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Southeast Asian mainland archaeological science 1964–2034: Multiscalar relations between individuals, communities and neighbouring populations during the Neolithic, Bronze and Iron Ages (early-3rd mill. BC to late-1st mill. AD)

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ABSTRACT

In this paper we seek to summarise the past, present and future applications, impacts and potential of archaeological science methodologies in late prehistoric Mainland Southeast Asian archaeology. The region is large and hosts significant cultural, biological and environmental diversity, throughout its territory and including its bordering areas with China and India. Reconstructing variable and potentially multi-directional intra and inter-regional cultural and biological interactions during the Neolithic, Bronze and Iron Ages, spanning the early-3rd mill. BC to late-1st mill. AD is critical to understanding Mainland Southeast Asia's historical trajectory as a distinct varied and vibrant cultural entity. These broad research objectives have driven a great deal of archaeological scientific investigation over the past six decades, which we review with particular respect to material culture evidence from high-temperature technologies (ceramics, glass and metals) and bioarchaeological data from a range of sub-disciplines. Following that, we propose some suggestions for how Mainland Southeast Asian archaeological science might develop over the next decade, in a way that strictly and systematically benefits regional scholars and students, and integrates the efforts of newer interested parties, with the over-riding aim of making more accurate and nuanced historical syntheses.

1. Introduction

On May 3rd 1964, Chester Gorman and Nai Vidya Intakosai discovered Nam Phong 7, subsequently known as Non Nok Tha, in Khon Kaen province of northeast Thailand, and in doing so arguably initiated modern hypothetico-deductive scientific archaeology in Mainland Southeast Asia (Bayard and Solheim II, 2010; Solheim and Gorman, 1966). To mark the occasion of the Journal's 50th anniversary and Dr Torrence's retirement from an adjacent research domain in the western Pacific, this paper will discuss the application, impact and potential of archaeological science methods for evaluating the role of multiscalar cultural and biological interactions during the regional Neolithic, Bronze and Iron Ages, spanning the early-3rd mill. BC to late-1st mill. AD. This core issue, of unravelling the relative, sequential and intertwined roles of exogenous and endogenous populations in Southeast Asia's historical trajectory was already prevalent in the 1960s, much influenced by colonial era thinking on donor versus recipient cultures (e.g. 'Indochina'), and continues to be a major field of regional research – albeit one that now seeks to reconstruct the diachronic multi-lateral, multi-directional and multi-mechanism social interactions of variable intensity that led to historic and present-day Southeast Asia. Naturally, there are a great many alternatives that could showcase the vast range of regional archaeological scientific practice, but we choose to focus on high-temperature material culture and bioarchaeological approaches, as well as a summary of regional site detection methodology, due to our combined expertise as an archaeometallurgist and director of a (suspended) generalist archaeological project in Myanmar (Pryce) and a regional bioarchaeologist (Willis). To set the scene:

Firstly, geography. The term 'Southeast Asia' only entered common parlance during World War 2 and is commonly divided into its

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Fig. 1. Map of Southeast Asia and surrounding regions, courtesy of the CIA World Factbook.

Mainland/Continental and Island/Maritime portions. Island Southeast Asia (ISEA) comprises the modern nation states of Brunei, East Timor, Indonesia, Malaysia (Bornean/East), the Philippines and Singapore. Mainland Southeast Asia (MSEA) is composed of Cambodia, Laos, Malaysia (Peninsular/West), Myanmar, Thailand and Vietnam (Fig. 1). All MSEA and ISEA nations are members of the Association of Southeast Asian Nations (ASEAN), with the exception of East Timor, which has Observer status.

Secondly, chronology. Pleistocene Southeast Asia was colonised by *Homo erectus* from 1.5 to 1 Mya (Sawafuji et al., 2024), and by anatomically modern humans by 86–68 kya (Bacon et al., 2021, 2023; Freidline et al., 2023; Higham, 2024a). Regional Late Pleistocene- Early Holocene hunter-gatherer groups are referred to by their lithic techno-complex classifier, Hòabìnhian, rather than the term Mesolithic (Forestier et al., 2017; Marwick, 2008; Shoocongdej, 2022). However, Neolithic is commonly used to describe early agricultural societies in Myanmar, Thailand and Vietnam, who are generally agreed to be the result of a demic diffusion out of southern China from the early-mid 3rd millennium BC (Higham and Higham, 2009; Piper et al., 2017; Pryce et al., 2024c). A Bronze Age horizon, as defined *strictu sensu* by the appearance of copper-base metallurgy in secure contexts, appears with remarkable chronological consistency across lowland MSEA from the 12th-10th c. BC, and is also thought to be Chinese-derived, as per the Neolithic, but not linked to substantial population movement (Higham et al., 2015, 2020; Higham and Higham, 2009; Pryce et al., 2024b; Pryce et al., 2024c). The MSEA Iron Age transition, as defined *strictu sensu* by the appearance of ferrous metallurgy in secure contexts, dates from the 5th, possibly 6th, c. BC and could be correlated with increased interaction with South Asia (Biggs et al., 2013; Glover, 1990; Petchey et al., 2018; Pryce et al., 2006; Pryce et al., 2024c). ISEA transitions, variably, to a Metal Age from the late centuries BC, based upon Bay of Bengal and South China Sea exchange networks (Bellina et al., 2019; Bellwood, 2007). The earliest regional textual records can be found in 1st c. BC Sinicised northern Vietnam (Higham, 1989; Kim, 2015), and in 1st c. AD for the Indianised Pyu culture of central Myanmar (Stargardt, 2016), but the mid/late-1st millennium AD is usually considered the threshold for historical archaeology in MSEA and ISEA (Higham, 2004).

Thirdly, economic and political development. Southeast Asia's varied experience of Western mercantilism during the 17th-18th c. (Andaya and Andaya, 2015; Tarling, 1993a), colonialism in the 19th-20th centuries, followed by Axis occupation and Allied liberation in World War 2, and subsequent entanglement in the Cold War and proxy conflicts (Tarling, 1993b) are critical factors for understanding the differential development of archaeology and archaeological sciences in post-colonial Southeast Asia.[1] Acknowledging ourselves as Western foreigners, our discussion of variable regional capacity is intended to be contextualised with an eye to the future, and not a critique of past and present governance.

Fourthly, diversity. Southeast Asia is a region of exceptional complexity: climatic, cultural, ecological, ethnic, geological, genetic and linguistic. Fundamental to the picture we are attempting to paint is that modern political boundaries absolutely do not equate to past cultural, economic, environmental and/or biological frontiers. As Southeast Asia lays at the eastern terminus of the Himalayan range, and has extensive terrestrial borders with South and East Asia, and immense contiguous maritime spaces, it is not, has never been, and never will be possible to answer Southeast Asian historical questions, whether by archaeological science or any other methodologies, without at least some reference to the much wider interconnected Eurasian and Pacific context. This observation will be central to our concluding remarks.

Fifthly, contingent on points three and four, we return to northeast Thailand in 1964 as the start point of our discussion, despite it antedating the Journal's foundation by a decade. This juncture is often considered the beginning of Southeast Asian scientific archaeology, certainly from a MSEA late prehistoric perspective,[2] as it marks the aforementioned discovery of Non Nok Tha by an American-Thai team fieldwalking in advance of dam construction in the Nam Phong catchment of Khon Kaen Province (Conrad et al., 2020; Solheim and Gorman, 1966). Prior to this, regional archaeology had been largely approached from Western orientalising art historical, culture historical and diffusionist perspectives, which primarily sought to understand MSEA history with respect to that of its perceived dominant neighbours, China and India (e.g. Cœdès, 1968; Pearson, 1962; Saurin, 1969). However, those, predominantly American, archaeologists arriving in Thailand in the 1960s were in the midst of a generational rejection of culture history in favour of the New Archaeology or Processualism in Western academia (Clarke, 1968; Trigger, 2006). Processualists' thirst for measured objectivity and universalising cultural tendencies, led to a desire to identify potentially multicentric origins for the development of major human sociocultural and technological achievements, e.g. farming, pottery, urbanism, and metallurgy. Within MSEA, this translated to a search for evidence of 'Indochinese' historical developments that were not necessarily dependent upon pre-existing invention/adoption of those practices in India or China (cf. Childe, 1939 for the Near Eastern equivalent). Furthermore, those archaeologists arrived ready and willing to use any and all archaeological science approaches that might help reveal a more nuanced, multilateral and quantitative regional history. Among Southeast Asian scholars, the post-colonial situation was also ripe for revisionist reconstructions that, not unreasonably, sought to emphasise the agency of indigenous populations (Benda, 1962; Smail, 1961). This confluence of factors meant that the pump was primed for the first, surprising, scientific archaeological results from Non Nok Tha (Solheim, 1968), Spirit Cave (Gorman, 1969) and then Ban Chiang (Bayard, 1972a), in which the original excavators applied radiometric, materials science and archaeobotanical techniques to argue for radically early and controversial chronologies for the regional appearance of agriculture and metallurgy.

1.1. *Southeast Asian archaeological science bibliometry*

Six decades later, and Southeast Asian archaeology remains heavily concerned with chronology, but it is not our objective to review those early results, which have for the most part been heavily revised as high-density, high-resolution and statistically-significant radiometric datasets continue to roll out across wide areas of late prehistoric MSEA (Higham et al., 2015, 2020; Higham and Higham, 2009; Piper et al., 2017; Pryce et al., 2018; Pryce et al., 2024c). Rather, we wish to emphasise that 'modern' MSEA archaeology was scientific from its outset in 1964, though the path of its development has not been linear through space and time. This can be seen in Table 1, which summarises the prevalence of Southeast Asian geographic terms in a selection of the major English-language archaeological science journals over the course of their publication. These search results include articles that only mentioned these countries/regions rather than focused on case studies there but nevertheless give an impression of the distribution of scientific archaeological research. Indonesia has the most returns in ISEA, which represents its enormous size and the importance of Palaeolithic research there (e.g. Ingicco et al., 2022; Simanjuntak et al., 2010), but the Philippines and Taiwan are not far behind for regions considerably smaller in size but with important Pleistocene deposits (e.g. Chang et al., 2015; Ingicco et al., 2018) and roles in the Neolithic Austronesian expansion (e.g. Bellwood, 1991; Blust, 2019; cf. Denham, 2013). Naturally, very small nations like Brunei are barely represented; but Singapore has five times as many returns despite being much smaller, which is probably due to the presence of major academic institutions. Within MSEA, Thailand dominates the results - likely due to it being the first in the region to see archaeological science widely applied (e.g. Gorman, 1969; Solheim, 1968) and, we emphasise, published in English. However, Vietnam is not far behind, reflecting a long history of Soviet-supported and independent national research, and more recent Western-collaborations. Apart from a few notable Palaeolithic and late prehistoric exceptions (e.g. Boulanger et al., 2021; Frelat et al., 2016; O'Reilly et al., 2006; Sophady et al., 2016), most Cambodian archaeological research has focused on its iconic Angkorian period, which was naturally art historical from the outset but has made important archaeometric strides in the last twenty years in remote sensing, settlement archaeology and material culture studies (see papers in Hendrickson et al., 2023). That Laos has the fewest returns of the continental nations is without doubt due to modern archaeological investigations starting within the last thirty years, as a number of important Palaeolithic and prehistoric archaeometric studies have been published recently (e.g. Cadet et al., 2022; Freidline et al., 2023; O'Reilly et al., 2019; Pryce et al., 2011a).

These temporal tendencies are reflected in Fig. 2, which shows Southeast Asian geographical search terms for the Journal over the last fifty years. A Thai study (Higham, 1975) appeared within a year of the Journal's founding, and regional appearances oscillated from zero to six

[1] This phase is extremely complicated but usually refers to the withdrawal of French forces from former Indochina (Cambodia, Laos and Vietnam) at the end of the First Indochina War in 1954; though it was later in Brunei (1984, UK), East Timor (1999, Indonesia), Malaysia (1957, UK) and Singapore (1965, UK); and earlier in Indonesia (1949, Netherlands), Myanmar (1948, UK), and the Philippines (1946, USA); with only Thailand [Siam] having never been colonised by a Western power (Tarling, 1993b).

[2] The Dano-Thai excavation at prehistoric Ban Kao from 1960 also has a solid claim (Sørensen, 1963).

Table 1
A count of Southeast Asian search terms for major archaeological science journals.

Search term	Journal of Archaeological Science (1974–2024)	Archaeometry (1958–2024)	Archaeological and Anthropological Sciences (2009–2024)	Journal of Archaeological Science: Reports (2014–2024)	Total
Southeast Asia	344	72	147	281	844
Brunei	2	3	3	0	8
Cambodia/ Kampuchea	49	21	21	39	130
Indonesia	96	27	29	72	224
Laos/Lao PDR	25	5	16	15	61
Malaysia	50	13	17	25	105
Myanmar/Burma	36	17	16	31	100
Philippines	71	15	24	52	162
Singapore	25	7	1	8	41
Taiwan	37	21	21	39	118
Thailand	126	49	55	83	313
Timor Leste	7	1	6	8	22
Vietnam	44	21	30	55	150

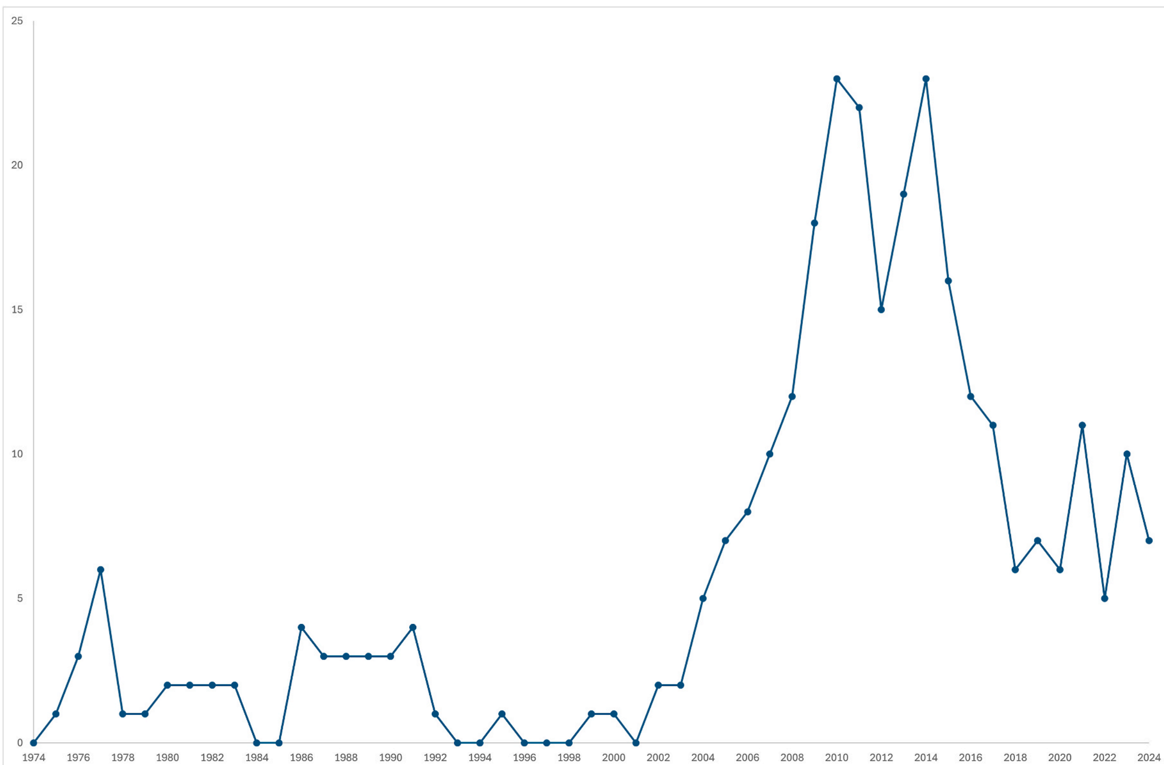

Fig. 2. Frequency of Southeast Asian geographic search terms appearing in the Journal of Archaeological Science 1974–2024.

for the next quarter century. However, from the mid-2000s there was a boom in Southeast Asian publications that lasted for about a decade, with the apparent decline doubtless corresponding to the founding of *Journal of Archaeological Science: Reports*, which saw a good proportion of regional output diverted there. Annual output in the journal over the last decade varies from five to ten papers per year, which could be argued to be on the low side for such a large region but also reflects ongoing discontinuity in the application of archaeological science methods that have a potentially global impact.

1.2. Challenges of conducting research on multiscalar relations between individuals, communities and neighbouring populations during the MSEA Neolithic, Bronze and Iron Ages

Naturally, generating interpretations for local, regional and inter-regional interactions relies on building chains of archaeological inference between assemblages that have reasonable chrono-spatial contiguity for human-scale movement. Notwithstanding the five major rivers, the Irrawaddy, Nu Jiang-Salween, Lancang-Mekong, Chao Phraya and Yuán Jiāng-Red, and their innumerable tributaries that fan out from the Tibetan Plateau and drastically improve regional connectivity, MSEA still has an area of over 2M km^2, which is over 50% larger than 'Western Europe' ("UNSD — Methodology," n.d.). Furthermore, of those 2M km^2, 30+% are classified as mountainous (Xiao et al., 2018), ca. 50% are forested (Dong et al., 2014), and the vast majority have a heavily erosional/depositional sub-tropical/tropical and monsoonal climate (Chang et al., 2005). These factors make MSEA archaeological sites hard and/or expensive to find on a systematic basis across much of the territory, which when combined with the relatively low numbers of archaeological practitioners and researchers, means regional site catalogues are dominated by historical monuments and mounded prehistoric settlements and cemeteries on the intensively farmed plateaux. Topographic, climatic and geomorphological characteristics mean archaeological science approaches to MSEA landscapes thus have the potential to be invaluable.

The importance of an elevated perspective was recognised during and after World War 2, when Peter Williams-Hunt took nearly 6000 aerial photos over Cambodia, Malaysia, Myanmar, Singapore and Thailand https://digital.soas.ac.uk/msea. While these images offer an unparalleled glimpse of the region at the cusp of industrialised agriculture, they were limited in spatial coverage, mostly concentrated on already-known historic monuments, and could not account for tree cover, but they did allow for the detection and classification of dozens of moated prehistoric sites in northeast Thailand and northwest Cambodia in the 1970s and 1980s (Moore, 1988, 1990; Supajanya and Vallibhotama, 1972). Historical projects have dominated subsequent regional approaches, with Shuttle-flown Spaceborne Imaging Radar-C/X-band Synthetic Aperture Radar (SIR-C/X-SAR) and Airborne Synthetic Aperture Radar (AIRSAR) targeted at the famous 9th-15th c. AD Angkor Wat complex (Evans et al., 2007; Fletcher et al., 2008; Moore et al., 2007; Moore and Freeman, 1997; Pottier, 1998). Damian Evans took this enterprise to the next level with helicopter-flown Light Detection And Ranging (LiDAR) allowing reliable vegetation penetration for the first time, and giving outstanding results in the detail revealed of everyday life, habitations and domestic water tanks nestled among the temples, many of which were followed up with Ground Penetrating Radar (Fletcher et al., 2015 and subsequent papers in this volume). Evans' LiDAR coverage expanded across major historic (Evans et al., 2015; Hendrickson and Evans, 2015) and prehistoric (O'Reilly et al., 2017) sites, to offer a diachronic view of Cambodian human-environment dynamics (Evans, 2016; Klassen et al., 2021). A subsequent project, "archaeoscape.ai", began in 2020 to combine LiDAR with artificial intelligence and machine learning, and expand coverage across monsoonal Asia in order to understand the relations between heritage and the contemporary environment. PI Evans' untimely death in 2023 was a grievous loss not only to Southeast Asian archaeology but also to tropical remote sensing research globally.

Other efforts have been made at MSEA site detection and landscape rationalisation using publicly available remote sensing data, including the use of Google Earth imagery to identify 150 undocumented moated sites of varying size and age in northeast Thailand (O'Reilly and Scott, 2015; Scott and O'Reilly, 2017). Statistical evaluation of these spatial data permitted the rejection of previous, implausible, hypotheses of random site distribution, arguing instead for clustering with river systems and altitude as factors (Yang et al., 2024). An expansion of such, relatively cheap, image screening across the region, with ground truthing for relative dating by surface ceramic assemblages, would be a great advance. As regards multispectral remote sensing data, an abortive attempt was made to detect prehistoric primary copper production sites with Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data but the instrument's spatial resolution was too low to calibrate known sites of 3–5 ha, whose elemental signatures were also insufficiently different from their surroundings (Pryce and Abrams, 2010). Nevertheless, the derivation of vegetation indices from such datasets could be of use for detecting anthropogenic anomalies in the landscape, be that due to lead or copper pollution resistant species growing preferentially at metal production sites, or in detecting introduced agricultural or associated pest species in formerly inhabited areas. Projecting to 2034, it can only be hoped that falling costs for drone-portable LiDAR and improving access to intense computer processing means that this vital approach can be expanded more widely across the region, to cover forested upland regions with very low present-day population density but occasionally surprising heritage resources (e.g. Evrard et al., 2016). Even in lowland regions without dense vegetation, having a more contiguous understanding of settlement patterning would reinforce regional interpretations, which must frequently jump hundreds of kilometers between pools of evidence.

2. High temperature material culture

2.1. Glass

Notwithstanding the vital role played by other sub-disciplines from A (rchaeobotany, Fuller and Castillo, 2021) to Z(ooarchaeology, Piper et al., 2014), scientific approaches to material culture have been fundamental to appreciating the scale and complexity of local, regional and inter-regional interactions. By far the most thoroughly studied artefact class is that of glass, which appears in funerary, settlement and industrial contexts from the 4th c. BC for MSEA and in ISEA from the 1st c. AD, usually in the form of beads and often in vast quantities. These glass ornaments were initially thought to have been exclusively Indian imports and thus evidence of a unidirectional exchange with South Asia (Carter, 2016) but, building upon previous typological (Francis, 2002) and archaeometric (Brill, 1999) research in neighbouring regions, high resolution elemental (LA-ICP-MS) analysis of glass samples spanning MSEA and ISEA consumption for over two millennia began in the late 1990s (Dussubieux and Gratuze, 2003). Regional glass was available in a wide range of colours, which might have, at least initially, been imitations of semi-precious stone ornaments, also of South Asian derivation (Dussubieux and Bellina, 2018). While there is still no solid evidence of early primary glass production in MSEA/ISEA, secondary glass production abounds in the form of cullet, rods and fused masses of misfired beads (Carter, 2016; Dussubieux and Bellina, 2018). When combined with the thousands of LA-ICP-MS glass analyses that have permitted statistically-significant definitions for a genealogy of Asian glass types and recipes (e.g. Carter et al., 2022; Dussubieux, 2021a, 2021b; Dussubieux et al., 2022; Dussubieux and Soedewo, 2018; Wang et al., 2021), regional glass research affords an increasingly detailed picture of the complex spheres of elementally-defined multilateral interactions spanning the entire Indian Ocean and South China Sea basins from the mid-1st millennium BC. Furthermore, inspired by combined Sr-Nd- Pb isotopic glass provenance research in the Mediterranean basin (Degryse and Schneider, 2008), new analyses began to test the isotopic homogeneity of elementally-defined glass groups (e.g. m-Na-Al), with the ultimate interpretative ambition of inferring geochemically accurate provenance in both South Asian production (Dussubieux et al., 2022) and MSEA consumption (Dussubieux et al., 2024) assemblages. This work is very much ongoing and can be expected to expand across the region in the next decade, adding important data density and quality for interpreting what is, if we consider glass ornaments as an inorganic proxy for less well-preserved materials, the phased development of what would become known as the Maritime Silk Road (Bellina et al., 2019).

2.2. Metals

2.2.1. Copper-base

Bronze, its production, consumption and technological origin, has been an overt focus for Southeast Asianists since well before Non Nok Tha's excavation, initially due to (Childe, 1944) associations between metals and civilisational stages (Pearson, 1962), but subsequently in the context of claims for regional exceptionalism in the lack of such associations (Muhly, 1988), and ongoing in that such assumptions hold but only to a very limited extent (Higham, 2024b). While the social context of MSEA metallurgy is of critical importance, here we focus on archaeometallurgical evidence for diachronic multiscalar interaction; from which part of the social impact is derived. Based upon Anthropology of Technology approaches to material culture, detailed technological reconstructions of metallurgical behaviour are fundamental to establishing reliable chains of inference for the intensity and directionality of relations between artisans based upon their communities of practice (Pryce et al., 2010; Pryce and Pigott, 2008). However, any chain is only as good as its weakest link. At present the links for MSEA prehistoric primary copper producing (mining and smelting) loci are few and far between; not least as the metallogenic regions most likely to host primary production sites are precisely those mountainous, forested and low population areas where they are hardest to find (Pryce, 2013; Pryce and Abrams, 2010). The nodes for secondary copper production (alloying, casting) assemblages are more regularly distributed among settlements but, with very few exceptions, the assemblages are insufficiently studied archaeometrically; though there is certainly a regional trend for small (ca. 50–100 ml), spouted vessels with a siliceous refractive layer (Cawte, 2011; Vernon, 1996; Vernon et al., 2018). In terms of final products, prehistoric MSEA copper-base consumption assemblages are, due to aforementioned site detection biases towards mounded settlements with residential burials on plateaux, mostly funerary in nature, with the amorphous/fragmentary finds from accidental discard often disregarded (cf. Hamilton and White, 2018; Higham, 2012; Pryce and Higham, 2025). The artefacts themselves, often very corroded in the tropical climate, tend to be utilitarian in their form (e.g. axes, spears) and relatively simple in their production methods (e.g. bivalve cast with sockets, edge hardening), certainly for the Bronze Age – and in any case nothing comparable to contemporary elite Chinese piece-mould cast bronze metallurgy. Only in the Iron Age do we see larger and more complex castings, forgings and decorations for bells, bowls, drums and mirrors, many of which can be reasonably traced to South or East Asian types (Pigott and Pryce, 2022; Pryce and Pigott, 2024).

For primary copper production evidence, the far-sighted efforts of the Thailand Archaeometallurgy Project (TAP) in the 1980s and 1990s identified site complexes at Phu Lon and the Khao Wong Prachan Valley, in northern and central Thailand, respectively (Pigott et al., 1997; Pigott and Weisgerber, 1998), which both have tolerably recent technological reconstructions (Pryce et al., 2010, 2011a). In the mid-2000s, the Vilabouly Complex in central Laos was added to the regional evidence, after its discovery during modern mining activity (Sayavongkhamdy et al., 2009). It too has been subject to detailed laboratory study (Cadet et al., 2022; Pryce et al., 2011a), as have a series of satellite smelting sites in the vicinity of the Khao Wong Prachan Valley (Cadet et al., 2024). All these MSEA prehistoric primary production sites share a common technique of crucible-based reduction of nearby copper ores; though techniques vary across time and space in terms of their proficiency, intensity and productivity (Pryce et al., 2024a). Although MSEA specialists suspect additional sites remain to be found, based on current evidence, we are obliged to leap 535–1165 km for broadly contemporary primary production sites in Yunnan at Longbohe (Fu et al., 2024) and Guangfentou (Zou et al., 2019), as none are known from northern Laos, Myanmar or Vietnam (Pryce et al., 2024b).

While identifying technological homologies is of great interpretative potential, we are on much firmer ground with copper-base provenancing research which, although less widespread than glass, does allow us to push back up to seven centuries from the mid-1st to the late 2nd millennium BC. Initiated by the TAP in the mid-1980s (Pryce et al., 2024a), lead isotope-based approaches to reconstructing copper and lead exchange networks gathered pace during the 1990s and early 2000s (Hirao and Ro, 2013), before becoming widespread and systematic with the founding of the Southeast Asian Lead Isotope Project (SEALIP) in 2008 (Pryce et al., 2011b). SEALIP began by characterising the known prehistoric copper production sites (Pryce et al., 2011a) and, once the ‘Provenance Hypothesis’ (Wilson and Pollard, 2001) was demonstrated, moved on to consumption sites across the region (Pryce et al., 2014a). The current database numbers over 1300 samples, from production and consumption assemblages spanning 1200 BC to AD 1700, from over 130 sites in MSEA: Cambodia, Laos, Myanmar, Thailand and Vietnam, ISEA: Indonesia and the Philippines, as well as neighbouring regions to pursue Southeast Asian research questions, Melanesia: Papua New Guinea, South Asia: India and Sri Lanka, and East Asia: China.

Focusing on the late prehistoric MSEA dataset, SEALIP is now able to identify social interactions at a wide range of scales and distances. Whereas twenty years ago, regional copper-base metallurgy ‘came from China’, archaeometallurgical data processed using Leiden community detection algorithms with regionally-adapted consistency parameters now allow us to distinguish Bronze Age population-scale networks between southern China, Laos, Myanmar, Thailand and Vietnam. These mostly appear to follow the paths of major rivers, the Irrawaddy, Nu Jiang-Salween, Lancang-Mekong and Yuán Jiāng-Red, as well as the historically-attested routes of the 7th-11th c. AD Southwest Silk Road (SSR) (Pryce et al., 2024b). Many of these relations need further testing with typological and other complementary datasets, but the algorithmic-processing allowed for the detection of potential community-scale interactions between sites, e.g. Non Nok Tha and Haimenkou, separated by 1100 km geodesic, though largely connected by the Lancang-Mekong. Detailed ongoing collaboration with Chinese archaeometallurgists should soon reveal the likelihood of these extremely long-range links. At the much smaller scale of central Thailand, SEALIP can reliably detect inter-community relationships within and between metal producers and consumers surrounding the Khao Wong Prachan Valley; including the novel distinction that local Iron Age copper smelters were systematically importing bronze (Pryce et al., 2024a), potentially from the Vilabouly Complex (Cadet et al., 2019) and arguably using their immediately-available commodities to secure access to salt and/or exotic glass, stone or metal ornaments (Pryce et al., 2024a). Moving less than 200 km east to northeast Thailand, SEALIP research at the mid-late Iron Age settlement of Non Ban Jak has managed to identify detailed copper-base consumption behaviours in funerary rituals, in the deposition of groups of similarly-alloyed and sourced bracelets and rings, in addition to compositionally-dissimilar ornaments that might have been those worn during the deceased’s life. These patterns can be detected between burials, not only at Non Ban Jak, and at nearby cemeteries, but with individual middle-aged males buried over 200 km southeast at Phum Snay in Cambodia (Pryce and Higham, 2025); supporting regional strontium isotope-derived hypotheses for matrilocality (Bentley et al., 2021).

Needless to say, this level of resolution is not generally possible but it is a regional and transregional ambition. Achieving this ambition will require the combination of several factors of varying difficulty. Firstly, it is necessary to build a geochemical dataset for regional copper and lead mineralisations, which exists to some extent but does not include lead isotope characterisations. Such research is underway, starting with the Lead Isotopes for Archaeology, Geology and Industry in Thailand (LIAGIT) project, and from there, we must build collaborations with geologists in neighbouring countries to produce reliable lead isotope coverage, and eventually meet up with the highly developed Chinese geochemical datasets along the 2500 km border with MSEA. To pursue proto-SSR interactions into South Asia, it will also be necessary to generate geochemical datasets for Bangladesh and India, at least in the regions immediately adjacent to MSEA, which will be a huge collaborative endeavour.

Secondly, we need archaeometric investigations of regional metal assemblages to be systematic rather than exceptional; and to contribute towards building a MSEA typology, which as yet does not exist. Accessing museum collections will probably remain difficult (Le Meur et al., 2021) but minimally-invasive portable laser ablation sampling methods may help (Seman et al., 2021). More viable is that every current excavation, as far as is possible, includes a reasonable budget for archaeometallurgical analysis, or makes sure their assemblage is dealt with by a specialist. On the subject of which, it is evident that one team cannot and should not do everything, and friendly competition to SEALIP has now entered the arena (Yang et al., 2024), which should be of benefit to all.

Thirdly, in addition to the lack of geochemical data for regional mineralisations, we need regular archaeometric study of secondary production assemblages, so we can at least assess compatibility between finished artefacts and foundries, even if we cannot link all the way back to smelters and mines. This work in underway in central and northeast Thailand, at Ban Non Wat, Khao Sai On and Non Nong Hor, so we can begin to identify the source of raw material commonalities between the aforementioned cemetery assemblages.

Finally, we need to develop data processing algorithms, whether by community detection or other statistical means, that can reliably identify historically pertinent groupings of artefacts over multiple scales of analysis. The method developed for the SSR (Pryce et al., 2024b) was experimental and designed to answer only one question for one region. We do not suggest the development of a universal method (Killick et al., 2020) but the recognition that each research question and geological context might require its own approach, which can hopefully be stacked to pursue longer range exchanges.

2.2.2. Ferrous

Aside from the interpretative window opening in the mid-1st millennium BC, much of what we wrote for copper/lead applies to early MSEA iron and steel, except the task is more daunting. While ferrous technologies have long been recognised as important in terms of agricultural and/or martial efficiency, their origin and development received less regional attention than those of copper/bronze. This is partly because the environment is not conducive to the preservation of detailed artefact typology, but also due to an overly-zealous application of Childe's (1942) 'democratisation of metallurgy' concept; such that as potential iron ores were thought practically ubiquitous, it was not worth committing resources to investigating early iron/steel production and exchange (Pryce and Natapintu, 2009). This perspective was not universal, as the wealth of ethnographic-attested iron metallurgy showed great socio-cultural promise (Bronson and Charoenwongsa, 1986). Prehistoric smelting sites were studied in central and northeast Thailand during the 1980s (Nitta, 1991; Suchitta, 1992), and there was even a slag inclusion analysis (SIA) based provenance study at Ban Don Tha Phet in west-central Thailand (Bennett, 1982), just a few years after the method was proposed in Oxford (Salter, 1976). Nevertheless, MSEA prehistoric primary iron production was not to be investigated in detail again until the 2000s, at Ban Kao Din Tai in Thailand (Venunan, 2016; Venunan et al., under review; Lertlum et al., 2008), at Sungai Batu in peninsular Malaysia (Chia and Mokhtar, 2011) and at Lung Leng in central Vietnam (Nguyễn and Lê, 2005). Despite the very frequent finds of smithing hearth bottoms on prehistoric settlements, only one forge has ever been provisionally identified (Petchey et al., 2018) and iron artefact assemblages also need a great deal more attention (Biggs et al., 2013). Although an undoubted advance, to build trans-regional chains of technological inference and geochemical linkage, a great many more ferrous-metallurgical loci must be excavated and thoroughly analysed given the likely density, though not ubiquity, of iron smelting loci across the landscape.

Indeed, we can turn to MSEA historical research for inspiration, which has not only shown that production sites can be detected in mountainous, forested and low-population areas when collaborating with specialists who spend a great deal of time on fieldwork (e.g., ethnologists in northwest Laos, Evrard et al., 2016; Pryce, 2013), but also that concerted efforts to reconstruct the nature and sequence of iron smelting technologies and iron supply networks for the Angkorian empire can generate critical data for regional state formation and development (Hendrickson et al., 2017, 2019; Hendrickson and Leroy, 2020; Leroy et al., 2015; Pryce et al., 2014b). To match this interpretative resolution for prehistoric periods, research should focus on just a few iron producing and consuming areas with a strong potential to impact broader, social, economic, political and environmental understanding of MSEA's development – again central and northeast Thailand, as well as Cambodia. This is not to disregard more peripheral areas but due to pragmatism in sustaining costly fieldwork and laboratory intensive investigations, which might fail to reach critical mass if attempted at a large scale from the outset. Furthermore, critical attention should be given to those areas that border potential metallurgical transmission routes from South and East Asia: namely the Thai-Malay-Myanmar Peninsula and northern Vietnam. Prehistoric iron has enormous potential for regional study but getting major results might be more a 2044 than 2034 horizon.

2.2.3. Tin, silver and gold

Historically, MSEA was not known for copper and lead, but rather tin, gold and, to some extent, silver. Exploitation of the region's enormous tin reserves, which run from Sumatra up the Thai-Malay Peninsula into Myanmar, Laos and Yunnan (Schwartz et al., 1995), was known from Arabic documents of the late 1st millennium AD (Tibbetts, 1978) and was a major industry into the mid-20th c. However, analysis of crucible slag from the 4th-2nd c. BC entrepot and industrial site of Khao Sam Kaeo on the Gulf of Siam coast, revealed a cassiterite cementation process, likely for the production of high-tin bronze alloys (Murillo-Barroso et al., 2010), and with potential technological links to India (Pryce et al., 2017). Efforts were made to characterise Thai tin deposits by their trace element chemistry in the late 1980s (Coote, 1990), and we consider tin provenance of the utmost regional research importance, as it is one of the Southeast Asian commodities, alongside forest products, likely to have been exchanged along the Maritime Silk Road. Regional cassiterites have not yet been assessed for their lead isotope signature, nor their possible contribution to bronze artefact signatures (Molofsky et al., 2014), but tin isotope characterisations (Haustein et al., 2010) are of great potential as tin-bearing plutons erode to form placers on river systems that may be associated with distinct peninsular polities (Bellina, 2018). Thus, we might be able to detect the participation of individual communities in very long-range exchange systems.

MSEA hosts several traditional silver producing areas, the prehistory of which is unknown, or at best vaguely hinted at in the case of Bawdwin, Shan State, Myanmar (Pryce et al., 2024b). Gold production continues to the present day, both industrially in Laos and Thailand, and artisanally by panning widespread across the region – nothing is known for prehistoric production but occasional ornament moulds could conceivably have been used for casting precious metals. Gold and silver-alloy artefacts are known from the Iron Age, ca. 1st c. BC but have rarely been studied in significant quantities; with the major exception being Schlosser et al.'s (2012) elemental analysis of silver and gold artefacts from Prohear, Cambodia, which should doubtless be expanded. Naturally, silver alloys are susceptible to be studied by lead isotope approaches but this has only happened for a handful of artefacts at mid-late Iron Age Non Ban Jak in northeast Thailand (Pryce and Higham, 2025). Clearly, precious metals offer great potential for prehistoric research and hopefully the proliferation of minimally-invasive sampling techniques will assuage curatorial reservations about analysing 'treasures'.

2.3. Pottery

We consider that due to their relative ubiquity, domestic ceramics are, or should be, the most important material culture class, high temperature or otherwise, for the study of pottery-using population interactions. That they are not currently perceived as such for MSEA prehistory can only be considered a research opportunity of vast proportions. This is far from saying that no ceramic analysis has been done, as pottery has been consistently considered on prehistoric excavations, from Non Nok Tha (Bayard, 1972a,b) and earlier at Ban Kao (Nielson, 1961), and even vast and comprehensive tomes as for Khok Phanom Di (Vincent, 2004) but despite early promise for interpreting long-range cultural exchanges (Sørensen, 1963), the most common artefact class on post-Neolithic sites has not coalesced into a regular and reliable means of inferring multiscalar interaction. This translates into late prehistoric MSEA not having regional pottery typologies that can be referred to for even such fundamentals as the relative-dating of neighbouring archaeological cultures. This has partly been due to pottery studies generally concentrating at the scale of a site or site cluster, with only relatively minor typo-technological (but more stylistic) variations between traditions, but also because each MSEA country has its own language and script, hindering mutual comprehension between grass roots practitioners, and there simply have not been enough trained ceramicists engaging in chrono-spatially wide-ranging studies. Notable exceptions include two ambitious Neolithic pottery studies, covering southern Vietnam in detail (Sarjeant, 2014) and from Yunnan to Thailand in scope (Rispoli, 1997, 2007), as well as laudable efforts to harmonise late prehistoric sub-regional sequences (Higham and Rispoli, 2014; Onsuwan, 2003). For the Iron/Metal Ages, in addition to broad-ranging stylistic approaches (Yamagata and Matsumura, 2017), there have been substantial advances made with purist *chaîne opératoire technique* analyses of Bay of Bengal and South China Sea wares, with increasing petrographic and provenancing components, and which have absolutely elucidated unimagined and extremely complex social interactions in the littoral and maritime arena (Bouvet, 2017; Favereau, 2018; Favereau and Bellina, 2016). For the sake of comparison, we also note the recent proliferation of elemental compositional (Grave et al., 2021; Polkinghorne et al., 2019; Thirion-Merle et al., 2019) and fewer technological (Stark and Fehrenbach, 2019) approaches to the study of historical MSEA ceramics, and contrast these approaches with the greatest MSEA prehistoric lacuna: Bronze Age pottery. The challenge is comparable to that facing the analysis of ferrous technologies (above) in that assemblages need consistent complete publication of techno-typological data (Favereau et al., 2017; Vincent, 2004), with the advantage that pottery decoration and styles might be more discernible or better preserved than those of iron/steel artefacts, but with potential clay and temper sources even more widespread than those of iron ores. Although a start has been made in some areas, we recommend a combined techno-typological and elemental approach, for its low cost and speed, to rapidly grow domestic ceramic datasets to the point where useful evidence for long-term human interactions may be reliably discerned and interrogated.

3. Bioarchaeology

Focused on analysing human skeletal remains from prehistoric and historic contexts (Buikstra et al., 2022), bioarchaeology developed as a discipline that represented a fundamental shift away from earlier descriptive and morphometric osteological analyses toward a broader contextual approach to understanding the lives of people in the past within the context of their natural and cultural environment (Buikstra, 1977). Recently, bioarchaeological analyses have focused on individual life experiences and social identity, interpreting the lesions on human skeletal remains as a cumulative culmination of adaptive responses to lived experiences throughout life utilising interdisciplinary frameworks and theoretical approaches (Baker and Agarwal, 2017; Cheverko et al., 2020; Klaus, 2012; Zuckerman and Martin, 2016). Temporal developments in analytical techniques, interpretive frameworks and social theory have been integral to the development of the discipline over the past 50 years. Bioarchaeology in Southeast Asia has followed a similar trajectory.

The first synthetic overview of bioarchaeology in MSEA (Oxenham and Tayles, 2006) provided stimulus for future bioarchaeological research in the region (Oxenham and Buckley, 2016). Since then, countless research papers have been written on Southeast Asian bioarchaeology that thematically fall into several key areas. Here, we have chosen a selection of papers that contribute to our understanding of diachronic and multiscalar interaction, with the caveat that this synthesis does not represent all important Southeast Asian bioarchaeological research.

Knowledge drawn from archaeological science is essential for contextualising and characterising bioarchaeological research. Situating our understanding of the life of people in the past relies on palaeoenvironmental, palaeobotanical, palaeogenetic, radiometric, and isotope data to understand the environmental context in which they lived, the resources they relied on, their level of mobility, movement and interaction and how these changed over time.

3.1. Population history

As a region, Southeast Asia is intricately genetically diverse. Bioarchaeological, archaeological and linguistic evidence suggests rice farmers moved into and spread throughout Southeast Asia admixing with the indigenous hunter-gatherers in the area. This is broadly understood as the two-layer hypothesis based on craniodental morphology (Matsumura et al., 2019, 2021). The first layer represents Hòabìnhians, the descendants of anatomically modern humans who were the first settlers of the region, and the second represents Northeast Asians that migrated from the Yangtze River basin area into Southeast Asia and their subsequent genetic admixture (Matsumura et al., 2019; Matsumura and Oxenham, 2014). This process of demic diffusion is clear among some temporally relevant prehistoric communities, for example, Neolithic Man Bac from northern Vietnam (Matsumura et al., 2008; Oxenham et al., 2011), with the presence of both populations captured in the archaeological record. The movement of agricultural farmers throughout Southeast Asia, likely influenced by geographic topography, explains the clinal genetic heterogeneity in prehistoric Southeast Asia, reflecting graduated diffusion from southern China (Matsumura and Oxenham, 2014). The skeletal assemblages these data derive represent a static period captured in time; their morphology represents their genetic ancestry but says nothing about admixture in future generations. Despite that, the patterns are clear and supported by ancient DNA (aDNA). While the preservation of aDNA is notoriously poor in Southeast Asia, due to the hot and wet conditions, where it has been successfully retrieved (Lipson et al., 2018; McColl et al., 2018), it has provided evidence of multiple migratory dispersals in Southeast Asian prehistory and clarity about the population history of the region.

3.2. Mobility and subsistence

Multi-isotope analyses of stable carbon and oxygen, and strontium isotopes in human tooth enamel have provided insight into subsistence practices and mobility among regional communities (Bentley et al., 2021, 2005; Cox et al., 2011; Ikehara-Quebral et al., 2017; King et al., 2015; Shewan et al., 2020). Among mainland Southeast Asian communities in Thailand and Cambodia, rice was focal in the subsistence economies, whereas millet may have been more integral to the diet of early communities in Myanmar (Willis et al., 2023). These differences are perhaps a reflection of the ancestral origin of the founders of these communities with individuals from Thailand, Vietnam and Cambodia showing closer genetic affinity to current Austroasiatic language-speaking people and Myanmar to the current Sino-Tibetan language-speaking people (Lipson et al., 2018; Yang et al., 2020). During the Iron Age, the construction of moats, a community response to increasingly dry conditions and reduced rainfall (Wohlfarth et al., 2012, 2016), saw a shift from dry rain-fed rice cultivation to wet-rice agriculture (Castillo et al., 2018).

Despite evidence for multiple waves of migration into Southeast Asia, analysis of $^{87}Sr/^{86}Sr$ ratios in human tooth enamel generally shows low levels of long-distance migration (Bentley et al., 2009; Cox et al., 2011; King et al., 2015; Shewan et al., 2020), although there are outliers representing non-locals at each site in all periods. Broadly, most of the movement between local communities was at a regional level, and possibly associated with matrilocality (Bentley et al., 2005, 2021). Because gene flow can occur between populations from a single pulse of admixture without continuous migration or demic diffusion (Cox and

Hammer, 2010; Kutanan et al., 2021), these outliers and evidence for community interaction are significant. While evidence for significant and enduring long-distance exchange networks exists (Hung, 2023; Pryce et al., 2024b) the degree of human mobility remains unclear. Research on mobility and migration in Mainland Southeast Asia has relied upon bulk sampling single teeth to identify non-locals who grew up in a different region and came into the community as adults. As the last to form and the best proxy for adult diet, third molars are often preferentially sampled in these multi-isotope approaches. Increasingly, there has been a focus on measuring $^{87}Sr/^{86}Sr$ in tooth enamel from multiple teeth (Hrnčíř and Laffoon, 2019). Analysing multiple teeth, representing different developmental periods may identify evidence for mobility and migration during childhood, otherwise not captured in the latest forming tooth. If identified, it would provide valuable insight into population movement as children moved with their parents.

3.3. Palaeodemography and palaeoepidemiology

Globally characterised by an increase in population size and total fertility rates coincidental with a move from foraging-focused to farming practices, the Neolithic Demographic Transition (NDT) marks a significant period in prehistory influenced by resource stability and sedentism and decreasing birthing intervals (Bocquet-Appel and Naji, 2006). Population growth intrinsically occurs due to an increase in fertility without a concomitant increase in infant mortality. Somewhat paradoxically, the number of deceased infants will correlate with the number of infants born. Due to this circumstance, the proportion of infants to adults in a mortality distribution is predictive of fertility (and the rate of natural population increase), but not a prediction of infant mortality rates. Ultimately, the proportion of subadults in a population echoes patterns of population fertility and growth, which in turn is tempered by the natural balance between fertility and population mortality (Larsen, 2015; McFadden et al., 2022). Based on fertility (Bocquet-Appel and Naji, 2006; Bocquet-Appel and Bar-Yosef, 2008), the palaeodemographic data show stability or decline in birth rates among preagricultural communities followed by significant increases in fertility during the shift to agricultural subsistence practice, which then levelled off or declined around 1000 years later (Bocquet-Appel and Naji, 2006; Bocquet-Appel, 2011).

Reframing these observations in the Southeast Asian context (Bellwood and Oxenham, 2008), the development of techniques to estimate fertility using assemblages where subadults are adequately represented (McFadden and Oxenham, 2018a), or underrepresented (Taylor et al., 2023), and to estimate natural rates of population increase (McFadden and Oxenham, 2018b), and maternal mortality (McFadden et al., 2020; McFadden and Oxenham, 2019; van Tiel and McFadden, 2021) have provided significant insight into how communities adapted during major transitional changes, and the subsequent impact these had on demography (McFadden et al., 2018). Because infants are a sensitive indicator of population growth, an estimate of natural population increase (McFadden and Oxenham, 2018b) was developed using the D0-14/D ratio, which includes infants, and correlates well with fertility rates. Although not sensitive to migration, there is a remarkable similarity in patterns of population growth among contemporaneous communities (McFadden et al., 2018) and they broadly match the global patterns observed during the NDT. With consideration of both birth rates and death rates, this palaeodemographic framework has provided a foundation for examining the transmission of infectious diseases (Vlok and Buckley, 2022) and the effect on maternal health experience over time.

3.4. Health and disease

In contrast to the pattern of declining health observed with the establishment and increasing reliance on cereal cultivation practices in other parts of the world (Cohen and Armelagos, 1984; Cohen and Crane-Kramer, 2007; Pinhasi et al., 2011; Steckel and Rose, 2002), the same trend has generally not been observed in oral and physiological health among MSEA communities (Domett and Tayles, 2007; Domett, 2001; Oxenham, 2016; Tayles et al., 2000, 2009). Due to the complex population history of Southeast Asia, the spatial and temporal variability in health is difficult to reconcile. However, with an increase in skeletal assemblages from archaeological excavations over the last decades, our knowledge of the health of individuals from Cambodia (Domett and O'Reilly, 2009; Frelat et al., 2016; Frelat and Souday, 2015; Ikehara-Quebral et al., 2017; Newton et al., 2013), Vietnam (Oxenham et al., 2018; Wang et al., 2023; Willis and Oxenham, 2013) and Thailand (Buckley et al., 2020; Clark et al., 2014; Domett, 2004; Halcrow et al., 2013; Tayles et al., 2007; Ward et al., 2019) has grown. An increased focus on applying more nuanced, community-based interpretations of life experience and adaptation during different transitional periods will continue to contribute to refining our understanding of the regional story.

3.5. Palaeopathology

A significant development in Southeast Asian bioarchaeology has been the utilisation of threshold approaches in palaeopathological analyses (Vlok, 2023). These diagnostic criteria have been utilised to identify parasitic infections of hydatic disease (Vlok et al., 2022) and thalassemia, a genetic adaptation to malaria (Vlok et al., 2021); bacterial infection of treponemal disease (Vlok et al., 2020); and metabolic diseases of scurvy (Vlok et al., 2024a), and rickets and osteomalacia (Vlok et al., 2024b). Due to the temporal and spatial heterogeneity among communities in prehistoric MSEA and a relatively low prevalence of disease (Vlok and Buckley, 2022), specific temporal trends are difficult to conceptualise, but palaeodemographic data on population growth and density (McFadden et al., 2018; McFadden and Oxenham, 2018b) have assisted in understanding the palaeoepidemiology of disease in the region (Vlok and Buckley, 2022). Interaction was the driving force of disease transmission, rather than climate or diet. Population interaction among mobile low-density communities increased susceptibility to acquiring new diseases, while interpopulation interaction among sedentary high-density communities increased susceptibility to transmission of existing infectious diseases (Vlok and Buckley, 2022).

3.6. Application, impact and future vision

Here we have summarised regional bioarchaeology, and yet barely scratched the surface. Broadly, two major transitions occurred during MSEA prehistory. Firstly, the Neolithic Demographic Transition, where rice farmers moved from northeast Asia into and throughout Southeast Asia, mixing with the indigenous hunter-gatherer populations. Secondly, the Iron Age, where increasing social complexity was associated with changes in land use and farming practices focused on water management and wet-rice agriculture as an adaptation to environmental and climate change (Higham et al., 2019; King et al., 2017). The effect of these major transitions is influenced by regional variation in population history and interaction. Still, palaeodemographic changes associated with these transitions are inextricably linked to the biosocial and biocultural context. The human history here witnesses biological and sociocultural adaptation during transformative transitional periods through variable environmental and climatic changes. With an exciting future, much remains to be done, but only by continuing to embed our observations within contextual data do we have the greatest chance of understanding the past lives of people in these communities. Bioarchaeology has been described as "explicitly interdisciplinary and aspirationally transdisciplinary" (Buikstra et al., 2022, p. 55) and we follow that aspiration.

4. Concluding remarks

In addition to our specific suggestions for diachronic and multiscalar interaction research above, as foreigners who operate as guests in Southeast Asia, we wish to highlight a number of challenges and opportunities for regional archaeological science in the coming decade. Most of these are evident, and many have been practiced by colleagues of all origins for decades but we reiterate them for completeness.

As mentioned in points three and four of our introduction, and cribbing the motto of the European Union, Southeast Asia can be considered 'united in diversity'; be the factors environmental, genetic, geological or geopolitical. It is not academically essential nor financially realistic that each ASEAN state have complete autonomy in archaeological science expertise or facilities - it is neither necessary to reinvent the wheel, nor build Rome in a day. Be it between individual scholars, institutions, nations or regions, collaborative research is usually mutually beneficial, providing key parameters for equity are met for partners of differing means. Projects can have their multiple objectives, serving individual, institutional, national and global interests, so long as the project's common ground ensures Southeast Asian research and training needs are met. Co-publication of results between specialists and generalists should be *de rigueur* and open access to data and resources facilitated as far as possible. If desired and where appropriate, outreach initiatives on project results and looting prevention can have important impacts on public education and engagement with cultural heritage. Archaeological science capacity building, whether in advanced training or the provision of equipment, should be adapted to the needs of the trainee or donee and their institutional situation.

Over the last sixty years, there have been innumerable examples of what we describe above, effected by hundreds of dedicated and generous colleagues from all sides, as well as dozens of Southeast Asian nationals having been successfully trained overseas to doctoral level, and returning home to multiply the effects of their experience through the teaching of their students. Regional conferences like the Indo-Pacific Prehistory Association (IPPA) and Southeast Asian Ministers of Education Organization Regional Centre for Archaeology and Fine Arts (SPAFACON) are locally financed and organised, and their programmes abound with specialised panels covering a wide range of archaeological science approaches. We applaud all that and more but something we would strongly encourage, and consider beneficial for the whole region, is that more Southeast Asian specialists participate regularly in international archaeological science conferences. This is often a question of finances but once trained in an advanced methodology, we all require regular interaction with other specialists to ensure we remain up to date on the latest developments, and that our regional research is disseminated, in person, on a global stage.

Although the criteria and terminology can certainly be debated (CIA, n.d.; UN, n.d.), there can be little doubting the significant upward trend in regional economic and political stability since 1964. A consequence of this is ASEAN states increasingly have the means to enact cultural heritage policy as they see fit, either individually or supranationally (ASEAN, n.d.). To a laudable extent, the years of archaeological 'capacity building' have resulted in a great deal of archaeological capacity built, but we consider it important to recognise the future role of other interested parties. While Western, Japanese and South Korean archaeologists have long been involved in regional archaeology, the last decade, and particularly the Covid era, have seen a great deal more activity from Indian and especially Chinese colleagues and institutions. As stated in the introduction, "it is not, has never been, and never will be possible to answer Southeast Asian historical questions, whether by archaeological science or any other methodologies, without at least some reference to the much wider interconnected Eurasian and Pacific context". Therefore, that those key neighbouring areas demonstrate a commitment to cutting edge, cooperative and collaborative seamless trans-regional archaeological understanding, we consider a most positive harbinger for knowledge generation out to 2034 and beyond.

CRediT authorship contribution statement

T.O. Pryce: Writing – review & editing, Writing – original draft, Conceptualization. **Anna Willis:** Writing – review & editing, Writing – original draft.

Declaration of competing interest

We declare no competing interests and have stated our personal limitations as far as possible.

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