Hongshan Culture: Controversy, Numbers and a Proto-Industrial Design Society?

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The Neolithic Chinese Hongshan culture attracts fascination and controversy in equal measure. It represents one of the highest volumes of diverse jade making with spectacular technical achievements and almost unparalleled variety. While researchers have explored Hongshan culture from different disciplinary perspectives, this research seeks to combine insights across archaeology, anthropology, geology, geochemistry, and history to make a new case for a design led analysis of Hongshan culture jade 'products' from a creative and production technology perspective. Examining Hongshan culture through a design lens creates new insights into the motivations for making jade artifacts, hints at the spiritual significance and socio-technological innovations and provokes the idea that Hongshan may be considered as a neolithic proto-industrial design society. Learning from Hongshan culture can provide new insights and inspirations to meet contemporary challenges and regenerative practices derived from this rich historical context.

Keywords: Hongshan Culture; Industrial Revolution; Jade Age; Neolithic

1 Introduction

Hongshan (Red Mountain) is a neolithic culture from 5,000-7,000 BCE that is increasingly renowned for its advanced artifacts made from hardstone and - controversially - other materials, some of which were considered impossible to shape with available technologies at the time. Centred around Liaoning province in Inner Mongolia in China, Hongshan people evolved from a hunter gatherer society to an agricultural community with tiered social strata, advanced burial practices and religious architecture (Dashun, 1995; Childs-Johnson, 1991; Nelson & Bell, 2014). Archaeological study finds a matriarchal society with evidence of a large female deity several times life size found at the Niuheliang temple site (Childs-Johnson, 1991; Dashun, 1995; Dashun, 2004; Nelson & Bell, 2014; Niu, Wenshu, Jiaxu, 2014). Weapons of war have not been discovered indicating a peaceful agrarian society. The evolution from hunter gatherers to a stratified society with specialised roles liberated Hongshan people to devote significant amounts of effort for making jade artifacts. These artifacts are highly significant indicating sophisticated spiritual and cultural beliefs, distant material sourcing and technical form making

achievements including the earliest iterations of the Chinese dragon or Zhulong (Fig. 1) and the 'C' dragon (Dashun, 1995; Childs-Johnson, 2017). Increasing evidence of carved symbology on Hongshan jade artifacts has been discovered (Anderson, 2012; Dashun and Dianxu, 2014). Symbols are not writing but if confirmed this would date the development of writing to several thousand years before the Oracle Bone scripts that were previously considered the earliest form of writing in China around 3,200 BCE (Liu *et al*, 2021).

This study takes an interdisciplinary approach assessing material across anthropology, history, archaeology, geochemistry, and geology to combine insights across research fields through a design lens for the first time. The methodology initially considers numbers; Hongshan jades appear in collections and are available on the market in far higher numbers that other neolithic groups and much higher numbers than in the official museum collections which number in the hundreds. Leading to speculation and controversies around how these pieces have become available. This has provoked major disagreements on traditional qualitative authentication verses scientific methods tackled by recent publications making significant progress.

The second element studies methods of authentication via scientific and other method to explore the case for volume production enabling more diverse design. A design lens is applied to the examination of a small number of pieces to explore form making and the evocation of meaning leading towards a hypothesis that the large numbers of jades, diversity of form making, evidence of advanced production methods and sophisticated abstracted forms can be reframed as 'industrial' designed production.

Figure 1. A typical Zhulong or pig-dragon form (age unspecified)

2 The Numbers Problem

While the formally recognised numbers of artifacts in museums excavated from Hongshan sites are low, the number proclaiming to be Hongshan or that pass scientific tests appear to be far greater. Even before the discovery of the Niuheliang site in 1983 (Dashun, 1995) earlier discoveries in the 1920 and 1930's (Childs-Johnson, 1991; Childs-Johnson, 2009) of 'unusual' jades had been found in private collections. Emperor Qianlong of the 18th century Qing dynasty rewarded people who brought ancient jades to his court such was his connoisseurship, passion and respect for ancient jade (Bernstein, 2019). The royal collection assembled over 1,000,000 objects during Qianlong's reign including some Hongshan pieces. Since the early 21st century increasingly large numbers of jades, some of which exhibit signs of considerable age have become available on the open market, some for very low prices. Anderson (2012) catalogued collecting over 4,000 pieces of jade verified via what he has referred to as methods of 'internal evidence' of originality, recognising microscopic features including tremolite crystals, spicular crystals, ice rivers, extruded crystals and radio-carbon dating. Reaction to this work diverges significantly with some arguing that all the pieces collected are fakes while others are more cautious admitting that some real pieces have become available on the market. In the intervening years since Anderson's original work a new generation of researchers in China have focussed efforts on the archaeology and minerology for non-destructive authentication of ancient jades making significant progress.

The archaeological finds and market numbers significantly disagree. Anderson (2012) bought Hongshan jades in the 2000's for less than $10 and pieces can still be bought on sites like Ebay and Etsy for as little as £12-£15 with some exhibiting what appear to be signs of age. In fact, the economic model is highly suspect. Sourcing Nephrite jade (most ancient sources have been fully exploited), transporting, roughing out, designing (many pieces are unique in a highly diverse range of shapes thereby unattractive for a copyist) carving, polishing, ageing, packaging, advertising, profit, seller fees and transport to Europe or the USA often with free postage, indicates little or no profit for conventional modes of making and suggests that pieces must have been sourced for extremely low prices. It is difficult to imagine a contemporary economic model possessing these qualities from original raw materials gaining such slow sales. The economic case and high artifact numbers question has not been answered satisfactorily by critics. In 1995 artist Ai Weiwei protested the low prices of Chinese ancient artifacts by deliberately smashing a 2,000 year old Han Dynasty urn bought from a farmer for a few hundred yuan (approx. CNY300=£32 in 2024 exchange rates) (Wai-Ying Beres, 2020).

Research by the author has found that the market is slow with some pieces on sale for months then buyable for significant discounts ranging from 30-50%. The archaeological case is clear that only pieces excavated and authenticated onsite are original and from auction houses that provenance must be available (reinforcing the highly lucrative market of selling jade collections from buyer to buyer). This can lead to a situation where an online sale for a piece regarded by some as fake and others with scientific research as original may be bought for 10,000 times less that its auction value. Auction market values are also accelerating with a 13cm jade Zhulong from the Florence and Henry Irving collection originally estimated at $5,000 selling for $2.295m at Christie's in 2019 indicating the increasing value placed on Hongshan jades (So, 2019).

The economic and legal issues leading to this situation were investigated by the China Daily (2015) reporting 170 arrests in relation to Hongshan relic thefts in Niuheliang. However, the idea of

production from a single era becomes more complex, an example on the Looting China website (2016) shows two Zhulong's (pig dragons) excavated from the same tomb, one of which is original Hongshan around 5,000-7,000 years old and another made in the Song Dynasty (960-1279 CE). Hongshan jades have been found in tombs of various ages including Xiajiadian Lower Culture (2200-1600 BCE), Shang Dynasty (1600-1046 BCE), Western Zhou (1046-771 BCE), Summer and Autumn Period (771-256 BCE), Warring States period (475-221 BCE), and the Qing Dynasty (1644-1911) (Dashun and Dianxu, 2014) indicating potential reuse as grave goods and or later periods of archaistic making.

Hoffman (2007) notes later production era's and differentiates four types of artifacts, including archaic (authentic period piece), archaistic (same or similar style to honour the original made later with no deception intended), reproduction (an intentional copy sold as such with no deception intended) and fake (sold as of the period but made later often with inferior materials and techniques and intended to deceive). Much confusion lies between these four types of artifacts, and they are commonly over-simplified into real or fake obscuring a more complex set of realities.

Underlying the question of available jades is that of population density and production capacity. Capacity for designing and making jades that represent belief systems is an important consideration. Clear archaeological evidence indicating overall population size and available effort is lacking however Drennan *et al* (2017) notes that larger numbers of artifacts are attributed to larger structures linked to communal activities and states that:

> 'Some suggest craft specialization, especially for elaborate ceremonial items of carved stone and pottery, on the basis of their elaborateness and the supposed difficulty of making them, but very little direct evidence of productive organization has been reported.' (Drennan *et al*, 2017, p.51)

Coring studies at Weijiawopu site indicates a population of around 900-1800 people and sample sizes ranging from a modest 45 to 5,893 sherds found at households surveyed at Erbuchi and Sanjia to lithic remnants ranging from 6 to 1,313 at Erbuchi and Fushanzhaung (Drennan *et al*, 2017). The researchers also note that early stage lithic reduction and late stage refinement appear to be spatially separated in villages. In terms of specialization, they note that:

> 'There is no indication of anything even remotely approaching full-time craft specialization. Indeed the modest scope of productive differentiation seen in Hongshan villages would be too minimal even to qualify for the label of specialization by some definitions.' (Drennan *et al*, 2017, p.66)

According to Drennan this indicates that evidence for craft production on a consistent scale is lacking leading to questions around how the high quality making skills, craft skill evolution, passing on knowledge between generations and embedded cultural making practices were socially held and spatially represented. Possibly these pieces were made elsewhere, located away from the scattered Hongshan villages or have yet to be discovered. Since Drennan's work the Cultural Relics and Archaeology data from 2017 shows an increase from 90 to 500 sites and settlements identified including many graveyards distributed around the Niuheliang site (Zhou & Hong, 2023).

A good indication of general Hongshan making capacity is given via the production of a ceremonial platform at Donshanzui estimated at taking 7,000 person days with a local population of 500-1,000.

Assuming a third of the population available as labourers this indicates a construction time of 21-42 days (Drennan *et al* 2017). If we took a modest average total population over a reduced Hongshan period (down from 2,000-1,500 years) of 5,000 people per year of available labour and assumed that 5% (125) were available for half of their time (182 days) taking 30 days to make a jade artifact, a total number of 1,137,500 pieces could have been produced. Of course, the number of days taken to make an artifact coupled with the fact that amulets could have been a much smaller production volume rather than stone tools for other functions plus difficulties in assessing exact making technologies and time taken could vary the numbers considerably.

Why Hongshan people appear to have made more objects than other neolithic cultures has yet to be answered. Potentially a link between spirituality, rituals, customs, and belief systems could be linked to motivating higher volumes. One motivation for specialising and increasing production may be the function of amulets as grave goods. The slow labour intensive production of making jade pieces waiting to be interred with a body would motivate faster production design and may account for some of the lower quality 'rushed' making evident on some pieces. Could a powerful spiritual design to inter people with jade pieces have accelerated methods for an early industrial design culture?

3 Authentication Methods

Authentication provides support to understand the number of jades available, when they may have been made and the mineralogical qualities that make the pieces so alluring from a design perspective. Authenticating jades is complex and practices vary although there are some consistencies, for example looking for patterns of jade infiltration, 'orange peel' surfacing, micro tooled 'hair' marks, the identity of the jade type, tremolite crystallisation, tuft cracks, and most famously 'Bao Jiang' (Xiang, 2007) which is the liquid 'sweat' produced by interred jade to protect itself from the soil, and the design and rendering of form. Xiang (2007) and Criski (2021, 2024) provide expert overviews of these techniques while Nephrite Jade Radix Cultura (2024) provides a comprehensive guide aimed at supporting visual and magnified identification of authentic jades.

Some seller and collector practices increase authentication difficulty by repolishing, staining, sanding areas, oiling and waxing and sometimes even re-shaping in later periods. The author has met sellers of high-end Hongshan jades who describe wearing amulets next to their skin for many years to reinflate the desert desiccated jade and increase its 'Bao Jiang'. Fakers are accused of using acids, alkali, and baking to prematurely age jades although these pieces can be recognised with diligent practice (Xiang, 2007; Hoffman, 2007). Conversely business models, academic, disciplinary, and institutional practices require forms of protection to support trade, scholarship and cultural factors creating barriers to accepting new research and moving beyond traditional assumptions.

Starting with material qualities Anderson (2012) provides significant amounts of evidence via high levels of magnification of tremolite crystallisation and raised crystals as significant signs of ageing based on some early geochemistry work. His work was originally rejected by some, however the weight of recent scientific evidence that follows reinforces his claims to look for scientific evidence.

In the field of geo-chemistry Cook (2013) explored whitening as one of the most obvious chemical weathering characteristics of ancient jades explaining that tremolite crystallisation is identified as the main process that produces this appearance with crystal relief or extrusion as an additional key visible

ageing characteristic. Post burial hydrous minerals or clays are presumed to expand below the crystals slowly over a long period of time pushing the crystals to the surface creating crystal relief. Cook experimented with six destructively analysed samples by slicing and studied via x-ray diffraction exposing the internal ageing processes. In terms of ageing, Cook concluded that:

> '…if raised relief involving pyroxene or amphibole crystals can be demonstrated in a nephrite jade artifact, it implies that the artifact is possibly archaic and that additional evaluation of authenticity is warranted.' (Cook, 2013, p.953)

Chen *et al* (2022) tackle one of the most interesting qualities of ancient jades focussing on weathering effects due to white surface crystallisation. This can be seen on numerous ancient jades and is one of the most cited indicators of age and visible on many, though not all Hongshan pieces.

Huang *et al* (2020) explore Liangzhu (a neolithic culture located in Hangzhou around 1000km south of Liaoning overlapping the later Hongshan period) finds including 'Chicken Bone' (Jigubai) jades that are well known for their solid white appearance. Chemical weathering effects over time on tremolite can turn artifacts from translucent green to a solid white and seriously undermine structural qualities. Lu *et al* (2023) also explore chicken bone jades from bronze age Sanxingdui culture archaeological sites in central China noting that the chicken bone effect is caused by acidic soils and that a neutral pH of 7 or 8 may retard chemical weathering. They add that red staining is likely caused by the presence of FE (Iron) in the soil. Huang *et al* (2020) also discovered a naturally occurring hyaline layer of nanospheres forming on high quality ancient, buried white jades producing a high gloss (Bao Jiang) finish. This has further compounded the weathering verses perfectly excavated jade narratives where jade historically was said to survive burial unscathed. Some may have been confused this with waxing or oiling on some pieces to improve the colour depth and translucency.

Researching colour effects Bao *et al* (2019) tested ancient jades in the Spring and Autumn period Lizhou'ao tomb finding that black staining was created by cinnabar or mercury being poured into the tomb. Human bodies decaying after burial are also thought to affect jades with Chen *et al* (2023) describing how mercury poured into the tomb reacted with sulfur in the corpse producing an alkali that affects jade colour potentially being responsible for black staining. Bao *et al* (2020) researched further using non-destructive ramen spectroscopy techniques to analyse the colouring of ancient jade due to natural chemical weathering. The jades from the Jinsha site in Sichuan were exposed to tests on a variety of colours including green stains. Malachite was discovered as a corrosion product of bronzeware indicating the piece examined may have been buried with bronze which leached into the surrounding soil over time creating a green stain. Several other colours were also examined leading to insights between nephrite jade burial and soil minerals creating infiltration stains.

From a material provenance perspective Casadio *et al* (2006) has proposed a database of excavated pieces using Ramen spectroscopy to identify Fe/Fe+Mg elements allowing jade types to be confirmed. Figure 2 illustrates some of the effects of chemical weathering on jades ranging from tremolite crystallisation, cracks filed with tremolite crystals (ice rivers) raised or extruded crystals, holes made with bow drills, inclusions, to fluorene chemical weathering on an agate piece.

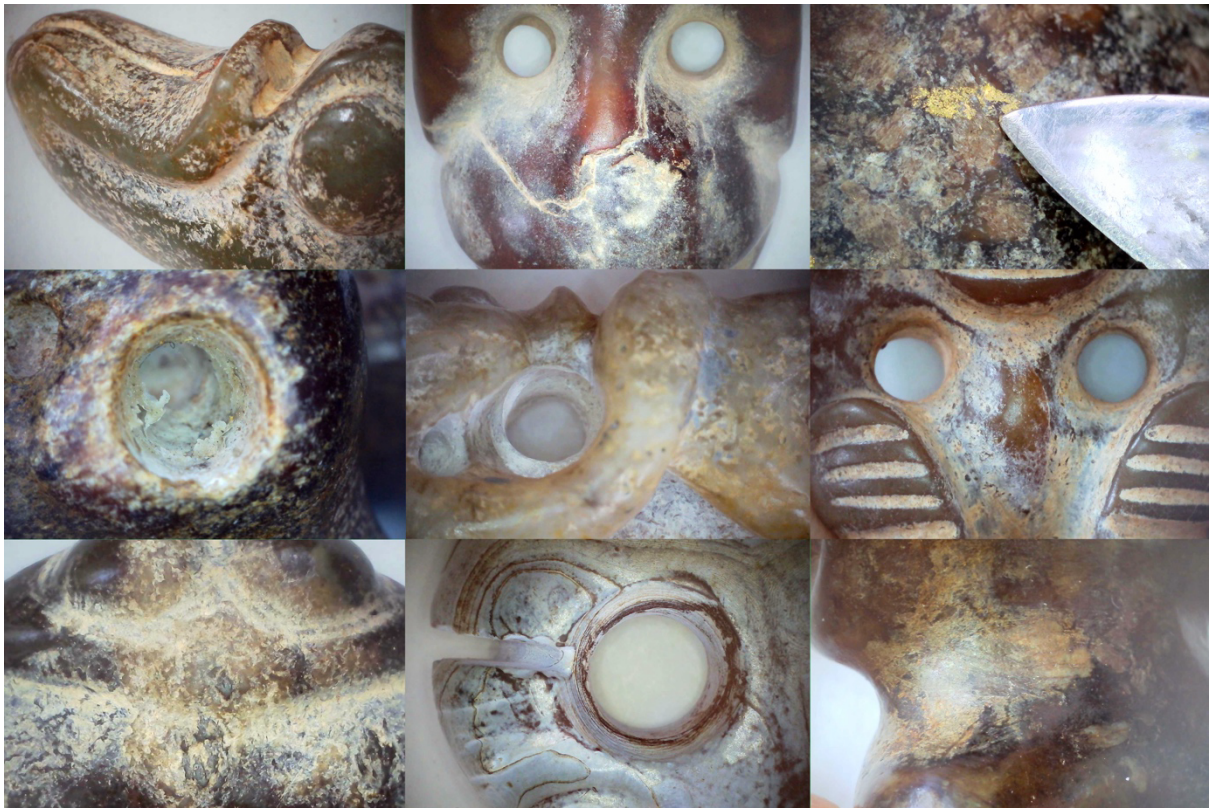

Figure 2. Indications of weathering: tremolite crystals and extruded crystals (Top Left, middle right, bottom left); an 'ice river' (tremolite crystallisation inside a crack)(top centre) on the back of a Helios amulet, large crystals approx. 1mm inside a skull eyehole (middle left), holes bored with a bow drill create uneven internal surface (centre); iron pyrites (actinolite jade contains iron traces) forming over tremolite crystals (top left); a chatoyant inclusion in a snakeskin jade (jade possibly from a mine at lake Baikal in Siberia), an agate piece with fluorine mineral weathering (bottom centre). All pieces viewed under magnification up to a max of 1000x. Images taken from pieces in Figures 3, 4 and 5.

This new body of research in geochemistry can be used to test if much larger numbers of archaic or archaistic Hongshan jades may exist than previously thought. If this is the case, the design potential becomes significant as the diversity of forms available for study increases and the production design and making specialisation processes become an important aspect of diverse volume production.

4 Hongshan Design

Putting aside the originality question and viewing Hongshan as an extended period of making in successive cultures as suggested by grave finds over thousands of years provides an opportunity to explore a widespread diversity of designed form, function and meaning. The form making is distinct from other neolithic cultures including Liangzhu and later bronze age cultures and dynasties including Western Zhou, Warring states and Shang. One of the strongest visual design features of Hongshan artifacts are their Zoomorphic qualities. Lakomska (2020) provides some description of Hongshan designs and their spiritual value describing transformative animal form functions including hawks and owls having the ability to break bonds with the ground, turtles transitioning between land and the ocean, a cicada's embryonic rise after being reborn from beneath the earth, and the snake - Zhulong - or dragon's ability to shed its skins and renew itself. These spiritual forms have an ability to transition between states, burial to rebirth, land to air, land to ocean and refreshing skins. The many different design combinations may imply greater transformative power to the owner.

Larrive-Bass (2023) provides a different case arguing for human bones as a basis for Hongshan jade forms. Some of the examples provided are quite convincing including plaques found close to pelvic bones and skulls and hooked cloud plaques linked to skull features. Others including the zhulong-thyroid and helios to nasal cartilage are less convincing as they have alternative plausible explanations or include other zoomorphic icons. If bones were indeed the genesis for form making it would be a revelation and a considerable challenge to existing ideas of Hongshan form making which have few expressions of the visceral (with the exception of the Hongshan skull).

Figure 3 illustrates a range of Hongshan helios or numen (sun god) forms from unproven era's with differing designs. The first appears to show eating and the second ear covering or hearing while all the helios illustrated have a wide variety of horns or ears emphasised, some of which have carved spirals while others have double pairs (2 and 6). Bovine and rodent forms are evident with eye shape apparently indicating gender, oval for male and round for female. The level of morphing sophistication is impressive and goes well beyond chimerical combinations leaving convincing and beguiling fluid design characteristics. The first two pieces in the middle row are much more abstracted than those of the top row with hands and fingers reduced to a simple set of parallel grooves and eyes rendered as elongated triangles. It's tempting to think that the abstracted forms are from a later era and the more representational ones are earlier, although they may have evolved for different functional or spiritual reasons or in different Hongshan locations.

Figure 3. Variation of Helios 'Sun God' forms from top row: highly zoomorphic to middle row left and centre highly abstracted, middle right hollowed out to bottom left and centre stacked skull heads and bottom right late Hongshan era protruding eyes (not to scale, age unproven).

Holes form critical functions both practical and spiritual. Criski (2021, 2024) amongst others have proposed that the holes perform a spiritual function by allowing prayers and blessings to exchange, effectively connecting the inner spiritual and outer human world. The first helios has a side hole that

is carefully positioned to support the hand-face junction while the second red helios has a beautiful fluid line between the arm and the ear visible in side elevation. Helios 6 is of the hollowed out form type where as many as 10 different bow drilled holes can be seen. Assuming the internal-external exchange significance these types of very difficult and laborious forms could have much higher value and power with a greater surface area. Holes also add an animated quality without which the jades would appear as more static forms. The first two helios in the bottom row show the Hongshan relationship with skulls which appear to be given places of power and significance potentially indicating ancestor worship, while the last piece of grey-white jade shows late Hongshan characteristics of greater abstraction with protruding eyeballs (Criski, 2024, 56), horizontal finger-ribs and a prayer hole with chamfered edges (Criski, 2024, 51).

The holes in Hongshan jades are often asymmetrical with larger cavities inside than the entrance hole with a drilling helix that is inconsistent indicating the use of reciprocating bow drills moving back and forth rather than continuous revolution. This is a potential function extension from hunting bows, corn grinding and fire making where an indented stone is used above the drill that is sawed to make fire. Some blind holes demonstrate a central nipple indicating that materials such as bone or bamboo may have been used. As for abrasives, sand and carborundum have been suggested and even magic sand (impregnated with micro diamonds) derived from meteor impact craters (Anderson, 2012). Generally, the helios are carved with three holes that are consistently placed under the arms and between connected feet. The location is convenient for carving and removing excess material in difficult spaces. Two other potential physical functions act as location points for making, tying to poles for religious ceremonies and hanging as a pendant via the 'bull's nose' hole pairs at the back of almost all Hongshan pieces (examples Fig. 4 bottom right). These holes are particularly challenging to drill at an oblique angle on a material harder than steel. Rarely some jades show signs of string staining inside the bull's nose holes or even crystallised remnants of string used to wear the amulet (Anderson, 2012, 109).

The Hongshan family of zoomorphic form types appears almost unlimited with many crossover modular combinations. Some forms exhibit one, or as many as 4 or 5 different integrated zoomorphic animals. Figure 4 shows an elephant-cicada (2), human, cicada, chameleon, bear-skull (5), serpent-fish (6) and a cuttlefish or squid, elephant, cicada, and bird all within one simple form (7).

Figure 4. Diversity of Hongshan design forms: top left a bird/parrot, top centre an elephant (note the side view similarity to some Zhulong features of ears and wrinkled nose) with a cicada upside down on its back, top right a human with a chameleon's tail and cicada combination note the head, staining and what appears to be sections of removed crystal growth to show the green seaweed jade underneath), middle left is an early zhulong (pig dragon) mushroom head with a human face and a cicada on its back, middle centre is a bear head above a human skull indicating apex predator position over the human, middle left is a fish or mermaid (note potential polished wear pattern from the user that has retarded the tremolite crystal formation in some areas), bottom left is an elephant, cicada, bird or possibly a cuttlefish depending on orientation, bottom centre is monkey and bottom left is a hawk (Yu Ying – Jade Eagle), one of the signature Hongshan forms. Numbered 1-9 from top left (age uncertain, not to scale).

The ability to create sophisticated compound organic carvings from a stone (nephrite jade is 6.0-6.5 on the mohs harness scale) harder than steel (5.0-5.5 mohs hardness) and without any known metal tools is remarkable. Significant ingenuity, effort, experimentation, and inventiveness would have been necessary to achieve this. Both Dashun and Childs-Johnson refer to wheeled machines found at Hongshan sites and mention of grinding stones are made at some locations. Contrasting with Drennan, Dashun reports that:

> 'In addition to tools for cutting, boring, etc., a primitive emery wheel and a simple machine with axle and transmission gearing may have been used….This might suggest that the making and using of jade implements had become in some degree commercialized.' (Dashun, 1995, p.43)

While Childs-Johnson also confirms evidence of mechanised advantage in jade making:

> 'Lathe marks sometimes appear, as on the interior of some horse hoof jades. In almost all cases the jade is handled as if modelled out of soft, pliable clay…' (Childs-Johnson, 1991, p.88)

Qiang (2014) has suggested that large numbers of jades are in circulation and based on his own bow sawing experiments (that did not succeed) along with some evidence of copper working (moulds but

no castings) proposed that slotted copper wheels with grinding powder must have been used. Zhu (2012, 83-186 & 197-198) shows historical illustrations of various jade making techniques with weighted bow saws, primitive lathes, grinding wheels and successful contemporary cutting experiments using some of these techniques. It is also possible to see production units or forms used in different combinations across the range of Hongshan designs illustrated above bringing the idea of a proto-industrial society to light.

Dashun's comment that 'This might suggest that the making and using of jade implements had become in some degree commercialized.' (Dashun, 1995, p.43) tempts the thought that jade production may have gone beyond individual craft pieces and evolved over thousands of years into a more efficient design production model with individuals, groups or households specialising tasks over time.

From a design lens it is tempting to view a Hongshan amulet as a 'product', an advanced state of the art manufactured artifact that combines physical and spiritual features that are a central part of daily life, highly prized and interred with the dead.

Jade and its related minerals nephrite, bowenite, serpentine and actinolite have remained the primary material of interest for academic study however there is considerable evidence of a wider range of materials. Agate, meteoritic iron, impact glass, quartz, turquoise, pseudo-turquoise, chalcedony and controversially chatoyant or 'tiger's eye' have been used for carving up to the present day (Fig. 5). Some of these including impact glass and meteoritic Iron are very difficult to age while agate only ages when certain minerals like fluorene are present in the soil during burial (Fig. 5. bottom right zhulong-bird and Fig. 2 bottom centre detail).

Figure 5. Other materials used to make Hongshan pieces from top left: meteoritic iron (with a well-worn character carved into the back of the head,) pseudo-turquoise, meteoritic impact glass, agate, quartz, chatoyant (tiger's eye) material, cobalt infused impact glass and fluorine weathered agate (not to scale). Note that pieces 4, 6 and 7 all use material layers to their advantage to enhance the carved form, a classic Hongshan making strategy.

5 7,000 Years of Design Making

As the evidence for authenticating jades via ramen spectroscopy and other techniques gathers pace alongside significant numbers of additional archaeological discoveries, the production numbers and economic picture will begin to clear. Whether the large numbers of jades exhibiting convincing evidence of archaic provenance is supported or whether this transitions to archaistic production via later periods as described above (Dashun and Dianxu, 2014; Hoffman, 2007) Hongshan jades can be seen as representing over 7,000 years of making practices. Design value can be gained by understanding the time based evolutions, zoomorphic groupings, form combination motivations, and the deep historical uses. Considerable effort and faith have been put into the production of these artifacts with thousands of years of advanced materials intelligence being developed and applied to a particularly challenging material group requiring new methods, imagination and creativity that is unequalled.

While it would be difficult to justify jades as products in a contemporary sense the potential mass customisation (Silveira, Borenstein and Fogliatto, 2001) concept of recombining standardised modules or form components is plausible. We could imagine the family of a deceased relative discussing known icons or desired characteristics and these modules being efficiently translated into a finished amulet. Ledderose (1998) makes a strong case for modularisation in Chinese art with examples from the Shang dynasty to the present day and a case is presented here for considering an even earlier modularisation of manufacturing via Hongshan.

Sun Shou-dao (1984) describes the discoveries uncovered in Liaoning as a ‘jade age’ evidencing the development of highly sophisticated material capabilities existing across both stone and bronze ages. There is clear evidence that wheeled machines were being used in specialised processes in neolithic China to make large numbers of diverse objects with sophisticated designs and form combinations requiring significant skill, thousands of years before western industrial revolutions.

If specialisation and home-made modularised piecework can be considered a form of industrialisation, then why not consider the emergence of evidence that Hongshan neolithic culture has some commercialised or optimised stone artifact production? If we question the western idea that industrial revolutions take place with iron and steel, then why not consider a jade production revolution in neolithic China?

Mendels (1972) original definition of proto-industry as rural industrial manufacturing increasing economic organisational effort leading to a greater centralised economy producing an industrial revolution is important. Recent work at Cambridge University led by Shaw-Taylor on the foundations of the industrial revolution has made the argument that outsourcing pieces of work to people at home can be considered as a dispersed form of industrialisation pushing back the industrial revolution in the United Kingdom over 100 years to the early 17th century (Lewsey, 2024). More recent work has suggested that both the Roman Empire (Dark, 2013) and the Southern Song dynasty (So and So, 2022) had elements of proto-industrialisation although neither achieved full industrialisation in the modern interpretation.

The term ‘proto-industrial design society’ includes the precursor effort of rural making for which there is evidence in Hongshan culture caused by surplus agricultural output allowing the purchase of material from distant sources and captures a unique design capability both in form sophistication, and

spiritual meaning alongside recombination of iconic modules. Design is an important aspect of developing cultural representation and an under discussed aspect of proto-industrialisation.

Guo Dashun has said:

> 'If we appreciate Hongshan jades and are influenced by their artistic values, perhaps we can achieve a greater understanding of the many important questions raised in modern society.' (Dashun and Dianxu, 2014, p.029)

Beyond stone carving and representation Dashun hints at reconsidering more sophisticated relations between things and beliefs with a view to more harmonious relations between people and environment. We tend to assume these solutions are ahead of us, yet some may be in the past and we can continue design by other technological means to bring about new sets of beliefs and functions. This challenges us to consider that knowledge of the past can be effectively transformed into knowledge for future transformations (Glanville, 2005; Hall and Galdon, 2023). We could gain inspiration from 'Bao Jiang' – roughly translated as a liquid life force – a quality missing from many contemporary products, and the sophistication of mineral infusion over millennia as a unique physical quality. The use of holes to mediate prayer and blessing exchange could offer new inspirations for communication interfaces or regenerative practices linking ancient and contemporary.

6 Future Research Opportunities

New research using a combination of high resolution 3D scanning and AI machine vision is making breakthroughs in locating palaeolithic hand axe production sites (Muller et al, 2024) from scattered finds. Grosman *et al* (2014) sets out how advanced computational techniques can support insights into ancient lithic production and digitally reassembling potsherds, and Dubinski & Grosman (2023) used 3d scanning and AI to uncover micro production technique diversification. Techniques such as this could provide significant insights into Hongshan production, particularly where some pieces exhibit some making marks consistent with rotating tools. Design evolutions between location or earlier and later periods or influences from other Chinese neolithic cultures could be mapped along with specific links between other overlapping jade making cultures such as the preceding Xinglongwa and Zhaobaogou, and the later Liangzhu.

7 Conclusions and Future Research

Following the 'rediscovery' of Hongshan culture in the 1930's and the subsequent historical investigations, archaeological, geochemistry and mineralogical work has begun to support questions about the number of jades produced reinforcing confidence on the higher numbers which subsequently challenge existing ideas when researched through design production and variety. We have few direct indicators of available labour, detailed tools and making processes or the full spiritual and belief systems that drove volume production and how quantity may have played a factor in the spiritual cosmology and the relationship to burial and rebirth.

This research has shown that viewing Hongshan as an extended culture over 7,000 years of highly diverse spiritually significant form making across long periods of time can provides a rich landscape for design research. Evidence uncovered so far shows that sophisticated making and spiritual practices

coincided with significant volumes of designed 'products' over an extended timeframe. There is direct evidence that production design has evolved efficient means using bow drilled holes, rope sawing and probably metal tools to shape and refine highly fluid organic forms. Wheeled or even geared machines may well have been used for grinding, polishing and lathe turning circular or tubular forms. Designing plays a major role in the zoomorphic combinations reflecting morphed animal forms that visualise spatial shifting between land, sea, and air reanimation via rebirth and reskinning. Opportunities for new design inspirations emerge from form variety, zoomorphic combinations, weathering effects on natural material and the underlying spiritual form-functions of holes, blessing exchanges, and transitions.

As a result of using a new design lens Hongshan is proposed as a proto-industrial design society with supporting interdisciplinary evidence from archaeology, anthropology, geology, geochemistry and history. This approach explores new historical venues for considering design research liberating new historical landscapes and opening novel ways of combining interdisciplinary evidence. It also allows design investigation into areas like Hongshan culture where very little design research currently exists. A proto-industrial design society combines direct design action in form making linking shape and spirituality with diversity of modular features and coordinated making practices for volumes of production over long timeframes from the neolithic to the present.

Looking towards the future, machine vision and AI could help uncover the evolution of form morphology, non-destructive ramen spectroscopy can identify the types of jade and the chemical weathering effects from soils, while isotope analysis holds significant promise in locating the source of the jade thereby supporting future design research on the evolution of form based development and tool making specialisation. Triangulating combinations of technologies can help set out landscapes of relationships helping to further uncover the industrial design society of one of the most enigmatic neolithic making cultures.

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