pottery. The design of lamps depends on parameters such as: purpose, functionality and economy.

Therefore it cannot be assumed that prehistoric cultures which diversified the design of their pottery for functionality reasons, did not create a specific shape for the function "lamp".

Thesis 2:

Neither the fire in the stove nor a glowing scale of wood is an appropriate replacement for lamps and candles. The fire in the stove is hardly ever ablaze, most of the time it is merely glowing. Open fire flickers and burns unsteadily. Many domestic tasks (e.g. textile works, weaving etc.) cannot be carried out in glimmering lighting conditions.

This is the same with wood scales. They burn unsteadily and require permanent control and supervision. Economicaly speaking, they are not interesting.

In contrast lamps and candles present important advantages: they burn steadily, do not glimmer and do not require permanent supervision.

Thesis 3:

The term "Dark Ages" may be taken literally, as well as

"Dark Middle Ages" and "Dark Past".

The lack of lamps or similar lighting equipment among prehistoric findings in Sachsen – Anhalt needs to be considered seriously. As a matter of fact, people had probably been sitting in the dark for economical reasons until the Early Modern Times.

Although illumination significantly increases the productivity of a society, the lights in Middle Germany remained off for economical reasons until the Early Modern Times.

Wick-fire lamps give a calm light

Lighting a bowl with petrol is easy. As soon as you hold the lit match over the surface of the fluid, the fuel ignites. Light paraffin is a little bit harder, but finally it works without the help of a wick. A bowl with olive oil cannot be lit so easily anymore. Why that ?

All three liquids are flammable and their combustion even exposes a lot of energy.

To create a flame however, we need inflammable gases. Since petrol is highly volatile, it releases at room temperature a sufficient amount of vapour to create an inflammable and, even sometimes, explosive mixture.

The vapour pressure of paraffin is lower, and therefore it is not so easily inflammable. But once lit, it heats up so such as to release a sufficient amount of flammable vapour to keep a fire going that can hardly be extinguished.

Because of its low vapour pressure, olive oil is not inflammable at room temperature, but if it is heated, its vapour pressure rises. This is why a hot deep-fryer is as inflammable as a can of petrol. The evaporation of a liquid does not only depend on the temperature only, but also on its surface. The functionality of the wick is based on this fact. The capillary effect makes the liquid rise in the wick.

Where the liquid is wetting only the fibres of the wick, without filling the spaces in-between, a broad liquid surface develops. The wick can be lit here, it carbonizes a little bit and the hot "carbon-fibres" causes enough fuel evaporatuion on the broad surface in order to keep the flame alive.

It is a popular fallacy to believe that wicks must be made of flammable material. Glass fibres and mineral are suitable materials for wicks and in ancient times wicks made of asbestos were used[1] occasionally.

Most of prehistoric wicks, however, were made of herbal fibres.

The cellulose carbonizes while the wick is burning, the result is a "carbon-fibre" which catalyzes the burning process described above, without burning down itself.

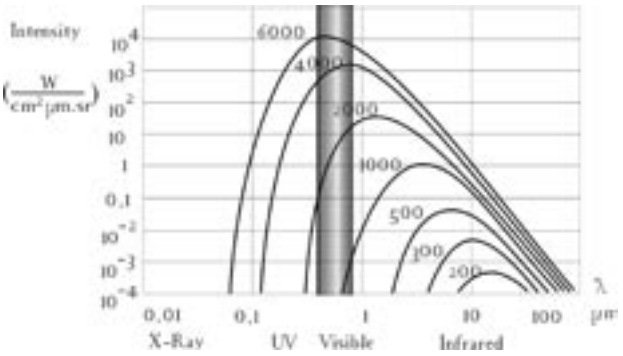
The candle is a specific form of wick-fire light.

Basically it works in the same way as oil lamps. Because of its high melting point the fuel does not need any coating. However, candlesticks are necessary for safety reasons as well as to collect dripping fuel for recycling purposes.

The advantage of wick lights is the following: if they are properly designed, they produce a long-living and steady-going flame. Their light does not flicker and their maintenance does not require much effort. All you have to do is to adjust the wick every once in a while and clean the lamp. Well-made lamps can, according to the amount of oil they store, burn for hours or even days without any intervention. The size and the form of the wick merely determines the size of the flame.

Why do flames shine ?

The light of a flame is body radiation. Each body that is warmer than 0° K (-273° C) produces electromagnetic radiation. This radiation stretches over a large band of wave lengths, from infrared (= heat radiation) over visible light to ultraviolet. The function of wave length and intensity is a curve and its form and maximum depend on the temperature of a body.



Black body light emission curves at different temperatures (degrees Kelvin).

This means, that a burner, heated up to 500°C produces a faint red light, which is hardly recognizable in the dark, but also a considerable amount of "heat" (invisible, infrared "light"). When increasing the temperature intensity, the amount of short wave emission (= visible light) increases. As a result, the light becomes brighter and whiter.

The origin of a flame in an oil lamp can also be

explained with body radiation (emission).

Are flames bodies ? No, not if they consist only of hot gasses, like nonluminous flames of a camping - or Bunsen burner. But the luminous flames of a candle or a wood fire contain very small soot particles, which are produced in the flame when the fuel is not completely transformed.

Those soot carbon black particles in the flame can be detected easily: if a spotlight is shined on a flame, the luminous part of it casts a shadow on the wall.

A spotlight is directed at a flame. The flame produces a shadow. The reason: soot particles.

Fuels

The fuel of almost all prehistoric lamps is fat[2]. Every kind of fat is suitable, no matter whether it is derived from animal or vegetable sources, whether it is fluid (oil) or solid. (Solid fats melt because of the heat development, taking the same properties as a fatty oil). The kind of fat, however, is not completely insubstantial: fats consisting mainly of unsaturated fatty acids produce less soot and, the flame is brighter and the light efficiency higher, because of their higher energy.

They contain more hydrogen which makes the flame temperature higher. Healthy fats are not appropriate fuel for lighting. Fats with a high content of poly unsaturated fatty acids produce a lot of soot, the flame is darker and the light efficiency is lower. Moreover, because of the heat, they tend to polymerization, which means they become viscous and cannot ascend the wick any longer.

Although, in comparison with olive oil, they produce less soot and have a higher light efficiency, they present a major disadvantage: they are solid at room temperature, and therefore cannot be used in lamps with narrow spouts.

On the other hand, solid fats, like suet, can be used for the production of candles.

A simple experiment will help to show the difference more clearly:

Lard, cod-liver oil and olive oil are filled into three models of lamp of the same size and are burnt.

The result: an unpleasantly poor dim light is literally outshone by its two proud sisters filled with expensive olive oil or the lard.

Resin balsam (extracted from carved-in fir trees), colophony (dried residue of balms) and pitch (made of pine resin) were also used as fuel in prehistoric times, but probably only for torches, as they smoke a lot, because pine resins contain multiple unsaturated fatty acids and cyclic hydrocarbons.

This means that the content of hydrocarbon is higher. The temperature of the flame is low, the colour is dark orange-red in contrast to the almost 'white' flame of a suet candle.

Pure resin or pitch (for example in pitch torches or pans) are not suitable for indoor lighting.

The Native Americans used birch bark torches that were rolled like cigarillos[3]. This technique was probably known in our latitudes, too. The smell of the smouldering birch bark pleasantly reminds of incense.

By the smouldering of birch bark, birch pitch was produced as from the Palaeolithic Age, a thermo-plastic, adhesive material which was one of the most important basic materials until the Upper Middle Ages. It was used as adhesive, antiseptic medicine and to cure meat. It was suitable for torches too, but not for candles[4].

Paraffin, a petroleum distillate, is not used as lamp fuel before the middle of the 19th century.

The upper heating value of this aliphatic hydrocarbon mixture is higher than the one of the best fats, but there is a danger: it is highly combustible; it burns without a wick and if the lamp fells down, it could lead to serious consequences[5].

Light efficiency

Light efficiency can be defined physically and measured experimentally. The graph above will help you to understand physical interrelationships.

You can measure the amount of energy required, for example the consumption of oil or grease in a given time, as well as the resulting upper heating value.

The radiated power can be determined by measuring the brightness with the help of a luxameter which is set up at a given distance. These measuring data can be used to calculate the light efficiency.

Table:

Calculations of light measurements taken from measured brightness, fuel consumption and time of combustion of the lamps.

- Normal oil lamp or stearin candle, ideally burning (not smoky).

  Fuel: olive oil. Heating value = 38 kJ/g. Consumption: 8 g/h. Capacity: 84 Watt.

  Measured from a distance of 1 m: 1 lux ⇒ luminous intensity 1 Candela, recovery = 0,15 lm/W.

- The same lamp, same fuel, big wick, smoky flame = 0,08-0,12 lm/W.

For comparison:

- Paraffin lamps with glass tubes = approx. 0,25 lm/W.
- Conventional electric bulb with tungsten filament = 12 lm/W.
- Halogen lamp = approx. 20 lm/W.

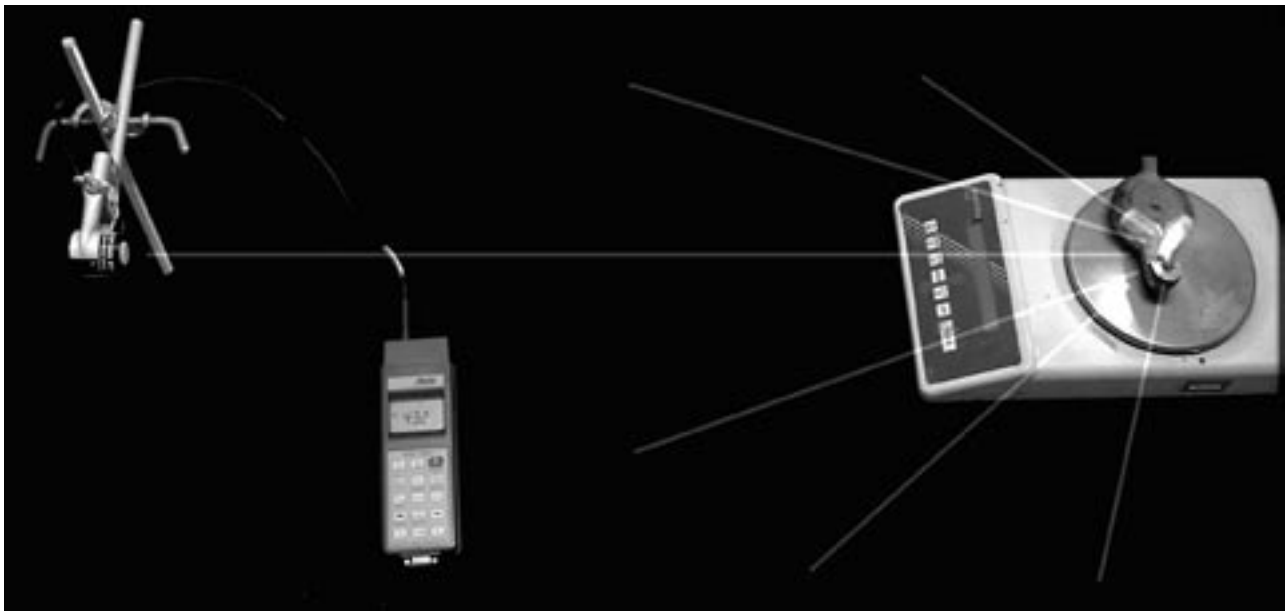
As the Planck Radiation Formula shows, the light efficiency depends on the temperature of the flame as well as on the existence of black bodies. A slight increase in the oxygen supply causes the flame temperature to rise; too much oxygen, however, makes the flame dark (see modern gas burners) because of a lack of sooty particles (Gas lanterns need an incandescent mantle for this reason.).

The theoretical foundations were laid by the works of the French chemist Lavoisier (1743-1794) and two disciples of his (Leger and Argand[6]). They are commonly regarded as the inventors of the "modern" oil and paraffin lamps with flat or circular wicks and glass tubes. (Which is probably not fully justified - see chapter "Firmalampe" below).

It is impossible to achieve a maximum light efficiency under 5000°C. This is equivalent to the temperature on the surface of the sun. Even the tungsten filament of an electric bulb is far from reaching this temperature (approx. 2500°C, coefficient approx. 12 lm/W).

A higher temperature can be reached by the tungsten filament in halogen lamps, a special mixture of gases (organic compounds with halogen) prevent the filament from evaporating at such hight temperatures.

Most animal fats with mainly unsaturated fatty acids (e.g. in suet) are ideal among natural raw materials; similarly, olive oil is suitable because of its mainly simple saturated acids. Oils with a high content of polyunsaturated fatty acids produce soot and a significantly lower light efficiency.



A simple application for measuring the light efficiency of ancient lamps.

Lamps, rivals of food

A small oil flame of approx. 2-3 cm height (which has the same luminous intensity as a candle) consumes 8 g oil per hour (cotton wick, approx. 1 cm long, 0,5 cm thick). This amounts to a "nutritive value" of about 300 kJ per hour and 7296 kJ per day – the average energy spent by an adult human doing no hard physical effort. This flame would be just enough to produce a dim light.

A "normal" flame of an ancient oil lamp has an efficiency of approx. 0,1-0,15 lm/W, as our measurements at the LfA have shown. The energy consumption, in contrast, is huge - such a simple little flame has an energy consumption of 85 Watt. A bigger flame (wick 1,5 cm long and 0,5 cm thick, height of the flame approx. 5 cm, slightly smoky) consumes 20 g of oil per hour, which is 760 kJ per hour, the energy consumption would be more than 200 Watt (compare this with the light efficiency of a 200-Watt halogen lamp !).

Lamps consuming fats are rivals of food and co-eaters at table.

The high consumption of calories/food may explain the small number of archaeological evidences of artificial lighting in Middle Germany.

Should we assume that, while the upper-class members of the Roman Cologne (which was only 400 km away from the current location of Halle/Saale) had a cheerful night life by the light of luxurious candlesticks or simple lamps, there was not much going on in the local "Barbaricum" after sunset ? What did people do during long winter nights with more than 16 hours of darkness ?

The question is: if light was really regarded as a luxury good, what did people do in the darkness ? They were probably not able to do much productive work. Could this be a possible explanation to the fact that the civilisations of the northern territories were for a long time not as advanced as the civilisations in the Mediterranean settlement areas ? Did this lack of productivity result from a lack of oil reserves and thus from a lack of lighting ?

It is unlikely that people took out fuel for lamps from their limited food supplies in the winter months.

We must assume that, in medieval times, ordinary people in Middle Germany, could only see artificial light in churches where lights and candlesticks were a symbol of splendour and divine glory.

As stated in Thesis 1 (see chapter "Form and Function"): the design of lamps depends on parameters like: purpose, functionality and economy. Most important are:

1. Self-shadowing of the lamp.
2. Shape and temperature of the flame.
3. Availability of the fuel/ food competition.
4. Constancy of the light source.

A flickering flame is useless for many purposes.

These factors not only determine whether lamps are used or not, but also the principles of their construction.

With the main focus on economy, I would like to show you four examples, three of them from Sachsen - Anhalt (Middle Germany), and one from the "High-Tech" Imperium Romanum.

Example 1 - Aspect of the own shadow: funnel cup with interior loops from Alsleben

Is it the oldest lamp known in Middle Germany ?

A very rare and special form of Middle Neolithic pottery is represented by Trichterbecher (funnel-shaped cups) with inner lugs. Most of these rare objects are clearly of pagan origin and were used in cult rituals. One of the oldest examples of this pottery was found in a sacrificial pit[7] and is dated back to 2700 BC.

A similar model was found in a gallery tomb in Calden/Hessen (Germany)[8], others could be found in Middle Bohemia, Lower Saxony and Upper Austria. The Trichterbecher from Alsleben is regarded as the oldest example of this rare form of pottery. The function of this object has not been clarified yet. Because of the inner loops it is unsuitable as a storage or drinking vessel.

A new theory may be developed here: this vessel could be a lamp. This theory would match with the idea that cult rituals took place at the bottom of this sacrificial pit. Light was indeed essential to all religions known throughout the world. To support the argumentation, let's look at the case from another point of view: What were the other possibilities to construct ?

Try to imagine: a potter in Neolithic times is asked to build a lamp that, thanks to special devices, could be hung up for a festivity or a ritual in a dark deep sacrificial pit.

In the rare cases when artificial light was needed, a normal ceramic vessel was filled with fat and wicks, jutting out over its edges, were lit. But what should the potter do to create a lamp that could be hung up ?

The light of the lamp should shine downward, which means the flame has to be on the edge of the lamp. A flame in the middle of the vessel would be useless, as it would shine upward only and the vessel would cast its own shadow downward. Nobody would want to waste expensive fat to illuminate smoky ceiling joists or the night sky.

To make sure that the flame shines out of the vessel as wide as possible, the rim has to be flat and thin. Normally loops can be found on the edges of vessels through which leather cords or laces can be threaded. But this solution had to be dropped; the wicks could shift and light the cords.

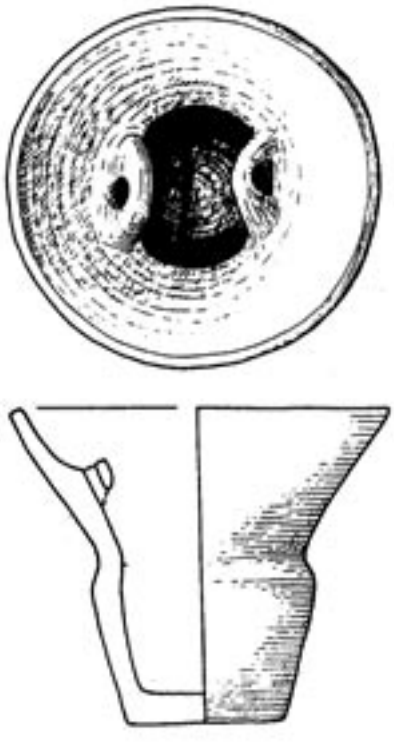
This is why the fastening, i.e. the eyelets, has to be attached in the middle of the vessel. There is still one problem. How can the lamp be balanced ?

The balance point has to be as far as possible under the rotation point of the eyelets. The solution consists in elongating downward into the shape of a funnel.

The shaft created can also be filled with pebbles or water, now the construction is stable. The result is a funnel vessel with inner loops.

With the help of a reconstructed object, it can be demonstrated how well the funnel vessel of Alsleben works.

Thus, although the "lamp thesis" has not been fully proved, it seems more plausible.



The funnel cup of Alsleben, as published in Doehle/Wagner/ Weigelt 1992.

(Burning reconstruction of the alsleben-lamp).

Reconstruction of the Trichterbecher from Alsleben, empty, view from above.

Example 2: Aspect of flame temperature and light efficency: the Firmalampe

In the chapter "Light efficiency" we have learned, that it depends on the temperature of the flame as well as on the existence of black bodies.

The theoretical foundations to increase the light efficiency of a flame lamp were laid by the works of the French chemist Lavoisier (1743-1794), who ranks among the most important founders of modern chemistry. He found out that the flame temperature can be increased by supplying more oxygen. Lavoisier's basic theory was applied by two disciples of his (Leger and Argand), who are regarded as the inventors of 'modern' oil - and paraffin lamps with a flat or cylindrical wick. They improved the oxygen supply in two different ways[9]:

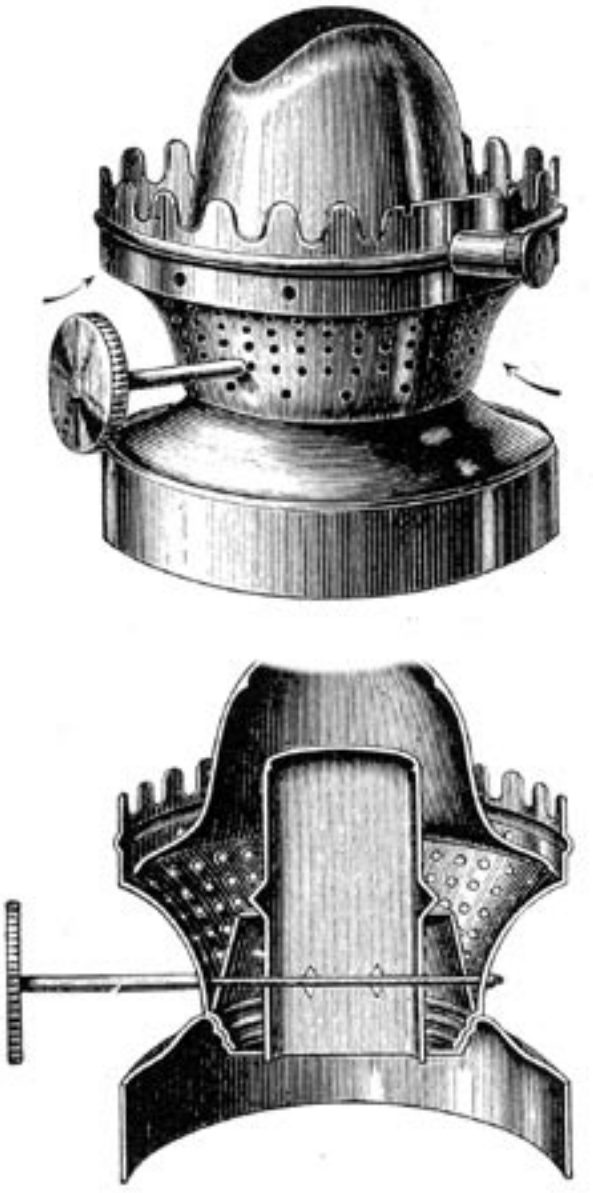
a)

The surface of the flame was increased, either by using a broad flat wick which created a laminar flame, or by using a hollow and cylindrically-shaped wick which was additionally supplied with oxygen from the inside. The invention of the broad flat wick is credited to Leger (Paris 1783). The circular wick, basically a ring-shaped and flat wick, was invented by Argand (1783).

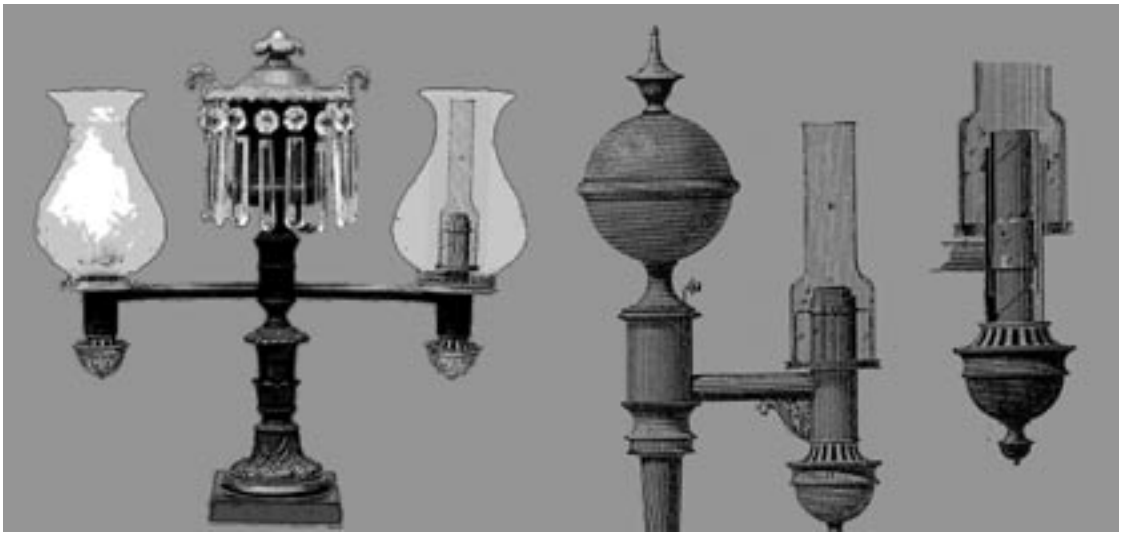
b)

Argand also invented the glass tube, as known in "typical paraffin lamps". He found out that by placing a tube or 'chimney' over the flame, the hot gases from the flame rose rapidly creating a draught and drawing air in from below, thus the flame was provided with more oxygen.

Is the laminar flame really an invention of Leger and Argand ? Probably not entirely, if we take the Roman "Firmalampen" in consideration.



Typical paraffin lamp burner for flat wick.



The construction of Argandlamp with cylindrical wick.

The Roman "Argand lamp"

A new kind of lamps comes into existence in Italy in the last quarter of the 1st century AD. Within a short period of time, this new and innovative lamp sells very well and is soon produced in potteries workshops throughout the Roman Empire[10].

In contrast to the richly decorated "Bildlampen", the new lamps are of simple and functional design. Their shape remains identical to the models created in the German "Bauhaus" workshops in the 1920's. Every detail has a function, there is no superfluous decoration.

(Exception: the "Knuppen" on the shoulders on the sides of the lamps: pierced initially, these holes were used to hang up the lamps, later they lost their practical function and became mere decoration.)

The magic slot

A new and very distinct element of function or decoration appears: the slot in the spout.

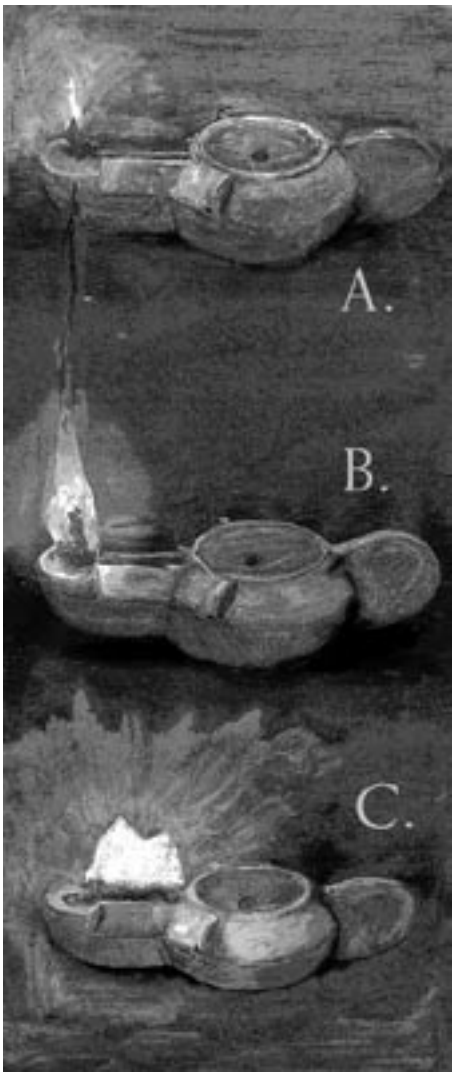
It is likely that in such an functional construction the spout slot also has a special function. It must be noted that all early Firmalampen (Loeschcke Type IX) have such a slot.

The following model (Loeschcke X) shows an opening from the slot towards the discus; otherwise, the principle remains the same.

Wagenfeld meets Firmalampe: two typical examples of functional lamp design.

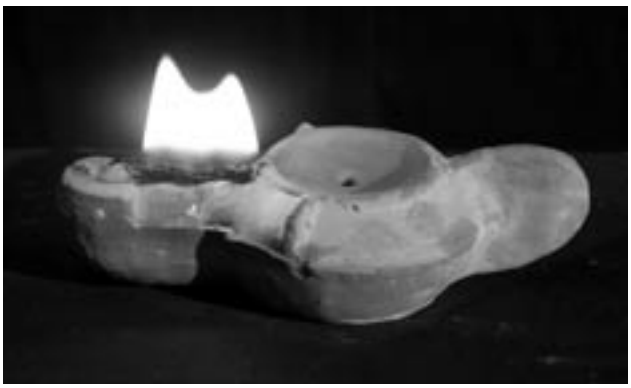
The author conducted experiments with reproductions of these lamps at the State Office for Archaeology of Sachsen - Anhalt. The experiments show that the spout in the Firmalampe is probably not a useless decoration or atavism.

Model of a typical "Firmalampe". Experiments were made with this model.



Three different ways to use Firmallampe:

A: Normal flame / B: Big, sooting flame / C: Laminar flame.



Firmalampe with laminar flame.

If a thin wick is pulled a few centimetres out of the spout and put horizontally in the slot, then a laminar flame can be obtained, just like in the "invention" of Argand and Leger.

This long laminar flame is surprisingly stable, the wick burns for several hours (i.e. as long as there is fuel in the lamp) in this horizontal position on full length.

Even the air supply for the laminar flame is optimised in the Firmalamp – thanks to ancient knowledge of aerodynamics: the sloping sides of the spout let ascending air get easily to the wick and prevent air perturbations that would occur if the wick was on a plane surface. thus the flame hardly flickers. In addition, the sloping spout walls minimize the self-shadow produced bythe lamp. The flame shines within a radius of approx. 270°.

Photometries on reproductions of Firmalampen show that the luminous efficiency with a laminar flame, approx. 0,15-0.18 lm/W, is substantially higher than with usual wicks (approx. 0,1 -0.15 lm/W on average). The Firmalamp: an ancient energy-saving lamp ?

Other arguments, put forward by different authors, still do not explain the function of the slot entirely. For instance, the slot is not able to redirect out-sweated oil back into the oil container as supposed by some of the authors. If the wick sweats out oil, how could the oil find its way into the slot ? Besides, in many lamps, there is no connection between the slot and the fuel container.

On the other hand, what would speak against the laminar flame theory ? It could be argued that among the archaeological finds no traces of soot could be found along the channel. Anyway, those traces on lamps are very rare. They, as well as the remains of the lamp oil, were probably decomposed biologically during their storage in the soil. Most of the Roman lamps completely lack those traces of use - but assuming that nearly none of all the Roman lamps found never burned is probably wrong.

As it is often the case with „experimental archaeology", the results of modern experiments do not really give out proofs, but can help to support the theory.

Example 3: Increase of light efficiency by reduction of self-shadowing with translucentlamp bodies

Hanging lamps and ampullae

In the 2nd century AD, a new type of lamps comes into existence thanks to the more advanced production of glass: a hanging glass bowl with a swimming wick. The concept of the glass bowl lamps is amazingly simple: a glass bowl filled with vegetable oil is fastened to the ceiling by three chains.

A floating wick is put onto the surface of the oil which is sometimes mixed with a watery coolant/refrigerant. Little cork slices can carry a normal wick which sticks out of the surface of the oil for about 1 cm. Little skewers used as spacers are attached to the cork.

They keep the wick away from the glass and thus prevent the bowl from getting too hot and from bursting.

This technique can still be found this technique in Greek orthodox churches: the dried achenis of a plant of the family of the labiatae (Ballota Acetabulosa) are used as floating wicks. Greek people call this plant *'fitilia'* (*'to fitili'* = wick, plural: *'ta fitilia'*).

The advantage of these glass lamps is obvious: it is not necessary to refill with oil all the time, because the wick rises and falls with the level of the fluid. The light efficiency is higher, because the light underneath the lamp can also be used.

The glass bowl lamps were often decorated artfully, especially the bowl itself. It is assumed that the so-called 'diatret glasses' were originally used as lamp bowls, the suspensions with three lugs would support this theory[11] (STECKNER 1999).

This argumentation is further supported by the fact that these vessels (not only the diatret glasses) cannot stand upright without other devices.

The pictures below show a replica of an ornamented Roman glass vessel, found in the prince's tomb in Gommern[12], in its supposedly original function as a lamp bowl. (3rd century AD). The vessel probably originates from the Rhine area. An object of this kind is not suitable as a drinking vessel: it does not stand firmly and is too big and bulky.

The decorative effect of the lamp is absolutely phantastic. The light is diffused through the artfully-cut glass. Coloured fluids (thinned red wine) were often used as coolants. The light of the flame is filtered through the fluid and magic colour effects are created.

Hanging glass bowl lamps were often used in early Christian and Byzantine churches.

Their design changed in Middle and Late Byzantine times: the glass ampulla was coated with an embossed and vase-shaped vessel, displaying a fine filigree design. Starting from that, the shape of hanging lamps, still found in Greek orthodox churches and islamic mosques, was developed.

However, the silver vase often just has a decorative function. Only in the upper part of the vase, there is a bowl-shaped insert of coloured glass, in which a floating wick burns, diffusing a dim, mystically-coloured light which shines through the decorative holes.

It is probable that many of the Sturzbecher of late ancient times and from Lower Franconia were not used as drinking vessels, but rather as lamp bowls for hanging lamps.

In this context, it might be interesting to think about the etymology of the word 'ampulla' or 'lamp'. The word 'amphora' was modified into 'ampulla' in Late Latin, meaning a little flask (still used today). The glass ampulla could be seen as the ancestor of the lamp (inversion of consonants). In German, 'Ampel' is the word for 'hanging lamps', inter alia still used in liturgical areas. It also means 'traffic light'.

A simple glass bowl hangs from three chains which end in a knot attached to a hook. The hook hangs from a rope which is held by a pulley mounted to the ceiling (An early version of a desk lamp ?).

A diatret glass lamp of Late Antiquity (ca 300 AD) with original suspension (ring of bronze, loops, three chains) Corning, the Corning Museum of Glas, inv. Nr. 87.1.1. (see: STECKNER 1999, p. 114, fig. 283).

Evangelist Luke, illumination, 10th century AD, British Museum.

Reconstruction of the Gommern glass ampulla in its supposed function as a lamp bowl.

Example 4: Aspect of availability: a Renaissance lamp from Schwerzau and the oil fields in Sachsen – Anhalt ?

In the 16th century, light comes into the dark cottages of peasants – almost abruptly.

A literally enlightening evidence for this fact is the lighter from the village of Schwerzau.

The lamp was found in a settlement pit, where it was left in the 17th century.

The village of Schwerzau had to give way to brown coal mining, but before that, it was completely examined from an archeological point of view and the post-medieval domestic culture could be re-created. The finds clearly show that oil lamps were to be found in all households – as well as everywhere else in Middle Germany, considering the amount of finds in the LfA collection.

The lamp is definitely made for the burning of fluid fats (oil). Alternatively, a candle (made of suet or with very expensive bee wax) could stick in the holder above the handle.

The reconstruction of the Schwerzau lamp proves that, although oil was easily available, nothing was wasted. The oil which, dripping from could escape out of the mouth hole while the flame was burning, ran down the stem of the lamp and was collected in a ring-shaped brim.

From there, it ran through two holes into the hollow bottom, where it could be gathered through the spout which was attached to its side.

Their frequency and sudden distribution since the late 16th/ early 17th century could be explained by the presence and spread of rape and turnip-rape. The use of these very profitable oil plants which began in the Netherlands finally provided people with a sufficient supply of lamp oil.

The oil of rape and turnip-rape could not be used as food, as it contained large amounts of an indigestible and dangerous fatty acid, called eruca acid.

If rape fields made it possible to light post-medieval times once, today they provide organic diesel, thus bringing hope to our search for tomorrow's new sources of energy.

Open questions at the end

Were there really no lamps in prehistoric central Europe or are they just difficult to identify nowadays ?

Were the ancient Mediterranean civilisations (blessed, in a way, in view of the smallest difference between the duration of night and day) superior to the northern European civilisations thanks to artificial lighting ?

One of the schwerzau-lamps.

Reconstruction of Schwerzau lamp, working in its double function as candlestick and oil lamp.

Acknowledgements

Special thanks to my wife, for her understanding when her husband was sullying the living room with oil and grease spots and blackening the ceiling with soot, following his playful instinct, which he finally justified with some scientific pretence.

I would also like to thank all my colleagues, coworkers and superiors, who by now have developed allergic reactions when they hear the word lamp, and Mrs. Anke Tippelt for the translation of the manuscript.

Notes

1 Goethert 1997, p. 23-24.

2 Plinius mentioned also the use of bitumen, but this was surely an exception (Plinius, Liber XXXI, caput XL).

3 Trilux 1987, p. 206.

4 Wunderlich 1999, p. 218-219.

5 For none of the lamps described here, paraffin or one of the 'lamp oils' or 'scented lamp oils'(scented paraffin), sold in drugstores nowadays, are used as fuels.

6 Trilux-Lenze 1987, p. 218-219.

7 Doehle/Wagner/Weigelt 1992.

8 Retzel-Fabian, D. 1999/2001.

9 Trilux-Lenze 1987, p. 218-219.

10 Werner 1997, p.108.

11 Steckner 1999.

12 Becker 1998.

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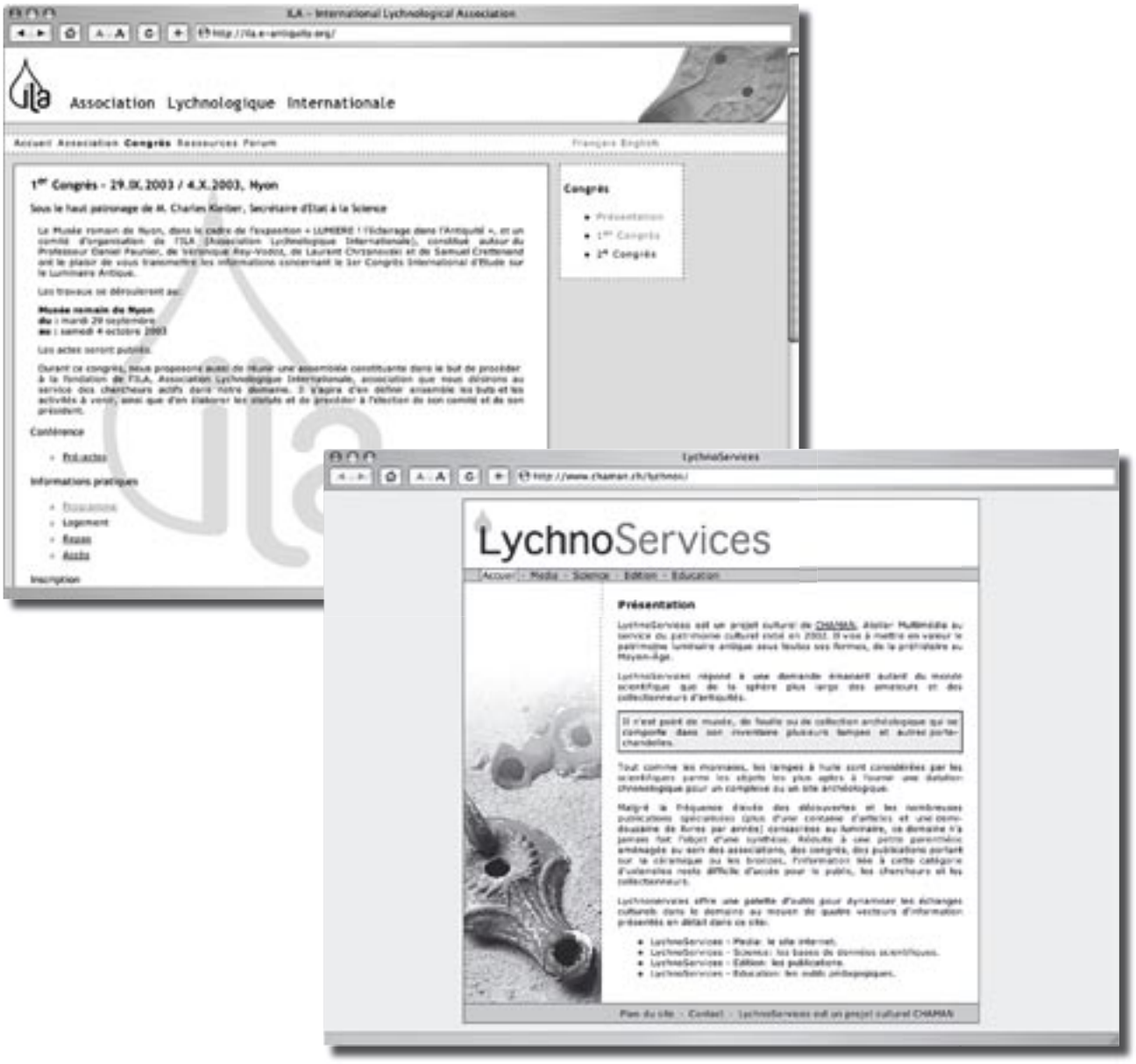

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