An 8th-9th century AD iron smelting workshop near Saphim village, NW Lao PDR

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ABSTRACT: A rare example of an organised industrial workshop is reported, from the environs of the ethnic Lamet village of Saphim in Luang Namtha Province in NW Lao PDR. The archaeological site contains the remains of seven sub-circular furnaces in a distinct linear arrangement. Two furnaces were excavated, one of which was largely complete and provided evidence for a forced blast, multiple use, slag-tapping iron smelting operation. Six thermoluminesence dates derived from wall fragments provide a date range from 621±270 to 1181±170 AD, indicating that the workshop relates to production in the historic pre-European contact period. The organised layout of the furnaces is suggestive of either simultaneous production or a production sequence, rather than the distribution expected of chronologically superposed production within dating resolution limits. A multi-furnace workshop level of supply was probably in excess of local demand, and thus contemporary regional comparisons for social contexts of iron production and exchange networks are explored.

Introduction

Despite a relatively early start under the late 19th/early 20th century French colonial administration (Colani 1935), Laotian archaeology long remained a substantially under-developed field, especially when compared with research activity in Thailand and Vietnam. Efforts by local and foreign scholars over the last two decades have begun to rectify this situation with investigations of Palaeolithic, Neolithic, Metal Age, and Historic sites and landscapes (collated in Goudineau and Lorrillard 2008). In the coming years the synthesised results of these projects can be expected to provide a much fuller picture of the Lao PDR's past to complement existing and on-going ethnographic and text-based studies of the country's rich cultural and ethnic diversity.

In terms of early metallurgy the Lao PDR has been remarkably silent in light of the substantial mineral wealth of this predominantly mountainous nation (Wu 2007). Excavations in the 1990s by Anna Källén and Anna Karlström at Lao Pako (102.860°E, 18.160°N) on the banks of the Nam Ngum (River Ngum, a tributary of the Nam Mekong in central Laos) revealed evidence of 4th to 6th century AD iron smithing and possibly copper-base founding activity in association with a settlement and burial site (Källén and Karlström 1999). More recently, collaboration between the Laotian Ministry for Information and Culture, James Cook University, and a commercial mining company has resulted in the discovery of a *c*2000 year old copper mining and smelting complex near Xepon in central-southern Laos (106.013°E, 16.966°N; Pryce et al 2011); comparable in significance to the prehistoric copper production centres at Phu Lon (102.140°E, 18.205°N) and the Khao Wong Prachan Valley (100.678°E, 14.971°N) investigated by the Thailand Archaeometallurgy Project (Pryce *et al* 2010; Pryce *et al* 2011).

Despite these advances, the paucity of data on Laotian metal technologies is important because, as David Killick (2008, 3045) noted, the Lao PDR lies on key potential transmission routes (particularly central and northern Laos) for competing models for the origin/s of Southeast Asian metallurgy at some point in the 2nd millennium BC (*eg* Higham *et al* 2011; White and

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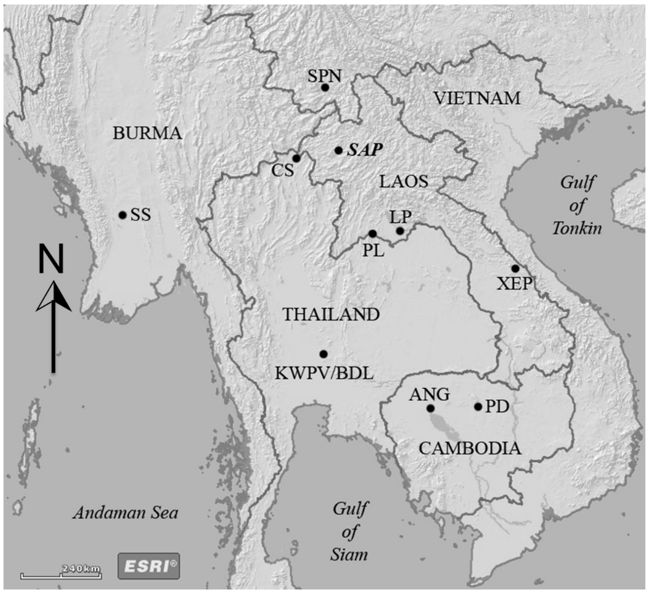

Figure 1: Regional map showing sites mentioned in the text. ANG = Angkor, BDL = Ban Di Lung, CS = Chiang Saen, KWPV = Khao Wong Prachan Valley, LP = Lao Pako, PD = Phnom Dek, PL = Phu Lon, SAP = Saphim, SPN = Sipsong Pan Na, SS = Sriksetra, XEP = Xepon.

Hamilton 2009). Ultimately, leaving 'origins' aside, an expanded archeometallurgical dataset should allow for an improved understanding of material exchanges, socioeconomic relationships, and technological transmissions between upland and lowland groups in the Lao PDR over the last three to four thousand years (depending on whose chronology you accept – see above references) and tying in with comparable research in neighbouring countries and regions (*eg* Juleff 2009).

The Saphim iron smelting workshop

This paper presents an initial report of an early historical iron production tradition in the ethnic Lamet (Rmeet) uplands west of the Nam Tha (River Tha) in Nalae District, Luang Namtha Province, NW Lao PDR (Figs 1 and 2). The site in question is located at 101.076°E, 20.320°N, at an altitude of *c*1100m on a heavily wooded ridge between the two hilltop Lamet villages of Saphim (*Sa Prim* in Lamet, meaning 'Old Place') and Talouy. A single small sub-circular surface feature was first reported by Hideyoshi Kavasima in 2008 whilst conducting ethnographic research on bronze drums in Luang Namtha province, which led to the present authors' rapid field assessment in July 2010. The Lamet uplands are quite remote and getting there took five days. Because of this and other logistical issues, the investigation was not as thorough as we would have liked, and added to that once at the site there were only five hours to work until monsoon rains made further excavation that season impossible. Nevertheless, the preliminary findings were somewhat surprising, and funding for further survey and excavation in the area has now been secured.

On arrival at the site the sub-circular feature noted by Kavasima was still visible, consisting of ceramic wall sections *c*100mm thick with a diameter of 0.5-0.6m. In order to understand the feature the surrounding leaf litter was cleared away, swiftly revealing a further five such fragmentary ceramic structures arranged in a row extending SW-NE, with a seventh slightly offset (Figs 3 and 4). With clouds gathering it was decided to remove c100mm of topsoil at the lowest point of the site around the original structure (F in Fig 4), levelling off the

Figure 2: Satellite image of the immediate area round the site. © 2012 Google, © 2012 Cnes/Spot Image, © 2012 Tele Atlas.

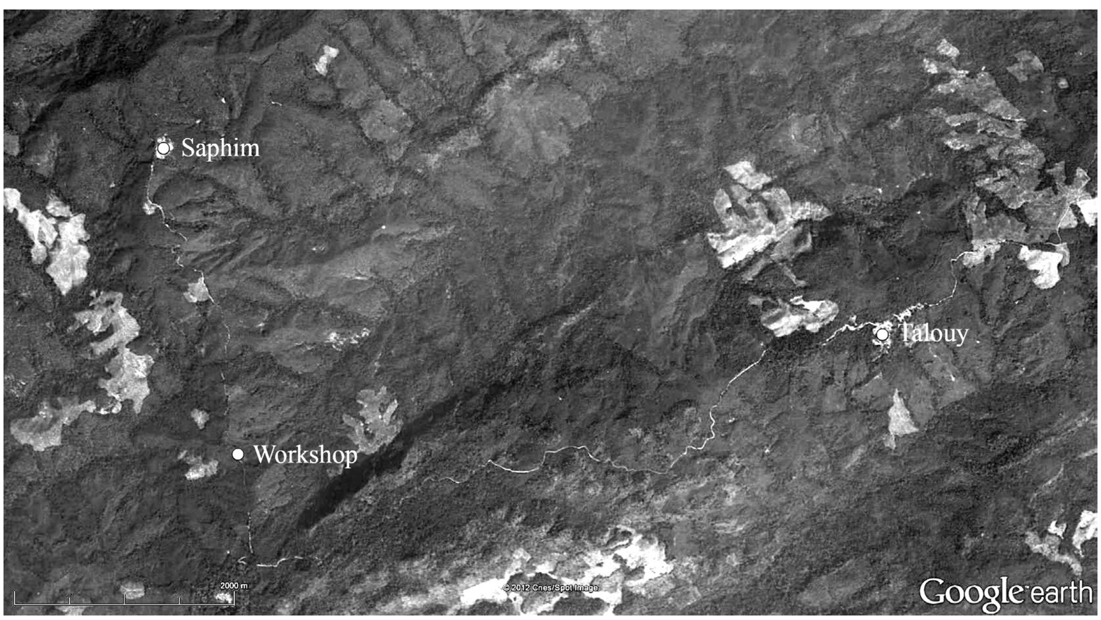

Figure 3: The Saphim workshop being topsoiled with Furnace Q being excavated in the background, looking NE.

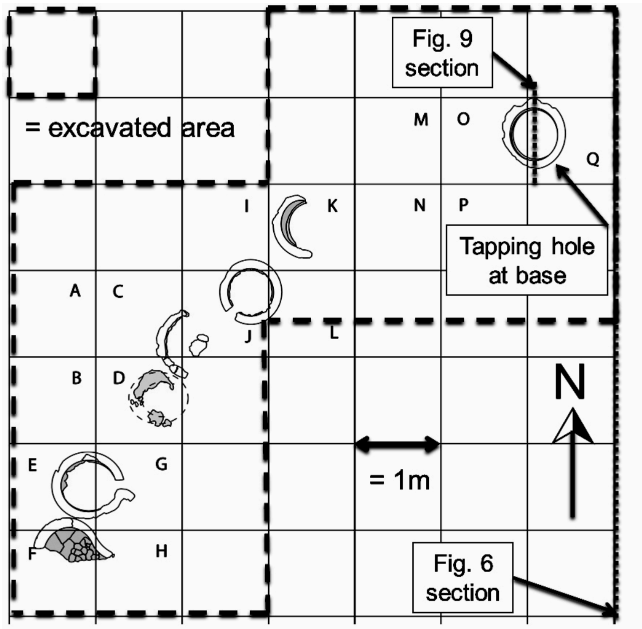

Figure 4: Plan of the Saphim workshop showing SW-NE alignment of furnaces within the excavated area (dashed line). The outlines indicate solid ceramic, pale grey fill is more friable ceramic, and mid grey fill was the original soil level.

rest, up to 200mm deep, within the area marked by the dashed line in Figure 4. Within this fill were recovered fragments of vitrified ceramic, tuyère, quartz, haematite, and dense slag with flow marks (Fig 5). As only 10-12 pieces totalling about 1kg were found, the relative proportions originally present cannot be reliably inferred, but their nature is highly suggestive of an iron smelting operation (Bachmann 1982). Settling on this initial interpretation the circular structures are hereafter referred to as furnaces, although the precise function of each is still not clear. Villagers said that both the haematite and quartz could be found nearby, the latter in stream beds, but there was no opportunity to confirm this.

The removal of topsoil had not revealed the base of any of the furnaces nor any floor, but the linear arrangement of the furnaces at a relatively uniform level suggested to us a workshop representing either simultaneous production or a production sequence – based on the supposition that chronologically superposed production would be less likely to produce a neat row of furnaces (Fig 4). To test this idea it was decided to section the two terminal features, F and Q, to try to identify a floor to the workshop, confirm the technology and investigate the form and date of the furnaces. Considering the typically poor survival of furnaces and most settlement archaeology in Southeast Asia, a relatively recent date was assumed for the site which was sampled for thermoluminesence (TL) rather than radiocarbon dating – performed by Dr Jean-Luc Schwenninger and his team at the University of Oxford.

Furnace F was *c*50% complete in circumference and 250mm in depth, but without any features characteristic of a particular furnace type. Despite excavating to 400mm no sign of a workshop floor was found, though archaeologists familiar with Southeast Asian stratigraphy would not be surprised by this. Practically no slag, ceramic, mineral, or charcoal was recovered from the interior, but this could be the result of the structure being incomplete and emptied. Three ceramic samples taken from the furnace wall provide TL dates of 631±170, 731±370 and 1011±150 AD.

Figure 5: A (substantial) sample of the materials recovered in the workshop topsoil: a. quartz, b. haematite, c. slag fragment, d. vitrified ceramic fragment, e. furnace wall fragment, f. tuyère fragment (curved interior uppermost).

Figure 6: N-S section of the Saphim workshop with furnaces F and Q excavated to their bases, and E, D, C, J and K scraped down.

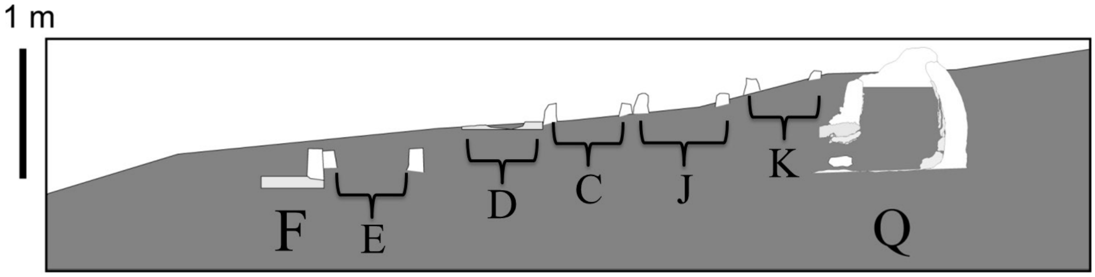

Figure 7: Furnace Q sectioned showing tap hole at SSE side of the base, with large stone (left) and protruding root (right).

Furnace Q was nearly complete and was buried in a bank of earth (Fig 7). Though it is uncertain whether the furnace was built into the bank or the earth accumulated over time, the latter is suspected due to the solid construction of the furnace. Standing about 1m tall, its external diameter varied from 0.6-0.7m at the circular rim to 1.1-1.2m at the sub-circular base, which formed a salient in the SE downslope direction (Fig 4). This feature allowed us to understand the other furnaces better; their sub-circular remains probably represent bases rather than rims. The wall thickness of furnace Q ranged from *c*100mm at the top to *c*200mm at the base, giving an internal diameter of 0.4-0.5m at the top and 0.7-0.8m at the base. At least seven re-linings could be detected, suggesting multiple re-usage (Fig 8). Despite excavating around the furnace no *in situ* tuyères were discovered, but a large root penetrating about halfway up the N section of the wall probably followed a pre-existing opening for air blast provision. The presence of a *c*150×200mm opening at the SE basal salient indicates a slag tapping operation, and a *c*100×150×250mm stone just inside the furnace may have been used to block the hole during the smelt (Fig 9). With rain beginning to fall and the soil thickening, no floor to the workshop could be detected in this area. Nor could a tapping pit be identified, but the direction of the tap hole would have led any slag to flow SE (downhill) out of the furnace. A single fragment of dense furnace slag weighing *c*1kg was recovered from the base of Q's interior and several similar fist-sized chunks from the surrounding fill, but there was an absence of the quantity of slag expected from furnaces of this size, especially if they were being

Figure 8: Multiple re-linings in E wall section of Furnace Q.

Figure 9: N-S section of Furnace Q. White indicates solid ceramic, light grey more friable ceramic, mid grey fill is stone, and dark grey shading shows the original soil level (with leaf litter on top).

used repeatedly as indicated by the re-linings (Fig 8). It should be noted that the workshop lies adjacent to a precipitous and now thickly forested slope (Fig 2) and it is thus quite feasible that past metalworkers kept their workspace clear by throwing cold slag down the hillside, a scenario that could not be safely checked. Three ceramic samples taken from the furnace wall gave TL dates of 621±270, 771±190 and 1181±170 AD.

Based on the range of available TL dates, and working with a conservative estimation of background radioactivity, Dr Jean-Luc Schwenninger (pers comm) suggests the last operation of the two terminal furnaces was around 800 AD, and possibly earlier. Furthermore, despite no workshop floor being detected, the relative contemporaneity of the sectioned furnaces F and Q and the seemingly uniform level of the intervening structures supports the initial impression that the site represents an organised industrial facility (see *eg* Egyptian Qantir Piramesses in Pusch 1995).

Discussion

The evidence presented can reasonably be interpreted as an 8th/9th century iron smelting workshop on a ridge in the northwest Lao PDR. This is a rather important discovery as it is the first pre-modern iron smelting site reported in the Lao PDR, although it is dated some 13 or 14 centuries after the appearance of iron in mainland Southeast Asian contexts. Its physical structure is indicative of an industry organised with some degree of social complexity. However, placing this iron production in its historical context is altogether more problematic.

The Lamet people living in the Saphim area were first studied extensively by the Swedish ethnographer Karl Gustav Izikowitz in the late 1930s (2001). They speak a Mon-Khmer (Austroasiatic) language and have a present day population of about 17,000 in Laos and some 600 in Thailand. Traditionally, the Lamet do not inhabit the lowlands but prefer to practice their swidden agriculture and animal husbandry, supplemented by hunting and gathering, at altitude. They are animists and their (pre-Lao PDR) level of social organisation is not recorded to have extended beyond that of the village, but comprised unilineal clan groups (*taa*) with wealthier individuals (*lem*), and only the village priest (*xemia* or *samaan*) occupying a central role (Sprenger 2008; 2010, 412).

In attempting a historical interpretation of the Saphim workshop, the major problem is that it is the first 'formally' excavated (given the limitations highlighted above) and radiometrically dated site in the entire province of Luang Namtha. There is absolutely no settlement history in the area, beyond the records of Izikowitz (2001) only eight decades ago, with which to correlate the iron smelting activity; so a well-evidenced interpretation of the social organisation of production (*cf* Costin 1991) is not yet possible. As Mon-Khmer (Austroasiatic) language speakers, the Lamet would generally be assumed to be the original inhabitants within the region, and thus good candidates to be the biological and cultural descendants of the 8th/9th century iron producers. However, in the absence of any supporting evidence, caution is necessary before assuming social continuity over more than a millennium. Nevertheless, considering the local ethnographic and historical data alongside regional iron producer comparators allow a basis on which to speculate while the necessary long term Lamet settlement and material culture data accumulate.

The decline of an industry

There are no known records of the Lamet having been associated with the production of iron. Indeed, Izikowitz (2001, 146) reports that in the early 20th century, not only did the upland Lamet obtain the iron they needed for agricultural tools by exchanging rice with lowland ethnic Tai groups near Luang Prabang, they were also noted for their lack of proficiency in the smithy (*ibid*, 79). So, if the Saphim workshop was operated by the ancestors of the present day Lamet, the latter have experienced the near total loss of a technological tradition over the course of twelve centuries. Such shifts in a population's productive repertoire are by no means extraordinary; peoples' subsistence and industrial output achieve punctuated equilibria with their social and natural environment (*eg* Roux 2003; Shennan 1999).

Given the continuing high communication costs in the Lamet uplands, it is quite reasonable that a degree of self-sufficiency in iron production was advantageous in an area comprising unstable and overlapping polities until the establishment of the Lao PDR (Stuart-Fox 1997), but perhaps it became culturally undesirable to smelt iron locally, or it was overwhelmingly economically expedient to import it, or the necessary raw materials had become inaccessible or depleted?

The economic expediency scenario may have some historical precedents as Izikowitz (2001, 313) also records that whilst French colonial steel was not in favour with Lao blacksmiths, being too costly and hard (presumably high in carbon), the low-carbon Swedish variety was extremely popular and was traded far into Southeast Asia's upland ethnic minority areas, including that of the Lamet:

> 'Such steel is produced today at a few Swedish foundries, and this only for the purpose of export to the primitive blacksmiths of exotic lands. The Swedish export of this steel has been going on since the 17th century, and it has partially displaced the native production of steel' (*ibid*).

Whilst the commencement of Swedish imports in the 17th century cannot account for the decline of the Saphim workshop some eight centuries earlier, the direct European contact experience does perhaps offer a comparative economic advantage model for the mid/late 1st millennium AD (Shennan 1999). It should be recalled that the Lamet uplands are less than 100 km from the modern border of the Lao PDR and the Peoples' Republic of China (Fig 1). The exact position and character of the southern boundary of the 8th/9th century *Nanzhao* kingdom is not clear (Backus 1981), but Tang dynasty iron production, by both direct (bloomery) and indirect (blast) methods, was operating with potentially substantial economies of scale and organisation, which could reasonably have disrupted or displaced production at the Saphim workshop; local people may have preferred to exchange their labour for 'Chinese' iron (Wagner 1993). We are not as yet overwhelmed with evidence for contemporary iron production in Southeast Asia, although it doubtless exists, but there are a number of places where alternative regional iron supply could have come from. There is not as yet overwhelming evidence for contemporary iron production in Southeast Asia, although it doubtless exists, but there are places from which an alternative regional iron supply could have come. These include Thailand (also attested historically by Izikowitz (2001, 146)), where for example Pornchai Suchitta (1992) investigated a 6th century AD iron smelting site at Ban Di Lung; Burma, also noted for the recent past by Izikowitz (2001, 146), where Robert Hudson (2006, 9) considers that the post 1500 AD furnace he excavated near Popa may have antecedents outside the mid/late 1st millennium AD city of Sriksetra; and Cambodia, where smelting sites associated with the iron-producing ethnic minority *Kuay* people have now been dated as far back as the 8th century AD (see below). So much for attempting to explain the death of the Saphim workshop; what can we offer by way of its life?

The rise of an industry

Firstly, if it is assumed that an 8th/9th century upland population in the Saphim area employed a comparable subsistence regime of swidden agriculture plus hunting and gathering as the modern Lamet, then they would have had an understandable need for iron tools and weapons. As mentioned earlier, we are not talking about the 'origins' of Lao ferrous metallurgy based on the current Saphim evidence. The intervening 1300-1400 years from the start of the Southeast Asian Iron Age presumably allows sufficient time for ferrous metallurgy to have been largely assimilated by most groups that wished to do so, given the constraints of high quality raw materials and the maintenance of a body of specialised technical knowledge (Pryce and Natapintu 2009). Thus a mechanistic or pragmatic rather than social display interpretation of upland iron demand and supply is quite feasible.

The potential complication comes when the scale and the organised nature of the Saphim workshop is considered. Only the terminal furnaces, F and Q, have been dated and it is not be certain that either they or the intervening structures were in literally simultaneous operation. However, for such a linear arrangement (Fig 4) to have arisen, at least two furnaces must have been visible at the time a new one was built. As the workshop's slag dump has not yet been discovered, no evaluation can be made of the standardization of metallurgical behaviour in terms of smelting charge recipe, nor the efficiency and output of the process calculated (eg Charlton *et al* 2010; Pryce *et al* 2010). Nevertheless, global experience with pre-modern iron smelting technologies suggests that furnaces of a similar size to Saphim furnace Q could produce several kilos of iron with each operation. If this is multiplied by the number of re-linings (at least seven), and again by the number of furnaces (at least seven), a picture is beginning to emerge whereby the potential metal output of the workshop seems in excess of the needs of small (a few hundred persons) villages like present day Saphim and Talouy.

In terms of organisation, furnaces the size of Saphim Q cannot be operated by one person. A family or clan group could certainly handle the workload, which is not inconsiderable when the major labour requirements of mineral extraction and preparation, charcoal production, clay processing, and the all-important air blast provision (bellows) are taken into account. What though if more than one furnace was operating at the same time, as could be interpreted from their layout? One can speculate that although the labour for multiple furnace iron smelting could be provided from one village, it would more probably require inter-clan or even inter-village cooperation. This requirement for the effective coordination of individuals' actions does not correlate well with the present day and historic Lamet data for social groups relatively undifferentiated by status and authority. This is not of course to say that the Saphim workshop could not have been operated in multi-furnace mode by Lamet ancestors, but rather that the social groups responsible may have had a slightly more hierarchical structure than the extant Lamet records allow (Sprenger 2008; 2010).

For whom was the iron made?

In terms of scale of production three major scenarios can be envisaged. The iron production was for:

- consumption by neighbouring upland groups,
- a means of accessing regional markets, or
- for consumption by a regional polity.

Of these, the first is entirely reasonable and should probably be the default interpretation, though it cannot be demonstrated with the current archaeological data.

The second possibility, production to access regional markets, can be explored using the Lamet ethnographic data. Buffalo ownership is one of the major indicators of wealth in upland Lamet society, key to attaining *lem* status, and the sacrifice of buffalo to the spirits and recently deceased is still commonly practiced at marriages, illnesses and deaths (Sprenger 2005). Although buffalo may be kept in upland Lamet villages they tend not to be reared there, being obtained instead from lowland groups of other ethnicities, which presumably enhances their prestige value. The buffalo are paid for with Lamet labour, in particular their specialisation in carpentry, and the necessarily shared Lamet effort in house building in foreign villages often results in complicated shared ownerships of buffalo (*ibid*). An alternative to the buffalo practice was noted by Izikowitz (2001, 102) in that Lamet males would go to Thailand (then Siam) in order to acquire bronze drums from upland *Karen* ethnic minority groups, which were used as a store of wealth to achieve *lem* status, in the purchase of brides, and in the performance of ancestor rites. Thus it seems that the present and recent historical Lamet have a predilection for the acquisition of 'exotic' items to satisfy their socio-economic needs. It is in this framework that the iron produced at the mid/late 1st millennium AD Saphim workshop could have been used as a medium of exchange for prestige goods. Given the shared labour in iron production, perhaps the resultant 'exotics' might also have had shared ownership, as with the buffalo (Sprenger 2005). Only the excavation of such 'exotic' materials from contemporary settlement sites in the locality may determine if any truth lies in this speculation.

Finally, there is the possibility of the Saphim workshop producing iron, freely or under some form of coercion, for a regional power centre or *müang* as they were beginning to be known in this period for *Tai* speaking lowland groups (Stuart-Fox 1997). Spheres of influence remain unclear but the nearest candidates are *Chiang Saen* (100.088°E, 20.275°N) and *Sipsong Pan N*a (100.797°E, 22.008°N), both of which sit on the banks of the River Mekong in present day Thailand and Yunnan respectively (Fig 1), and could thus have conducted trade and other relations with the Lamet highlands relatively easily via the River *Tha* tributary (Fig 2). Again, whilst the necessary methodologies exist to track iron exchange networks (Leroy *et al* 2012), a huge expansion in the archaeological dataset is needed before this hypothesis can be tested.

The best known contemporary Southeast Asian power centre, Angkor, in NW Cambodia, was in its nascent form *c*800 AD and at no point in the next 650 years did the Khmer Angkorian Empire exercise direct political and economic influence over the Lamet uplands (Hendrickson 2010). Angkor can thus be ruled out as a direct destination for Saphim iron, but it does offer a potential analogy in upland/lowland socio-economic relationships. The ethnic *Kuay* minority have an historic homeland in Preah Vihear province, which also contains Cambodia's only extensive reserves of high-quality iron oxides around Phnom Dek (Fig 1). Late 19th- and early 20th-century accounts of francophone travellers record certain *Kuay* groups as specialising in the production of iron, which was exchanged in ingot form, sometimes serving as money, across colonial Cochinchina (*eg* Harmand 1876). Recently, investigations by Dr Mitch Hendrickson's 'Industries of Angkor Project' and the lead author's 'Iron *Kuay* Project' have identified iron smelting sites in the Phnom Dek region dated to post-Angkorian (15th-16th century AD), Angkorian (9th-15th century AD), and pre-Angkorian (8th century AD) periods (Hendrickson *et al* in press), which provides empirical support to earlier speculation that the ancestral

Kuay may have interacted with, and been integral to, Angkor, due to their provision of the iron needed for the Khmer's intensive agricultural production, vast building programs and fervent militarism (Cœdés 1968). Whether a similar situation exists for Saphim iron has still to be determined. However, as regional metal-related archaeological research continues to attract an increasing number of local and foreign scholars, there may soon be sufficient data for understanding the complex, interdependent relationships that have existed between the populations of mineral-rich upland areas and those of the fertile lowlands of Southeast Asia.

Conclusion

The recording of a well-dated near complete furnace form and the technology it represents provides a solid beginning to understanding the cultural heritage of the Lamet uplands, and also offers a firm basis for comparison with other regional metal industries as they are exposed. Given the presence of iron artefacts in Southeast Asia from the mid 1st millennium BC, earlier sites doubtless remain undiscovered but to the best of our knowledge the Saphim workshop represents the first unequivocal evidence for pre-modern iron smelting in the Lao PDR. Complementary evidence for a definitive interpretation remains sparse, but taking into account local and regional ethnographic and historic data a range of explanatory possible models can be suggested, ranging from local consumption to market exchange or regional upland/lowland hierarchical interactions.

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