Gold and Silver: Relative Values in the Ancient Past

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We have documented more than 200 relative values of gold and silver across almost 3000 years (2500 BCE–400 CE) to establish value benchmarks for essentially pure metal. Our aim is to improve understanding of ancient economies by enabling regional and temporal comparisons of these relative values. First, we establish silver as an early, reliable benchmark for valuing gold of varying purity before implementation of parting. Whilst purity accounted for two to threefold variation in the value of gold, we conclude that availability was more influential. Access to Nubian gold until about 1100 BCE seems an important influence on gold-silver value ratios in Egypt and the Near East, which increased significantly following loss of this source. This investigation yields a suite of relative values for essentially pure gold and silver, subdivided by regions and intervals from 2500 BCE–400 CE. These will enable future comparisons of precious metal-denominated costs of labour and commodities, including with today.

Introduction

This study focuses on the material value and relative worth of gold and silver from 2500 BCE to 400 CE within most advanced civilizations of that period (Fig. 1).[1] It is part of a larger study of their relative values to the present. They were unrivalled as 'precious metals' and stores of wealth, with values inextricably linked to standardized measurements of weight prior to introduction of coinage (Renfrew 2012). Their relative values varied between regions and periods in response to supply and demand, but simultaneous variations indicate differences in metal purity. Unless we understand value differences, we cannot establish benchmarks, make meaningful comparisons between contemporaneous regions, or compare past values with today.

Our aim is to establish such benchmarks and assist understanding of ancient economies by enabling regional and temporal comparisons. The starting point is longitudinal compilation of more than 200 relative values of gold and silver, shown in Figure 2 and recorded in the Online Appendix. They are expressed as ratios of the value of a unit weight of gold to the value of the same weight of silver, hereafter the *gold:silver ratio* (GSR). The wide range in values, especially prior to 550 BCE, highlights the challenge in establishing realistic benchmarks.[2] How do we fix reference points when both values are subject to variations in purity and supply and demand?

Coinage did not exist before the seventh century BCE (Kerschner & Konuk 2020) and most earlier transactions were based on monies of account, commonly expressed as a standard weight of silver, even if not physically exchanged.[3] Widespread use of silver as a unit of account, from *c.* 2600 BCE and possibly earlier (Englund 2004; Van De Mieroop 2014), probably reflected abundance and capacity to achieve high levels of purity by cupellation since the fourth millennium (Helwing 2014; Nriagu 1985; Wood *et al.* 2021). The apparent dominance of silver as money of account in the Near East, Egypt (at least from New Kingdom: Janssen 1975; Van De Mieroop 2014), Greece and most of the Roman Empire, indicates silver as that principal reference point. However, sharp GSR increases after introduction of the gold standard in the nineteenth century CE, from about 15 to 80 today, suggests silver is unsuited for comparing past values with today.[4]

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Figure 1. *Near East and Egypt showing locations mentioned in the text. (Sources: Van De Mieroop 2007; Wilkinson 2010 and miscellaneous.)*

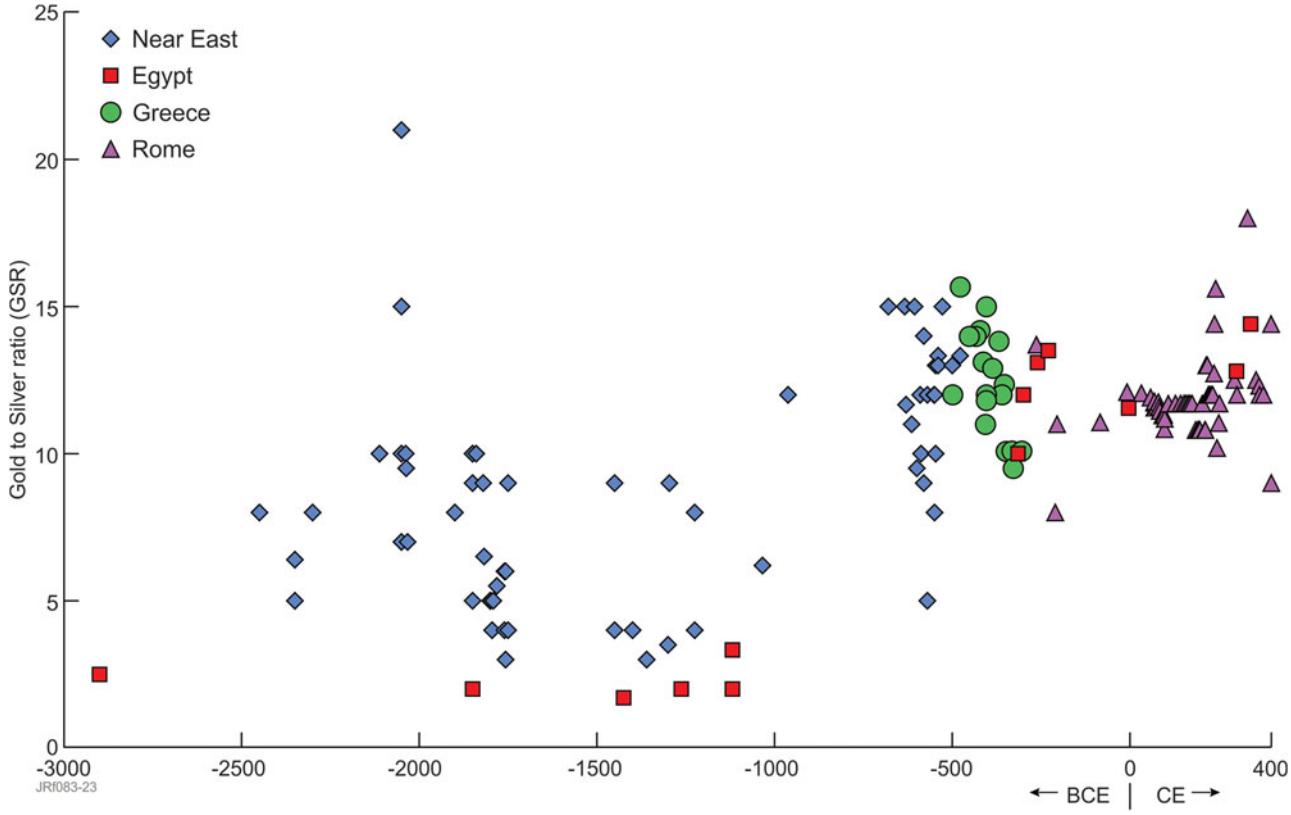

Figure 2. *GSR values 3000 BCE–400 CE, differentiated by regions. (Sources: references provided within this paper and Online Appendix.)*

In contrast, prior to widespread adoption of parting and coinage in the sixth century BCE the naturally varying silver content of native gold led to multiple, simultaneous GSR values. For example, compilation of GSRs within limited time periods by Waetzoldt (1985) from tablets at Ebla (twenty-fourth century BCE), Ur III (twenty-first century BCE), and Mari (eighteenth century BCE) indicate approximately threefold variations, a range matched in early nineteenth century BCE Larsa (Sweet 1958). However, the highest GSR within each, presumably for best quality gold, ranges from 6 (Mari) to 21 (Ur III).[5] Dercksen (2014) recorded 4–10 for Assur and Anatolia in the nineteenth century, and Kassite Babylonia (thirteenth century BCE) recorded 4–8 when gold was the money of account (Del Monte 2009). Gold-rich Egypt recorded a range of 2–3.33 for 'normal' and 'good' gold in the twelfth century BCE (Černý 1954).[6] In sixth-century BCE Babylon, Kleber (2016) identified a range of 5–12, and possibly higher, whilst Dandamayev (1988, 57) recorded 9–14 for Lydia. These ranges from different regions over almost 2000 years are shown in Figure 3 where wide variation in maximum GSRs (more than sixfold), for mostly higher-quality gold, exceeds variations in purity and indicates availability as an additional factor.[7]

To resolve this, we investigate the relationship between purity and value, the natural distribution of gold and silver deposits, and possible routes of supply. GSR values are reviewed in several contexts: how these metals were used and valued; their most likely sources; textual references to quality; and key events and periods that affected value and availability. We conclude by summarizing GSR values that may provide benchmarks for essentially pure metals by region and time intervals. These selected GSRs could enable comparison of economic markers, such as labour costs and grain prices, between regions and across almost 3000 years. They also provide potential to extend comparisons to today.

Precious metal purity and value

Silver is the logical starting point because its long-established role as money of account indicates trust in quality and availability. Furthermore, natural sources were more widespread and abundant,

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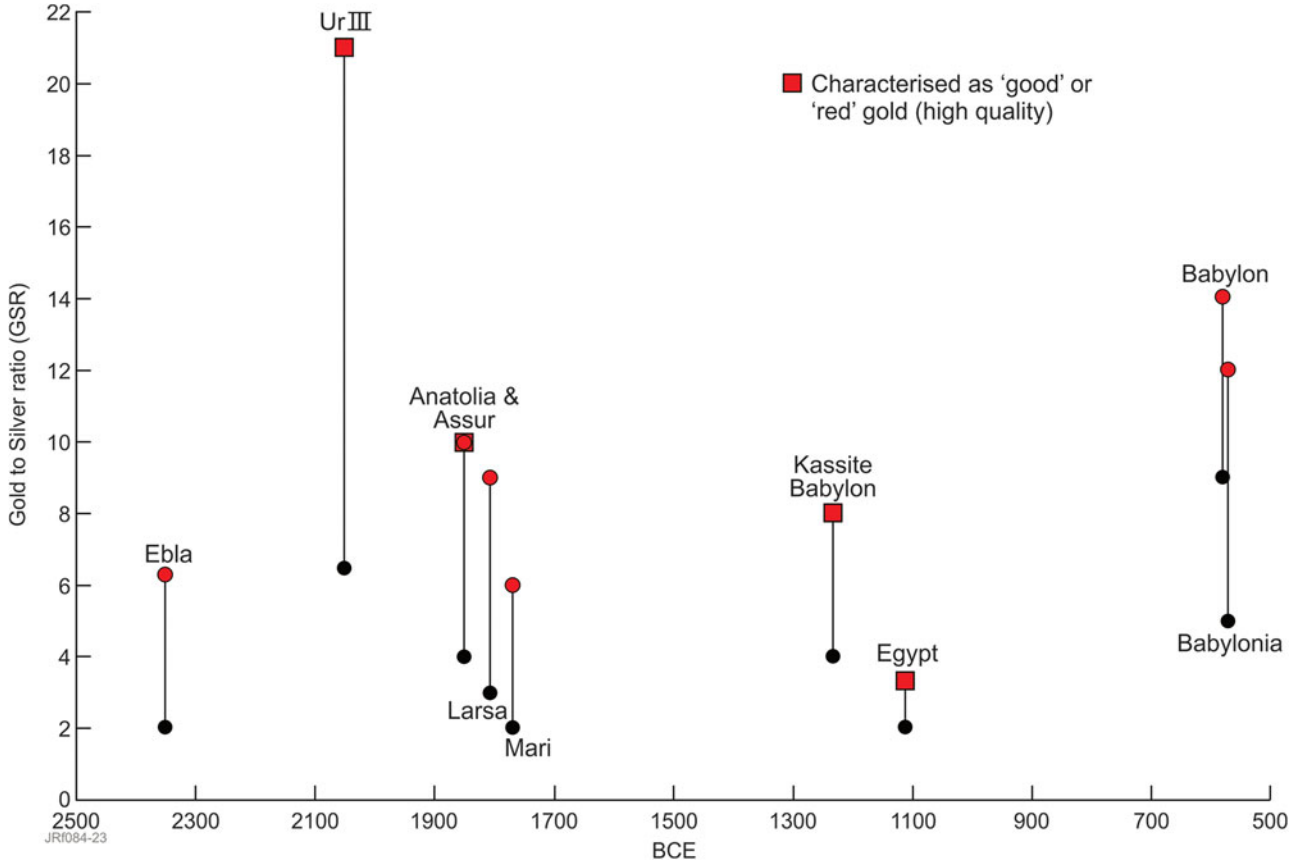

Figure 3. *Nine sets of GSR values derived from textual records in four regions across the Near East, and Egypt, showing sources and characterization of gold quality in the period 2450–550* BCE. *(Sources: references provided within this paper and Online Appendix.)*

hence its value may have been less sensitive to changes in supply and demand.[8] Silver's relative abundance is evident in records from the Old Assyrian merchant town of Kanesh, Anatolia. Tablets from the 30-year period *c.* 1893–1863 BCE provide estimates of silver shipments to Assur at 233–417 kg per annum, whereas annual gold exports averaged about 3 kg (Erol 2019).[9] These tablets refer to several qualities of silver with most common (in Kültepe text) being *sarrupum* ['purified']. Others included *amurrum* ['checked']; *dammuqum* ['fine']; *hat'um* ['bad', 'faulty']; and *massuhun* ['dirty']. They imply a capacity to classify silver (probably by colour), assess its purity, and increase it by refining, observations consistent with Veenhof (2014) and Levey (1959), who recorded small losses of impurities during refining of silver in Assur (nineteenth century BCE) and Ur III (twenty-first century BCE). Bartash (2019, 183) identified references to 'purified silver' in EDIIIa tablets (2600–2450 BCE).

Silver rarely occurs as a pure metal, unless alloyed with gold. Instead, it forms sulphide inclusions and solid solutions in sulphides (Boyle 1968; George *et al.* 2015; Ross *et al.* 2021). The lead sulphide, galena, and weathered derivatives, which can include native and horn silver (AgCl), are particularly important.[10] Silver recovery usually required lead and cupellation, as indicated by lead oxide (litharge) residues, which currently date from about 4000 BCE, at Sialk, Iran (Thornton 2014).[11] By 3000 BCE finds of litharge were spread over the Near East, Aegean and southeastern Europe, reflecting the distribution of technology and numerous silver sources. The outcome was relatively pure silver (above 90 per cent) with minor alloyed gold. Contaminants (lead, copper and bismuth) could be removed by repeated cupellation, described as 'refining' in Ur III tablets and as 'purified' back to 2600 BCE. The process of testing and improving purity, and silver's availability, favoured its role as a dominant measure of value (together with grain) from about 2600 BCE until coinage.

Prior to introduction of coinage, there was a close link between silver and barley:

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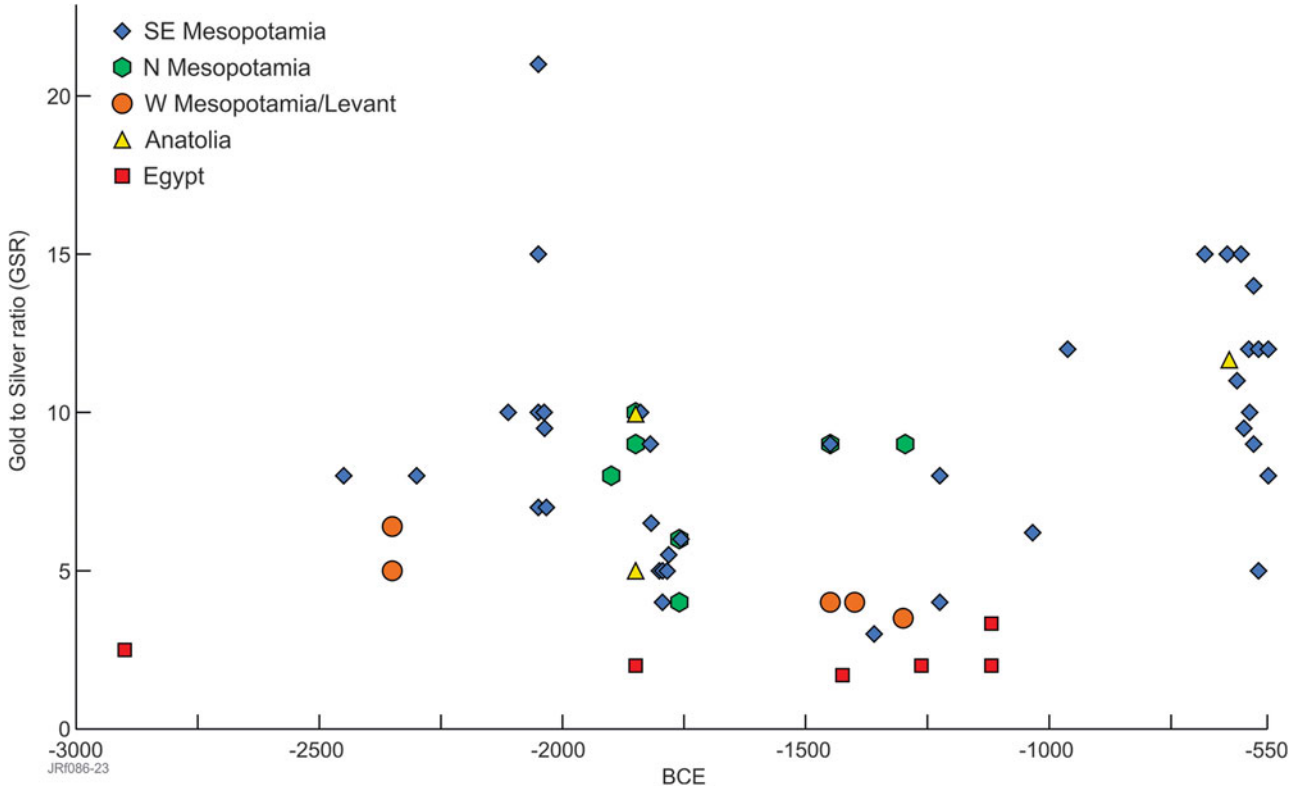

Figure 4. *GSR values 3000-550 BCE by regions. (Source: Online Appendix.)*

> Barley and silver are the only commodities attested in a paired value relationship throughout most of the history of the cuneiform tradition. From c.2600 BC to c.400 BC they occur in a value relationship with one another and repeatedly as independent measures of the value of other things. (Powell 1990, 88)

This relationship could not endure without essentially pure silver providing a benchmark for substantial changes in the value of barley, and we believe that refined or purified silver was the early benchmark of value. If correct, differences in GSR values should essentially reflect the quality and availability of gold, except for intervals when silver supplies were scarce. Anatolia in Old Assyrian times (Barjamovic 2011, 26–37), and the apparent scarcity in Middle Assyrian times until at least 900 BCE (Müller 1997), provide examples, but increased supplies were insufficient to replace copper money until about 700 BCE.[12] The Middle Assyrian is poorly represented in our data (Fig. 4), but the single GSR of 12 for good gold from Babylon at *c.* 960 BCE (Kleber 2016) suggests scarcity of gold, not silver.

Natural gold occurs almost universally in metallic form, as solid solutions with varying amounts of silver, plus minor copper and mercury (usually <2 per cent). Silver ranges between 5 and 50 per cent, but usually <25 per cent (Stos-Fertner & Gale 1979) and is accompanied by colour changes that enabled estimates of purity and recognition of deliberate alloys in ancient times, and by goldsmiths today (Fig. 5). Fortunately, some early records of gold colour and quality are unequivocally linked to variations in GSR. Furthermore, analytical data (Hauptmann *et al.* 2018) provide a more confident relationship between gold purity, colour and relative value.[13]

Gold malleability depends on purity, diminishing with increasing silver and addition of copper (Hough *et al.* 2009). Higher purity permits thinner foil covering larger areas per unit weight (Chaston 1977), enhancing its main ancient applications of foil, sheet, and ribbons.[14] Higher purity meant higher value; hence purity, colour, utility, and value of gold were probably linked, prior to widespread implementation of parting about 550 BCE.[15]

In earlier times gold purity could be estimated, but not improved, so natural gold with differing silver was valued with different GSRs relative to silver of verifiable purity. The resulting link between value and purity is shown in Figure 3 where most contemporary GSRs during this 2000-year period range by

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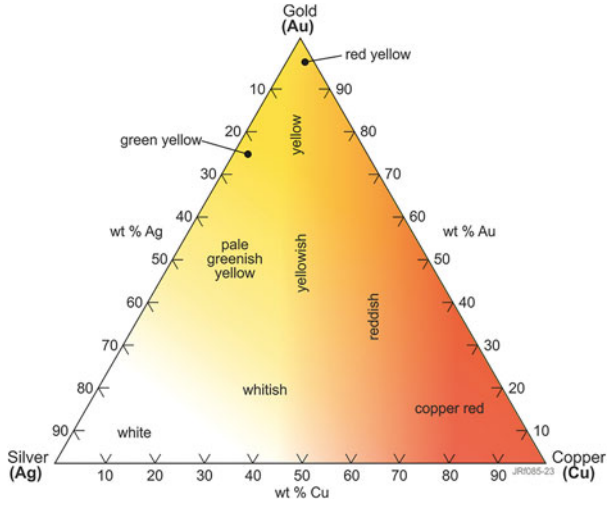

Figure 5. *Au-Ag-Cu ternary diagram showing variations in composition and colour, employed by jewellers today. (Source: Uncoloured version based on Metallos, CC BY-SA 4.0, <https://creativecommons.org/licenses/by-sa/4.0> and Hauptmann* et al. *2018.)*

no more than threefold. However, highest values, mostly attested as 'good' or 'red' (high-quality) gold, differ by more than sixfold, pointing to availability as another influence on recorded GSRs. In the following overview, we consider factors likely to influence availability and value, such as contexts in which the metals were valued, likely sources, and geographic locations.

Overview of the GSR through time: 3000 BCE–400 CE

GSR values in Figure 2 and the Online Appendix range from about 2 to 21, with most within 6–14. Data are scarce before the seventh century BCE with substantial gaps, especially 1750–1500 BCE and 1100–700 BCE, so what can we make of such variable and incomplete data? First, we applied a breakpoint at 550 BCE to separate values prior to adoption of parting (Fig. 4) from later GSRs, essentially based on pure gold and silver bullion (Fig. 6). These plots are strikingly different, and our first step towards understanding them is to briefly consider ancient use and sources before focusing on their spatial and archaeological contexts.

Ancient use and value of gold and silver

The adjective 'precious' has a duality that probably existed since each metal was first held in the hand of man. Unique qualities of colour, lustre, texture

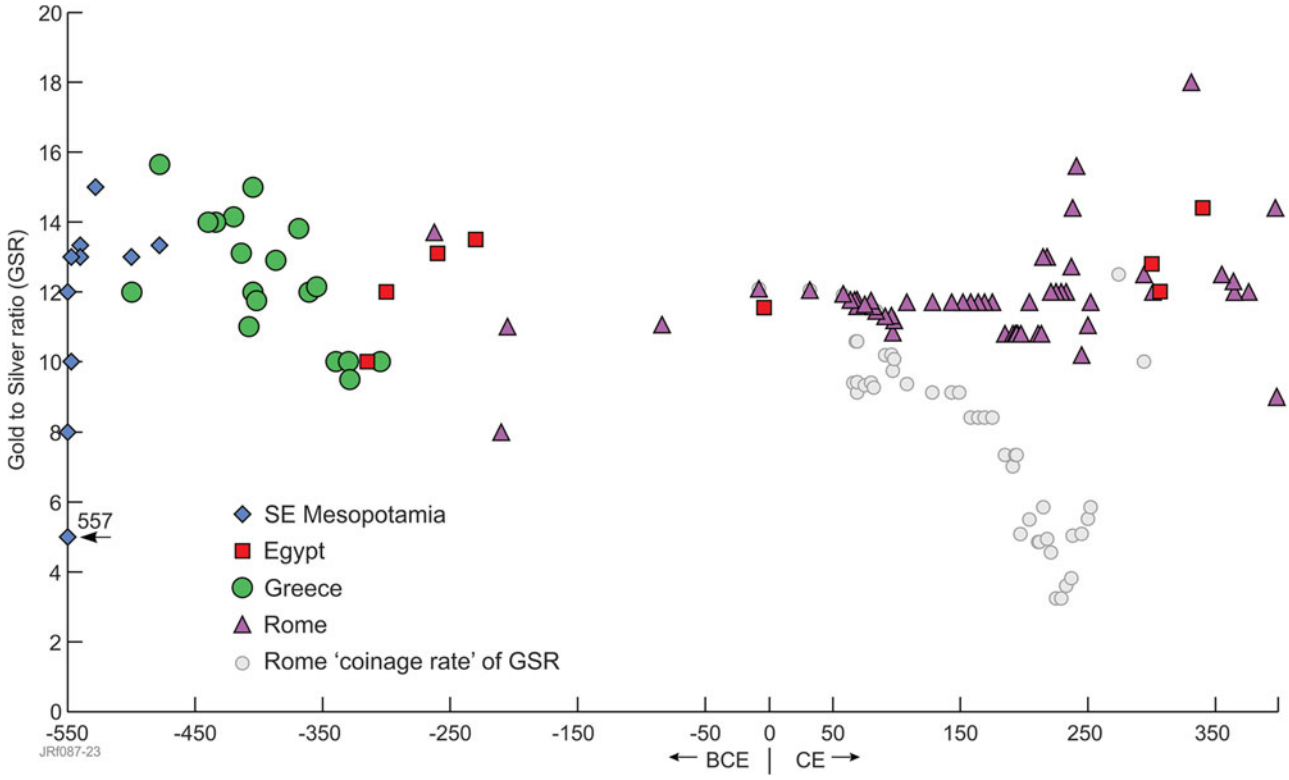

Figure 6. *GSR values 550 BCE–400 CE by regions. (Source: Online Appendix.)*

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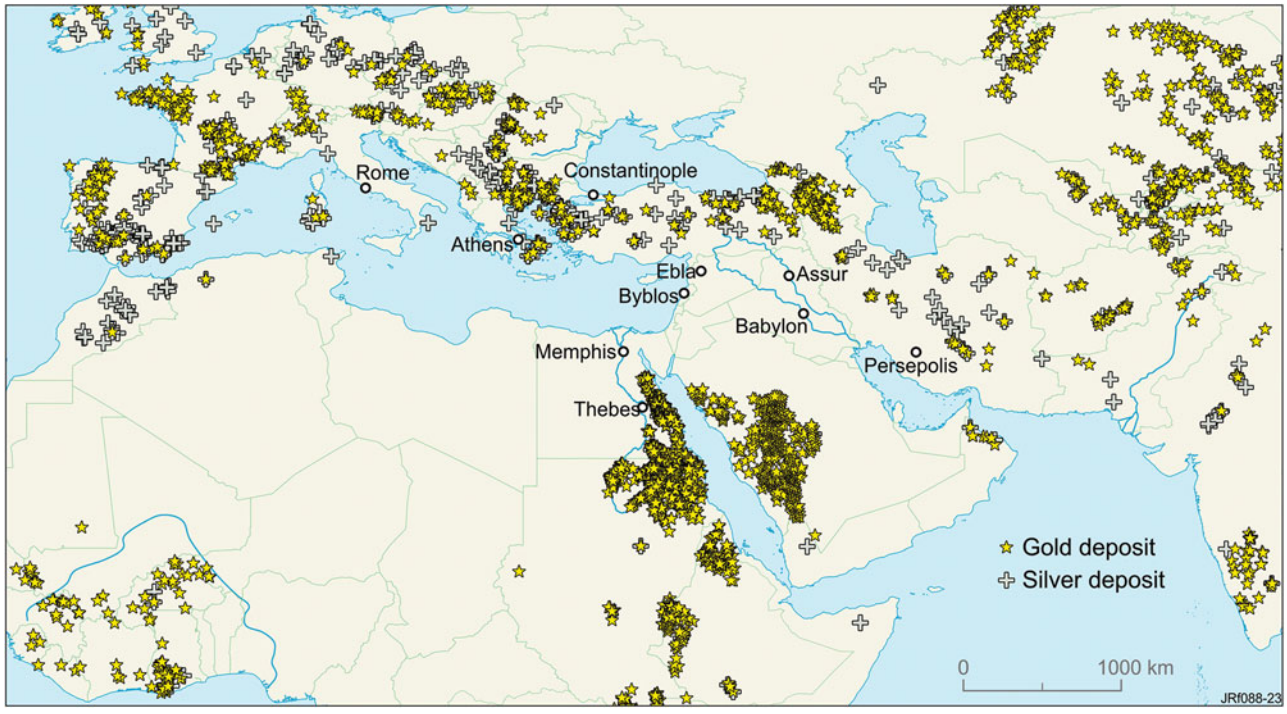

Figure 7. *Gold and silver deposits within Alpide belt and adjacent regions. (Sources: Asia: Kamitani* et al. *2014; Turkey: Menant* et al. *2018; Europe: Cassard* et al. *2015; Africa: Taylor* et al. *2009; West Africa: Milési* et al. *2004: Arabian-Nubian Shield: Johnson* et al. *2017; Egypt: Klemm & Klemm 2013; Zoheir* et al. *2019; Caucasus: Erb-Satullo 2021; Hauptmann & Klein 2009.)*

and scarcity probably imparted a spiritual dimension (Benzel 2015), which materialized in temple decoration and honouring the gods, especially in ancient Egypt and Mesopotamia. These attributes, and exceptional malleability, ductility and chemical inertness, also imparted premium material value, suited to symbols of prestige, stores of wealth, mediums of exchange and a unit of account. In each, gold is superior to silver and has been more highly valued. Demand probably always exceeded supply, as indicated by the Amarna Letters (Moran 1992) and Egypt's pursuit of gold from Punt (Bard & Fattovich 2018).[16] This dual role and widespread use focuses attention on their natural distribution and likely sources.

Likely sources of gold and silver

Field observations indicate almost all precious metal deposits within our regions of interest experienced previous mining. This is expected, because surface weathering of exposed sulphides produces iron-rich gossans: distinctive visual anomalies that ancient prospectors recognized. We conclude the best guide to deposits mined in antiquity is their distribution today; few are lost to current knowledge. Figures 7 and 8 illustrate the distribution of known gold and silver deposits within regions of interest and their geographic asymmetry. Egypt and Nubia have numerous gold deposits, but few silver, while elsewhere silver deposits are widespread. This asymmetry indicates early need for trade,and potential for regional differences in precious metal values.

Precious metal deposits typically form in areas of active tectonism; hence, likely sources occur mostly within the Alpide-Himalaya-Tethys (Alpide) tectonic belt, between Iberia and the Himalayas (Richards 2015), shown in Figure 7. Exceptions include older gold deposits in Egypt, Nubia and Arabia. The geologically active and topographically uplifted regions of the Alpide belt are antithetic to the geological stability and well-watered alluvium favoured by early urban civilizations in lower reaches of the Euphrates and Tigris rivers, and the Nile and Indus valleys; their metal supplies thus relied on expeditions and trade networks. For Mesopotamia, this meant adjacent regions of Anatolia, the Caucasus, Iran, Afghanistan and central Asia as possible sources (Jansen *et al.* 2021), but with differing costs and security of supply. The long-distance trade between Assur and Kanesh is a prime example (Fig. 1).

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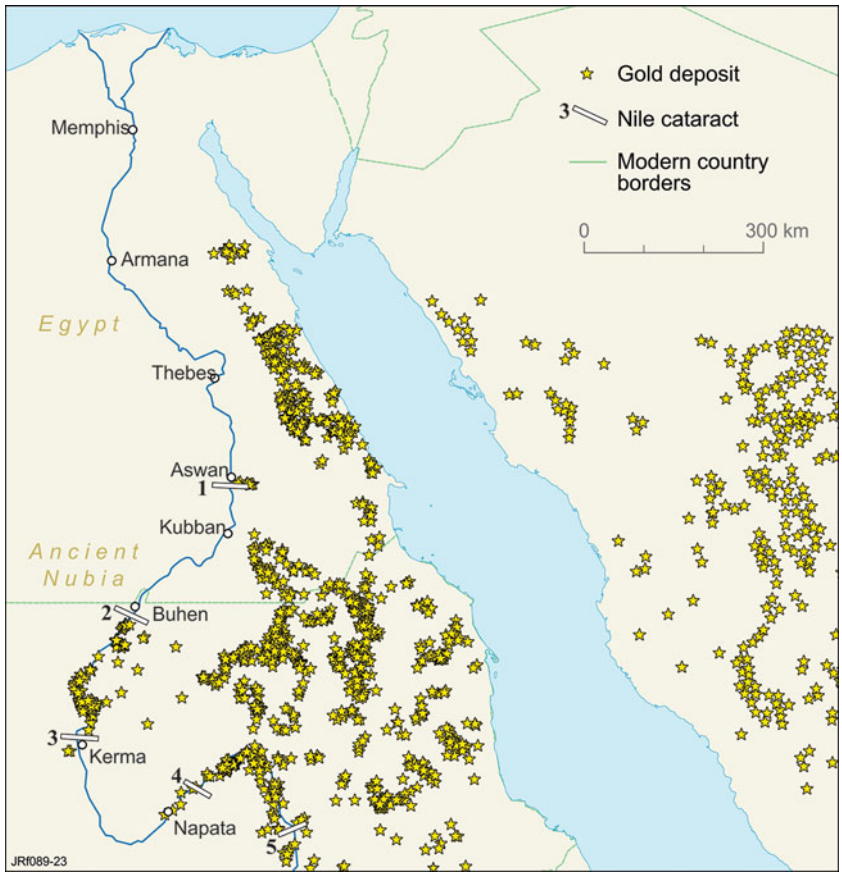

Figure 8. *Location of gold deposits in Egypt and Nubia. (Sources: Arabian-Nubian Shield: Johnson* et al. *2017; Egypt: Klemm & Klemm 2013; Zoheir* et al. *2019.)*

Determining provenance of precious metal artefacts is challenging. Silver is progressing, but gold sources are difficult to characterize.[17] A common belief is that Egypt and Nubia provided much of the gold accessed by the elites of the Near East, consistent with the distribution of deposits in Figures 7 and 8.[18] If so, availability depended on the extent of Egyptian control over gold-rich Nubia, long-term dynastic stability and ambition within Egypt, and Pharaohs' desire to procure silver, cedar and luxury goods from the Near East.

After about 1100 BCE, possible depletion of high-grade resources and loss of control over gold-rich Nubia made Egypt an unlikely source of significant gold for the Mesopotamian world.[19] Dynastic instability and tomb robberies ensued. Subsequent GSR values are rare until the early seventh century BCE (Figs 2 and 4), when high-purity alluvial gold, probably from the Arabian Peninsula, reached Babylonia (Kleber 2016). Later suppliers included Iran and possibly India (Kleber 2016), northern Greece and the Balkans (Marchev *et al.* 2005; Ross *et al.* 2020), the Iberian peninsula via the Phoenicians (Eshel *et al.* 2019; Sagona 2004) and possible extension of trade networks into central Asia and further east (Mørkholm 1991). Diversification increased during successive empires of the Persians, Philip II, Alexander III and successors, and the Romans. In addition, first access to West African gold may have begun by about 400 CE (Fenn *et al.* 2009).

Turning to silver, once cupellation was discovered and the technology disseminated, numerous and widespread argentiferous base-metal deposits (Fig. 7) ensured ample opportunities to sustain the benchmark role of silver within most regions and periods. Deposits in Anatolia (Bayburtoğlu & Yıldırım 2008; Yener 1986), Iran (Nezafati & Pernicka 2012; Stöllner 2004), Greece (especially Lavrion, Siphnos and Chalkidiki: Ross *et al.* 2020), Central Asia (Merkel 2017), the Balkans, Thrace, and Romania (Heinrich & Neubauer 2002) could have supplied the needs of the Near East and Egypt, supplemented by Sardinia, Iberia and western Europe (Fig. 7).

GSR variation: spatial and archaeological contexts

GSR values prior to 550 BCE (Fig. 4) are classified into the five geographic regions of Figure 1: Egypt; south-east Mesopotamia; north Mesopotamia; west

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Mesopotamia/Levant; and Anatolia. Most striking are exceptionally low values for Egypt across almost 2000 years (maximum 3.3) in contrast with higher values from Ptolemaic and Roman Egypt (10–14.5: Fig. 6).[20] Low GSR values also typified west Mesopotamia/Levant before 1100 BCE, when five values from Ebla and Ugarit did not exceed 6.4. Both cities were close to the ancient Egyptian trading port of Byblos, its source of cedar, silver, lapis lazulite, textiles and other exotic goods (Sowada 2009). Four contemporary values from more distant north Mesopotamia range from 9 to 10, suggesting proximity to likely sources influenced the availability and price of gold.[21] Nevertheless, wide-ranging values in southeast Mesopotamia, and contrasting low values in Egypt before 1100 BCE, cannot result solely from geography. Supply requires more attention, especially from Egypt.[22]

Gold supply prior to 1100 BCE

There is positive correlation between the extent of Egyptian control over Nubian gold mines during the Old, Middle and New Kingdoms and cultural efflorescence, temple building, and Egypt's military action in the Levant and western Mesopotamia (Ross & Bettenay forthcoming a). In each kingdom the pattern repeated: military incursion leading to firm control over Nubian gold mines, weakening authority, then loss of control, with final loss in the early eleventh century BCE. Thereafter, Egypt was unable to project significant power and its status in the Near East was diminished (Wilkinson 2010, 369–82). Did this pattern influence gold prices?

Peaceful trade with Nubia in the pre-Dynastic period, probably including gold, was replaced by aggression and control from the Early Dynastic period onwards (Tallet 2020). It intensified in the twenty-sixth century BCE (fourth Dynasty, Old Kingdom), when control extended to include lode and alluvial deposits upriver along the Nile valley from the second cataract and beyond (Fig. 1; Tallet 2020). Control may have weakened by about 2380 BCE, following rise of the early Kerma culture, and was lost during the sixth dynasty, in response to weakened central authority within Egypt.[23]

Almost 400 years later, Middle Kingdom Egypt regained control over Lower Nubia under Amenemhat I at the beginning of the twelfth Dynasty (twentieth century BCE). Old Kingdom forts were extended to Semna South, enabling access to lode, alluvial and wadi gold deposits bordering the Nile and Wadi Allaqi (Fig. 1; Bard 2022; Klemm & Klemm 2013; Ross & Bettenay forthcoming a; Wilkinson 2010). This dynasty of almost 200 years coincided with efflorescence in Egyptian history, but its glory faded in the eighteenth century BCE, as did control over Nubia. However, at the end of the second intermediate period (about 1550 BCE) Ahmose established the New Kingdom (eighteenth Dynasty), invaded Nubia and re-established control of mines between the second and third cataracts. Almost 100 years of conquest followed; the Kushite kingdom was vanquished, and Egyptian control extended to Jebel Barkal with its proclaimed southern boundary at Kurgus (Fig. 1; Grandet 2022). Egypt then ruled for more than 300 years, despite frequent rebellions.

Egyptian control and gold production in Nubia increased in each period, together with capacity to purchase goods from the Near East and achieve conquest and hegemonic power. Large quantities of Egyptian gold circulated in the Near East during the New Kingdom, as attested in texts such as the Amarna Letters (Moran 1992). Nubian mines were vital to New Kingdom prosperity, and it was a period of unmatched wealth, military action and projected influence. But early in the thirteenth century BCE, Seti I ordered new mines in the Eastern Desert (Wilkinson 2010, 318), suggesting a decline in production. Egyptian control weakened late that century from a combination of Libyan invasion, Nubian revolt and attacks from the 'Sea Peoples'. By the early eleventh century BCE, control was completely lost, including associated trade routes (Wilkinson 2010).

To assess the influence of Egyptian gold in Mesopotamia, we excluded background 'noise' in Figure 4) and focused on three GSR categories likely to represent relatively pure gold. Eleven attested as 'good gold' (GG), and its sometimes equivalent 'red gold' (Veenhof 2014, 411); seven unclassified values which topped the ranges in Figure 3, categorized as 'likely good gold' (LG); and six selected as 'possibly good gold' (PG) based on a high GSR compared with surrounding values, and separation of at least 50 years from other values in that region. They are shown in Figure 9, and 14 values prior to 1100 BCE plot within the range 6–10, with two exceptions, the consistently low GG value from Egypt and the Ur III outlier of 21. If two lower values from western Mesopotamia/Levant are excluded, the remaining 10 are within 8–10.

Figure 9 includes shading to highlight Egyptian control over Nubian gold mines. It has two striking features. First is that all GSR values before 1100 BCE plot within periods when Egypt exercised influence over Nubian gold production, except the single Ur III value. Second is the sharp GSR increase to about 12–15 after Egypt lost control of Nubia. It suggests

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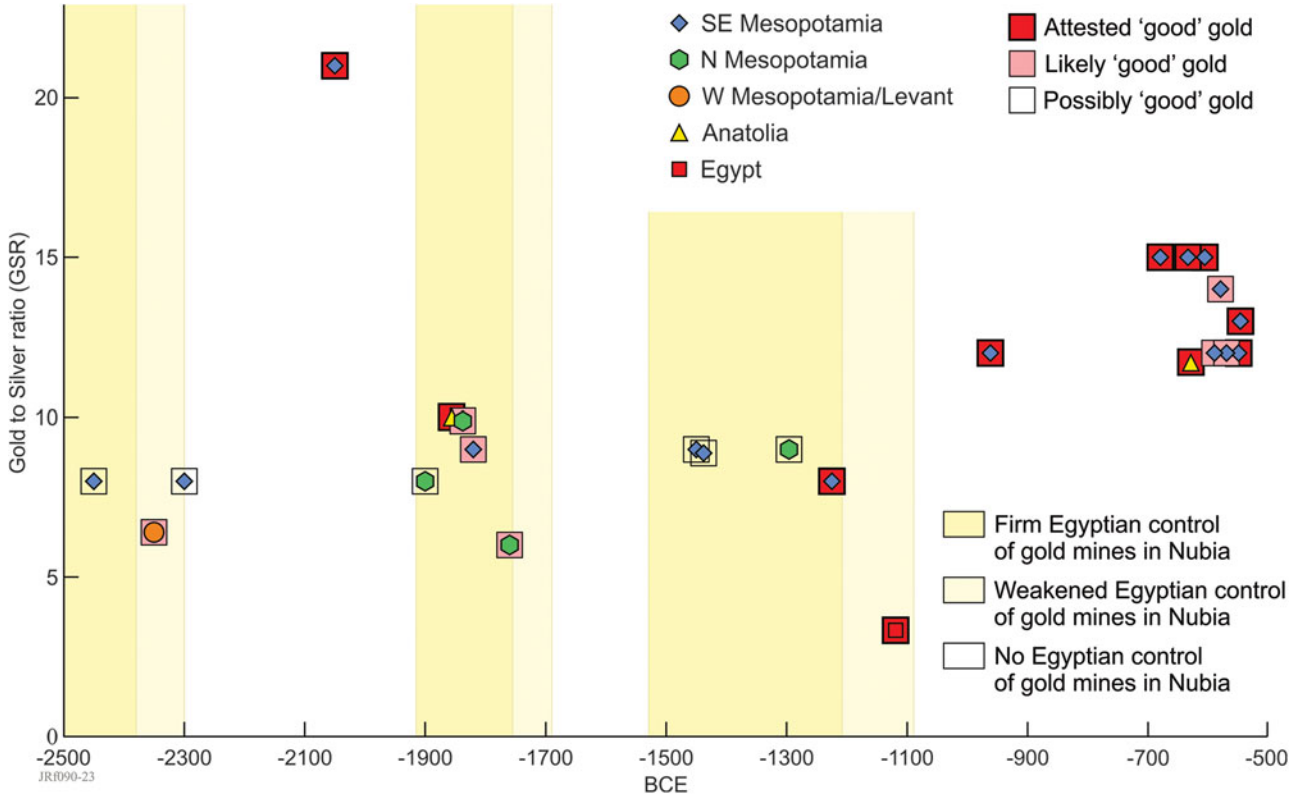

Figure 9. *Twenty-four GSR values for higher-quality gold, 2450–500 BCE, differentiated by region and gold quality, and showing Egyptian control over gold mines in Nubia. (Sources: GSR values: Online Appendix; Egyptian control of gold mines in Nubia: detailed within the text and sourced from Bard 2022; Grandet 2022; Klemm & Klemm 2013; Tallet 2020; Wilkinson 2010.)*

that availability of Egyptian gold, largely sourced from Nubia, exerted significant and increasing influence on the supply and value of gold in the Near East for most of the period *c.* 2400–1100 BCE.[24]

An example of possible influence occurred during Kassite rule in Babylonia (1594–1155 BCE), when gold became the unit of account. It coincided with exceptional Egyptian events between 1350 and 1250 BCE, when two new capital cities required large quantities of timber and exotic goods from the Near East, and availability of Egyptian gold probably peaked, as suggested by the Amarna Letters.[25] Del Monte (2009) studied Kassite transactions between 1342 and 1213 BCE: 22 of 25 were valued in gold (rarely exchanged), with GSRs of 4 for normal gold and 8 for red gold (GG: Figs 3 and 9). The timing, moderate GSRs and adoption as a unit of account all indicate substantial gold supplies.[26] Malko (2014, 133) suggests that significant Kassite control over distribution of highly valued lapis lazuli and export of chariots and horses to Egypt facilitated their acquisition of raw gold and precious stones.

Other logical gold sources prior to 1100 BCE include Anatolia, Caucasia and Armenia for northern and western Mesopotamia, and Iran and Afghanistan for Babylonia (Steinkeller 2016). Steinkeller contrasted substantial quantities of gold and silver in twenty-fourth century BCE Ebla with apparent scarcity in contemporary Babylonia.[27] The powerful Akkadian Dynasty (2334–2193 BCE) could have plundered gold sequestered in temples and treasuries throughout Mesopotamia, Elam and southeast Anatolia, while also controlling key trade routes and extracting tribute (Michalowski 2020). However, based on meagre records, temple offerings of 29 kg and 15 kg of gold (Schrakamp 2020, 652) are dwarfed by dedication of 2000 kg of gold to the Egyptian temple at Karnak during the forty-sixth year of Thutmose III (Graefe 1999).

The Sargonic kings in Mesopotamia established integrated trading networks, including Anatolia, that continued through Ur III (Michalowski 2020). These led to abundant silver in Babylonia (Steinkeller 2016), but unmatched by gold, as indicated by the

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peak GSR value of 21 in Ur III. Similar imbalance is evident in Erol's (2019) estimates for Assyrian trading with Kanesh in the nineteenth century BCE. Other examples include New Kingdom conquests and booty during campaigns in western Mesopotamia and Levant. For example, the siege of Megiddo by Thutmose III in the mid fifteenth century BCE yielded only 10.3 kg of gold and another 12.7 kg of mixed gold and silver (Breasted 1906), while Amenhotep II reported 54 tonnes of silver, but only 89 kg of gold, after crushing a Syrian coalition.[28]

Undoubtedly the Near East obtained gold from Anatolia, Iran, Afghanistan and elsewhere, and perhaps in considerable quantities for short intervals, with trade, diplomatic gifts, and booty and tribute as the principal means of circulation. However, we lack evidence suggesting these resources were comparable to Egypt/Nubia.[29] Once higher-grade, easily mined surface alluvial and eluvial gold deposits were exhausted, production would decline and increasingly depend on narrow, sub-vertical quartz veins that hosted most lode gold. In contrast, Nubia had extensive areas of alluvial and eluvial gold, in wadis, colluvium, and along the Nile, plus abundant lode gold, all subject to limited prior exploitation.

Leemans (1969) summarized references to gold in Mesopotamian texts and observed that texts from Ur, dated to the Royal Tombs (2600–2300 BCE), excluded gold, although attested elsewhere; frequent mentions in texts from Ur III (2100–2000 BCE) were of small quantities. Gold was apparently more abundant in Babylon from about the mid nineteenth century BCE, and Mari had significant supplies during the reign of Zimri-Lim (1775–1762 BCE). Pfälzner (2007) noted the prosperous Levantine city of Qatna, on the trading route from Babylonia to Byblos, built an immense palace in the eighteenth century BCE, with evidence for royal communication with Egypt, and abundant gold, lapis lazuli and carnelian objects in its royal tombs. Similarly, palace construction at the prosperous coastal city of Ugarit (late fifteenth century BCE) was clearly influenced by Egypt (Margueron 2008).

These disparate observations about gold abundance and prosperity in Mesopotamia appear to coincide with periods when Egypt accessed Nubian gold (Figure 9), while few GSR values at other times suggest reduced availability. As noted above, trade, diplomatic gifts, booty and tribute were common enablers of gold circulation and would have provided incremental additions to Near Eastern gold stocks at these other times. Nevertheless, the continuous need to adorn temples, present votives and provide gifts to elites and allies suggests gold demand was always strong, with conquest and hegemony an attractive option for a king to increase his holdings.

Gold supply 1100–550 BCE

Ten GSR values in Figure 9 for GG and LG range from 12 to 15, indicating that gold had become more expensive relative to silver. Arabia was a probable new source from the early seventh century BCE (Kleber 2016), when high-quality *naltar* gold was first recorded in Babylonia about 690 BCE. It is interpreted as about 90 per cent pure, derived from Arabian alluvials, and the first three contracts had a GSR of 15, before declining to 12 at about 590 BCE (Fig. 9). The first reference to essentially pure uncoined gold in Anatolia was about 625 BCE (Kerschner & Konuk 2020), and Kroll (2020) estimated a GSR of 11.7 from a tablet from Ephesus referring to pure gold. Nimchuk (2002) calculated a GSR of 12 for gold/silver Croesid coinage dated at about 560 BCE.

Whilst apparently more expensive in this period, gold was not rare. Summaries of booty and tribute claimed by Neo-Assyrian kings (De Odorico 1995) indicate considerable quantities in Mesopotamia during the ninth to seventh centuries BCE. For example, Adad-nirari III (810–783 BCE) 100 talents (3000 kg); Tiglath-pileser III (744–727 BCE) 150 talents (4500 kg); Sargon II (721–705 BCE) 164 talents 26 mina (4933 kg): while Sennacherib (704–681 BCE) claimed 30 talents (900 kg) from Hezekiah of Judah.[30] Furthermore, Sargon II claimed donation of 150 talents (4500 kg) to the gods in Babylon. We speculate that much of this booty probably originated from earlier mining in Egypt and Nubia and was subsequently sequestered by elites and transferred by conquest.

550 BCE–400 CE

This period is characterized by a narrow range of GSR values (Fig. 6) without textual evidence for transactions involving natural gold of variable quality. Parting and introduction of coinage progressed unevenly, but values seem to be based on relatively pure gold and silver bullion.[31] Electrum coinage in Lydia and nearby Greek cities on the Ionian coast, and the bimetallic coins of Croesus before 550 BCE, appear to have catalysed rapid adoption by the Greek world in the sixth century BCE, including in Italy and Sicily (Harl 1996), with silver as the predominant metal.[32] Nevertheless, use of weighed metal continued within the Persian Empire, and by Punic traders (Kroll 2011). Subsequent conquests by Alexander III across Egypt, the Near East and central

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Table 1. *Representative GSR values for relatively pure gold and silver by region and time intervals 2500 BCE–400 CE.*

Region	~2500–1100 BCE	~1100–355 BCE	355 BCE–~320 CE	~320–400 CE
Southeast & north Mesopotamia	8–10	12–15		
West Mesopotamia & Levant	6–7			
Anatolia	8–10	12		
Egypt	3.33		12–14	14–18
Greece from 550 BCE		12–15	10–14	
Rome			11–12	?14–18

Sources: Figs 4, 6 and 9; Online Appendix; and accompanying text. Blank cells indicate no data available.

Asia in the fourth century BCE almost certainly influenced their widespread uptake of coinage.

Prior to the late third century BCE, most GSR values lie between 12 and 14, except for the decline to 10 and 9.5 in Greece after 355 BCE, probably caused by increased gold supplies. Desecration of Delphi by Phocis in 356 BCE and monetization of plundered gold to recruit mercenaries during the Social Wars occurred in parallel with Philip II of Macedon (359–336 BCE) increasing exploitation of many precious metal deposits in northern Greece and the Balkans and issuing gold coinage about 348 BCE (Hammond 1994).

Well-attested market values for gold and silver bullion are rare from Republican and Imperial Rome. Most plot within 11–12, rising to around 14.4, and possibly 18, between about 300 and 340 CE (Fig. 6).[33] Many values in Figure 6 derive from official rates for minting gold and silver coins from a Roman *libra* (pound) of essentially pure bullion, together with exchange rates for converting silver coins to gold.[34] One exception is the Senate-imposed GSR of 8 from 211–208 BCE, during the second Punic War, when Rome lacked silver to maintain military pay (Harl 1996, 33; Woytek 2012). High values of 14.4 and 15.6 from 238–244 CE fall within the Military Anarchy period. In the later third and fourth centuries CE the GSR is poorly constrained with limited, often contradictory, information. Bagnall (1989) provides a firm but variable range of monthly values averaging 14.4 at 340 BCE. Constantine's restoration of silver coinage with the *siliqua* was made at a nominal GSR of 18, which soon returned to 12 until 395 CE when a lighter *siliqua* of 192/lb indicated a theoretical GSR of 9 (Moorhead 2012).

Discussion

This investigation of the relative values of gold and silver over almost 3000 years aims to improve understanding of ancient economies by enabling regional and temporal comparisons of their relative value. These precede meaningful comparisons of precious metal-denominated prices and wages. Compilation of more than 200 GSR values (Fig. 2) provides a bewildering array, but recognition of silver as a benchmark prior to widespread adoption of parting about 550 BCE has focused attention on gold and factors likely to influence its relative value: purity, availability, demand, proximity to source, and political developments.

Textual compilations of contemporaneous GSRs varying by two to three times indicate widespread recognition of variable gold quality and its impact on value, confirmed by analytical work (Hauptmann *et al.* 2018). However, variations in the GSR of highest-quality gold exceed sixfold, suggesting other influential factors. To identify these, we restricted our focus to 24 values for GG, LG and PG (Fig. 9) and their temporal and geographic contexts. We believe they provide a reasonable basis for nominating GSR values for different regions and intervals prior to about 550 BCE, subject to two key assumptions: that we have an adequate sample of GSR values, including the ranges shown in Figure 3; and that selections of PG and LG in Figure 9 are representative.

Prior to 1100 BCE, we propose that gold sourced from Egypt (Nubia) was the dominant influence with a local peak GSR value of 3.33 increasing with distance from source. For west Mesopotamia/Levant we propose a GSR of 6–7, in proximity to the Egyptian trading ports of Byblos and Ugarit, increasing to 8–10 for southeast and north Mesopotamia.[35] This range (8–10) also applies to Anatolia, based on parity with Assur in the nineteenth century BCE when it was also a source of gold (Dercksen 2014, 90–91). In contrast, from 1100 to 550 BCE the GSR for GG increases to 12–15 (Fig. 9: Egypt not represented), and we extend this period to 355 BCE to include entries from Greece (Fig. 6). After 355 BCE, values from Greece and the Roman Empire largely lie within the range 10–12 (Fig. 6), rising to 14.4 and possibly higher from about 320 CE. These proposed GSR values, regions and intervals are summarized in Table 1. They provide a foundation for

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comparing ancient costs expressed in either silver or gold, between developed regions and across time (Ross & Bettenay forthcoming b).

Conclusions

Our assessment of more than 200 wide-ranging GSR values began by reviewing analytical and textual data linked to the quality of silver derived by cupellation, the dominant method of ancient production. High levels of purity were verifiable from at least 2600 BCE, which explains its widespread early use as a unit of account. By contrast, natural gold with varying silver content could be recognized, but not purified, prior to widespread adoption of parting from about 550 BCE. Varying GSR values indicate silver provided a benchmark for valuing gold of variable quality, a role supported by its more numerous and widespread sources, larger quantities recorded in cuneiform texts, and apparent absence of substantial and widespread variations in supply.

Numerous textual attestations of gold quality, together with integrated studies by Hauptmann *et al.* (2018), indicate that differences in gold quality usually accounted for two- to threefold variations in contemporaneous GSR values prior to 550 BCE (Fig. 3). This suggests a capacity of merchants to assess gold quality, mostly by colour, across almost 2000 years. However, differences of more than sixfold in the value of highest-quality gold between 2500 and 550 BCE indicate that other factors, like supply of both metals, influenced the silver price of gold, as evidenced by the low GSR for silver-poor but gold-rich Egypt.

Consideration of metals' availability, proximity to source, and political developments suggest that varying Egyptian control over gold mines in Nubia prior to 1100 BCE was most influential, as indicated in Figure 9. Apparent shortages of gold in Mesopotamia coincide with diminished Egyptian control. Ultimately, when Egypt finally lost Nubia shortly after 1100 BCE, the GSR increased significantly. Variation in the GSR narrowed after 550 BCE, most likely in response to essentially pure gold bullion, more diverse sources and increased regional integration.

This investigation of GSR values highlights the benchmark role of silver, especially prior to about 550 BCE, despite the higher value of gold. Prices expressed in silver can be applied to first-order comparisons of ancient costs within and between regions and over time, subject to intervals of scarcity. Unfortunately, fivefold depreciation in the relative value of silver since the late nineteenth century CE precludes extension to costs in silver today. However, the GSR values we propose in Table 1 for essentially pure silver and gold enable cross-conversion of ancient costs in either silver or gold and, when expressed in gold, allow first- order comparisons with equivalent costs today. While gold may have been the most prized precious metal, it was not until the widespread adoption of parting, *c.* 550 BCE, that it could also become a benchmark of value.

Notes

1. Exceptions include China, which valued gold less than jade and bronze (Zhang *et al.* 2015).
2. Natural gold was alloyed with varying proportions of inseparable silver, until development of parting in the seventh century BCE.
3. Money is usually accepted as a third-millennium innovation beginning with copper and barley from at least Early Dynastic IIIa (2600–2450 BCE); silver joined and became the dominant unit of account in the Sargonic period.
4. Increased recovery in mine processing, and adoption of the gold standard, probably caused silver devaluation.
5. Linkage between GSR and gold quality was confirmed by Hauptmann *et al.* (2018).
6. Mesopotamian dates follow Van De Mieroop (2007) and the Middle Chronology. For Egypt we follow Wilkinson (2010).
7. We acknowledge that inevitable fluctuations in silver supply also contributed to the relative values of these metals and discuss in more detail below.
8. Crustal abundance of gold is usually estimated *c.* 10–12 times less than silver; Rudnick and Gao (2003) estimate *c.* 40 times.
9. Erol (2019) assessed about half of *c.* 23,000 tablets found at Kanesh; *c.* 90 per cent date from 1893–1863 BCE.
10. It weathers to cerussite (lead carbonate) or anglesite (lead sulphate); both can retain some original silver as particulate inclusions (Ross *et al.* 2021).
11. Cupellation is deliberate oxidation of melted argentiferous lead; resulting litharge (PbO) is removed and molten silver accumulates (Conophagos 1980).
12. The Neo-Babylonian siege of Troy (586–573 BCE), and its disruption of Phoenician silver supply to the Near East, may have led to the lower-quality silver money used in the Neo-Babylonian period (commonly attested as 875 fine: Vargyas 2001; Jursa 2010). Of course, low GSRs in Egypt highlight the impact of asymmetric availability of gold and silver.
13. GSRs of 15–21 were classified as 'yellow brilliant gold'; 6.5–10 were 'normal gold' (Hauptmann *et al.* 2018).
14. Cast gold objects are rare in early Egypt and Mesopotamia (Ogden 2000).

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15. Parting is the cementation process of separating silver from gold, dated at Sardis, Anatolia, to the early sixth century BCE (Craddock & Cahill 2020); compelling evidence favours introduction prior to 625 BCE (Kerschner & Konuk 2020). Adoption probably proceeded unevenly; Persian imposition of a GSR of 13 does not imply uniformity (Mundell 2002).
16. Silver preceded gold in lists of valuable materials during Old and Middle Kingdoms (Lucas & Harris 1962), thus a possible exception.
17. For progress on silver, see Gale and Stos-Gale (2008); Artioli *et al*. (2020); and Albarède *et al.* (2020). Probable mixing of gold during artifact production complicates sourcing.
18. Neumann (1995) estimated about 80 per cent of ancient world gold came from Egypt.
19. Control was finally lost in 1091 BCE (Wilkinson 2010, 377–8); influence diminished after 1208 BCE.
20. We acknowledge that ample gold furnishings in elite tombs of pre-dynastic Egypt indicate exploitation of lode and 'wadi' (alluvial) deposits in the Eastern Desert (Fig. 8). Also, by 3000 BCE Byblos was an established trading centre with evidence of a pre-2700 BCE Egyptian presence (Bestock 2020; Sowada 2009).
21. Earlier values from Ebla may reflect gold from Kablul, Cilicia (Biga & Steinkeller 2021, 16 & 26); Ebla also acquired gold from Egypt, with a GSR of 5. Evidence for GSRs elsewhere in Anatolia is restricted to Old Assyrian trade (Fig. 5), which indicates similar values to Assur.
22. Absence of domestic silver production, and distance from alternative sources, probably suppressed Egyptian GSRs and increased gold supply in the Near East.
23. Tallet (2020) interpreted weaker Egyptian control by 2350 BCE, with Kerma culture 2450–2050 BCE. However, Bartash (2019, 196–8) referenced increased gold weighing in Sargonic and Ur III periods, with Lagash purchasing gold from Anatolia and Pakistan. The gold treasures of Troy and Alacahoyuk, and numerous gold deposits in western Anatolia (Ross *et al.* 2020), evidence the capacity of Anatolia to supply Mesopotamia, subject to price.
24. Notwithstanding evidence from Biga & Steinkeller (2021) that most gold in late third-millennium Ebla was sourced from Anatolia.
25. Akhenaten's capital, Akhetaten (Amarna), from about 1350 BCE; and the capital and industrial complex, Per-Ramesses, of Ramesses II, completed about 1245 BCE (Wilkinson 2010).
26. Leemans (1969) recognized Egypt as the likely source of Kassite gold. Amenhotep III (1390–1353 BCE) married a daughter and granddaughter of Kassite king Kurigalzu II; dynastic marriages included Rameses II to a Kassite princess (Paulus 2022, 839). The relatively low GSR of eight for good gold may have also been influenced by scarcity of silver in Middle Assyrian.
27. Ebla received annual income of about 556 kg silver and 17.9 kg of gold over 10 years (Archi 1993). Texts from Palace G referred to import of Egyptian gold (Steinkeller 2016), and royal vessels, dating to the fourth and sixth dynasty (Tallet 2020).
28. Commonly cited as 6800 Deben (Breasted 1906) and up to 750 kg of gold (Wilkinson 2010), assuming a gold *deben* of 91 g, but Weigall (1908) and Graefe (1999) proposed a gold *deben* of 13.1 g in the New Kingdom.
29. Several GSR values are recorded in the first intermediate period (Fig. 2 and Online Appendix); all are restricted to Ur III and lie within the range 6.5–21 (Fig. 3).
30. The talent varied between 25 and 30 kg; we adopted 30.
31. Persia adopted parting following conquest of Lydia about 546 BCE, when they minted high-purity *darics* and *sigloi* with a GSR of 13 (Nimchuk 2002). This GSR applied in Persian Babylon (Dandamayev 1988; Kleber 2016), implying use of parting.
32. More than 100 Greek-speaking cities produced coins by the end of the sixth century BCE (van Alfen & Warternberg 2020).
33. Egyptian papyrus *POxy*. 3773 (about 340 CE) is interpreted to record monthly GSR values of 14.25–16.25, with 14.4 most common; market prices may have exceeded the GSR of 12 attested in Diocletian's Price Edict of 301 CE (Bagnall 1989).
34. We applied 327 g as the weight of the Roman *libra* (Butcher & Ponting 2014, 703), and derived GSR values from periods with confidence in the attested rate of minting per *libra*, and coinage exchange rates (Online Appendix). They may differ from values based on measured coin weights and fineness (Butcher & Ponting 2014).
35. These ranges exclude outliers such as the 21 from Ur III GSR. However, exclusion results in more conservative outcomes when applied to conversion of silver prices to gold.

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Supplementary Material

Supplementary material may be found at https://doi.org/10.1017/S0959774323000355

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