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Comments on the development of pyrotechnology in early societies

The beginnings of fire-making are understandably obscure. It is not an aspect of early prehistory that has received abundant attention, though a recent book by Catherine Perlès (1977) does pull together the existing references and offers a cogent outline to the use of fire in the Palaeolithic. As the use of fire – pyrotechnology – is one of the underlying determinants of the formation of Neolithic society, it is essential that we understand the transformations it underwent since its use in early cultures.

Lower and Middle Palaeolithic

It is generally accepted by most scholars that since the Mindel glaciation in Europe early man was able to make fire.[1] Not only did he make it, but he made use of hearths to render it more efficient. By the Riss glaciation numerous examples of hearths existed in France,[2] which show such refinements as paved bottoms and draught channels (Bordes, 1972 : 60-62). Fire had by then become mastered by many early groups, and at least for Europe, the existence of hearths at campsites was on its way to becoming the rule, rather than the exception. In the contexts of the Lower and Middle Pleistocene, Northeast Africa has not yet yielded any traces – direct or indirect – of hearths or fire, but this could be due to archeaological chance.

[1] Hearths have been recorded at the following sites: 1. La Grotte d'Escale (Bouches du Rhône) France, excavated by de Lumley in 1960 and dated to Mindel I; 2. Vertesszölös, Hungary, dated to Mindel I but more recent than the above; 3. Fossilized dune near Nice where hearth stones were recovered and dated to Mindel III; 4. Torralba, Spain, dated to Final Mindel; 5. At Locus 13 Choukoutien, China, and dated to Final Mindel. The above are according to Perlès, 1977 : 14 - 17.

[2] For example at: 1. Observatoire (Monaco); 2. Peche de l'Asé II (Dordogne); 3. Cagney-la--Garenne (Somme); 4. La Grotte de Rigabe (Bouches du Rhône); 5. Orgnac 4 (Ardèche); 6. Cotte-Sainte Brelade, level H (Jersey). The above are according to Perlès, 1977 : 20 - 21.

Discovery and use of fire

How could fire-making have originated? Early man had no doubt seen natural fires brought about by the eruption of volcanoes or fires caused by lightening. He may also have seen fires as a result of spontaneous combustion of peat, gas or bituminous substances. But all these natural sources, if indeed they were used, could not have been very regular. Moreover, we must take into account the low population density, which reduced the chances of man being at places where natural fires broke out.

For most archaeologists there is a link between fire and chipped stone. It is more or less accepted that a spark produced by striking flint against flint was one of the first fire-making methods. Hence, once a chipped flint industry had become established, fire-making was a possibility. It may have been realized soon afterwards that using flint against a ferruginous stone, such as pyrite, a hotter spark could be obtained, thus constituting a superior fire-making method. On the other hand, it has been established that one cannot produce a spark by striking quartz (Perlès, 1977 : 33). A Middle Palaeolithic piece of carbonized wood has given evidence of having been rotated, thereby suggesting that it was used as a turning stick to produce fire by friction (*Ibid*: 36). Other methods – also using wood – have been suggested, but right now they are only speculative.

The technique of fire-making requires the use of proper combustible material. In most cases, easy-burning materials have been identified, such as dried shrubs, driftwood, roots and bark. In some rare cases bone was also used (*Ibid*: 42). There are instances where hard woods were preferred, even though easy-burning soft woods were available. This suggests that a certain selectivity was practised by some fire-using groups, and their preference for hard woods may be related to the type of fire they required.[3]

What were the uses of fire prior to the Upper Palaeolithic? We do not know for certain all of the applications, but using indirect evidence, we can suppose a few. The preparation of food comes quickly to mind. Food, generally speaking, is easier to eat and digest when cooked, and some food, namely cereals and certain roots, can be eaten only when cooked. Moreover, by cooking food one spends less time eating, particularly meat, thereby affording more time for other activities.

Heating must have been a common use of fire, and there is no reason to doubt that this was one of its first applications. Heating a cave permitted man to modify his immediate environment and struggle successfully against the cold. Although not proven, one may wish to see a relationship between the colonization of Europe and the use of fire (Perlès, 1977 : 58).

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[3] In this paragraph, the use of these materials applies to all of the Palaeolithic, the Upper Palaeolithic included. No comprehensive, chronological treatment is yet available on combustibles.

Fire was also used for light. Lamps date only from the Upper Palaeolithic, but simple campfires could have been used for lighting from the Lower Palaeolithic onwards when the first hearths are known. Light offered the possibility of increasing daily activites, if not to say productivity. The greatest benefit of this may have been a hastening of artifact development.

Fires were used in craftmaking in the Lower Palaeolithic. As early as *Sinantropus*, fire was being used to burn off projecting bulges on antlers, and bones were severed by burning and cutting. Reindeer antlers were heated and straightened in the Upper Palaeolithic, but there is reason to believe that this technique was also applied to wooden sticks in earlier periods. In the Riss-Würm interglacial stone points were heated for easier flaking (Perlès, 1977 : 112-115). The technique required that the flint be burried in hot sand for 24-72 hours, the limit being established according to the type of flint. The heat (above 200°C) caused dehydration of the stone, and it then became possible to pressure flake objects into shapes that would have been impossible with untreated flint (Bordes, 1967 : 45). This is a technique which is complex in the sense that the flint must be maintained at a constant temperature during the heating period. Apart from cooking, this is the first evidence that we have (prior to the Middle Palaeolithic) of temperature control over a particular length of time.

Fire-making did not replace another task, and someone had to tend to it. There was more involved than just igniting a fire. Fuel had to be collected and the fire had to be maintained. These jobs fell to certain members of a group, perhaps to children who otherwise would have remained unoccupied. So, while fire-making became an additional burden, it probably did not provoke any profound changes in social structure.

It is only with the advent of the Late Acheulean phase in the Upper Pleistocene that our attention can be directed to Africa. One of the first African examples of the use of fire comes from Kalambo Falls in Zambia and dates to ca. 60,300 B.P./61,700 B.P. Fragments of charred wood were uncovered which had friction grooves in them. These artifacts were interpreted as fire-making utensils. In addition, fire was employed to shape and harden wooden digging sticks and other implements, and at least one hearth was identified (Coles and Higgs, 1975 : 107).

Fires have been mentioned in the context of the Cave of the Hearths at Makapansgat, South Africa (Clark, 1959 : 105, 129; Perlès, 1977 : 21). There, hearths with as much as 4 feet of ash were observed in relation to Final Acheulean handaxes and cleavers.

Taken as a whole, the Lower and Middle Palaeolithic cultures of Europe, Africa and Asia established a wide variety of pyrotechniques, albeit dispersed. Nevertheless, they constituted a valuable legacy for the following period, the Upper Palaeolithic, and the arrival of modern man. It is odd that in the Upper Palaeolithic *Homo sapiens* did not innovate as much in this domain as his intellectually inferior predecessors.

Upper Palaeolithic

At the Upper Paleolithic site at Ballana (Site No. 8950 between localities B and C) hearthstones and fire-cracked stones were found dated between 16,000-14,500 B.C. (Wendorf, 1968, II : 859). In the same area, at Locality C, charcoal and more hearthstones were observed and dated to 12,550 B.C. (*Ibid*: 861). In the area south of Halfa (Site No. 443) hearth and earth ovens were located (*Ibid*, I : 399). Fire-cracked stones and burned clay lumps were also found in this context (*Ibid*: 433-434). Charcoal from earth ovens was dated to 14,500 B.C. Lithic tools were found in these fire-using contexts. Even a few burnt cores turned up, suggesting that the preheating of flint before flaking (and even stone splitting by fire) may have been practiced there.

Lamps and torches make their appearance in the Upper Palaeolithic at numerous sites in Europe (Perlès, 1977 : 62-69), which points to increased activity in the caves. No doubt portable light was directly responsible for cave art so characteristic of this period (Laming, 1959 : 98-103). In this respect Africa, again, seems to have lagged.

To sum up the Palaeolithic as a whole, we can say that the use of fire was wide--spread. It had afforded a longer work day, and it became a means of artifact manufacture. It allowed groups of early man to survive in cold climate, and it affected their diets through cooking. The side effects of fire could even have been more profound. As a point of reunion the hearth or campfire could have favored the elaboration of a structured language and thereby facilitated the exchange of ideas, the development of oral traditions and the use of fire as ritual. It has been suggested that fire is the second greatest technical achievement after chipped stone, and it constitutes an absolute criterion for the difference between early man and the animal world.

The Neolithic

It is in the Neolithic that great strides were made; the most significant are considered to be the development of pottery and metallurgy. With this period another set of inquiries comes to the fore, and we must now observe the relationships between the different applications of pyrotechnology. For reasons of brevity and to comply with the geographic limits of this symposium we will limit out discussion to the Nile Valley as a principal contributor to pyrotechnology. This does not mean that we should discount influences from other people outside this area, for technological changes surely took place, but the Nile Valley cultures provide us with a wide spectrum of technologies that is useful as a basis for further inquiry.

The Fayum A unit – the oldest Neolithic culture known in Egypt – is thought to have had its origins in the Delta, or at least in the North of Egypt (Hoffman, 1979 : 189-190). This view is consistent with the North-South orientation of Egypt in later predynastic times, but as Hoffman (*Ibid*) has suggested, we cannot isolate the possibility of a multiferous origin. The mixed economy of the Neolithic people (hunting, fishing, stock raising and agriculture) and the fact that they carried on long distance trade may be indications of this.

The pottery from this period is generally poor in quality and was fired most likely in open hearths. Kilns would come much later. No analyses have been done on firing temperature or clay composition, but it is not difficult to imagine that pottery was not the most important craft of the Fayumis, and it was produced as simply as possible. Vessels for holding liquids are the predominant form, just what one would expect in a warm climate. Though rudimentary, the pottery of Fayum A may not necessarily have been the oldest in Egypt as it could have been the result of an earlier pottery-making tradition.

The passage from a non-ceramic society to a ceramic society is definitely an important one, but we may not wish to see it as dynamic as some authors would have it. There is no reason to relegate the development of pottery-making to Neolithic cultures *a priori*. The special conditions for the availability of pottery clays in Egypt may have been exploited by Late Palaeolithic cultures. A pre-Neolithic ceramic could have been one of the threads which linked Upper Palaeolithic to Neolithic *per se*. There could have been a slow, but deliberate, development of pottery-making along the banks of the Nile by nomadic groups who utilized the clayey silts to fashion crude pots and bake them in campfires. Utlimately, this pottery became one of the elements of a hybrid Neolithic society. While this is speculative, the present archaeological record can tolerate it. Moreover, it would seem odd that after 50,000 years since the first use of hearths in Africa ancient man had not observed the virtues of baked clay for vessels.

The flint napping remains found in the contexts of hearths at Fayum A may suggest that pre-heating of flint was a common practice and another legacy inherited from the Palaeolithic. Unfortunately, dehydration studies have not been carried out on the lithic assemblage, which might have clarified this point.

The site of Merimde offers the improvement of harder-fired pottery. This suggests that the Merimdens used pottery kilns, as opposed to simple hearths, to reach a higher temperature[4]. They were more attentive to the decoration of pottery, and it would stand to reason that a hotter firing temperature would be developed in consequence, even though the fabric did not surpass that of Fayum A. Hearths for parching grain were found at the site, but, on the archeaological record, this is not a new application of fire. There is now recent evidence for the parching of grain at the Upper Palaeolithic site of Wadi Kubbaniya (Wendorf and Schild, 1981).

The Badarian sequence offers an innovation in pottery-making: the use of reduction for a black-topped effect. The explanation of this technique has not been totally agreed upon by scientists (see Lucas, 1962 : 372-376 : 377-381; cf. Eisa *et al*, 1973;

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[4] It must be recalled that no kilns have been found dated prior to the Old Kingdom.

Reisner, 1966), but it is nevertheless clear that the Badarians were toying around with reducing fires. They had grasped the notion that a different type of fire would produce a different color on pottery. This is important in the sense that they may have understood the difference between reducing and oxidizing kilns.

With the Badarians we normally associate the introduction of a rudimentary metallurgy. The Badarians were probably using native copper, as there was sufficient supply to meet the small demand. The smelting of copper ore would come in a later phase. Few though they are, the copper artifacts from El Badari attest to the understanding of the annealing process, that is, softening of copper by heating after it has become hard by hammering. This would be an important technique later, particularly when chisels and axes were manufactured. But now the Badarians were interested only in making copper beads, stripes, tubes and pins.

There is no evidence for melting at this time, which means that the size of the metal artifact was governed by the size of the piece of native copper found. Copper melts at 1,083°C, and an ordinary campfire cannot reach this temperature. However, the Badarians were apparently able to reach a temperature well above this, as seen in their manufacture of glazed beads (infra). Why they did not melt copper bits together in order to produce larger artifacts may be explained by their conservative attitude towards new materials an attitude which seems to be inherent thorughout the history of ancient Egypt (Harris, 1971: 83-91).

The use of copper did not significantly improve the quality of Neolithic life, even though metal has certain advantages over other materials. Traditional materials such as bone and flint were sufficiently abundant to compensate for their lack of durability. The fact that the first copper artifacts were decorative items is a clear indication that Neolithic man had found no practical applications for metal. Again, the innate conservatism of the Egyptian Neolithic had undoubtedly a dampening effect on the adoption of new ways.

Glazed steatite is likewise found in Badarian contexts and provides us with another example of pyrotechnology in the Neolithic. Steatite is a soft form of massive talc. It can be easily carved with a knife, but when it is heated in a hot fire, it dehydrates and becomes hard. Its early use was as a base for Badarian (and later) glazes. Glazes are crystalline in Badarian times but vitreous in the Predynastic period. Beck (1934: 75) identified the crystals in the Badarian examples as mullite, which indicates that the beads were baked at around 1,300°C, the temperature at which mullite crystals form. Chemically speaking the glazes are either a sodium-calcium silicate or a potassium calcium silicate, but Beck was not sure how the mullite crystals formed. The surface of the glazed Badarian beads are hard enough, like the core, to scratch glass, but what is odd, the later Predynastic glazes are generally softer. Even though Predynastic glazes were formed at a higher temperature, from the point of view of hardness they are inferior to the Badarian examples. Nevertheless, this new application of heat to form glaze may have given Neolithic man the notion that hard or earthy materials could be melted. Although the Badarian glazes did not melt at any stage of their formation, it was clear to the glaze-maker that a fusion had taken place. This realization may have eventually urged him to attempt fusing other hard substances such as native copper, but this would not happen until the succeeding phase of cultural development, *i.e.* in the Amratian period.

Copper was not employed for more than simple trinkets in the Amratian period, and there is no evidence for the use of copper tools, apart from some non-descript borers. Hence, from the point of view of metalwork, the Amratian is a continuation of the Badarian. There is something new, however, in the realm of precious metal. At El Mahasna were found gold and silver beads. This is the earliest occurrence of gold and silver, and while gold can be thought as having come from the Eastern Desert and being native in origin, the presence of silver poses some problems.

Silver can occur native, but it is rare[5]. Silver metal had already occurred by Amratian times in Anatolia[6], but we know very little about silver-working this early. Could it be that cupellation of silver had already been developed in Anatolia by the Late Chalcolithic (ca. 4,800 B.C.)? Or was silver somehow a by-product of some other pyrotechnique such as copper smelting? Whatever the case, the Amratian bead was no doubt a traded item from abroad. As it was probably melted at some point in its manufacture, we can say that the silver metalworker – Egyptian or foreign – had realized a temperature of 1,000°C, the melting point of silver metal. If the gold bead had also been melted we can say that the goldworker – probably Egyptian – had realized a temperature of 1,060°C, the melting temperature of gold and, incidentally, the maximum temperature possible in a campfire without draught air. Hence, somewhere in the ancient world metalworkers had learned to fuse metal.

By the Amratian period metalworkers had become a standard element in the make-up of Neolithic societies, and not a specialized and separate group. At El Badari were found amorphic copper fragments[7] and while only tentative, these bits have been interpreted as the remains of copper working at the settlement itself.

In the Gerzean period the intensification of metal production called into use the various techniques known in the previous periods, such as melting, annealing and hardening by cold hammering. In addition, the Gerzeans – or their contemporaries somewhere in Egypt – appear to have innovated considerably by introducing copper smelting and casting into moduls. An impressive adze from Matmar (Brunton, 1948: 21, 23) is the largest cast artifact to occur this early[8]. Its analysis reveals not only that it was smelted but that it is characteristically high in nickel content. At one time it was believed that high nickel in copper was indicative of foreign copper, but now

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[5] Ransom-Williams (1924 : 28) suggests that all early Egyptian silver is native.

[6] In Late Chalcolithic contexts at Beycesultan XXXIV (de Jesus, 1980 : 76).

[7] At Spur 3 in Area 3000 and in Area 3200 (Brunton and Caton-Thompson, 1928 : 45, 46, pls. XVIII (4) (5)). Also in Area 3200 a copper pin was found.

[8] A similar axe, but smaller, was found at Maadi of approximately the same date, M. Amer, Bull. Fac. Arts Cairo Vol. II, Pt. p. 177. It is illustrated in Excavations of the University of Cairo at Maadi 1930 - 1935 (in Arabic) fig. 16a.

we cannot isolate the possibility of its having come from the copper deposit at Abu Swayel in the Eastern Desert where nickel is a prominent constituent in the ore-body[9].

Increased production of copper means that more individuals were involved, thereby increasing the chance for innovation and diversification. The range of metalwork in the Gerzean period increased, for it now included tools and weapons such as harpoons, fish hooks, axes, gouges, adzes and knives. It is not unlikely that small copper vessels were also produced during this period. The quantity of copper suggests that smelting had become a regular part of the metalworker's activities, for native copper would not exist in these amounts.

It has been reported that the hard-fired pottery from this period was baked at ca. 1,200°C (Krzyżaniak, 1977: 165), and this would seem consistent with the high temperatures used in the production of copper metal. Copper ore smelts at about 800°C under ideal conditions, but ancient smelters probably operated at temperatures well above 1,000°C (de Jesus 1980: 34). We can conclude from this that high-temperature kilns for smelting and melting were becoming commonplace.

The abundance of silver artifacts found in Gerzean contexts[10] attests to foreign trade but it is conceivable that the items themselves were manufactured on Egyptian soil. The sudden appearance of silver in substantial quantity suggests that production was being carried out on a regular basis somewhere in the Neolithic world. While Anatolia seems to be the most obvious source of silver, as in the Badarian period, one cannot eliminate Western Saudi Arabia as a potential candidate, as argentiferous galena deposits are known there (Roberts *et al.*, 1977).

Wood was used as fuel in the Neolithic just as it was in the Palaeolithic. In the Fayum at Kom W, it was discovered that wood was used as cooking fuel which points to a certain abundance of this material (Caton-Thompson and Gardner 1934, I: 25; II: pl. XIII [81), probably tamarisk. Dung fuel was used in the Badarian period; remains of dung storage were discovered at Hemamieh (Brunton and Caton-Thompson, 1928: 73, 83, 95, 106). Lucas (1962: 456) points out that charcoal was known n Badarian times, but one may wish to suspect that it had been used as early as the Pialaeolithic with the advent of hearths.

Conclusion

From its humble beginnings in the Lower Palaeolithic to the Neolithic pyrotechnology followed primarily a single course. There were, to be sure, offshoot uses such as lighting and heating, but the most consequential applications were directed to-

[9] A report of this deposit and its possible role in antiquity is in preparation.

[10] Some of these are the followings: 1. A silver dagger from Hamra Dom (Quibell, 1905, pl. 58 (14514). 2. A silver knife from Hamra Dom (*Ibid*: pl. 58 (14515). 3. Silver and gold foil from Hamra Dom (*Ibid*: no. 14516). 4. A silver adze from Ballas (Petrie and Quibell, 1895: pl. LXV (6)). 5. A silver figurine from Naqada (*Ibid*: pl. LX (14). 6. A silver dagger from El Amra (Baumgartel, 1960: pl. II(1).

wards the transformation of materials by an efficient use of fire. A rough chronological list of these applications would look something like the following:

Lower-Middle-Upper Palaeolithic	Maximum operative temperature
1. heating	1060°C
2. cooking	200 - 600°C
3. light	1060°C
4. heating flint, cracking stone	200°C
5. heat-hardening of wooden points	600°C
6. grain parching	600°C
Fayum A	
7. pottery kilns	1060°C
Badarian	
8. reducing fires	1060°C
9. annealing of native copper	1060°C
10. glazed steatite	1300°C
Amratian	
11. silver melting	1000°C
12. gold melting	1060°C
Gerzean	
13. hard-fired pottery	1200°C
14. melting of copper	1083°C
15. copper smelting and reducing kilns	1100 - 1300°C

While the temperature of a campfire does not appear significantly less than that of a pottery kiln, the control of the fires is vastly different. Hence, it is in the control and manipulation of fire where the story of early pyrotechnology is told.

References

Baumgartel, E. J. 1955/1960. *The Cultures of Prehistoric Egypt*. 2 Vols. Oxford.

Beck, H. C. 1934. Notes on Glazed Stones. *Ancient Egypt*: 69 - 83.

Bordes, F. 1967. Considérations sur la typologie et les techniques dans le Paléolithique. *Quartär* 18 : 25 - 55.

— 1972. *A Tale of two Caves*. London.

Brunton, G. 1937. *Mostagedda and the Tasian Culture*. London.

— 1948. *Matmar*. London.

Brunton, G. and G. Caton-Thompson. 1928. *The Badarian Civilization*. London.

Caton-Thompson. G. and E. W. Gardner. 1934. *The Desert Fayum*. 2 Vols. London.

Clark, J. D. 1959. *The Prehistory of Southern Africa*. Harmondsworth.

Coles, J. M. and E. S. Higgs. 1975. *The Archeology of Early Man*. Harmondsworth.

de Jesus, P. S. 1980. *The Development of Prehistoric Mining and Metallurgy in Anatolia*. British Archaeological Reports, Oxford.

Eissa, N. A., H. A. Salam, A. A. Saleh, F. M. Taiel and L. Kesthelyi. 1973. Mössbauer Effect Study of Ancient Pottery and the Origin of Color in Black Ware. In: A. Bishay (ed.), *Recent Advances in Science and Technology of Materials*: 85 : 98. London.

Harris, J. R. 1971. Technology and Materials. In: J. R. Harris (ed.), *The Legacy of Egypt*: 83 - 111. Oxford.

Hayes, W. C. 1965. *The Most Ancient Egypt*. Chicago.

Hoffman, M. 1979. *Egypt before the Pharaohs*. New York.

Krzyżaniak, L. 1977. *Early Farming Cultures on the Lower Nile*. Warsaw.

Laming, A. 1959. *Lascaux*. Harmondsworth.

Lucas, A. 1962. *Ancient Egyptian Materials and Industries*. (Revised by J. R. Harris). London.

Perlès, C. 1977. *Préhistoire du Feu*. Paris.

Petrie, W. M. F. and J. E. Quibell. 1895. *Naqada and Ballas*. London.

Quibell, J. E. 1905. *Archaic Objects. Catalogue Générale*. Cairo.

Ransom-Williams, C. 1924. *Gold and Silver Jewelry and Related Objects*. New York.

Reisner, G. A. 1966. Black-Topped Pottery. *Journal of the American Research Center in Egypt* 5 : 7 - 10.

Roberts, J. R., W. R. F. Greenwood, R. G. Worl, F. C. W. Dodge and T. H. Kiilsgaard. 1977. *Mineral Deposits in Western Saudi Arabia*. Saudi Arabian Project Report 201. U. S. Geological Survey. Revised. Jiddah (1975).

Wendorf, F. 1966. *The Prehistory of Nubia*. 2 Vols. Dallas.

Wendorf, F. and R. Schild. 1981. The Earliest Food Producers. *Archeaology* 34 (5) : 30 - 36.