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Daniel T. Potts:

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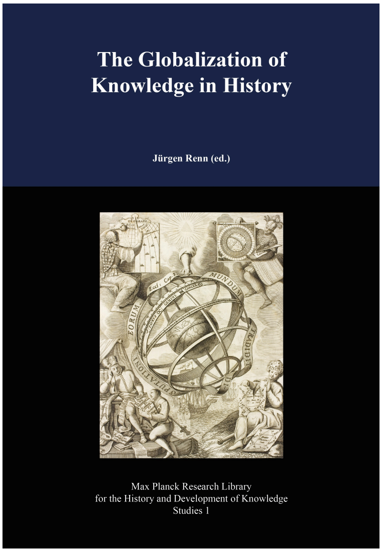

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Chapter 4
Technological Transfer and Innovation in Ancient Eurasia
Daniel T. Potts

4.1 Introduction

The pre-modern transfer of knowledge within Eurasia had to contend with a complex set of both physical and mental obstacles. Deserts, mountains and oceans had to be crossed, but so too did language barriers and ingrained traditions of cultural praxis. The fact that knowledge transfer occurred in spite of a seemingly long series of hurdles that had to be overcome has often been attributed to some fairly potent "vehicles"—Buddhism, the and Jesuit missionary activity, to name just a few of the more obvious ones which operated in the literate past. But archaeological investigations have shown that knowledge and technology transfer can also be documented in the pre-literate past.

The enormity of the Eurasian landmass, not to mention the multiplicity of linguistic and cultural entities inhabiting it, have rarely, if ever, been viewed by archaeologists as insurmountable impediments to long-range contacts between the many cultures inhabiting it in antiquity. Journals such as *Eurasia Septentrionalis Antiqua: Journal for East European and North-Asiatic Archaeology and Ethnography* (1927–1938), published by the Finnish Society of Archaeology, or the more recent *Ancient Civilizations from Scythia to Siberia: An international journal of comparative studies in history and archaeology* (established 1995) bear witness to the fact that archaeologists have been thinking on an inter-continental scale for many, many years. Nor have such studies been limited to discussions of shared art styles or artifact types. The possibility that technologies and "knowledge complexes" may have spread from one part of the continent to another during the past has long been entertained and in this sense the globalization of knowledge has, both implicitly and explicitly, been on the agenda of many archaeologists. The difficult problem of discriminating autochthonous innovation and independent invention from the complete or partial adoption of an allochthonous technology has been a particular concern of scholars working in Europe and Asia and in what follows I shall present several cases of technological transfer in ancient Eurasia. First, however, I should like to say a few words about how transfer and transmission, or what is often termed "diffusion," have been dealt with by archaeologists and others concerned with the ancient world.

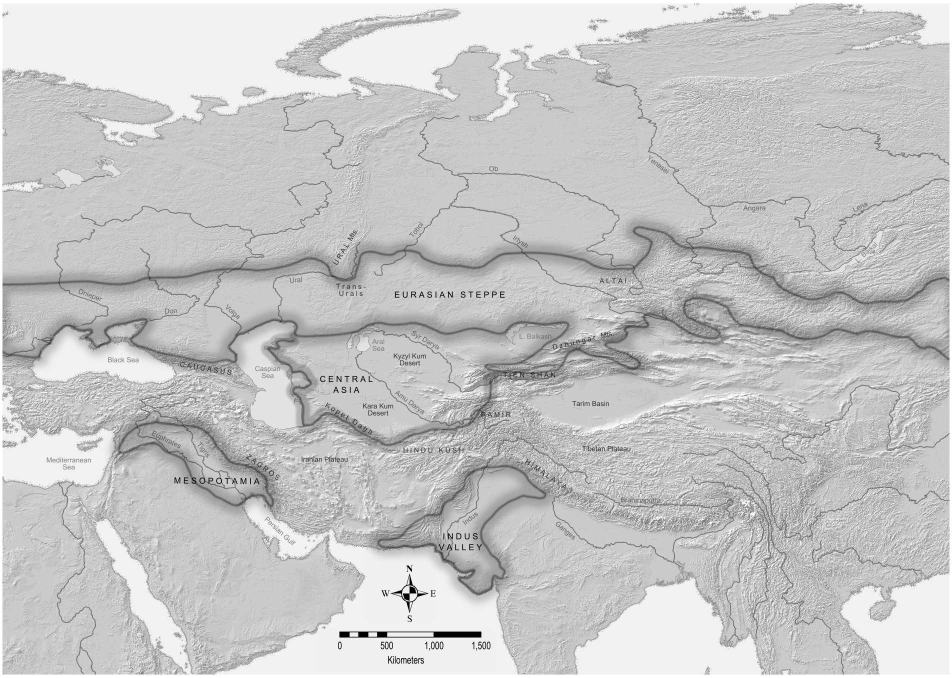

Figure 4.1: Map of Eurasia showing the regions of greatest relevance to this chapter (Frachetti and Rouse 2012, Fig. 36.1). With kind permission of the authors.

4.2 Terminology and Ideology

As part of its 300th birthday celebrations in 1936, Harvard University convened a symposium entitled "Independence, Convergence, and Borrowing in Institutions, Thought, and Art." On that occasion, V. Gordon Childe, widely esteemed as one of the greatest prehistorians of the twentieth century, offered what he entitled *A Prehistorian's Interpretation of Diffusion* (Childe 1937). A voracious reader, Childe was more aware than most of archaeological discoveries made throughout the vast area extending from the Pacific coast of China to the Atlantic shores of Ireland and Iberia. Despite the fact that he boasted more than a passing acquaintance with dozens and dozens of regional cultures across Eurasia, Childe was an unapologetic proponent of diffusion, something he described as "essentially the pooling of ideas, building up from many sides the cultural capital of humanity" (Childe 1937, 4). In their crudest form, many pre-Childean discussions of diffusion had striven to prove that entire civilizations owed their origins to the external stimulus of an advanced society (e.g., Mesopotamia > Indus Valley; Mesopotamia

> Egypt; Mesopotamia > China; Phoenicia > North America). More sober discussions of diffusion were often preoccupied with cultural contacts that effected the spread of superficially obvious stylistic traits, such as patterns on painted pottery.[1] This fixation on epiphenomena or superstructure, as Marx would have called it, rather than core technologies and infrastructure, was not characteristic of Childe, an avowed Marxist. Indeed, Childe's Harvard lecture cited examples of technological transfer ranging from printing and paper to the steam engine before indulging in the more traditional, broad brush look at links between civilizations in Egypt, Mesopotamia and the Indus Valley evinced by portable items of material culture (ceramics, stone vessels and cylinder seals) that were accumulating rapidly during the pre-war era.

Several years after Childe delivered his lecture, the American anthropologist Alfred Louis Kroeber published a very different paper on what he termed "stimulus diffusion." There he examined what might be called "partial" or "selective" technology transfers, citing, among other things, the case of porcelain manufacture in eighteenth-century Europe (Kroeber 1940). The existence of high quality porcelain in China and its export to Europe, he argued, created the stimulus for the local invention of the technology to replicate, at lower cost, the same sort of end product. This entailed everything from the identification of suitable kaolin deposits to the design and construction of appropriate kilns. As Kroeber wrote:

> The consequence is that we have here what from one angle is nothing else than an invention. Superficially it is a "parallel," in the technical language of ethnology. However, it is equally significant that the invention, although original so far as Europeans were concerned, was not really independent. (Kroeber 1940, 2)

In this context Kroeber's views anticipated those of the eminent MIT metallurgist Cyril Stanley Smith who, almost forty years later, stressed the importance of studying "why a society will not absorb things into which it is brought into contact," observing:

> A human culture, existing at the apex of a long chain of historical selectivity cannot easily incorporate large chunks of another, though occasionally small things can seep in without opposition and later interact to form a nucleus that can grow by rearranging the connections between things already present. (Smith 1977, 84–85)

Viewpoints like Kroeber's (and later Smith's) became increasingly unpopular during the 1960s and 1970s as anti-diffusionist views, sometimes fueled by chauvinistic, nationalist sentiment, gained ground. A quarter of a century later, while

[1] For a useful review of the main proponents of diffusionism, see (Trigger 1989, 150–160), particularly Oscar Montelius' *ex oriente lux* views of European cultural development and its Near Eastern antecedents; cf. (Montelius 1899).

shots were still being fired in the ideological battle between indigenous evolution and "stimulus diffusion," the concept of the "interaction sphere" (Caldwell 1964) appeared as a kind of theoretical bandage to heal the wounds of the diffusion debate. With its implicitly egalitarian outlook, suggesting equally weighted interactions between contemporary constituents of a cultural mosaic, interaction spheres were conceptualized as "the areal matrices of regular and institutionally maintained intersocietal articulation" (Binford 1965, 208). Lewis R. Binford suggested that the "comparative structural and functional analysis of interaction spheres [...] allows us to define, quantify, and explain the observation [...] rates of cultural change may be directly related to rates of social interaction" (Binford 1965, 208). Such a perspective, however, smacks of scientists in the laboratory dispassionately viewing the interactions of cultures as conglomerations of atoms that can be studied in some kind of closed atmosphere. Not only is there no causality implied in the interactions that take place, there is no intent, directionality or hierarchy in the interactions charted. As Lightfoot and Martinez rightly noted in describing developments in Anglo-American archaeology during the 1960s and 1970s, "the theoretical underpinnings of New Archaeology, with its focus on cultural ecological models, closed systems, and antidiffusionism, were not conducive to the study of cultural interactions" (Lightfoot and Martinez 1995, 474).

It was not just theoretical underpinnings that were to blame for the increasingly geographically narrow views of archaeologists. Combined with an attitudinal prejudice against anything that smacked of migration and diffusion (against which Härke (1998) wrote eloquently), the explosion of scientific data (in part due to excavation and survey, in part a product of the "publish or perish" syndrome that emphasizes quantity over quality) made it more and more difficult for anyone to achieve the kind of synthetic oversight of Eurasian archaeology which Montelius, Childe or Grahame Clark (1969) were able to achieve. Symptomatic of the difficulty of controlling the data necessary to address broad-scale questions of technology transfer in antiquity was the failure of most scholars at a 1978 symposium in Aarhus, entitled "The origin of agriculture and technology—West or East Asia?" to come anywhere near to achieving their aims (Muhly 1981). As J. D. Muhly noted in reviewing the conference (no proceedings were ever published):

> [...] no one wanted to draw far-reaching conclusions or to develop wide-ranging theories. This is in keeping with the spirit of the times: we are in an age of cautious and detailed specialization, an age suspicious of hypothetical speculation and the "great theory." [...] Theories based upon influences from outside a given archaeological culture, theories using traditional ideas about migration and diffusion, are now anathema to most prehistorians and field archaeologists. [...] In this sense it could be said that everyone systematically ignored the theme of the symposium, and indeed such charges were made during the course of the meeting. In defense, I believe that most scholars would agree that we are simply not in a position to discuss the influence of East upon

> West or vice versa […] We are still too busy trying to figure out what was going on in a particular area to worry about the possibility of cross-cultural contacts. (Muhly 1981, 126–127)

Many archaeologists and ancient historians working today would probably agree with Muhly as they continue, thirty years on, "trying to figure out what was going on." Yet it could be argued that focusing on the concrete outcomes of technological praxis—for example, harvested cultivars, decorated weaponry, or painted pottery, whether at the macroscopic or the microscopic level—is neither the only nor the best way of investigating intercultural contact and technology transfer. The deficiency in such an approach is that it almost always ignores the technology behind those outcomes—the cultivation, irrigation and harvesting practices used to create the crop; the smelting and casting techniques used to fashion the metal; and the clay preparation and firing methods used to make the pottery. I suggest that an examination of the technologies underpinning cultural production offers a viable alternative to the study of the epiphenomena themselves and a potential way forward in trying to move beyond the impasse highlighted by Muhly's comments.

4.3 Inverting Kroeber's Stimulus Diffusion Model: From Polemics to Applied Science

In his discussion of stimulus diffusion, Kroeber was at pains to describe situations in which a technical problem had been solved in one culture in order to replicate a foreign product through home-grown ingenuity. In the case of porcelain, the idea had spread to Western Europe, as had examples of the finished product, but everything else, from appropriate clays to kilns, had to be found and/or invented *ab novo* in the European context. In antiquity, I suggest that we look for instances where exactly the opposite occurred, where the technologies spread, enabling the production of distinctive, culturally "local" products that would otherwise escape notice and not arouse any suspicion of inter-cultural contact. Acknowledging the distinctiveness of ways of doing things, as opposed to end-products, is somewhat akin to identifying the difference between "cultural patterning" at the level of praxis and "technological style" as its external or "formal, extrinsic manifestation," a concept advanced thirty years ago by the MIT materials scientist and historical metallurgist, Heather Lechtman. Using a linguistic analogy, Lechtman observed: "The oft-cited distinction used by linguistics between langue and parole is precisely that distinction between pattern and style," observing that:

> Style is the manifest expression, on the behavioral level, of cultural patterning that is usually neither cognitively known nor even knowable by members of a cultural community except by scientists who may have analysed successfully their own cultural patterns or those of other cultures. (Lechtman 1977, 4)

Although these concepts are applicable to any sort of material culture, Lechtman was writing in the first instance about prehistoric metallurgy and it is to a metallurgical example that I wish now to turn.

4.4 A Eurasian Problem: Western Influences in the Development of Chinese Metallurgy

Nineteenth-century scholars, including the Assyriologist W. St. Chad Boscawen (1854–1913), the Sinologists Albert Étienne Jean Baptiste Terrien de Lacouperie (1845–1894) and E. H. Parker (1849–1926), and the missionary Joseph Edkins (1823– 1905) wrote learned and, today, largely forgotten works attempting to demonstrate everything from the Western, more particularly Babylonian or 'Aryan' origins of ancient Chinese language and writing to agriculture, astronomy, weights and measures.[2] One of the most contentious and emotionally charged topics in the history of metallurgical scholarship concerns the origins of and external influences exerted upon China's earliest bronze technology. In light of recent DNA analyses on population affinities in Inner Asia that strongly suggest contacts between Western and Eastern populations in the first millennium BCE (Comas et al. 1998; Bennett and Kaestle 2006), metallurgical analysis is also potentially vital to an understanding of the earlier phases of population dynamics as well as technology transfer.

Briefly stated, there exist wildly divergent views on the extent to which Chinese metallurgy was or was not influenced by contact with the West (i.e., Central Asia, the Near East and/or the Mediterranean). In 1954, Lauriston Ward asserted that there were bronzes in the Shang period:

> such as the bronze ceremonial vessels [...] like nothing in the West [...] There are, however, other bronze artifacts from Anyang which are of convincingly Western type, namely helmets (cf. Early Dynastic forms in Mesopotamia), socketed celts of European Late Bronze Age type, and socketed spearheads with two loops for binding, like those occurring in Europe in the Middle Bronze Age. (Ward 1954, 138)

Two years later Max Loehr argued very strongly for external, Western influence on the earliest development of bronzes in China (Loehr 1956). As one reviewer noted, Loehr definitely tightens the chain of evidence and inference concerning Mesopotamian, Steppe, and Siberian influence in much of the early Chinese bronze art (Kaplan 1957, 378).

Contrast these positions with that of Ho Ping-Ti two decades later. In an unabashed *apologia* for the independence of Chinese civilization, Ho rejected any suggestion of foreign influence from the West; argued for the autochthonous origins

[2]See, for example, (Edkins 1871; Parker 1883; Terrien de Lacouperie 1885; Boscawen 1888; Terrien de Lacouperie 1894).

of "the primitive copper metallurgy of the loess highlands of China"; and derived the later Shang bronze industry from it (Ho 1975, 221). In his review of Ho's *Cradle of the East* and Noel Bernard and Tamotsu Sato's *Metallurgical Remains of Ancient China* (1975), the distinguished MIT metallurgist Cyril Stanley Smith wrote extensively about the problem of diffusion vs. independent invention. As he noted:

> It is clearly true that metallurgy did not creep slowly and continuously into China from its boundaries, but, taking a world view, can we be sure that the nuclear suggestion did not come from somewhere else by a route that left no record of its passage? Bernard gives a world map on page 16, which combines his own data with those of Colin Renfrew, who has argued strongly for similar independence of the earliest metallurgical developments in the Balkans. The map shows no fewer than six "independent regions of early metallurgy," with China the last of all to appear. This reviewer, while granting that technical elaboration occurs differently in different locations, finds it impossible to believe that the basic ideas of metallurgy were so easy to come by ad nuovo. It is incredibly difficult to invent anything really new, while information, albeit garbled and incomplete, is easily carried by travelers. Does transmission have to leave a record? […] On a very detailed scale, there would be little evidence beyond intangible style for links between the sites noted in China itself. One must take into account the stage of development involved in a transfer, the stage both of the technological details and of the receiving culture. Rather than postulating independent invention, it seems to me that the interesting questions concern how, with many nuclei in the air, a strong culture can incorporate into its own fabric as compatible only very few of the things it hears of, while resisting most suggestions that come to it from continuing if superficial contacts with neighboring and sometimes remote peoples. Regardless of whether the first idea of making and shaping metals arose spontaneously in China or came from outside by a barrier passing process akin to quantum-mechanical tunneling, there can be no question that the subsequent development of metallurgy was indigenous. The furnaces, the crucibles, the molds, and the almost exclusive dependence on casting, even of iron when it appears, all bear the unique stamp of that great civilization.[3]

In 1993 Donald Wagner leapt to the defense of Ho, Bernard and Sato, launching a determined attack against diffusionists like Smith (and Joseph Needham, see below). After admitting that transmission does not have to leave a record, he argued:

[3] (Smith 1977, 81–82), cf. (Chang 1978).

> The anti-diffusionists cannot hope to provide the sort of positive proof that the diffusionists may, under fortunate circumstances, be able to provide. It is therefore incumbent on the diffusionists to provide positive empirical evidence. Broad untestable opinions [...] are not useful in a scientific discussion. (Wagner 1993, 33)

The polemical positions adopted in this debate are obvious. Full of post-colonial outrage, one camp is morally affronted by the very notion that a civilization the size of China should owe anything to outside influence, while some hard-nosed metallurgists and historians of science cannot let go of the sneaking suspicion that somewhere along the line, the esoteric, technical lore of bronze-working, so unlikely to have been "invented" in the second millennium BCE in a Chinese vacuum, must have diffused from the west. Recently, however, a whole host of new data has emerged from research conducted by Chinese scholars who seem to be undaunted by nationalist rhetoric in the face of scientific evidence. The prime scholar in this new movement is Mei Jianjun whose Cambridge Ph.D., published in 2000, provides a wealth of important analytical results and previously unpublished material from Xinjiang that must alter the views of even the most die-hard indigenous evolutionist.

4.5 New Perspectives on an Old Problem

Mei's research has isolated two important sets of external linkages in the earliest copper and bronze-using cultures of Xinjiang. The first group concerns the Afanasievo Culture of southern Siberia (Minusinsk and Altai regions). This consists of ceramics from the Ke'ermuqi cemetery in the Altai region as well as similarities in funerary customs (monumental structures on the surface above graves, skeletal position and copper objects) between Afanasievo sites and Gumugou in the eastern part of the Tarim basin (Mei 2000, 58).

The second and, in my view, far more important source of linkages is with the Andronovo culture, a name given to a vast conglomeration of related cultural complexes extending from the Urals in the west to the Yenisei in the east, and from the forest-steppe in the north to the Pamirs in the south. Stockbreeding, including horse, cattle and sheep, was economically important to Andronovo communities, as was bronze metallurgy. The presence of Andronovo-type ceramics at Central Asian sites in Turkmenistan and Uzbekistan with calibrated C14 dates of c. 1900–1750 BCE, coupled with evidence for the diffusion of Andronovo material culture from west to east, suggests that the origins of the complex in the Urals might be placed around 2000 BCE.

Mei has conclusively demonstrated the infiltration of Xinjiang by characteristic elements of Andronovo (steppe Bronze Age) material culture, including metals (weaponry, tools) reflecting "a wide range of metallurgical technologies, such as casting, forging, annealing and cold-working [...] during the latter part of the second and the early first millennium BCE."[4] These have been documented at Aga'ersen, Gumugou, Weixiao and Sazi in the Yili-Tacheng district of northwestern Xinjiang (Mei 2000, 60). The presence of copper sulphide inclusions in the Tacheng objects, in particular, has suggested that copper sulphide ores were being smelted, a more complex procedure than the smelting of copper oxide ores and one likely to have involved the exploitation of local copper ores in Xinjiang (Mei 2000, 48). Mei has suggested that the "matte smelting process" was being followed, whereby the ore was partially roasted so as to convert the iron sulphides into oxides; the roasted ore was then smelted to produce matte (molten metal sulphide phase); the matte was roasted; and the roasted matte was reduced to yield copper. In comparison with the direct reduction of copper oxide ores, the process of smelting sulphide ores is far more complicated.[5] Interestingly, Song Dynasty (960–1279) texts describe this process in detail and direct evidence from the first millennium BCE is provided by slag found at Nulusai which has been analyzed by Mei (2000, 55–57).

Where might such complex technology have originated? The predominance of true bronze in this corpus, with tin levels between 2–10%, "suggests a cultural affiliation of the Tacheng objects with the Andronovo complex" (Mei 2000, 46). As Chernykh noted, Andronovo bronzes containing 3–10% tin comprise "90–100 per cent of the metal artifacts in assemblages from the various regions of the community" (Chernykh 1992, 213). This, he suggested, owed its origins to yet more westerly innovations:

> The original stimulus for metallurgy and metalworking in the Andronovo community came from the west, from the region where the productive centers of the CMP (Circum-Pontic Metallurgical Province), which was in collapse, or the workshops of the CMP-EAMP (Eurasian Metallurgical Province). (Chernykh 1992, 214)

Other metals besides bronze may have been involved as well. Seven years before Mei's dissertation appeared, Emma Bunker published an important paper on gold in ancient China where she pointed to the presence of a cast gold earring, "penannular with one funnel-shaped terminate" at "Liujiahe in Pinggu, Beijing district, east of the Taihang mountain range in Hebei" as well as bronze earrings of the same type elsewhere in Hebei and at Lower Xiaojiadian culture sites in Liaoning, which are "a diagnostic artifact universally associated with Andronovo material found to the northwest in the Altai region of southern Siberia, in Tomsk in western Siberia, and further west along the Amu-Darya River near the foothills of the Ural Mountains" (Bunker 1993, 30). While chronologically contemporary with the Shang period (trad. 1766–1123 BCE), these sites were culturally non-Shang and showed "indigenous regional characteristics" as well as the aforementioned

[4] (Mei and Shell 1999, 573), cf. (Mei et al. 1998).
[5] Cf. (Pigott 2002).

evidence of contact with the outside world. In Bunker's opinion, the location of the sites in Hebei

> gave them access to Inner Asia via the ancient 'Fur Route,' a complex trading network that crossed Eurasia long before the opening of the more southerly 'Silk Route.' The Fur Route ran in an eastward direction north of the fiftieth parallel from the Caspian Sea to southern Siberia, and then southward to ancient China and its border areas via the Amur Valley. The existence of this route explains the presence in Hebei of an Andronovan type of funnel-shaped earring. (Bunker 1993, 31)

As Joseph Needham wrote in 1964:

> I believe that the longer the time which has elapsed between the first successful achievement of an art or invention in one place and its appearance in another, the more difficult it is to entertain the idea of a purely independent invention. (Needham 1964, 403)

Although he was referring to the much later, westward diffusion to Europe, via Iran, of Chinese cast-iron technology,[6] the same applies in the case of bronze much earlier, albeit in the opposite direction. The far greater antiquity of bronze metallurgy in the Near East, which dates to the early to mid-third millennium BCE, the complexity of the copper sulphide reduction process, and the timing of the first Andronovo contacts with western China, all combine to provide several necessary preconditions for a transfer of technology, followed without any doubt by centuries of creative, indigenous invention as Chinese metallurgists developed a uniquely Chinese bronzeworking tradition.[7]

In the future, additional technical studies that throw light on the precise techniques used by the earliest metallurgists in Xinjiang will be important to undertake since it is clear that once the "Chinese" (Shang) bronze industry appears, it is very different, in most technical respects, from that of the Andronovo complexes (Sherratt 2006, 45). While arguing vigorously for a common metallurgical ancestry, Smith was always at pains to stress the uniqueness of Chinese bronze production which eschewed the cire perdue or lost wax technique in favor of "the sectionalism of the molds, the alternating levels of positive and negative décor, the coring and the casting-on" (Smith 1977, 82).[8]

In conclusion, despite the rejection of the perspectives of diffusionists like Max Loehr by scholars such as Ho and Wagner, it is striking that forty-five years before Mei's dissertation was written, Loehr had prophesied:

[6] Cf. (White 1960; Wertime 1964); on Chinese iron, see esp. (Wagner 1999).
[7] Cf. (Sherratt 2006).
[8] Cf. (Linduff 2005) who suggests that even this may be a Eurasian rather than a Chinese invention.

> If any culture in the West did convey elements likely to promote metalworking in North-China, it must have been the Andronovo culture. (Loehr 1956, 86)

4.6 Perspectives on the Study of Technology Transfer in Eurasian Metallurgy

At the beginning of this paper I reviewed some of the history of archaeological and anthropological debate over independent invention vs. diffusion in general terms, and later some of the more specific debate generated in the case of Chinese metallurgy and its origins. Several sociological aspects of the science involved in this entire field of study, not mentioned earlier, are worth noting.

First, achieving anything like a "Eurasian" perspective is incredibly difficult, given the multiplicity of sources, in a multitude of languages, that must be assessed. Archaeologists who have dealt with Central Asian material are acutely aware of the enormous difference in the potential for creative scholarship between the Soviet and the post-Soviet eras. Access to Soviet archaeological literature was extremely difficult for Western scholars prior to the 1980s, when active cooperation with Soviet scholars began a trend which has obviously greatly accelerated since the collapse of the Soviet Union. One can look at a work like Chernykh's *Ancient Metallurgy* in the USSR, which was written shortly before the end of the Soviet regime, and marvel at its scope, but at the same time recognize that Chernykh's Laboratory for Spectral Analysis, in the Institute of Archaeology (Academy of Sciences, Moscow), enjoyed a privileged position in being able to undertake tens of thousands of analyses on objects found throughout the Soviet Union. In many ways, this political situation, coupled of course with the genuine curiosity of Chernykh and his colleagues, permitted the construction of a Eurasian perspective that was all but impossible for anyone outside of that country to achieve.

At the same time, Chernykh's horizon ended at the borders of Mongolia and Xinjiang, an artificial eastern barrier inhibiting what ought to have been a truly Eurasian perspective. One must remember not only the often adversarial history of Soviet-Chinese relations, but the almost complete dearth of contemporary Chinese archaeological data in the West during much of the twentieth century, a situation only ameliorated by K.C. Chang (Yale and later Harvard University) via his mainland contacts. Neither North American and European scholars, nor Soviet ones, had access to the sort of data that Mei has now made available.

One can, therefore, only marvel all the more at a scholar like Max Loehr whose prescience in divining the likelihood of an Andronovo contribution to early Chinese metallurgy now seems extraordinary. For not only was Loehr's view informed largely by his studies in China during the years 1940–1949, when he was a researcher and later director of the Sino-German Institute in Beijing (Cahill 1989), but it is apparent that, notwithstanding the great difficulty of accessing Soviet archaeological literature, he was familiar with the little that was available outside of the Soviet Union on Andronovo matters as well. What Chernykh called the Eurasian Metallurgical Province really only became a reality when Jianjun Mei's analyses shone the spotlight on Xinjiang and its Andronovo connections, but the vast architecture of such a concept was already apparent in Loehr's mind by the early 1950s.

4.7 Fellow Travelers in Eurasian Transfers

In my opinion, the metallurgical example of technology transfer in Eurasia outlined above is bolstered by other instances of cross-cultural interchange which reflect comparable inter-regional contact. Four such cases seem particularly apposite.

Tin – the sine qua non of Andronovo metallurgy, has long been a problem for Near Eastern and European archaeologists, but recent studies, some of which were unavailable when Chernykh was writing, have identified significant tin sources in Uzbekistan, Tajikistan and Afghanistan (Boroffka et al. 2002). During the early second millennium BCE, i.e., precisely the same time as Andronovo expansion to Xinjiang is thought to have been taking place, we have cuneiform sources from Mari on the Euphrates, near the modern border of Syria and Iraq, that throw exceptional light on traffic in tin. In particular, the fact that Mari's rulers solicited tin from the king of Elam, a powerful state in southwestern Iran (Potts 1999), and then passed some of it on to their client kingdoms further west in Syria (e.g., Qatna), shows us how tin from Central Asia could travel all the way to the Mediterranean. If that sort of movement was possible in an east-west direction, there should have been no technical impediment to the same sort of movement of tin in a west-east trajectory.

Bactrian camel – it is now clear that the Bactrian camel, which originated in Mongolia (Baotou) and Xinjiang (Lake Barkhol) and had nothing to do with the ancient land of Bactria at all (northern Afghanistan/ southern Uzbekistan), was already present in the West by the early second millennium BCE, having reached Anau in Turkmenistan by the mid-fourth millennium BCE (Potts 2004). By the mid-third millennium Bactrian camels figured prominently in the iconography of Central Asian (Bactrian and Margianan) stamp seals and by the early second millennium (c. 1750–1700 BCE) one appears on a cylinder seal in Old Syrian style, now in the Walters Art Gallery in Baltimore. Bactrian remains are attested at the Andronovo site of Aleksejevskoje in Tatarstan; at Il'inskaja gora, a Karasuk culture cemetery in the southwest Ural foothills; and at Gorodsk, north of Kiev, in the Ukraine, all contexts dating to the second millennium. The most probable use of these Bactrians was as stud animals since Bactrian-dromedary crosses are extremely strong, capable of carrying 500kg, double the load of a dromedary. These "super cargo" carriers of the second millennium BCE (and later) would, without any doubt, have facilitated trans-continental travel across Eurasia at precisely the time when Andronovo cultural groups are thought to have been spreading into Xinjiang with their metallurgical technology.

Figure 4.2: Herd of *Camelus bactrianus* in the Nubra Valley, Ladakh, India. Photo: John E. Hill, with kind permission.

Wheat – there is a growing body of palaeobotanical data in the form of charred wheat grains, now known at "all of the early Xinjiang oases" (Chen and Hiebert 1995, 287) including Gumugou, Shirenzi, Lanzhouwanzi and Qunbake. At Gumugou, where preservation was excellent, wheat was found in a grass basket close to the head in a number of graves, a practice strongly reminiscent of Andronovo funerary practice at sites like Alekseevka in southern Siberia. In Xinjiang wheat was being grown in deltaic fans where flood irrigation could be easily practiced in a manner reminiscent of that followed in the oases of Bactria and Margiana (western Central Asia). Even if "the *idea* of oasis-based agriculture" reaching Xinjiang from western Central Asia remains unproven (Thornton and Schurr 2004, 85) there is no doubt that wheat was an introduction from the west. Additional data comes from Donghuishan in western Gansu where domesticated, carbonized wheat remains have been dated to c. 3000–2500 BCE (although based on C14, it is not clear whether the dates were calibrated or not). Again, little detail is available (no indication of what type of *Triticum*), but Chinese archaeologists believe this must have been an import from the west via the Hexi Corridor (Li 2002, 180). Wheat is, therefore, a cultivar which may well provide a parallel to the example of metallurgical technology transfer discussed above. It may even have moved in association with metallurgical technology.

Horse – As Jansen et al. (2002, 10910) stress:

> Although there are claims for horse domestication as early as 4500 BCE for Iberia and the Eurasian steppe, the earliest undisputed evidence are chariot burials dating to c. 2000 BCE from Krivoe Ozero (Sintashta-Petrovka culture) on the Ural steppe.[9]

It is tempting to associate the transfer of metallurgical technology via Andronovo cultural complexes with the spread of both the Bactrian camel, heading west, and the horse, heading east from the Ural steppes and Central Asia (Levine 1999; Jansen et al. 2002), to which we may add the chariot to China (Shaughnessy 1988). As Muhly noted twenty years ago:

> Piggott now places the first development of […] chariots within the Timber Grave/Andronovo cultures of south Russia, between the Ural mountains and the Irtysh river and dating to ca. 1700–1400 BCE (calculated from uncalibrated dates which, on the basis of the MASCA 1973 calibration, would be 2060–1600 BCE). Innovations there spread both to the west (as far as Mycenaean Greece) and to the east, where chariot burials from Shang Dynasty China have almost their exact counterparts in those from the waterlogged tombs at Lchashen on Lake Sevan in the Armenian SSR. (Muhly 1988, 89)

Speaking of these latter finds, which were compared in great detail with Shang-period chariots in China, E. L. Shaughnessy wrote:

> If we now compare the technical characteristics of the Chinese and Trans-Caucasian chariots, I think there can be no doubt as to their typological similarity, or even identity. (Shaughnessy 1988, 206)

Bunker has suggested that the Fur Route, discussed above, may have been one of the routes whereby elements of foreign technology "such as the chariot, could have been introduced into the ancient Chinese world from cultural centers to the west" (Bunker 1993, 31).

4.8 Conclusions

The work of Chernykh, Mei and Li, and its evaluation by metallurgists like Piggott, suggest to me very strongly that the pendulum has swung well away from the adamant rejection of diffusion evinced by Wagner and Ho, in favor of a much

[9] Cf. (Levine 1999).

more Eurasian perspective in the tradition of Loehr and Smith. The fact that two Chinese scholars are in the vanguard of this new appreciation of Andronovo influences in Xinjiang is, I believe, highly significant, suggesting that a new generation of Chinese scholars is more interested in divining the technological secrets of bronzeworking, wherever they may have originated, than in forcing hollow claims for priority based on geography and political affinities. In this respect, the demise of the Soviet Union and the opening up of China have contributed enormously to the attempt to understand technological transfer at a Eurasian scale. Nevertheless, there are still many issues that require attention if the case for significant Andronovo (early second millennium BCE) contacts with Xinjiang, and via the Hexi or Gansu Corridor (a narrow strip of territory leading southeastwards, past the western end of the Nei Mongol Autonomous Region, into Gansu), with the Chinese heartland, is to move beyond the realm of possibility into that of probability. Perhaps foremost amongst these is the analysis of ancient mtDNA from the regions where the technology transfer discussed here is thought to have occurred.

At the present time the available studies of mtDNA from Eurasian populations[10] do not include material contemporary with the period of postulated Andronovo-Xinjiang contact. Li Shuicheng has emphasized the anthropologically mixed nature of the Yanbulak cemetery in Hami, a site located in eastern Xinjiang at the head of the Hexi or Gansu Corridor. Mongold and Caucasoid individuals were said to be present, with Caucasoids in the minority (Li 2002, 175). Further west, at Lop Nor (Luobunoer/ Lopnur, still in Xinjiang), the individuals found in a cemetery dated to the early second millennium BCE (1710–1535 uncal. BCE) were said to be entirely Caucasoid.[11] The status of these anthropological analyses is unclear.[12] New, multivariate craniometric work by Brian Hemphill suggests that, in the earliest Bronze Age population of the Tarim Basin does not manifest admixture from either the steppes (Andronovo) or the oases (Bactria, Margiana) of western Central Asia, and that not until 1200 BCE did significant gene flow from groups in the Ferghana Valley (Uzbekistan) and the Pamirs occur.[13] The DNA studies undertaken to date are promising, but clearly there is a serious need for similar studies on older genetic material.

Of course, on their own such studies do not merely answer old questions, they pose new ones. Did the posited diffusion of metallurgical technology from the West to the East, via the Andronovo-Xinjiang cultural/geographical regions, necessarily involve the movement of large enough numbers of specialists and their families to be detectable in the bio-archaeological record? Was the "technological package" brought back by indigenous peoples who had travelled to the West,

[10] For example, (Comas et al. 1998; Bennett and Kaestle 2006).

[11] Cf. (Thornton and Schurr 2004, 93–94), citing mtDNA research by Cui Yinqui at Jilin Univ. suggesting "the earliest mummies of the southern Tarim Basin grouped closely with the modern Sardinian and Basque samples without evidence for any mtDNA contribution from the east."

[12] They were conducted by Chinese anthropologist K. Han and published in China in the 1980s and early 1990s. For references, see (Li 2002, 181).

[13] (Hemphill and Mallory 2004); cf. (Thornton and Schurr 2004, 90–91).

thus resulting in no genetic admixture detectable in their DNA? These and similar questions—which go to the very heart of longstanding debates on diffusionism—continue to resonate in a world where globalization, both ancient and modern, is now regarded as a fact of life.

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