This article was originally published in the Roland Silva Felicitation Volume: Thantilage, A "Protohistoric copper metallurgy in Sri Lanka : An Overview" in Roland Silva Felicitation Volume, Chutiwongs N, Siva. N (eds), PGIAR Publication, 2008

Protohistoric copper metallurgy in Sri Lanka: an overview

Arjuna Thantilage

Introduction

Although Sri Lanka has no significant 'Bronze Age' culture, it would appear that copper metallurgy had played some role in the beginnings of settled and literate or proto-literate civilization in the island. In this chapter we make an attempt to contribute to the reconstruction of the beginnings of metallurgy in Sri Lanka in what would be a completely new interpretation in this matter.

From a global viewpoint, we see that copper is a magnificent metal that came to be known at the very beginnings of the human knowledge and use of metals. This was probably due to the inherent properties associated with 'copper'. Unlike most other metals copper exists as a pure metal in nature (i.e.native copper) owing to its low chemical reactivity. If we consider the availability of native metals to ancient pre-metallic (especially. mesolithic) cultures, the quantities and prevalence of native copper is much greater than is the case with the other major metals found in their native state, such as silver, gold and meteoritic iron. Further, because native copper is often associated with colourful copper oxides, which must surely have won the attention of humans in early periods, this attraction may well have been a significant factor in precipitating the invention of copper smelting technology and use of this wonderful and magnificent new material, which also possessed properties not found in the varieties of stone widely used in the making of tools and weapons. Properties such as colour, malleability, the capability of being bent and shaped, reusability and also the most important factor, availability, made copper easily the earliest metal to be used extensively by human societies.

The Beginnings of Metallurgy in the World

The development of metal usage and the introduction and use of particular metals and alloys were quite varied both in location and time. Much depended on the availability of raw materials and the development of social capabilities (Charles 1985: 21). Generally, the development of metallurgy in the world can be divided in to four ideal stages (Forbes 1969: 87):

1. The use of metals as varieties of stone

2. The selective use and manipulation of native metals (hammering, cutting etc. of copper, gold, silver and meteoric iron)

3. The smelting of copper ores and the formation of copper alloys along with other components such as lead, tin, bronze, and brass.

4. The discovery, smelting and use of iron

It is very clear that the use of native metals as a medium for tools (like stone, bone, etc.) had begun long before the beginnings of metal technology and that metal technology actually started in the second and third stages mentioned above where people tried to manipulate metals according to their requirements and also to extract the metals from metal-bearing minerals. Further they discovered most probably accidentally and subsequently experimented with trying to increase the quality of native and extracted pure metals by combining two or more metals (i.e. an alloy). Only at the final stage of the story of ancient metals do we have the discovery of the metal 'iron'.

The beginnings of iron technology usually lies in a previous pyrotechnological background of copper smelting and the capability of reaching temperatures as high as 1200^0C or more (Wertime 1980:15). It is extremely significant that it took more than six millennia after the first knowledge and use of metals before human society comes to the stage of the intentional smelting of iron and an 'Iron Age' This fact alone indicates the technological difficulties that lay behind the discovery of iron and iron smelting.

If we consider the nature of the world's first metal artefacts from different cultures, they share many common attributes. They were small, mostly of copper, and have universal shapes and functions (pins, wires, arrow heads, beads etc.), which could be obtained mostly by hammering a small piece of metal into a desired shape. The small size of the artefacts is essentially due to the difficulty of achieving big metal masses by the available production methods, involving either the use of small native metal pieces or primitive extraction methods where the extracted metals were in the form of small pills or nodules inside residual slag (Tylecote and Merkel 1985:4-8; also, Rothenberg and Freijeiro 1980:52; Tylecote 1980: 184).

On the other hand, extraction by the crucible method instead of by the use of a furnace could also produce only a very small amount of metal. We can safely assume, in general, that the diminutive size of the earliest metal artefacts anywhere in the world was due to the use of primitive technologies in extracting the basic raw metals of which these artefacts were made.

Looking at the relationship between copper and iron in a world context, we see that iron objects were made and used before the Iron Age in the Bronze Age civilization of Mesopotamia and Anatolia, but the numbers involved were quite small, they had very little iron mass, nearly all of them had ritualistic or ornamental rather than household or other utilitarian functions, and they were all from burial contexts. The rarity and the

ornamental use indicate fairly clearly that there was not at that stage any established technique for smelting the abundant ores of iron (Forbes 1971: 34).

The Earliest Metals in Sri Lanka

It is also true nearly everywhere that the first occurrence of metal in archaeological contexts is from burials. This is the case in Sri Lanka too where the evidence of the use of metals is almost always from the burial contexts of what is now widely (though not always appropriately) referred to as the 'megalithic' culture. Even though several types of megalithic burials have been found in Sri Lanka, so far there is not enough data in the Sri Lankan context to arrange them chronologically (Seneviratne 1984: 264-267), although it is generally thought that the urn burials are the oldest. Of all the urn burials sites, the site at Pomparippu, situated in the northwestern province, also occupies a very special place, as it is the only megalithic burial site where microliths have been found in direct association with the characteristic black-and-red ware and other artifacts associated with early Iron Age lifeways. The chert and quartz flake tools found here were placed inside the urns. (Begley et el.1981: 83). This site, therefore, may be considered one of the earliest sites ideal for understanding the transition from the Mesolithic to the Iron Age in Sri Lanka. (Seneviratne 1984:277) It is strange, however, that the microliths found inside the urns have been attributed to a different phase (Deraniyagala 1990:253) without any explanation why this should be the case.

The megalithic burial at Pomparippu has been dated to about 1000BC– 800BC by several scholars, by comparison with similar cultural attributes and radiocarbon dates in peninsular India (Seneviratne 1984:287; Sitramplam 1990:276; Romila Thapar referred in Sitramplam 1990:275). At the other end of the chronological spectrum, Seneviratne suggests that this form of burial practice went out of the vogue at least in the core area around the 2^{nd} – 1^{st} Century BC (Seneviratne 1984: 289). Again considering the excavations carried out at the Annaikoddai burial mound it was evident that there was a time span of at least six hundred years in the continuing practice of this burial method in the same location. This is established by the palaeographic evidence found from two burials ranging from the 3^{rd} Century BC to the 3^{rd} Century AC. (Ragupathy 1987: 121-122) Further Ragupathy suggests the possibility of finding still older burials in the same mound. At the other end of the chronological spectrum, a megalithic cemetery found recently in Tissamaharama has been dated by C^{14} to 600 CE by the Uppsala University under the Urban Origins of Southern Sri Lanka project (pers.comm. Gamini Adikari 2006).

These extremes show that the task of identifying the earliest evidence of metals in Sri Lanka is difficult because we may infer from the Tissamaharama evidence that the same, or similar, funerary practices seem to have prevailed in Sri Lanka for about 1500 years. Thus artefacts belonging to burials deep into historical times may well have confused the true picture.

No careful study has been carried out so far regarding the metal artefacts found in Sri Lankan megalithic contexts. Although the discrepancy has been noted, the striking

and so far neglected feature regarding the metal artefacts found in these early burial contexts in Sri Lanka is that the quantity of copper artefacts is high compared to the occurrence of iron. Proto Historic burials and habitation levels in Sri Lanka point to a somewhat high occurrence of copper bronze objects (Seneviratne 1995: 123; Sitramplam 1990: 274; Deraniyagala P.E.P 1958: 15). This fact is also confirmed by Raja de Silva (pers. comm. Raja de Silva 2005) who had carried out several megalithic burial excavations in Sri Lanka such as Gurugalhinna (Raja de Silva 1970: 2, referred to in Seneviratne 1984: 248), Kok-Ebe (Seneviratne 1984: 249), Diwul Weva (Seneviratne 1984: 253), Vadiga Weva (Seneviratne 1984: 248) and Kadiraveli (Raja de Silva 1970: 2, referred in Seneviratne 1984: 257). Although de Silva's results have not yet have been published, he had found only very few iron artefacts, in the burial sites he investigated most of the metal finds being of copper. He further observes that he does not know whether these artefacts were copper or bronze since no metallurgical analysis had been possible.

At Pomparippu too, very few iron objects have found along with a high number of copper implements (Begley et el. 1981: 77-78; Deraniyagala P.E.P 1958: 15). Interestingly, in an excavated Megalithic burial at Karainagar, where microlithic flakes of quartz present as offerings yielded no metal implements at all (Ragupathy 1987: 130). But at upper levels "iron slags" were found. A similar situation occurs at a number of other Megalthic sites such as Makevita (ASCAR 1958: 41); Malikapitti (H. Nevill, referred to in Sitrampalam 1990: 268) and Mukkarugoda (Godakumbura 1965: 90) which contain no metal implements at all, quite possibly implying that metal – and especially iron --was not a common material during these early periods. At Gurugal Hinna only copper objects and no iron were found (Raja De Silva 1970: 2 referred in Seneviratne 1984:248). At Ibbankatuwa there are more copper artefacts than ~~the~~ iron objects (pers. comm. S. Bandaranayake 2006)**.** At Diwul Wewa amongst the other metal objects an iron plough coulter? was obtained from one of the cist burial (pers. comm. S.K. Sitrampalam 1982 referred in Seneviratne 1984: 248). At Gal-Altara both copper and iron artefacts have been found but there is no information regarding their numbers (ASCAR 1966-1967: 64). At Pin-Wewa, excavations carried out by C.E. Godakumbura yielded only two iron artefacts (ASCAR 1965-1966: 104). The excavations carried out recently in the same place also revealed only iron artefacts (an adze and an arrow head) and no copper artefacts (Liyanage 2006: 42).

Interestingly the two burials excavated at Annaikoddai which have also been mentioned above, the older one (SK1), which had been dated to *circa* 3^{rd} – 2^{nd} Century BC had an iron point, copper artefacts and "iron slags?" as burial offerings while the other burial (SK2) which had been dated to *circa* 2^{nd} – 3^{rd} Century AC had a copper/bronze seal and iron artifacts, which were interestingly utilitarian artefacts (i.e. iron dagger, iron lamp) indicating a true iron age. (Ragupathy 1987: 121-122). When we look at carefully at the available evidence from the limited megalithic sites examined so far, it is possible to categorise them in the following way:

1. Sites with no metal artefacts

   Karainagar, Makevita, Malikapitti, Mukkarugoda

2. Sites with only copper implements

Gurugal Hinna

3. Sites with more copper implements than iron implements

Pomparippuwa, Ibbankatuwa

4. Sites with copper and iron artefacts but no information which material is predominant

Kok-Ebe, Diwul Weva, Vadiga Weva, Kadiraveli
[Note: Because no published data is available regarding the numbers of the metal artefacts found from these sites they have been placed in this category, but according to the excavator Dr. Raja de Silva he had found more copper artefacts than iron from these sites (pers. comm. Raja De Silva 2005) Thus, some these sites should have been categorized under Categories 2 and 3], Gal-Altara

5. Sites with more iron implements than copper implements

Annaikoddai (SK2) burial, Pin-Wewa

With the very few available results and the uncertainties involved what we see is that there as yet no clear picture in Sri Lanka -- and no critical study -- regarding the earliest use of metals, the transition from copper to iron and the generalised use of iron.

Gedige Excavation

A good example of the difficulties involved is seen in the excavations at the Gedige in Anuradhapura, where copper slag was found with some iron inclusions in Layer 3A, establishing the fact that copper smelting was practiced here as early as the 6^{th} – 5^{th} Century B.C (Deraniyagala 1972:145; Seneviratne 1995: 123). This does not necessarily mean the knowledge or use of iron. What iron inclusion in copper slag usually implies is the use of iron rich copper ore or iron oxides as a flux for copper extraction (Waldbaum 1980: 80; Wertime 1980:15).

The few pieces of slag thought to be iron slag found in Layer 3A in the Anuradhapura Gedige excavations need to be subjected to laboratory analysis before they can be definitively identified as residue from iron smelting, as is the case with the iron slag from the Aligala rock shelter at Sigiriya (Karunaratne and Adikari 1994: 59-61). Slag could form during several metallurgical processes. Moreover slag from iron production visually resembles slag from copper production. Useful evidence would be the presence of slag and iron ore at the same metal producing site, although even then one cannot definitively attribute slag as residue from iron production without analysis since iron ore has been used as a flux material in early copper extraction processes (Charles 1985: 23-24; Wertime 1980: 8).

Moreover, the real ratio of iron to copper artefacts in Layer 3A, which had more than 3 feet of deposit, needs reconsideration. It would appear at first glance that there are

many more iron artefacts than the copper artefacts since only the total number of three copper related objects have been found against 23 iron related finds. The largest iron artefact is also one of a type that has not been determined – it is surmised to be a point with a length of 8.0cm and a thickness of 0.7cm. But when looked at carefully the iron artefacts from Layer 3A it is clear that the remaining 22 out of 23 iron finds are small, fragmentary pieces. Moreover, the distribution of the copper and iron finds within the 3 foot thick Layer 3A has not been mentioned a consideration extremely important for any interpretation regarding these objects. The average sizes of the metal finds are follows: (Deraniyagala 1972: 152)

No. of iron artefacts with an average length of 2 – 3 cm = 7
No. of iron artefacts with an average length < 2.0 cm = 15

Although three of these fragments have been described as a nail, the tip of a knife blade, and a point it would have been difficult to be even certain of this identification It is possible that these 22 fragments may have belonged to a few individual iron objects which is a very fragile basis to justify the categorisation of Layer 3A as representing an 'Iron Age' in the way that Layer 4 of the same excavation does.

Metals and Megaliths: Sri Lanka and India

If we look at the earliest metal artefacts from the megalithic sites of Sri Lanka such as Pomparippu they are small metal artefacts displaying universal shapes most probably obtained by hammering. Pictures of several artefacts have been published (Deraniyagala P.E.P. 1958: 15) A striking difference that can observed regarding artefacts from Sri Lankan megalithic contexts when compared with contemporary megalithic Indian sites is that in Sri Lanka there are more copper artefacts and only few iron artefacts whereas at the Indian sites like Adichhanallur and the Godavari basin sites, the iron artefacts are much larger and more numerous and the copper much fewer, a totally different picture from the Sri Lankan situation. Several scholars in Sri Lanka have referred to this as a special situation. (Sitrampalam 1990: 274; Begely 1981: 78), but little attention had been paid to understand or explain this phenomenon. The situation is made worse by the fact that only very few sites with metal remains have been excavated in Sri Lanka, so that there is only a very limited amount of data available regarding the earliest metal usage in the country. Moreover, none of the sites have been excavated with the intention of investigating the earliest developments in metallurgy.

Copper Resources and Iron as a By-Product of Copper

The availability of the resources is one of the major factors associated with the places where the use of metal first began in many parts of the world. (Charles 1985: 21-26; Forbes 1971: 37) Thus the first metal using sites were close to natural copper ore deposits where small amounts of native copper were found on the surface along with colourful metal oxides (Charles 1985: 23). In this context we should take into account the fact that the existence of more copper artefacts than iron artefacts in the earliest occurrences of metals in Sri Lanka is in direct contrast to the Indian situation. It puts into question the possibility that metal usage in Sri Lanka was initiated by direct transmission of iron from Indian Iron Age contexts or the importation of copper from

the subcontinent, where copper was a rare metal. If we consider the availability of resources principle, we cannot disregard the fact that Sri Lanka had an extensive copper magnetite deposit at Seruwila (Jayawardhana and Premasiri 1977; Seneviratne 1995), which as we shall see was heavily exploited in historical times.

In considering the early presence of iron in Sri Lankan sites the possibility that iron could be found as a by product of copper extraction at low temperatures especially when using iron rich copper ore like that found in the Seruwila deposit has not been taken into account at all. It is an established fact that metallic iron could be produced accidentally as a by product during the copper smelting process either through the use of iron rich copper ores or through the use of iron oxides as a flux (Charles 1980: 165-166; Waldbaumn 1980: 80). The main impurity of impure smelted copper is iron and due to the difference in density and the immiscibility between copper and iron, iron could float on to the surface of the melt, which could be separated subsequently and used for the making of iron implements (Tylecote and Merkel 1985: 7).

All the descriptions reproduced below[1] describe the presence of iron in the Bronze Age before start of the Iron Age. But copper smelting could surely not have been a regular or reliable source of iron, but might account for some of the occasional small lumps and pieces of smelted iron known since the beginning of the Bronze Age (Waldbaum 1980: 80).

It is interesting to note that the iron objects found in Layers 3 and 4 of the Anuradhapura Gedige contain a considerable amount of copper and nickel elements in their composition and also the copper-nickel ratio can be consistently found in all samples. Because of this consistent copper-nickel ratio, the raw materials for these iron objects are derived from one and the same, which is seen to be particularly rich in copper (Maliyasena 1987). The origin of this this ore has been attributed to the

[1] "In case where the gangue content of copper iron oxide used for smelting of copper was low, so that the chemical activity of the iron oxide was not reduced by combination with silica, etc. and if the iron oxide was not very well mixed in with the other components, metallic iron would have occurred as small peaces here and there not separated to the hearth but held up in the surface cinder. Also under condition where the activity of iron is high but not heading to some metallic iron formation, some iron reduction in to the liquid copper will occur, to be rejected from the copper as it solidifies. Where the originally dispersed smelted copper was remelted in a crucible, this ferrous separate as a rim of distinct material (Charles 1985: 24)"
"Chemical analysis of the Messkani slags showed 2.4% metallic iron, a by product of the use of hematite or gossan flux with a roasted calcocite ore. These iron could be freed of its matrix by hammering and turned into useful object of iron (Wertime 1980: 15)"
"Smelting experiments carried out with Chalcopyrite ores yielded a slag interlaced with copper veins and inclusion of iron. The experiment uses no flux (Maddin & Muhly 1977: 16 referred in Wertime 1980: 16)"

Seruwila deposit (Seneviratne 1995: 123).[2] Further, it is important to note that the iron implements which have been found in Gedige Layers 3A , 3B, and 4A have a low iron content of about 40 –50 % in their composition (with the exception of one object: (Maliyasena 1987). We may well ask the question whether these iron artefacts are from purposely smelted for iron process, and if so why they have such low iron content? It could well be that this low iron content is because these metals are not produced by an iron smelting process, but are a by product of copper extraction. It would have far-reaching implications if we are able to establish that the limited number of small primitive iron implements found in the Gedige excavations were made from iron found as a by product of copper smelting from an iron rich copper ore. Even without such evidence we may say that there are clear indications that the presence of sporadic iron artefacts along with several copper artefacts does not necessarily imply the beginnings of an Iron Age.

Megalithic Culture and the 'Iron Age'

Similarly, although the term 'Iron Age' has been attributed to the earliest megalithic contexts in Sri Lanka, if we apply this term to the entire time range of this period, we cannot but conclude that we lack firm evidence of a significant range of iron artefacts, indications of processes of iron extraction, or the remains of the furnaces used, that would justify such attribution. The Megalithic BRW culture complex in peninsular India, on the other hand, has yielded sufficient evidence of the type of furnaces used during that epoch (Tripathi 2001: 110-115, 140-148; Seneviratne 1985: 150), which justifies calling it a true iron age. The fact there are as yet no clues of iron furnaces or any other evidence of iron extraction belonging to an "early iron age" in Sri Lanka may probably indicate that iron in that early epoch was not obtained by the extraction of that metal from iron ore. Iron extraction procedure needed a more sophisticated technology than the extraction of copper, and temperatures at least as high as 1200^0C were required. Moreover, if the earliest megalithic contexts in Sri Lanka constituted a fully-fledged Iron Age, we could reasonably expect that the copper artefacts from those contexts would have been much more sophisticated than those we have found so far. This observation is also applicable to Layer 3A of the Gedige at Anuradhapura. Iron artefacts of a significant or substantial size require the use of large metal masses, to obtain which high heat capacity furnaces are essentially needed. Unlike with copper, the consolidation of small metal peaces by melting was not possible for iron until the 18^{th} Century, since iron has a very high melting point of 1540^0C. A large number of number of iron artefacts for household use and as agricultural implements are utility implements involving large metal masses, indirectly indicating that the extraction of iron by smelting is essential to represent a full fledged Iron Age.

The situation we have encountered so far is very different. The iron objects found within the megalithic contexts in Sri Lanka are extremely limited – such as a piece of a knife, a small iron rod hammered at one end to form a arrows head, a piece of blade,

[2] By metallurgical analysis of the Sri Lankan historical bronze icons it was shown that the high content of nickel in copper objects along with a considerable content of iron implies the use of Seruwila deposit ore for the extraction of copper (Thantilage 2008).

a piece of nail, etc (Seneviratne 1984: 277; Begley 1981: 77-78; ASCAR 1965-1966: 104; ASCAR 1957: 30-31). All these iron implements involve a very small mass of metal mass and possess primitive shapes most probably obtained by hammering. Morevover, no laboratory investigation has been done so far on any of these metal artefacts to understand the technology involved in their production.

It would appear that the term 'Iron Age' has been applied to these earliest megalithic contexts mainly on the basis of what, from a metallurgical point of view, are the few primitive iron objects found, along with a larger number of similarly primitive copper artefacts. Another reason for the use of this terminology is probably on account of the presence of the Black-and-Red Ware (BRW) pottery that has long been associated with a true Iron Age in the Indian context. A true Iron Age, however, should represent a technology of iron extraction which should produce the large utilitarian household and agricultural iron implements as in the case of the South Indian megaliths. In the case of Sri Lanka it is very doubtful that earliest iron objects found so far have been made using iron obtained locally by a process involving the purposeful smelting of iron ore. When and how that happened still needs investigation.

Cultural Formation and the Spread of Technology

Another hypothesis offering an explanation for the primitive nature of the megalithic metal artefacts of Sri Lanka is that they represent early stages in the transfer of technology: 'the probable borrowing of the metal technology by the indigenous Mesolithic people of Sri Lanka from the intrusive megalithic BRW culture may have been another reason resulting in the limited range of objects as well as the undeveloped stage of this technology during the proto historic period' (Seneviratne 1984:283 – 286).

The processes involved in the formation of a new culture and the transfer and acquisition of new technology are extremely complicated and require critical study and careful analytical investigation, especially in the case of metallurgy. Proper assessments of internal and external factors have to be made. If the 'intrusive' megalithic culture brought with it the knowledge of iron extraction, we could reasonably expect it to have artefacts involving high metal masses, which have not yet been found in most Sri Lankan megalithic contexts. If only the technique of extracting iron from iron ore was transferred to a Sri Lankan context by acquisition or intrusion, then the 'primitive' artefacts we find could represent early experiments in iron smelting with considerable metal masses but possibly low metal quality.

We can also propose other possibilities: one would be where the local mesolithic peoples adopted 'megalithic' burial practices and at a later stage used, 'imported', otherwise acquired and ultimately fabricated iron artefacts, or were joined or replaced by iron using groups. These questions can only be answered by further field research, excavations and laboratory investigations. It is no longer possible to advocate an 'Iron Age' directly and initially connected with a megalithic culture or suggest a simple connection between megalithic burials practices, BRW pottery, the significant use of

iron, and a knowledge of iron smelting technology as has been observed: “One of the major problems that archaeologists and historians encounter in the study of ancient cultures is the need to differentiate and to identify the sources of the various concepts, techniques, institutions, forms, designs, motifs, etc., that, at any given moment of time from the constituent elements of the culture or cultural product to which they have turned their attention; or-to pose the question in its proper framework- to analyse the process of cultural formation inherent in the subject of their study (Bandaranayake 1980: 65).

Pottery and Microliths

A new aspect of development that has been identified in the Sri Lankan Mesolithic is the association of pottery with microliths, occurring in several prehistoric excavations in different parts of the island (Adikari and Tantilage 2006). Strata with this combination of artefacts had previously been described as ‘disturbed layers’ In this situation the pottery found in a layer associated with microliths in the Dorawakkanda excavation which had been dated to what seemed to be a much too early time horizon of 6300 BC (Wijepala 1992: 9 - 16) has to be reconsidered as a possibility. More recent scientific investigations have also has indicated that cereal cultivation had taken place in Sri Lanka as early as about 13000 BP (Premathilake 2003). No research has been carried out so far on the extremely significant phenomenon of pottery found in association with the microliths. This link may be as important a factor in the study of the beginnings of settlement in Sri Lanka as the study of the early use of metals. We may well have to revise the general view that pottery in Sri Lanka started with the megalithic culture. Similarly, the idea expressed nearly 35 years ago that ‘Sri Lankan Mesolithic culture was succeeded *circa* 400BC.by the advent of the civilized man from India (Megalithic) who possessed the horse and a knowledge of iron working (Deraniyagala 1972: 50)’ is no longer really tenable. Much research has to be done to even begin to understand what happened between the last phases of the Sri Lankan Mesolithic and the beginnings of settlement, the origins of copper metallurgy, the generalised use of iron and the emergence of historical society.

An Early Presence of Bronze

It is reasonable to suggest that the major copper magnetite deposit at Seruwila could be the main reason for the presence in Sri Lanka of a high number of copper artefacts and sporadic iron artefacts in the earliest archaeological contexts containing metals. Some of the metal implements found from the Pomparippu megalithic burial site have been identified as bronze implements (Begely et el 1981: 78).

The origin of this attribution lies in a qualitative test carried out on some artefacts at the University of Pennsylvania laboratory, which reported the presence of, tin and lead in the artefact/s examined (Begely et el. 1981: 78). Qualitative analysis of this nature showing the presence of tin and lead metals in a copper artefact as a basis to identify the artefact even tentatively as ‘bronze’ is totally misleading since copper in nature could contain small amounts of tin and/or lead as impurities (Marechal J.R.1985: 35). Normally, to consider a metal as an intentionally added component requires quantitative rather than qualitative analysis to show that that particular metal

was more than 1% of the total composition of the alloy being analysed (Reedy 1997).[3] In this particular instance, it is only if the two elements of lead and tin were manual additions that we can conclude that these Pomparippu finds were made with a leaded bronze alloy. But a quantitative analysis is essential before reaching such an important proposition that we have leaded bronze (or bronze) in our earliest metal contexts.

The primitive shapes of these artefacts indicates most probably they may have been produced by method of hammering a small peace of metal rather than casting as in the case of leaded bronze. Since lead implements are absent from our earliest metal context, it is not realistic to think that leaded bronzes were produced here[4].

The Differences in Megalithic Metal Artefacts – India and Sri Lanka

It is important to note that copper and bronze objects occur only in very small quantities in the South Indian megalithic contexts, although the workmanship displayed there in bronze is of an unusually high standard when compare with the associated pottery and terracotta figurines. As a result these bronze objects have been attributed as imported ones possibly from Mediterranean cultures (Gururaja Rao 1972: 265-272), a fact showing its high value, its use probably confined to the richer strata of that society. Three types of metal artefacts can be seen in the contemporary Indian megalithic contexts; almost all of them of iron (Murthi 2000:149). These iron implements consist of: (a) implements of war; (b) household implements; (c) agricultural implements. All of them are of a substantial size, involving large metal masses. According to Tripathi the South Indian Megaliths have more sophisticated iron implements like swords, spikes, tridents, horse's bits and also utensils along with the less sophisticated usual shapes (universal shapes) of this period i.e. arrow-heads, wires, bangles, fish hook etc. (Tripathi 2001: 112).

It is clear from all this that copper was a scarce and highly valued metal in the Indian context. The sub-continental situation presents a very different picture from that in Sri Lanka where we have an apparently high ratio of copper to iron and a relatively poor quality of copper artefactual remains. It would be unrealistic in the face of this evidence to suggest that the copper artefacts in the Sri Lankan sites have their origin in importation from India, either through migration or exchange.

[3] In this study no element present less than 1% from total composition is considered as a manual addition.

[4] Sri Lanka has no known lead source and no lead artefacts have been found in Sri Lankan megalithic contexts, even though lead is one of the earliest metal that man came to know and to use due to its low melting point. As has been shown elsewhere (Thantilage 2008) lead was imported in later historical times in Sri Lanka to produce bronze artifacts. It is possible to think that the metals of the earliest contexts of the megalithic culture represent the existing metal technology in the island prior to the arrival of the Megalithic culture. i.e. they may have used metal implements already available here to fulfill the burial rituals of the newly introduced megalithic culture in its earliest contexts.

As we suggested earlier a few small and primitive iron artefacts found along with a larger number of equally poor copper implements and fragments found in our early megalithic contexts do not imply the same kind of 'Iron Age' that we see in contemporary India, if we can use that term at all in our situation. On the other hand, as we have a major copper magnetite deposit it is also true that a little amount of iron could be found during the copper extraction as emphasized earlier in this preamble. There is, therefore a good possibility that the indigenous inhabitants of Sri Lanka initiated experiments in this new medium as has happened elsewhere in the world.

An Early Sri Lankan Copper Metallurgy?

The copper slag found in Mesolithic contexts at Matota (Deraniyagala 2000: 85) indicates that the indigenous peoples here had used the available resources around them. Deraniyagala further emphasize that this is the first time a soil layer contemporary to the Calcolithic of Indian Sub Continent found in Sri Lanka. Only further field research combined with metallurgical investigations would make it possible for us to understand the origins of the earliest use of metals in Sri Lanka. It would now appear that this is essential before concluding that metal usage and its related social developments had started with an 'Iron Age'. It may well be the case that the use of copper preceded iron technology in the country. Although that may not constitute a proper 'Copper Age' it would indicate that there were already metal (mainly copper) using communities when megalithic culture was introduced to Sri Lanka.

The copper slag found along with microlithic tools in a cave at Matota (Deraniyagala 2000: 85) is an excellent example to support such an argument. It is clear that the earliest metal implements of Sri Lanka are very different from those in contemporary India and that they seem to reflect the existing level of local technology during that period. The presence of a larger number of copper rather than iron artefacts present in the earliest record of metal implements in Sri Lanka may well indicate the existence of copper using communities in the island before the beginnings of the 'megalithic' culture and its associated practices and artefacts.

It is relevant to reproduce here the multi-linear model proposed by Bandaranayake (Figure 1) in a chronological chart (Bandaranayake 1992:16) summarising 'what we know or can reasonably hypothesise' about developments in Sri Lanka in the 1st millennium BC, which shows that settlement, wet rice cultivation, irrigation and early metals may have preceded the megalithic complexes:

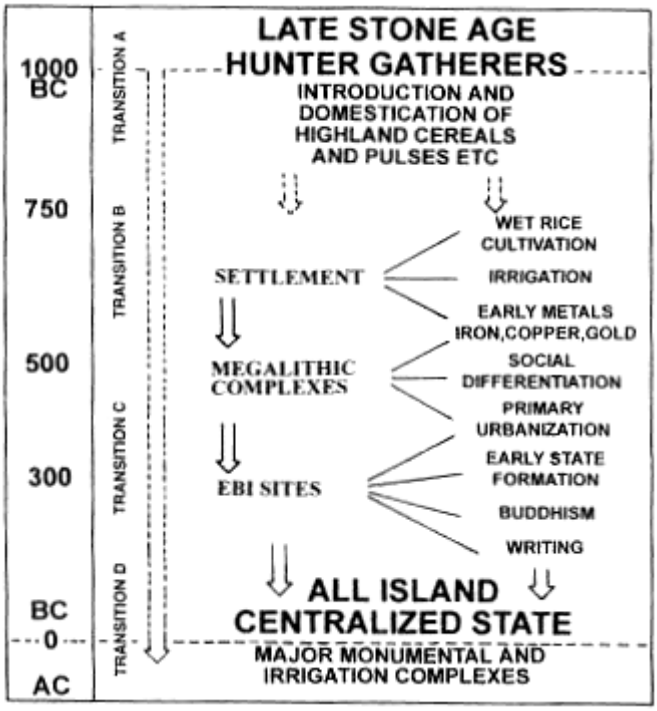

Figure 1 Chronological chart by Bandaranayake (Bandaranayake 1992: 16)

Cultural Formation of Sri Lanka from a Metallurgical Point of View

We attached below a revised chronological chart (Figure 2) based on a modified version of Bandaranayak's 1992 chart, taking into account arguments in this article regarding the cultural formation of Sri Lanka from a metallurgical point of view.

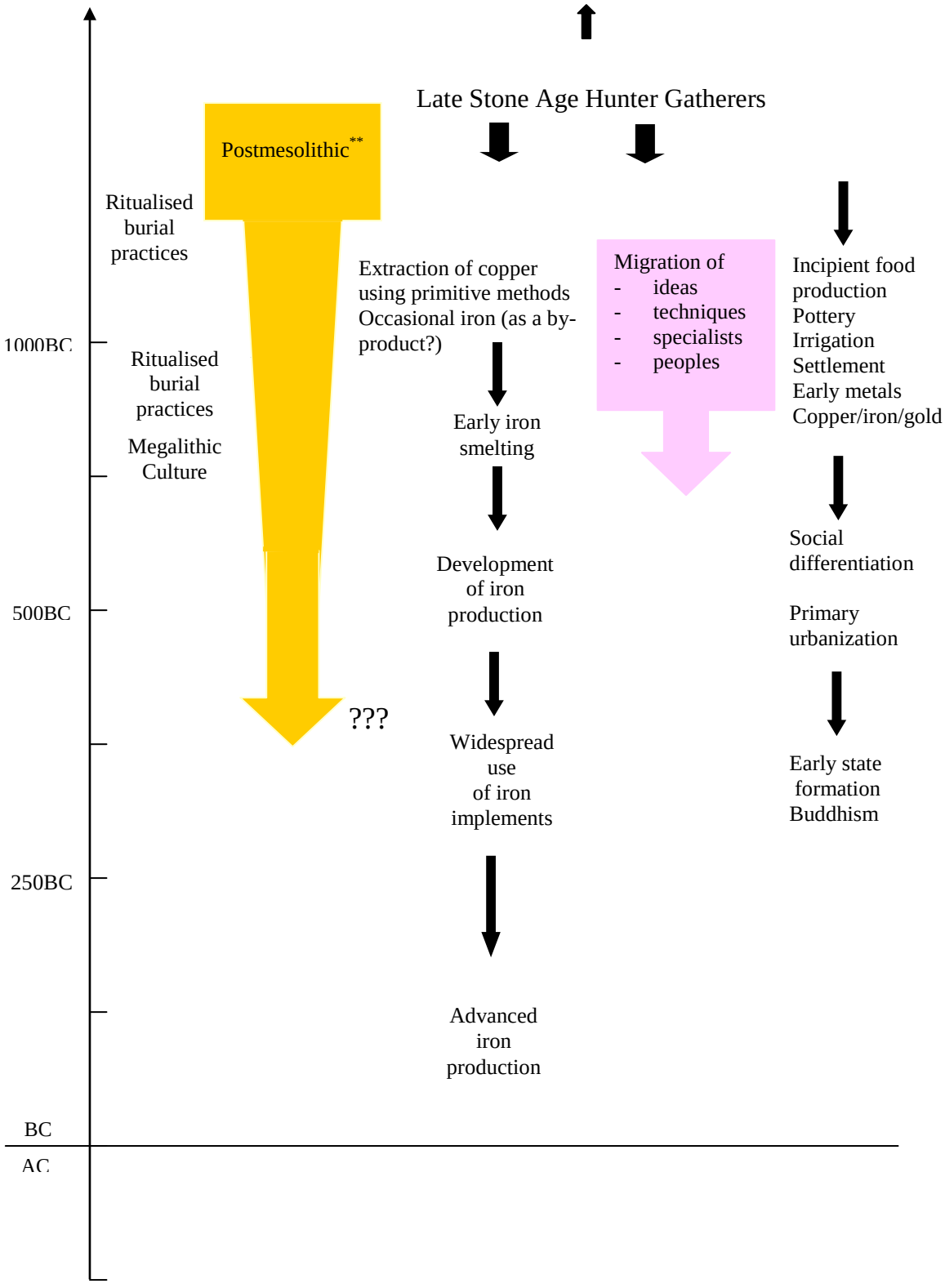

Figure 2 Revised chronological chart based on the Bandaranayake's chronology (Thantilage 2007 after Bandaranayake 1992)

** Postmesolithic is a newly identified cultural phase in Sri Lanka where microliths coexisted with pottery and later with pottery and metal (Adikari and Thantilage 2007: 23-30)

Conclusion

It is a fairly reasonable assumption that iron technology must have come to Sri Lanka from India. However, it is no longer possible to assume that there is a direct connection between megalithic culture and iron technology. The assumption that iron technology and an Iron Age were initiated in Sri Lanka with the coming of a megalithic culture is no longer an assumption that we can readily accept. The sequence of cultural and technological developments such as pottery, a variety of 'megalithic' burial practices, copper metallurgy and iron metallurgy has yet to be properly researched. We can only question some of the basic assumptions of the past and observe some important new aspects such as the use of pottery by people who also used microliths, the early development of copper smelting before the knowledge of iron, and the delinking of an inevitable connection between iron and megaliths. Laboratory based metallurgical analysis has can important role to play in researching some of these major issues in Sri Lankan pre- and proto-history.

Adikari, G and A.Thantilage, 2007. The New Chronology for Sri Lanka : The Identification of New Cultural phase "Postmesolithic" **In** Gunawardhana, P. et el. (eds), *Archaeologia,* Vol.3,Department of Archaeology, University of Kelaniya, Sri Lanka

Bandaranayake, S.1980. Hypothesis on Unity and Differentiation of Cultures: Patterns of Architectural Development in Monsoon Asia **In** *Quarterly Journal of the International Council for Philosophy and Humanistic Studies,* No 111

Bandaranayake, S.1992. The Settlement Pattern of the Protohistoric Early Historic Interface in Sri Lanka **In** Jarrige. C. (ed), *South Asian Archaeology 1989*, Papers from the tenth international conference of South Asian Archaeologists in Western Europe, Monograph in World Archaeology, Prehistory Press, Wisconsin

Begley, V., Lukacs J.R and K.A.R. Kennady 1981. *Excavations of Iron Age Burial at Pomparippu, 1970*" Ancient Ceylon No 4, Department of Archaeology, Colombo

Charles, J.A. 1985. Determinative Mineralogy and the Origins of Metallurgy **In** P.T. Craddock, M.J.Hughes (eds), *Furnaces and Smelting Technology in Antiquity,* British Museum Occasional paper No. 48, British Museum Research Laboratory

Charles, J.A.1980. The Coming of Copper and Copper-Base Alloys and Iron: A Metallurgical Sequence in T.A. Wertime, J.D. Muhly (eds), *The Coming the Age of Iron,* New Haven and London Yale University Press

Deraniyagala, P.E.P. 1958. *Administration Report for the Archaeological Comissioner for the Financial Year 1958*, Archaeological Survey Department, Ceylon

Deraniyagala, S. 1972. *The Citadel of Anuradhapura 1969: Excavation in the Gedige Area,* Ancient Ceylon No.2, Department of Archaeology, Sri Lanka

Deraniyagala, S.U.1990. *The Proto and Early Historic Radiocarbon Chronology of Sri Lanka,* Ancient Ceylon No 12, Vol.6, Department of Archaeology, Colombo

Deraniyagala, S.U. 2000. Sri lankave prag ha purwa aithihasika janawasa in Sinhala **In** *Chiranthana,* No. 4, Department of Archaeology, Sri Lanka

Forbes, R.J. 1971. *Studies in Ancient Technology* Vol. VIII, E.J.Brill, Leiden

Godakumbura, C. E. 1965. *Administration Report for the Archaeological Comissioner for the Financial Year 1963-1964*, Archaeological Survey Department, Ceylon, 1965

Gururaja Rao, B.K. 1972. *The Megalithic Culture of South India*, University of Mysore, Mysore, 1972

Jayawardhana, D.E. de S and S. Padmasiri 1977. *Report on the Copper Magnetite at Seruwila Arippu Prospec*" Ceylon Geological Survey Department

Karunaratne, P. and G. Adikari. 1994. Excavations at Aligala prehistoric site. In S.Bandaranayake and M.Mogren et al. (eds.) Further Studies in the Settlement Archaeology of the Sigiriya-Dambulla Region. Colombo: Postgraduate Institute of Archaeology, University of Kelaniya

Liyanage, G.L.S.L. 2006. *Pin wewa Galsohonkanattha gaweshanaya saha kenima 1997* in Sinhala, M.Sc Thesis, Postgraduate Institute of Archaeology, University of Kelaniya

Maliyasena, H.B. 1987. *Metallurgical and Archaeological Studies of some iron objects from the 1969 Anuradhapura Citadel (Gedige area) excavation* in Seminar on the Archaeometallurgy of Sri Lanka, September 1987, IFS Kandy

Marechal, J.R. 1985. Method of Ore Roasting and the Furnaces Used **In** P.T. Craddock, M.J.Hughes (eds), *Furnaces and Smelting Technology in Antiquity*, British Museum Occasional paper No. 48, British Museum Research Laboratory

Murthi, P.R. 2000. Megalithic *Culture of Godavari Basin*, Sharadha Publishing House, Delhi

Premathilake, T.R. 2003. *Late Quaternary Paleoecological Event Strtigraphy in the Hortan Plains* a PhD thesis, The Department of Physical Geography and Quatenary Geology, Stockholm University

Ragupathy, P.1987. *Early Settlement in Jaffna An Archaeological Survey*, T. Ragupathy, Madras

Reedy, C.L. 1997. Himalayan *Bronzes Technology, Style and Choices*, University of Delaware Press

Rothenberg, B and A.B. Freijeiro, 1980. Ancient Copper Mining and Smelting at Chinflon (Huelva, SW Spain) **In** P.T. Craddock, (ed) *Scientific Studies in early*

mining and extractive metallurgy, British Museum Occasional paper No. 20, British Museum Research Laboratory

Seneviratne, S.1984. *The Archaeology of the Megalithic – Black and Red ware complex in Sri Lanka,* Ancient Ceylon No 5, Department of Archaeology, Colombo

Seneviratne, S. 1995. *The Ecology and Archaeology of the Seruwila copper magnetite prospect northeast Sri Lanka,* The Sri Lanka Journal of the Humanities, Vol. XXI, No 1&2, University of Peradeniya, Sri Lanka

Sitramplam, S.K.1990. *The urn burial site of Pomparippu of Sri Lanka,* Ancient Ceylon No 7, Vol 2, Department of Archaeology, Colombo

Thantilage, A. 2008. *Archaeo-metallurgical Investigation of Sri Lankan Historical Bronzes,* PhD Thesis, Postgraduate Institute of Archaeology, University of Kelaniya, Sri Lanka

Tripathi, V. 2001. *The Age of Iron in South Asia, Legacy and Tradition,* Aryan Books International, New Delhi

Tylecote, R.F.1980. Furnaces, Crucibles, and Slags **In** T.A. Wertime, J.D. Muhly (eds), *The Coming the Age of Iron*, New Haven and London Yale University Press

Tylecote, R.F and J.F. Merkel 1985. Experimental Smelting Techniques: Achievements and Future **In** P.T. Craddock, M.J.Hughes (eds), Furnaces and Smelting Technology in Antiquity, British Museum Occasional paper No. 48, British Museum Research Laboratory

Waldbaum, J.C.1980. The First Archaeological Appearance of Iron and the Transition of the Iron Age **In** T.A. Wertime, J.D. Muhly (eds) *The Coming the Age of Iron*, New Haven and London Yale University Press

Wertime, T.A.1980. The Pyrotechnologic Background **In** T.A. Wertime, J.D. Muhly (eds) *The Coming the Age of Iron*, New Haven and London Yale University Press

Wijepala, W.H.1992. Doravakin Labena Nawa Sadhaka (in Sinhala), Svasthi Sri, Department of Archaeology, Colombo