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Behind and Beyond the Archaeology of the Silk Road: Laboratory Analyses in Eurasia, Some Results, Discussions, and Interpretations for Protohistory and Antiquity

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The paper presents some new results illustrating some developments related to the concept of the Silk Road and subsequent methodological reflections. New laboratory results of scientific analyses of plants, minerals, and human remains in combination with more conventional methods of research contribute to a better understanding of the multidirectionality of exchanges in Pre- and Protohistory. Unsuspected long-distance transfers of items, especially of metals (tin) and biological materials (plants, pathogens, etc.) are discovered. Adding ancient DNA and petroglyphs to the vexed question of the Indo-European migrations across Eurasia complexifies the familiar linguistic, historical, and archaeological research landscape. Recent excavations show the impact of the adoption of artistic elements adapted from the Achaemenid arts, far in the steppe world, and up to China. Multidirectional (including North-South lanes) and multidisciplinary approaches leave space and hope for more rigorous scientific modelizations for the archaeology of Eurasia and the Silk Road.

Keywords: Achaemenid art, Andronovo steppe, Indo-Europeans, Indo-Iranians, ancient DNA, tin trade, gold trade, plague, Scythian art, rock art.

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The concept of the Silk Road, it is well known, has expanded its original meaning in recent years beyond the description of trade in Antiquity between the Roman World and Han China, through the Parthian and Kushan empires. Long ago the Middle Ages were added and the earlier Hellenistic, pre-Hellenistic, and Bronze Age periods too. More recently the itineraries considered became more diversified, including the maritime routes but also the steppe roads in the Northern areas. Similarly, the North-South roads, crossing the Himalaya-Karakorum ranges, and the territories of the Indian subcontinent came into the picture. Thematically, the trade of silk and other goods and facilities was augmented to any product or raw material that was transferred along these roads. Moreover, peoples and ideas moving along these routes were incorporated, including techniques (any sort), art, language, money, philology, philosophies, religions, polities, and empires, even by way of migrations or conquests. I shall not list here all kinds of relevant materials and entities involved in the concept of "Silk Road" but we may ask if the idea of the "Silk Road," so widely expanded chronologically, geographically, and thematically is not going to become a kind of all-purpose pseudo-concept, too broad and too fuzzy to be still scientifically useful.

By this question, I do not contest or challenge the usefulness and utility of a great number of studies, journals (*Silk Road Journal*, *The Silk Road*, and a number of others), book series, websites, UNESCO programs, etc. As stated, for instance, by the editor of the series *Silk Road Studies*, Johan van der Beke: "The exchanges that arose along the Silk Road produced intercultural outcomes that go beyond mere syncretism since they generated phenomena that integrated art, religion and philosophy at a deep level" (Van der Beke 2023). In other words, are "intercultural outcomes that go beyond mere syncretism since they generated phenomena that integrated art, religion and philosophy at a deep level" specific outcomes of the Silk Road, or are they a more general product of History everywhere at any time? Formulated in another way: can we conceive, except for islands (Andaman, New Caledonia, parts of Indonesia for instance) or separated continents (Eurasia vs. Australia, Americas), civilizations or cultures without "intercultural outcomes…"? (see Bentley 1999 about the problematic term of "Asia;" Beckwith 2023, n.1, 297 on "Silk Road"). My purpose, after asking this question directly, but without any negative criticism, and after some interrogations with archaeologists (Brosseder 2015), is to analyze some case studies in order to reach possible interpretative conclusions regarding the heuristic potential of the "Silk Road" concept for archaeological-historical research and to conclude with some methodological and epistemological reflections.

In order to try to achieve this goal for the periods and regions I am familiar with, i.e. Protohistory and Antiquity of Central Asia, rather than to list a large number of cases, since the literature is overwhelming, I will analyze three case examples (Francfort 2019), two dealing with Protohistory (Chalcolithic and Bronze Age). The first tackles parts of the early long-distance transportation of plants and minerals. The second is about the Indo-European question, relating to linguistics, art, archaeology, and ancient DNA studies. The last example, concerns the historical periods, Antiquity (here including Achaemenid to Hellenistic periods and Zhou to Han period in China), dealing with the Achaemenid finds in the steppe world among the Asian Scythians and further East up to China.

Early Long Distance Transportations of Plants and Minerals: Archaeology, Physico-chemical, and Natural Sciences

The Silk Road concept was originally invented and utilized for the study of transported or transferred items between China and the Mediterranean in a consistent historical framework. As said above, this idea has been enlarged and almost all that was possibly identified between the 1st cent. BCE/CE and the Modern period could have been integrated. Books and articles are definitely too numerous and there is no question of any survey here. Besides the journals mentioned above, among the most comprehensive, original, or well-documented synthesis publications, one may mention non-exhaustively (and more below): Schafer 1985; Francfort 1990; Lubo-Lesnichenko 1994; Boulnois 2001; Beckwith 2009; Hansen 2017; Hildebrandt 2017. Specifically on the roads linking Central Asia and India: Foucher 1942-1947; Neelis 2006; Rtveladze 2012. On the "globalization" or "big history" perspective: Christian 2000; Doumani Dupuy, Spengler, and Frachetti 2017; Betts *et al.* 2019; Von Reden 2020, 2022. Additionally, many exhibitions were organized and catalogs were published.

Some recent results must be emphasized, coming from various laboratory analyses. Such is, as an example for various periods, the questions of the glass from West to East with probable transfers of techniques beginning before the Graeco-Roman time of exchanges (Debaine-Francfort and Abduressul 2001; Cheng *et al.* 2016; Henderson *et al.* 2016; Pankova and Simpson 2020; Lü *et al.* 2021). On the other hand, from East to West, the Chinese lacquer and Han mirrors found in burials in Central Asia in Antiquity seem to have never been subject to attempts of imitation. One may also multiply such parallels and comparisons on sections of the Silk Road, or all along the itineraries between the Graeco-Roman Mediterranean and China, either via the Black Sea zone, Caucasus, or South of it through Iran and Bactria (not speaking of the Red Sea, Persian Gulf etc. maritime lanes), or via the steppes. But all this concerns mainly the Graeco-Roman and Han period, slightly later than the main focus of this paper, which is devoted to the Bronze and Iron Ages (in Central Asia: Oxus Civilization, ca. 2500-1750 BCE and Yaz periods, ca. 1400-330 BCE).

Recent discoveries from early periods are nevertheless enlarging the concept of the "Silk Road" to the time since Protohistory (Chalcolithic and Bronze Ages). Analyses of trace elements in gold objects from the Royal tombs of Ur in Mesopotamia (ca. 2400 BCE) show that platinoid inclusions, notably osmium, can be traced by their isotopes to Central Asia, suggesting an alluvial gold placer located on the Panj (Upper Oxus), between Afghanistan and Tajikistan, at Samti (Jansen *et al.* 2016; Hauptmann *et al.* 2018). This result is of tremendous importance since it demonstrates a very large early exchange/transportation network and provides possible explanations for the location of an Indus Civilization settlement (Shortughaï: Francfort *et al.* 1989; Francfort and Parpola 2022) and an Oxus Civilization site (Farkhor: Vinogradova and Bobomullaev 2020) in the same place neighboring Samti (Francfort 2016b, 2022) (fig. 1).

Another new result concerns the tin ingots of the Uluburun wreck in Mediterranean Turkey (1320 BCE): one-third of them are made of tin originating in Central Asia, in

Uzbekistan and Tajikistan (Powell *et al.* 2022). The tin deposits of the Zeravshan Valley are well attested as is their use since the 2nd mill. BCE (Garner 2013, 2015) (fig. 1; fig. 2). The site of Sarazm in Tajikistan (Zeravshan Valley), excavated by our team in cooperation with the Tajik Academy of Sciences since 1984, was occupied from the 4th (Chalcolithic) to the late 3rd millennium (Bronze) BCE and it exhibits remains and goods coming from extremely remote countries: Middle East, NE Iran, Southern Afghanistan, Indian Ocean, remote Asian steppe (Afanasevo culture) (fig. 1.; fig. 3). The search for gold and/or tin in the alluvial deposits is suggested for explaining such an attractiveness (Mutin and Razzokov 2014; Francfort 2022) but the recent discovery at Uluburun is of utmost importance since it may also explain the tin of the Kanish *karum* in Anatolia, attested by commercial cuneiform tablets along with lapis-lazuli (originating as we know in Afghan Badakhshan, at Sar-i Sang) (Michel 2001) (fig. 1). Incidentally, the term "Lapis-lazuli Road" was coined in the 1970s, as a sort of predecessor to the Silk Road, for the Chalcolithic and Bronze Age periods (Tosi 1974). The question of tin at Mari (Syria) has been studied by J.-M. Durand through the cuneiform tablets with a reflection on the question of "trade" compared to other ways of obtaining goods (Durand 2018).

Another important new find has evidenced the transfer of plants and food over very long distances in the second mill. BCE (sesame, soybean, turmeric, and probable banana) (Scott *et al.* 2020), anticipating later fruit and animal transfers (I shall not detail these here since it is known well enough). However, other recently evidenced plant grain transfers concern wheat from the Middle East and Central Asia to China in Protohistory and millet the other way round, from China to Central Asia, Middle East, and Europe (Betts, Jia, and Dodson 2014; Frachetti 2014; Spengler *et al.* 2014; Dong *et al.* 2017; T. Wang *et al.* 2017; Huang *et al.* 2023) (fig. 4). Among others, they also demonstrate that cultivation was not foreign to steppe populations.

Besides this (and there is certainly more), there is another new field: the transmission of pathogens and notably of *Yersinia pestis*, the plague. Until quite recently, the historical documents were almost the unique source for the study of plague but now the analyses of skeletons permit us to find *Yersinia pestis* and to sequence its genome in laboratories. The results, just beginning to appear and cumulate, are quite significant. The plague has been identified, until now on a small number of samples and individuals, from the Neolithic to Bronze Age, meaning that we are far from the punctual late episodes of the Justinian Plague or of the Mediaeval "Black Death" (Rascovan, Drancourt, and Desnues 2016; Valtueña *et al.* 2017, 2022; Spyrou *et al.* 2018). If we consider that apparently the main reservoir in Eurasia, if not the unique one, is located in the Altay Mountains region, among the big marmots (*surok, bobak,* i.e. *Marmota sibirica*) (Suntsov and Suntsova 2000), this opens new perspectives for studying the spreading of plague towards the West and also to China. But many more excavations of burials and systematic mass analyses are required, which is a very big task. It is also necessary to study the possible long-term survival of *Yersinia pestis* in soils and to check if the flea is the only possible transmitter. Recently, even *Salmonella enterica* found during the Xinjiang Bronze Age was tentatively associated with a "Proto-Silk-Road" (Wu *et al.* 2021).

Such studies are extremely illuminating, however, the mechanisms of transmission and transfer are not always clear because of the lack of precise archaeological data due to the insufficient careful excavation and collection of minute finds, organic remains, and soil samples, in huge series, for mass analyses in laboratories. Nevertheless, I shall now proceed to the second case, which is less material and quite complicated since it implies the collaboration of a number of disciplines: the Indo-European question.

The Indo-European Question: Linguistics, Archaeology, and Biology

The spread of the Indo-European languages and peoples (Indo-Iranian, Indo-Aryan also, with more nuances including Proto-Indo-Europeans and Proto-Indo-Iranians, for instance, but I shall not enter in details in the present paper) was searched for long ago by linguists with the assumption that homogenous languages corresponded to homogenous ethnic groups and populations. This opened the possibility for many racist derivations, that are now rejected, but we know today that the question is not very simple. A huge literature explains this problem at length, I mention here only a small sample of it: Haudry 1981; Mallory 1991, 1998; Lamberg-Karlovsky 2002; Kuz'mina 2007; Demoule 2014. In our regions of Central Asia, the question becomes specifically linked to Indo-Iranians and Indo-Aryans: Mair 1998; Parpola 1999, 2002, 2015, 2022; Mair and Mallory 2000; Mallory 2002a, 2002b; Anthony 2007; Sarianidi 2014.

After the Palaeolithic migrations and the peopling of Eurasia from Africa, generally represented on maps by long arrows, many unobserved and not recognized events probably took place but the accuracy of our tools of investigation is not fine enough for evidencing them. Among them, one considerable "event" took place between the fourth and the second millennia BCE: the expansion of the Indo-Europeans. The question so formulated is in part wrong since we lack the minimal information about the languages of the Eurasian populations in early periods, except in some countries, Egypt, Mesopotamia, and Iran, where writing was practiced but they are all non-Indo-European languages: Egyptian, Sumerian, Elamite, and others. Therefore, in order to support the idea of migration, scholars examined proxies as markers supposed to "carry" the Indo-European linguistic group. In this manner, the expansion of various phenomena in Eurasia was utilized: certain types of artifacts, the use of wheeled carts and chariots, the practice of agriculture, and others. Nothing really convincing for all students of the question emerged during this period of research, and various centers were proposed for the original place. Two of them emerged as more popular: Anatolia and South Russia/Ukraine. Simultaneously, the question of chronology arose: should we look after 4th or 3rd millennium BCE cultures?

Additionally, among the groups of Indo-European languages identified and studied, represented by great arborescent graphs, some concerned Central Asia: the Tokharian and the Indo-Iranian groups. The first showing some analogies with Celtic languages, but written only in late texts, triggered many speculations on ancient migrations from Western Europe to

Xinjiang (not validated). The second, with the most ancient Vedic and Avestic texts, generated a number of hypotheses regarding not only the languages and the archaeology but also the domestication of the horse from the steppe and the ancient religions (with an early schism between Indians and Iranians) as well as migrations in the 2nd mill. BCE. The discovery of some texts in an Indian Rigvedic dialect in Mitanni (roughly North Syria), launched a number of discussions about the movements of populations. These questions remain still unsettled, sometimes even controversial. The texts, often absent, partial or ambiguous, the archaeological artifacts, and the ancient zoological (horse, cow) and botanical remains (the example of the search for the original plant for *soma/haoma* the intoxicating sacred drink is typical, with a great number of proposals) left the researchers without a complete solution of the questions.

More recently, ancient DNA analyses have been taken as a salvation by some scholars, since they seemed to offer real scientific solid conclusions for identifying skeletons of "Indo-Europeans" (long ago typologized by physical anthropologists). Alas, it was clear since the beginning that if the analyses and typologies of materials (of any material, including bones and genes) provide solid scientific classifications, the Indo-European case cannot be solved so simply, in spite of the accuracy and sophistication of the analyses methods. The reason is that the haplogroups, as good as they can be, do not speak, no more than pots do. Without written tablets, parchment, or leaves found in the same tomb, a direct link between human remains, archaeological material, and languages is all but hypothetical. Moreover, the number of DNA analyses at hand today is not sufficient to accept that they can be representative of an entire population group. And worst, it could be that among Indo-European or Indo-Aryan speaking groups, not all had a similar or homogenous genetic profile (just think as an example of the migrations of the youngsters from the archaic Greek cities, marrying among the populations of the territories where they settled, not Indo-European speaking necessarily…).

Presently, the most widespread theory about the Indo-European expansion is the one that makes these groups move from South Russia / Ukraine with oxen carts in the 4th mill. BCE. An archaeological culture known since long ago provides hard data for supporting the theory: the Yamnaya culture. That is fine, but there is still a doubt before we can accept this theory of a great migration going up to the frontiers of China can be admitted as demonstrated. Actually, there is another culture, of the same period, and quite similar archaeologically, the Afanasevo culture. Interestingly, Afanasevo is centered in South Siberia and Central Kazakhstan and could have moved Westward while Yamnaya is considered to have moved Eastward. Both master oxen carts but the domestication of horses was wrongly attributed to them (see below). It is a matter of chronology: the earliest of the two *could* represent the Indo-Europeans. Yet, there is another question complicating the problem: the languages of the preceding cultures, from the Neolithic substrate.

This is, nevertheless, not all since a recent study brings new results seeming to solve a part of the questions: "Our results reject the commonly held association between horseback riding and the massive expansion of Yamnaya steppe pastoralists into Europe around 3000

BCE, driving the spread of Indo-European languages. This contrasts with the scenario in Asia where Indo-Iranian languages, chariots, and horses spread together, following the early second millennium BCE Sintashta culture" (Librado and Orlando 2021). So, looking at the general picture of migrations in Eurasia, on the "Silk Road" territories, the question remains unsettled today and, the problem of horses apart, the Yamnaya hypothesis is still used for a part of the migrations, at least in West Asia and Anatolia, with or without Indo-European languages (Haak *et al.* 2015; Narasimhan *et al.* 2018; Narasimhan *et al.* 2019; Lazaridis *et al.* 2022).

On the other hand, further East, in the 2nd mill. BCE, the question seems also uncertain with the problem of the Sintashta and subsequent Andronovo groups of steppe cultures, often connected with Indo-Iranian migrations, though not without controversies (Lazaridis *et al.* 2022). For instance, recent genetic studies of Xinjiang ancient mummies populations between 3000 and 1700 BCE now exclude the "proto-Tokharian" theory and the immigrations from Steppe or Oxus Civilization (BMAC) but differences appear between Dzhungaria and Tarim basin populations that are still to be explained (Doumani Dupuy 2021; F. Zhang *et al.* 2021). All this shows that the question of the Indo-European and Indo-Iranian or Indo-Aryan migrations and origins of languages is not as simple as it was thought some years ago. The recent genetic data and their interpretations are always tentatively connected to the question of the languages' origins and it seems certain now that an unequivocal connection is not to be considered anymore (Jeong *et al.* 2020; Kristiansen, Kroonen, and Willerslev 2023).

Again, however, the case of the Indo-Iranian or Indo-Aryan coming from the steppe (Sintashta and Andronovo) and moving southward towards India through the territories of the Oxus Civilization (BMAC), a central Asian civilization (ca. 2500-1750 BCE) exhibiting no data corresponding to Indo-Iranians or Indo-Aryans (Francfort 2005), is another example of the complexities of transfers during the second half of the second mill. BCE. Indeed, the apparition of Andronovo potteries in all Southern Central Asia is well attested but nothing of these archaeological remains is found south of the Hindu Kush: all appears as if coming from the steppe world, only the horses had crossed the mountains and found their way down to the site of Pirak in Pakistani Balochistan (Jarrige 1979; Mair ed. 1998). Moreover, rock art (petroglyphs) contributed to demonstrating a constant flow of populations from the steppe to North India via Himalaya-Karakorum passes, from the Bronze to Iron (Scythian) ages and later, instead of one unique episode of big Vedic migration (Francfort 1994). For this Asiatic part of the Indo-European question, the archaeological material, the remains of cult installations, and the funerary rituals are as important as the linguistic data (Witzel 2004, 2019; Fussman *et al.* 2005; Lubotsky 2023), however, the picture is not yet settled (Narasimhan *et al.* 2018).

Similarly, the question of the use of the horse-drawn two-wheeled chariot has been the subject of many studies, representing, according to some students, the Indo-Iranian/Indo-Aryan expansion or migration. The case seems clear at first sight with the early Sintashta and the following Andronovo chariots, or with their pictures and engravings scattered almost everywhere in the steppe and in the Karakorum region, in Altay, and up to Shang China,

with a special role attributed to the Mitanni Aryans and the Hittites (see the Kikkuli treatise). The only problem is that if we consider the chariot as a general marker of the Indo-Iranians or Indo-Aryans in the East, we will have logically to conclude that the Egyptians and the Chinese were Aryans. Naturally, technical borrowing and techno-cultural transfers must also be taken into consideration and, therefore, we must carefully examine which chariot or chariot pictures can safely be linked to Indo-Iranians or Indo-Aryans. This sends us back to the previous problem: the same reasoning applies to the 4th-3rd mill. BCE period with the ox-driven carts of Afanasevo, Yamnaya, and other European, Central Asian (Oxus/BMAC), or Caucasian cultures (Lchashen, Novotitorovskaya) (Kohl 2007).

Finally, with the exception of the few regions where texts complement the archaeological and biological data, the question of the movements of languages, populations, and cultures in Eurasia between the 4th and the 2nd mill. BCE is not an easy one to solve. However, it is certain that, according to the majority of studies, three or more regions are always referred to: the steppe zone, the Central Asian, and the Middle-Near Eastern regions or areas, some being subdivided according to the requirements of the studies. It is by itself a form of "Silk Road," though not as continuous, linear, or clearly delineated as usually expected.

Achaemenid Finds in the Steppe World Among the Asian Scythians and Further East up to China: Art and Archaeology

In this section, I shall consider briefly the question of the obvious presence of Achaemenid or Achaemenid-like artifacts in the burials (kurgans) of the Asian Scythians from the Southern Urals to China, i.e. in cemeteries such as Filippovka (Aruz *et al.* 2000), of the Altay Pazyryk culture in Russia (many publications on Pazyryk, Bashadar, Ak-Alakha, etc.), of Berel' in Kazakhstan (see below), of Alagou (B. Wang 1987), and Djoumboulaq Qoum in Xinjiang (PRC) (Debaine-Francfort and Abduressul 2001), of Majiayuan in Gansu (PRC) (H. Wang 2011; Xiaolong Wu 2013; Yang and Linduff 2013). This is only a small sample of the finds but it is significant first because, along with objects imported from the Persian empire, other objects were manufactured as copies and, secondly, especially because many of these "Achaemenid" finds came out of kurgans built at a date later than the end of the Persian empire. This shows the importance of the Achaemenid arts for the Asian steppe Scythians and raises the question of the reason for such great popularity. This is not a little question since not only did the Asian Scythians (or Saka if we adopt the Achaemenid terminology) take and copy objects but, above all, because they adapted beautifully the Persian art forms into their own artistic language and style. They took their inspiration from the monumental arts such as the Persepolis palaces and from the prestige goods such as the silver wares of the royalty and of the satraps courts in Asia. On a large scale, we can identify a southern "oasis" road via Bactria, Sogdiana, and/or Chorasmia (Francfort 2020a) but also a steppe road between the Caspian and the Kazakh steppe (Xin Wu 2021). I do not list here all finds relevant to this question but a number of references are relevant: Debaine-Francfort 1990;

Francfort, Ligabue, and Samashev 1998, 2000; Francfort 2001, 2007, 2009, 2013, 2020a; Francfort and Samashev 2002; Jablonskij and Meshcherjakov 2007; Treister 2010; H. Wang 2011, 2014; Trejster and Jablonskij 2012; Xiaolong Wu 2013; Yablonsky 2015; Yablonsky and Treister 2019.

The question of such a success of the Achaemenid arts in the Asian steppe seems to be the result of the presence of the Scythians in the Achaemenid territory, in the armies and in the courts, especially if we read the written sources and observe the figurative documents. Ultimately, Persians and Scythians were sharing a part of their culture of horsemen related to the steppe zone. The other question, relating to the choice of the subjects and themes adopted by the Scythians is less obvious. If we select the example of the horned lion (or dragon-lion) image, whose image in Iran originates in the ancient Mesopotamian and Assyrian arts, we see that this monster is a main adversary of the royal hero in the Persepolis reliefs, with its lion head, horns, wings, and scorpion tail, all elements replicated in Scythian mobile arts (torcs, horse pendants, etc.). A possible, if not probable, explanation for such a choice is that it matched with a traditional figure of the earlier steppe arts, such as the Okunevo culture dragons engraved on stone stelae in the Minusinsk basin, but the way it was transformed into mobile ornament and rendered in a very original style, on its side, results from the pre-existence of a strong local artistic tradition in the steppe with its corpus of stylistic rules, represented for instance at the kurgans of Arzhan 1 and 2 (Russia), Chilikta, Eleke Sazy (Kazakhstan) (Chernikov 1965; Grjaznov 1984; K. Chugunov, Parzinger, and Nagler 2006; K.V. Chugunov, Parzinger, and Nagler 2010; Bejsenov 2013; Samashev 2021a, 2021b) while also existing in the innumerable petroglyphs observable in the steppe zone.

Petroglyphs also help to demonstrate that the 7th-century Scythian migrations, known by the texts and archaeology, linked, for instance, the mountains of Sajmaly-Tash and the Kelermes site: a very peculiar type of panther engraved on the Kirghiz rocks finds its perfect counterpart in a gold plaque from a burial on the Black Sea (Sher *et al.* 1987) (fig. 5). This is a very clear example of the interest to bring together various data for such "Silk Road" migrations but there are several other cases, along the centuries, for instance, the anthropomorphic stone stelae from Mongolia to the Black Sea (Ol'khovskij and Evdokimov 1994), or the bouterolles of *akinakès* sheath (Bernard 1976), and other elements of material culture shared by the Persians and the Scythians. This kind of common cultural background and the mobility of the Scythians can explain the analogies exemplified here.

The transfer of Achaemenid artistic elements to China may also be demonstrated. For instance, originally, the flying capability of imaginary animals in steppe art was rendered by bird's beaks (Francfort 2016a, 2016c). Winged composite animals, originally Achaemenid, were introduced in steppe and Chinese arts in the 6th century, via the steppe. Other similar transfers occurred in China: a typical steppe stylistic convention, the reverted hindquarter of animals, found its way into Chinese arts (Pirazzoli-t'Serstevens 2007). The chariot image was changed during the Western Zhou period, abandoning the old "aerial" view of the Shang period (see above) analogous to Bronze Age Andronovo rock representations, in favor of a profile view, characteristic of Middle Eastern arts, notably the Achaemenid: beautiful royal

lion hunts from chariot on Mashan silks appear as if copying a royal Persian cylinder-seal; the profile view for chariot was definitely adopted by the Han artists (Thote 1999; Francfort 2002). On the other way round, Chinese arts were imported into Central Asia, west of the Pamir Mountains, steppe and sown, during the Han period after the conquest by Alexander the Great, the settlement of Greek populations, and the foundation of Greek kingdoms (Graeco-Bactrians, Indo-Greeks, Early Parthians, and pre-Kushans for our timespan) (see above).

It is suggestive that nothing equivalent to the penetration of Achaemenid arts in the steppe world ever occurred from the Greeks. Possibly, the cultures were too foreign to offer anything to be adopted, copied, or transformed by the Scythians in the steppe, meanwhile the case could have been different with China as with Maurya India (Boardman 2015; Bopearachchi 2017; Nickel 2021). The Achaemenid's legacy in the arts of the steppe lasted about one century after the fall of the empire (Pazyryk 5 or Berel' 11 in the 3rd century) but nothing of the Hellenism, of the culture brought by Alexander and his successors, was transformed and incorporated into steppe arts and styles. Only some objects circulated south of the Urals and in Kazakhstan (among the Sarmatians), in Xinjiang (among Saka and Yuezhi: ex. Shampula), and in Mongolia (among the Xiongnu: ex. Noin-Ula). A partial transmission to Saka-Yuezhi occurred in the agrarian kingdoms in Central Asia, in Bactria (at Tillya Tepa, Khalchayan, and Begram, for instance), and then to the Kushans. However, the Greek legacy developed in a part of India, more precisely in Gandhāra. There, after the fall of the Graeco-Bactrian kingdoms and the migration of the Greeks from Bactria to India, the Indo-Greek, Indo-Scythian, and Indo-Parthian kingdoms mixed the Greek heritage with Indian, Scythian, and Parthian influxes. Taxila, Charsada, and Shaikhan-Dheri are major sites for understanding this evolution. They are manifestations of a North-South itinerary of the Silk Road (Cambon and Jarrige 2006; Rtveladze 2012; Francfort 2020b, 2022).

Some Reflexions and Conclusions

To conclude, I shall insist on the important contributions of laboratory studies of the physico-chemical and natural (biological) sciences to the schema of long-distance exchanges in Eurasia, known under the name of the "Silk Road." Today, we are far from the routes and stops along linear itineraries, concentrated on the transportation of goods from China to Central Asia, the Middle East, and Europe in historical periods. The addition of a great number of transferred "things," material, organic, biological (including cultivars and pathogens), immaterial, as well as the extension of the time scale to the earliest epochs (Pre- and Protohistory), configure a completely different "Silk Road." The roads are multiple, including, maritime itineraries, many tracks in the steppe world, and North-South itineraries linking Central Asia and India. Therefore, we may consider that the interesting spotting of finds on maps is important regarding a great variety of objects in the Eurasian Bronze and Iron Ages but also heuristically limited (Aruz 2003; Brosseder 2011). Moreover, the traditional

mapping of the "Roads" has been seriously modified. Linear itineraries can represent only local phenomena, not a general one, and no river, desert, or mountain ever was an absolute barrier at any period: all cultures and civilizations crossed these so-called "natural obstacles." Another consequence of these new observations and changes is that we must recognize that Eurasia, whatever the human and political entities dominating its various territories throughout History, was an open system from Brittany to Kamchatka.

Besides the "Silk Road," the concept of trade also needs re-examination, since many of the transferred items were not traded per se, for historical reasons (Prehistory had no "trade" *stricto sensu*), or because the transfer was not deliberately designed for exchange or "business," or it was not deliberate at all, perhaps even unconscious (plague for instance). The complexity of the developments of exchanges, for earlier times, has been recognized including using a unique concept, the steppe and the sown, i.e. the cities and the nomads (Parzinger 2008; Hickman, Mair, and Renfrew 2014; Høisæter 2018; Francfort 2019) but processes of migrations and conquests, selections and imitations, were very strong, as we have seen. No dominating preferential orientation can be observed: West-East (Achaemenids, Greeks), East-West (Saka, Xiongnu, Indo-Europeans?), or North-South (Scythians, Aryans?) or South-North (Indus Civilisation, Buddhism), to mention a few examples. Even the tendency of the steppe people to move towards the agrarian territories of the empires and seize them seems balanced by the appetite of the agrarian imperial powers for conquests and domination in the steppe. The steppe/sown divide is important in Eurasia, no doubt, but apparently, it is not determining the totality of the exchanges, in the sense of a strong causality, no more than the "trade" phenomena. Therefore it is better not to generalize too much too quickly. Similarly, the distance between the source place and the end place of the goods (or whatever) transported has no universal value and, sometimes, it is not necessary to travel from China to Europe (like silk) to obtain a significant "Road": it is the case of the "lapis-lazuli road," from Badakhshan to Mesopotamia and the Levant for instance, or of the "tin road," from Zeravshan to Anatolia. Many other examples could be proposed.

The new analytical laboratory tools permit such an evolution of the research on the "Silk Road" towards a better understanding of invisible, microscopic items. At the same time, complementary interpretive techniques by using quantitative methods (not exposed here), help to design economic or cultural networks that are more accurate than the ancient road maps, dot distributions, or bold arrows crisscrossing maps. Such are, for example, the conceptual networks, sometimes finding again (or anew) old concepts such as "centre and periphery" or "world systems" (Morris 2013, 2018; Scheidel 2019; Ling, Chacon, and Kristiansen 2022). A number of publications, more or less explicitly, try to use the more recent concept of "globalization" that I will not comment upon here (Miller and Brosseder 2017; Boivin and Frachetti 2018; Chew 2018; Grinin and Korotayev 2018; Von Reden 2020, 2022). In any case, we touch upon here, for Eurasia, the questions related to the emergence and development of "State," "Empire," "complex societies," "chiefdoms" and the role of traded prestige goods in the emergence of social hierarchies along with the questions surrounding urbanization with the definitions of "cities" and many others.

Furthermore, the concept of "big history" seems also relevant to our "Silk Road" problems of long-distance exchanges (Fernández-Götz and Krausse 2017; Krakauer, Gaddis, and Pomeranz 2017). "Trade" and long-distance exchanges are an important part of the picture, as demonstrated by the various scales of observation of the phenomena considered under the "Silk Road" but not all (Frachetti 2009 for example). The geography, the natural circumstances, and their evolutions, in connection with environmental changes, also require great attention in relation to natural determinants (Fouache *et al.* 2015; Li *et al.* 2016; Francfort 2018; Tan *et al.* 2021; Weiss 2016). The search for general rules in the history of the Eurasian continent is not an easy task, even by using a limited set of parameters, which requires a conscious and possibly rigorous scientific reductionism for constructing models (Currie *et al.* 2020).

Finally, one may wonder if the concept of the "Silk Road" is still relevant in the face of so many aspects to be taken into consideration for research. Would it not be better to substitute it with a general "Eurasian History" multidisciplinary concept? Perhaps, not only if we consider the tremendous importance of exchanges in all fields of the societies considered (and we have seen only a small part of the question), the focus upon the systems of exchange ("trade") leaves place for a concept of the "Silk Road" maybe more rigorously extended or generalized in time, space, and function and resolutely multidirectional, including more quantifications and mathematical treatments as required by the developing approaches partly and briefly described here.

Figure 1. Map of mineral transportation and exchanges in the 4th-3rd mill. BCE: gold, tin, lapis-lazuli. Courtesy of David Sarmiento-Castillo 2023.

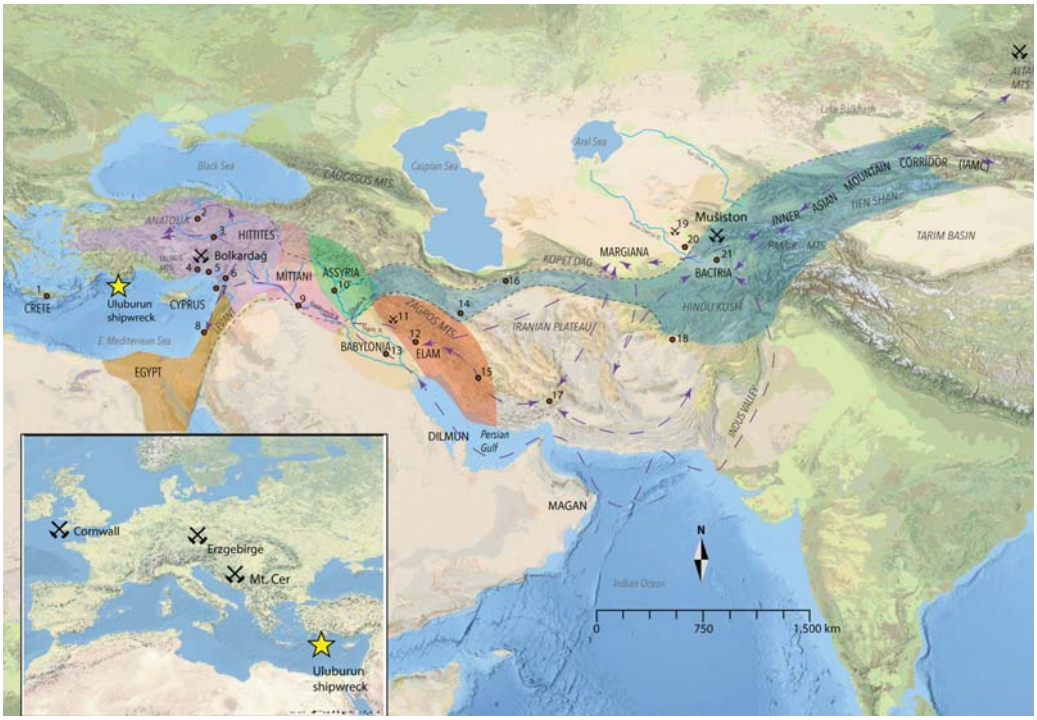

Figure 2. Map of tin from Central Asia to the Mediterranean in the 2nd mill. BCE. Courtesy of M. Frachetti (after Powell et al. 2022).

Figure 3. Map of Sarazm in the Zeravshan Valley and imported goods evidencing its long-distance relationships in the 4th to 3rd mill. BCE. Courtesy of Benjamin Mutin 2023.

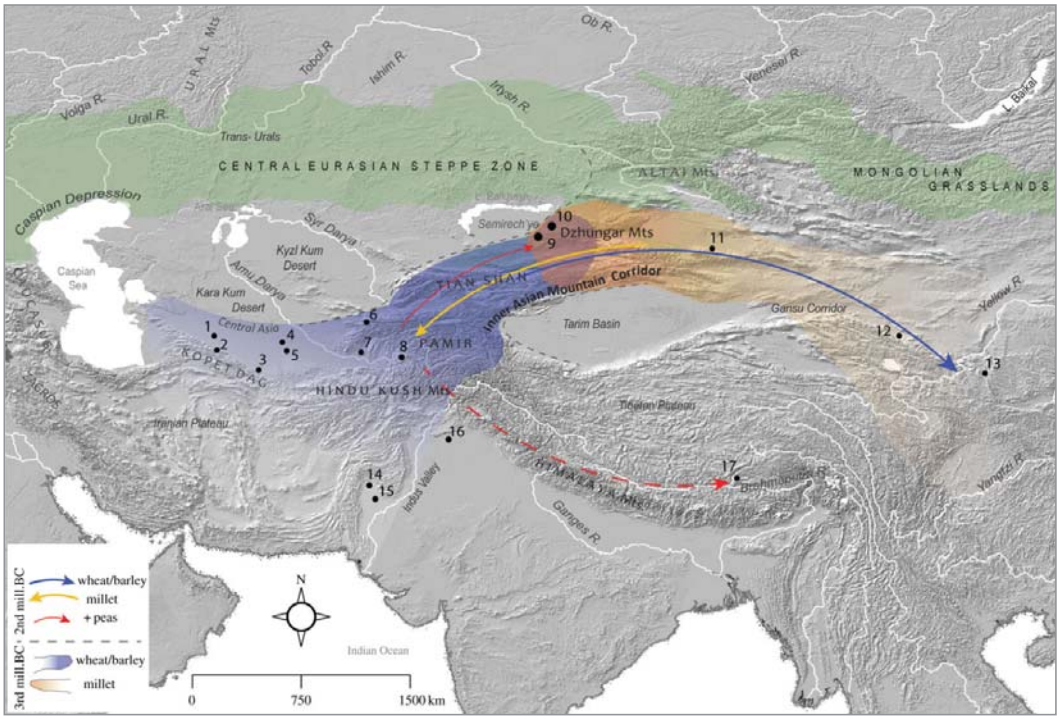

Figure 4. Map of the transfers of wheat and millet.
Courtesy of M. Frachetti 2023 (updated from Spengler et al. 2014).

Figure 5. Panthers in petroglyphs of Zhaktyrak-Tash, Kirghizstan (right after Sher et al. 1987 and photo author) and in gold from Kelermes (after Schiltz 1994).

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