Zeitschrift für Assyriologie 2016; 106(2): 198–214 **DE GRUYTER**

Abhandlung

Shiyanthi Thavapalan*, Jens Stenger* and Carol Snow*

Color and Meaning in Ancient Mesopotamia: The Case of Egyptian Blue

DOI 10.1515/za-2016-0014

Abstract: Despite its ubiquitous presence and obvious cultural significance in Mesopotamian art and architecture, the Akkadian language never developed a specific term for the color 'blue.' This article seeks to explain this omission and the Akkadian color system in light of ethno-linguistic data collected in the University of California-based World Color Survey project and the physical evidence for blue pigments and colorants. Special attention is paid to the results of multispectral-imaging analysis conducted on Yale University's Assyrian relief sculpture from Nimrud. This investigation has revealed the use of Egyptian blue pigment in unexpected and hitherto unknown contexts in Assyrian architectural design.

Color is both a part of the natural world and a linguistic phenomenon. Everyone perceives it, experiences it. Every language has words to describe it. Everyday color language in ancient Mesopotamia, however, has very little to do with perception. Akkadian color words frequently take their meaning and value *not* from perceptions of hue, but rather from the brightness and luster characteristic of particular materials. This paper is concerned with the color blue and the role of the pigment known as Egyptian blue in the artistic program of the Assyrian royal palace at Nimrud (ancient Kalhu). Beginning with an examination of how color was conceptualized in ancient Mesopotamia, the textual evidence for Akkadian color words is discussed in light of recent ethno-linguistic studies conducted on modern, spoken languages. These linguistic data are then correlated with the physical remains of blue pigment on the alabaster wall reliefs from the Northwest Palace, constructed by King Assurnasirpal II (883–859 BCE), that are now at the Yale University Art Gallery. Given that only traces of ancient coloration survive, the post-excavation history, past conservation treatments and current condition of the reliefs are also reviewed. Finally, the most recent multispectral-imaging study and chemical analysis of the surviving pigments that were conducted on the reliefs are discussed. The results are compared with written records from the time of the palace construction to show how polychrome decoration and Akkadian color language worked in tandem in Assyrian palatial spaces to create a dazzling stage for the king to display his wealth and authority.

I The Semantics of Color

The absence of an abstract word for the color blue is a striking feature of many languages, both modern and ancient. In these cases, the color is often described using a substance, such as a stone or dye.[1] Although it was an essential feature of Mesopotamian art, fashion and architecture, the Akkadian language too never developed a

Article Note: Thanks are expressed to the editors of ZA, who read this paper and made several corrections and suggestions. Susan Matheson, Lisa Brody, Anikó Bezur, Giovanni Verri and Mei-An Tsu helped at many stages in the research and provided access to museum equipment and archival material. The abbreviations used here follow those listed in Akkadisches Handwörterbuch III, ix–xvi.

***Corresponding authors: Shiyanthi Thavapalan,** Yale University,
E-mail: shiyanthi.thavapalan@yale.edu
Jens Stenger, Swiss Institute for Art Research,
E-mail: jens.stenger@sik-isea.ch
Carol Snow, Yale University Art Gallery,
E-mail: carol.snow@yale.edu.

1 In fact, in the Old English period (c. 600–1150), the word *blæwen*, which becomes *blue* in Modern English, designated the dye obtained from the woad plant. The majority of Old English terms for the color blue are related to tangible substances, such as dyes, textiles and in one case, the eyes of horses (Biggam 1997). Based on the evidence from Egyptian, Akkadian, Linear B and Greek (Homeric and Classical), Warburton (2010, 231–236) notes, "Virtually all essential colour terms for 'blue' across the ancient languages are linked to concrete objects."

specific term for blue, a fact that has led to the general belief that it has a simple and imprecise color vocabulary.[2]

The misconception that Akkadian contains just four primary color words, white, black, red and yellow-green, can be traced to a seminal ethnographic study published in 1969. In 'Basic Color Words,' University of California-based anthropologists Brent Berlin and Paul Kay tried to explain how languages name their most important abstract color words. From a survey of ninety-eight spoken languages, they proposed that a definite number of 'basic' color categories are to be found in all human cultures and that the terms for these develop in a fixed seven-stage progression.

The Sequence of Color Category Acquisition (1969)[3]

Stage I	Stage II	Stage III	Stage IV	Stage V	Stage VI	Stage VII
BLACK and WHITE	+ RED	+ GREEN or YELLOW	+ YELLOW or GREEN	+ BLUE	+ BROWN	+ PURPLE and/or PINK and/or ORANGE and/or GREY

According to this model, if a language has only two colors, which is referred to as Stage I in the evolutionary sequence, these will be black and white. At Stage II, red will be added. At Stage III, either yellow or green are added, and so on. The number of basic color words in a language, Berlin and Kay suggested, correlates to the cultural and technological development of that society: "All the languages of highly industrialized European and Asian peoples are Stage VII, while all representatives of early Stages (I, II, and III) are spoken by people with small populations and limited technology, located in isolated areas" (Berlin/Kay 1969, 16). Although intended for present-day spoken languages, Berlin and Kay's universal model for color naming has greatly influenced studies in 'dead' ancient languages as well.[4] Accordingly, the colors that appear in fixed number and sequence in Mesopotamian lexical lists—*peṣû, ṣalmu, sāmu, arqu* and *birmu*[5]—have been interpreted as the basic color terms in Akkadian.[6] Having a single word to signify both yellow and green positions Akkadian at Stage III in the Berlin and Kay scheme, a point at which an abstract word for blue is not yet conceivable.

Color in the Mesopotamian Word Lists

The color vocabulary of Akkadian is neither as limited nor as rudimentary as this model suggests. First, the notion that the most salient abstract color terms are those found in lexical lists is incorrect, because it is based on an assumption that such texts express an early form of scientific classification.[7] As Veldhuis and others have shown,

2 Landsberger (1967, 139) began his seminal study of Sumero-Akkadian color terminology by observing the deficiencies of Akkadian and Hebrew in this realm. This notion has been taken for granted in scholarly literature since. Take the following statement by Moorey (1999, 322), for instance: "Both Sumerian and Akkadian (like ancient Egyptian) possessed four basic colour terms: black, white, red, grue (green/blue), with a term for 'variegated' (Unger 1957–71; Nunn 1988: 17–18, 238 ff.). They are given in the canonical bilingual lexical lists in this order with 'variegated' between red and grue, possibly pointing to a later inclusion of the latter". In the RlA article on 'Farben,' only *ṣalmu*, *peṣû*, *sāmu* are given as main colors (Hauptfarben). *Ruššû* "rot(gelb)" like gold and *pilû* "rotgelb(braun)" like urine are explained as nuances of *sāmu* "rot." Two shades of blue are given—*uqnû* "blau" like lapis lazuli and *šamaʾitu* "blau" like the sky—without any discussion about how they are related to the so-called main colors. Curiously, (*w*)*arqu* "grün" and "gelblich/grünlich" and *burrumu* "bunt" are listed separately from the three main colors; again, no explanation is provided (*RlA* III, 19. 20).

3 The words in capitals in the table represent concepts, not the form of the color word adopted in a particular language. At Stage I, WHITE represents all light hues and BLACK all dark hues. The category RED, at Stage II, includes English reds, oranges, yellows, browns, pinks, purples and violet. GREEN, at Stage III, includes yellow-greens, greens, blue-greens, blues, blue-purples and sometimes tans and light-browns. YELLOW indicates light greens, tans and light browns. Depending on which category developed previously, either YELLOW or GREEN is further distinguished in Stage IV. By this time, RED signifies reds, yellow-reds, purple and purple-reds. Blues, purples and violets emerge from the GREEN at Stage V, while the latter is circumscribed to only green. At this point, BLACK and WHITE represent achromatic values. At Stage VI, brown breaks off from the scope of RED and YELLOW. Finally, at Stage VII, there is what Berlin and Kay call a "rapid expansion" to incorporate the remaining basic color categories (Berlin/Kay 1969, 17–20). As research into color vocabularies progressed the 1969 evolutionary sequence was revised several times. Later sequences simplified the process of color category acquisition to five stages and allowed for different paths or trajectories by which languages move from one stage to another (Kay 1975; Kay/Maffi 1999).

4 For instance, see Brenner (1982), Baines (1985) and Schenkel (2010). Warburton (2010. 2012. 2016) argues against using the Berlin and Kay model to understand ancient color language because it disregards the importance of material-based color terms. In his view, the words for precious stones and metals constitute a significant part of the ancient Egyptian color vocabulary.

5 The category "variegated" does not exist in the Berlin and Kay sequence, a clear indication that a hue-based understanding of color is inadequate to explain the Sumero-Akkadian system.

6 The same color terms also appear in the omen literature, although there, the vertical sequence is not fixed (Landsberger 1967, 142 f.; Sallaberger 2000, 248–251; Vederame 2004, 329 f.).

7 A notion introduced by Landsberger in "Die Eigenbegrifflichkeit der babylonischen Welt," initially published in Islamica 2 (1926) however, lexical lists are organized by *linguistic* principles and their meaning must be understood within the context of the invention and spread of writing: "Lists such as Plants or Vessels are hardly inventories (or classifications) of *all* plants or vessels—they are both less and more … The kinds of things that are treated in the lexical corpus do not describe a universe in any accepted sense of the word" (Veldhuis 2014, 55. Italics added).[8] In other words, the 'paradigmatic sets' of color that reoccur in the same vertical order in UR$_5$.RA = *ḫubullu* and other encyclopedic lists do not necessarily tell us what colors Babylonians actually saw in ancient times. Instead, they designate the objects they are associated with within one of five visual categories. Color is a concept so closely identified with perception that it is often overlooked that color language in daily speech frequently does not describe color. There is no information about perceptual reality to be extracted from frozen expressions such as the "white of the eye" (*pūṣi īni*) or the "black-headed ones" (*ṣalmāt qaqqadi*), the Babylonian poetic term for humanity, for instance. A bloodshot[9] or jaundice eyeball[10] was still designated as *pūṣi īni* in Akkadian just as red-headed or bald Mesopotamians would still be *ṣalmāt qaqqadi*. Presumably in the Old Babylonian period, the 'paradigmatic set' for color (*peṣû, ṣalmu, sāmu, birmu* and *arqu*) was adapted from its original context, the older Sumerian word lists, to other genres of Akkadian texts organized by the same list-principle, such as omen texts.[11]

Berlin and Kay's study was carried out under the assumption that 'color' is a concept that can be defined in terms of hue, saturation and brightness. However, as linguists and ethnologists have since shown, these aspects are not universally understood as the most important qualities of color.[12] Softness, glossiness and fluctuation, emphasis on lightness and darkness, distinction between wetness or succulence and dryness or desiccation, surface texture, transparency, even edibility, symbolism and emotion are now acknowledged to be potential features of a language's color system.[13]

Analysis of the textual evidence indicates that the language of color in Akkadian is primarily focused on brightness and saturation (Figure A1).[14]

Among the colors in the lexical lists discussed so far, *peṣû* is the brightest color and *ṣalmu* the darkest.[15] They can describe variations in shade in addition to the hues white and black. Thus, in Akkadian textile designations, SÍG *peṣû* signifies not white but rather un-dyed, light-colored wool just as SÍG *ṣalmu* is un-dyed, dark-colored wool.[16] To

355–372. Landsberger's idea was taken up by von Soden, who called this 'theory' expressed in the vertical organization of the lists *Listenwissenschaft*. In von Soden's view, the lexical corpus gives us insight into the ancient Sumerian's conception of the universe and his mentality, which is driven above all by a will to organize and classify reality: "Diese (Listen) erweisen sich dann als nur eine der vielen eigenartigen Schöpfungen des den Sumerern seit alters in ganz einzigartiger Weise eigenen Ordungswillens, der alles, Sichtbares und Unsichtbares, in einer höheren Ordnung zusammenzufassen und zusammenzudenken sich bemüht" (von Soden 1936, 419).

8 For how Landsberger's and von Soden's ideas have influenced Assyriological scholarship and the responses to it, see Veldhuis (2014, 53–55) and Sallaberger (2007).

9 CT 28, 33: 3: BE BABBAR IGI^{II}-*šu* SA$_5$ (*pūṣi īnīšu sām*) *zu-u*[*r* …] "If the white of his eyes is red …" (Fincke 2000, 154).

10 CT 28, 33: 5: […]-⸢ru⸣$^{?}$ BABBAR IGI^{II}-*šu* SIG$_7$ (… *pūṣi īnīšu aruq*) <*i*>-*mar-ra-a*-[*ṣ*]" … (and) the white of his eyes is yellow, he shall become sick" (Fincke 2000, 180.181).

11 While there is enough evidence to suggest that extispicy was practiced in the 3rd millennium, there is no reason to connect this practice to a corpus of technical literature (Richardson 2006, 2010). The earliest omen compendia, from Larsa (19th century), Babylon and Sippar (18th–17th centuries), date to the 2nd millennium BCE. The Mari liver models, written in the *šakkanakku*-script, were probably also composed in the early 2nd millennium (the dating is discussed by Richardson 2010, 233. 234 and fn. 43, 44). Concerning whether or not 3rd millennium forerunners existed for the OB omens, Richardson (2010, 236 and fn. 55) writes, "In the cases of both the omens and [Early Dynastic] proverbs, there is no "primitive" literate background to these massive, well-organized corpora. This absence suggests that, while the compilations may have been genuine in the sense of collecting existing knowledge based on oral tradition, they did not emerge from a scholastic tradition over time, gathered from multiple sources". As Richardson (2010, 232) has argued, the extispicy letter from Ebla dating to the 23rd century BCE (TM.76.G.86) *describes* an omen but cannot be classified as an exstispicy report.

12 In a series of articles since the early 1990s, Wierzbicka (1990. 2006. 2008) has argued that 'color' is not a universal concept and that any investigation that seeks to find universal color categories was founded on a false premise. Wierzbicka and several others consider aspects of Berlin and Kay's methodology and model to be Anglocentric, based "on the assumption that all languages can be legitimately described and compared in terms of such English words [that is, the names of BCTs in the Berlin and Kay sequence]" (*ead*. 2006, 2). The Munsell array, used by field researchers to interview native speakers, is a prime subject for this criticism because they can only display limited features of color: namely hue, saturation and brightness.

13 See Biggam (2012, 3–6. 86 f.) for examples and further references.

14 A comprehensive treatment of color in the Akkadian language is in preparation by Thavapalan for her doctoral dissertation at Yale University.

15 This is the case in certain other Semitic languages as well: Old Arabic *ʾabyaḍ* and *ʾaswad* (Fischer 1965), Biblical Hebrew *lābān* and *šāḥōr* (Brenner 1982), Syriac *ḥwr* and *šḥr* (Smith 1903, 134. 572).

16 Because of the large quantities of wool designated by these terms, SÍG *peṣû*, SÍG *ṣalmu* and SÍG *sāmu* are thought to refer to wool that is naturally and not artificially colored. For wool colors during the Ur-III, Old Assyrian, Neo-Assyrian and Neo-Babylonian periods, see Waetzoldt (2010, 201 f.), Lassen (2014, 259), Villard (2010, 397) and Payne (2007, 134–139) respectively.

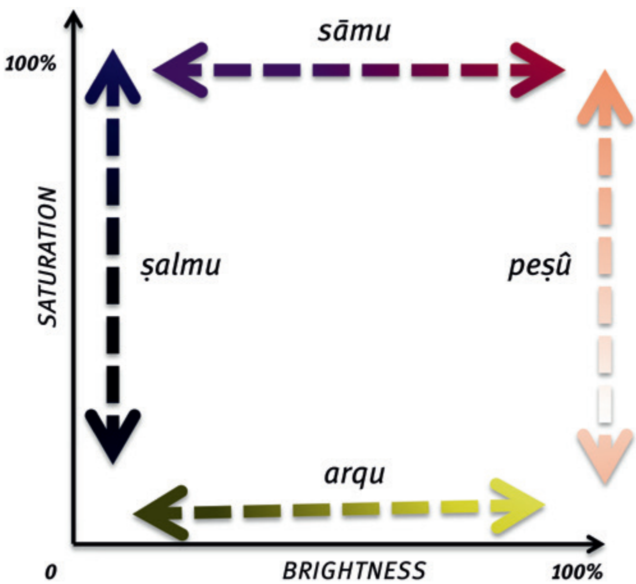

Fig. A1: Akkadian color words on a scale of brightness and saturation

take another example, TÚG *tabarri peṣî*[17] refers to a "bright red garment" and SÍG ZA.GÌN.GI$_6$ to "dark purple wool."[18] Likewise, when *peṣû* is used attributively with metals and stones that are not white, it must be understood as denoting a lighter shade of the substance's original color. Thus, ^{na_4}*dušû peṣû*[19] is a "lighter shade of *dušû*-colored stone" and *ḫurāṣu peṣû*,[20] literally "white gold," probably refers to an alloy of gold with high silver content.

The pair *arqu* and *sāmu*, understood as yellow-green and red-brown in previous scholarship, more precisely distinguish contrasts in color intensity.[21] Objects and images commonly associated with *sāmu* in Akkadian texts—red and orange gemstones (^{na_4}*samtu*), the anemone flower (*illūru*), blood (*dāmu*), madder and kermes-dyed textiles (SÍG *tabarru*)—all share a vibrant, saturated visual quality. In comparison, *arqu*, the color of vegetation (*urqītu*), jaundice (*amurriqānu*) and putrid rivers, is a paler, duller color. *Sāmu* and *arqu* often form a complementary pair in figurative language, the former signifying vitality, health and beauty, and the latter, distress, disease and decay.[22] In one letter to the king of Assyria (7th century BCE), they describe the emotional state of the writer: "(When I heard what the king had done) my heart grew happy and revived, it became as strong as a bull's, my *pale* face *flushed* (with joy)."[23] In the following therapy to counter witchcraft too, it is evident that *arqu*, *sāmu* and *ṣalmu* indicate levels of brightness and intensity: "If a man eats and drinks, but (the food) does not reach his flesh, (and if his) appearance is in turn *pale* and *feverish*, his face becomes ever *darker*, it becomes gloomy, he becomes depressed …"[24]

Using a definition of color that prioritizes brightness and intensity over hue permits us to understand why Akkadian has many terms to describe what in English is subsumed under the single word, blue. The remainder of this study will focus on one of these terms, *zagindurû*, which manifests as a pigment, glass and color in ancient Mesopotamia.

II Blue pigment in the Mesopotamian Textual Tradition

In Akkadian written sources, *zagindurû* is likened to a valuable, gleaming gemstone, but is also described as a commonly available pigment. The earliest references to it as a pigment date to the first half of the second millennium BCE.[25] At the Syrian kingdom of Mari, large quantities of *zagindurû* were used by local carpenters. In one instance, it is destined for the paint work[26] of two wooden model

17 PBS 2/2, 135 i 27: [x TÚ]G *ta-bar-ri* BABBAR *ta-kil-*[*ta* …]-*pu-us* "x number of bright red garments … purple (*takiltu-*) color." This is an administrative record from the Kassite period, which lists quantities of various dyed garments.

18 VAS 19 24: 8′: 1 MA.NA SÍG ZA.GÌN.GI$_6$ *ša* ^{uru}ŠÀ-*bi* URU "one mina of dark purple (*takiltu-*) wool from Ashur." This is a list of textiles and wools from the Middle Assyrian period.

19 Oppenheim [e. a.] (1970, 50 iv 18. 20).

20 This is a commonly attested variety of gold in Near Eastern sources; see CAD Ḫ, 246, AHw. I, 358 and Arkhipov (2012, 10 f.) for references.

21 The traditional views are expressed in the dictionaries and by Landsberger (1967, 140) and Foulger (2006, 40 f. and 49–55).

22 For the color of the face and emotions in Akkadian figurative language see Streck (1999, 71 f.), in omens see Sallaberger (2000, 250).

23 ABL 358: ŠÀ-*bi it-ṭi-ba-an-ni ib-tal-ṭa am-mar ša* GUD-MEŠ *in-ti-ṣi pa-ni-ia er-qu-tú i-sa-a-mu* (SAA 10, 227 r. 6–8)

24 AMT 86/1 ii 12–18: DIŠ NA GU$_7$ NAG-⸢*ma*⸣ *ana* UZU.BI NU *i-ṭe$_4$-eḫ-ḫi za-mar* SIG$_7$ (*aruq*) *za-mar* SA$_5$ (*sām*) *za-mar pa-nu-šú iṣ-ṣa-na-al-li-mu ú-ta-ad-dar* ⸢*uš-ta-na*⸣*-aḫ* (Abusch/Schwemer 2011, 86).

25 The substance *zagindurû* rarely features in the Old Assyrian corpus, a single attestation is known to the present authors: the mention of 5 minas alongside 10 minas of silver in a contract without its use being specified any further (CCT 5, 24b: 2). Michel (2001, 341 f.) thinks it is a more brilliant variety of lapis lazuli.

26 ARM 9, 28: 1: 6 MA.NA ^{na_4}*za-gi-id-ru-ú a-na ši-pí-ir te-q*[*í*?]*-tim ša* 2 GIŠ *e-ri-qí-im*. The determinative NA$_4$ suggests that the pigment was stored as dry blocks. Necessary quantities of the material could then be broken off, powdered and mixed with a liquid binder such as gum or glue to create paint. The phrase *ana šipir tēqītim* refers to this process and must be understood as "for paint work (lit. work of overlay)."

chariots.[27] In another, a Mariote receives 20 minas (about 10 kg) of *zagindurû* to finish a Cretan-style barque, again, probably a model[28]. In a couple of unpublished texts dating to the early reign of Zimri-Lîm (c.1775–1761 BCE), the compound is listed among raw dyestuff, madder, alum and the mineral pigments *kalû* and *kalgukku*.[29] Interestingly, a thousand years later, far from Mari, in the southern Mesopotamian city of Uruk, *zagindurû* appears with the same pigments, though this time in a literary context. In the myth *Nergal and Ereshkigal*, the god of the underworld fashions a throne and paints it lavishly to give it the appearance of being decorated with precious metals and stones. *Zagindurû* is used to imitate the color of lapis lazuli.[30] This visual link with the luster of blue gemstones is maintained in the bilingual word lists.[31] In Diri and Ur$_5$.ra = *ḫubullu*, *zagindurû* is explained as "gleaming" or "shining" ZA.GÌN (*uqnû ebbu/ellu/namru*). This need not make it a variety of lapis lazuli, because the Sumerian term ZA.GÌN can designate any blue gemstone, even faience and glass.[32] The *zagindurû* in glass-making recipes from the Neo-Assyrian period is a turquoise-blue shade of glass, produced by coloring frit with a copper compound.[33] In light of this evidence, it is possible to identify *zagindurû* as a vitreous material—a glass or glassy faience—that resembled the luster and hue of blue gemstones. In pulverized from, it served as the pigment[34] we know today as Egyptian blue.[35]

Unlike its counterparts in the Egyptian language, *ḫsbč* and *tfrr* "lapis lazuli-like blue," *zagindurû* does not become a color word in Akkadian. In a rare exception from an Assyrian king's campaign account quoted below, the image evoked by the color may be of a flax field in springtime, when the powdery blue blossoms appear to glow in spots against the greenery:[36]

> (Rusa's) attractive agricultural land, which was overlaid with bright flecks (looking) like turquoise-blue glass, and the pasture land, which was richly seeded with spring grass and growing shoots, (did I Sargon, trample).[37]

Color terminology generated within specific contexts, such as a craft industry, generally sees a semantic shift,

---

27 The idea of the chariots being wooden models was suggested by Guichard (1993) and is based on parallel texts. For instance, in M.5702, similar chariots are specified as being produced by woodworkers; there it is also indicated that these objects were destined for a religious ceremony of the goddess Ishtar.

28 Guichard (1993, 53): *i-nu-ma* GIŠ.MÁ TUR *ka-ap-ta-ri-tam*^{ki} *i-pu-šu*

29 M.10816 and M.11218, which date to year nine of Zimri-Lîm's reign. Both texts are discussed by Arkhipov (2010).

30 SBTU 1, 17–18: 7′–9′: [...] *i-ban-na-a* GIŠ.GU.ZA ^{d}*é-a* ^{d}*nin-ši-kù* [*me-eḫ-rat*] KÙ.BABBAR IM.BABBAR *ú-taq-qa me-eḫ-rat* ^{na_4}ZA.GÌN ^{na_4}ZA.GÌN.DURU$_5$ *ú-taq-qa* [*me-eḫ-rat*] KÙ-GI IM.GÁ.LI IM.KAL.GUG *ub-tar-rim* "He (Nergal) built ... a throne, Ea the Prince. In imitation of silver, he painted it with gypsum. In imitation of lapis he painted it with Egyptian blue. In imitation of gold he (made) it many-colored with *kalû* and *kalgukku* pigments."

31 Diri III 91–94 (MSL 15, 140) and Ur$_5$.ra = *ḫubullu* XVI 54–56 (MSL 10, 6). Chronologically, this is not too far removed from the Mari letters quoted above, as the Old Babylonian Nippur manuscripts of Ur$_5$.ra = *ḫubullu* are generally dated to the end of the Hammurabi dynasty.

32 Schuster-Brandis (2008, 453): "Es ist kaum noch strittig, daß za-gìn /*uqnû* eine ganze Palette blauer bis bläulicher Steine bezeichnen kann". In the stone list Abnu šikinšu, ZA.GÌN functions as a category to which, ZA.GÌN, ZA.GÌN *marḫaši* "blue stone mottled with yellow-green," ZA.GÌN ANŠE.EDIN.NA *sirrimānu* perhaps "blue stone mottled with bright spots," and ZA.GÌN.DURU$_5$ "blue glass (or faience)" belong. ZA.GÌN is likewise used to describe blue stones other than lapis lazuli in Hittite texts (Polvani 1980).

33 For a summary of the raw materials necessary to make copper-based blue and turquoise glasses, see Henderson (2013, 65–82 and the references therein). The recipes for *zagindurû* call for the addition of a copper compound (*erû nīḫu* "slow copper") to a soda-lime-silica frit (^{na_4}*zukû*) under oxidizing conditions in the kiln. This results in the formation of translucent blue/turquoise glass (*tersītu*). In the final stage, a calcium antimonate-containing primary glass (*būṣu*) is combined with this, in order to produce an opaque, turquoise-blue shade of glass (Oppenheim [e. a.] 1970, 34–39). These 7th century BCE manuscripts probably go back to the mid-second millennium, when glass-making and glazing first began on a large-scale.

34 Naturally occurring mineral pigments are listed in Ur$_5$-ra = *ḫubullu* XI beginning with entry 314 (MSL 7, 140). *Zagindurû* is not included here because it was synthetically manufactured and considered a type of lustrous blue (ZA.GÌN) stone.

35 The connection between *zagindurû*, blue pigment and faience was made earlier by Reade (1963, fn. 25) and Arkhipov (2010). For the identification of *zagindurû*-color, see Landsberger (1967, 165), who understood it as lapis lazuli of the purest, deepest blue color based on the lexical evidence equating it with the adjectives *ellu*, *ebbu* and *namru* (Diri III 91–94; Ur$_5$-ra = *ḫubullu* XVI 54–56). Landsberger opposed the idea of translating *zagindurû* as a particular color, green or otherwise; he understood the reference to *zagindurû* in Sargon's Eighth Campaign as *tiefsatte Färbung*, "deeply saturated" (1967, 166 fn. 122). Oppenheim [e. a.] (1970, 36) understood *zagindurû* in the glass recipes to be a "greenish type of lapis lazuli"-colored glass. Marchetti (2009, 85–90) suggested that the *zagindurû* was a bluish "veined marble."

36 This interpretation is based on the following parallel from Egyptian literature: "(the fields) being lapis-like with (the plant called) color-of-heaven (i.e. the flax blossom)" (Edfou IV, 31, 109, 10.11 quoted by Schenkel 2010, 220). Moreover, in some Egyptian tomb paintings, flax flowers are depicted with blue pigment (Vogelsang-Eastwood 2000, 270). An alternative translation was suggested by Heyer (1981, 83–86): "Sein schönes Weideland, das wie mit Lapislazuli und roter (Farbe) eingelegt war, und die Flur, bepflanzt/bewachsen mit Gras und Schößlingen (habe ich ...)". He identified the blue blossoms with the Alfalfa plant (*Medicago sativa L.*) and the red with Sainfoin (*Onobrychis sativa L.*). Heyer claimed that the plants are still grown in Northwestern Iran and Eastern Turkey as a forage crop (*ibid*. 84).

37 TCL 3: 229: A.GÀR-*šu as-mu ša ki-i za-gìn-du-re-e ṣer-pa šak-nu-ma i-na di-še ù ḫab-bu-re šu-ru-šat ta-mer-tu* (Mayer 2013, 120).

from materiality to abstraction, over time.[38] But this is not the case with Akkadian pigment names. Retaining their original material identity, these terms were never fully integrated into the color vocabulary. Instead, literary and historical texts describe the colorful effects of pigments that enlivened art and architecture—Egyptian blue, ochre red, cinnabar red, carbon black—in terms of precious stones and metals. Evoking the brilliance of such materials was one of the intentions of polychrome decoration in ancient Mesopotamia.

III The Assyrian Reliefs from Nimrud: Provenance and Appearance

So far, the present discussion has focused on language, which is ultimately only a crude map of a civilization's wider visual experiences of color. In order to illustrate the aesthetic and cultural significance of *zagindurû*, we now turn to the Northwest Palace at Nimrud. *Zagindurû* or Egyptian blue, was *key* to the decorative program of Assurnasirpal II's royal residence, which consisted of murals, polychrome architectural details, such as glazed bricks and ceramics, as well as painted sculpture and reliefs.

The palaces of Nimrud once situated on the Nineveh plains south of modern day Mosul, Iraq, were discovered in the 1840s by British explorer Austen Henry Layard. Large-scale excavations ensued. Carved alabaster sculptures and reliefs entered the marketplace and were distributed to institutions around the globe.[39] In March 2015 the terrorist group known as Islamic State used explosives and bulldozers to level the site as a part of their war against 'false idols.' Images and video released subsequently show militants using sledgehammers and power tools to systematically obliterate the stone reliefs and statues that were left *in situ*.

Yale College (later University) bought five reliefs in 1854. Two of these, 1854.1 and 1854.2a–b, were originally positioned on the walls in room S of the Northwest Palace, and are of the larger, A-type relief, which measure over two meters in height and contain an inscription running through the image in a band. The B-type reliefs, 1854.3, 1854.4 and 1854.5, are from room I. In these, the image is divided into two registers, separated by the text.[40] It was not uncommon in the mid-19th century for paper "squeezes," i.e. paper pulp impressions applied wet and allowed to dry, to be taken of the inscriptions as a way to document them.[41] Anecdotal evidence has indicated that some pigment was imbedded in the paper fibers and lost from the alabaster surfaces during the "squeeze".[42] Correspondence at that time regarding the purchases warned that reliefs from the nearby mound of Koyunjik were less well preserved:

> The slabs have been at some time removed probably for burning to be used in building ... A few weeks' exposure to the air has however sadly defaced those which have faced the fire.[43]

The correspondence also includes a statement that the utmost care was taken in packing the slabs for transport from Mosul to the port of Alexandretta (modern Iskenderun, Turkey) where they were loaded on an American barque bound for New York. Recommendations for their care included this note:

> When you wash the slabs off better do it with sea or brackish water lest a thorough washing in fresh water should predispose to injury from the climate. The British Museum have found it necessary to enclose their spoils from Nineveh in air-tight cases with glass fronts. Don't let those who wash, in their zeal, wash off the black paint of hair and beard nor the black and red of the shoes as that is as old as Sardenapalus nor dig out the white of the eye for the same reason.[44]

38 For instance, in 10th century Spain, *purpura* referred to the name of a silk fabric colored with murex dye, and not the color. In 11th century German-speaking world, *scarlet* was a fine, expensive shorn woolen cloth. It could be dyed or un-dyed. By the 13th century, the term specifically referred to the bright dye color obtained from the *kermes* or *coccus* insect (Gage 1999, 80 f.).

39 http://oracc.museum.upenn.edu/nimrud/catalogues/museumsworldwide/#nwp-nd-map Accessed 9/28/15. For the original positioning of the scattered reliefs, see Merrill (1875), Stearns (1961), Meuszyński (1981) and Paley and Sobolewski (1987–1992).

40 1854.1 (slab S-8) was positioned beside a relief currently at Amherst College (Amherst 2, slab S-7). The location of the slab to the right, a human-headed winged genius facing right, remains unknown. 1854.2a (slab S-4) joins on the left with a slab representing the king facing left, currently at the British Museum (BM 124563). 1854.2b joins with a representation of a right-facing winged genius. The bottom part of this relief was left at the site and was probably destroyed by Islamic State in 2015. The location of the upper part is unknown (Paley and Sobolewski 1987).

41 http://oracc.museum.upenn.edu/nimrud/livesofobjects/standardinscription/ Accessed 9/28/15.

42 This is the case, for instance, with the Achaemenid-period reliefs from Persepolis and Naqsh-e Rustam (Nagel 2010, 165–176). The squeezes from Naqsh-e Rustam, now in the Freer Gallery of Art and Arthur M. Sackler Gallery, Washington DC (M 13860), contain traces of Egyptian blue (Nagel 2010, 146 fn. 123).

43 YUAG archives, February 1, 1854 letter from American missionary W. F. Williams, Mosul to Reverend Leonard Bacon, New Haven.

44 YUAG archives, June 15, 1853 letter from American missionary W. F. Williams, Mosul to Reverend Leonard Bacon, New Haven.

On April 4, 1854 the Yale Prudential Committee authorized repair and casing of the Nimrud slabs. The reliefs were repaired from numerous fragments. By 1928, when the Art Gallery expanded into its new, neo-Gothic building, the iron frames were corroding badly and so were repainted for reinstallation of the reliefs. Further unspecified repairs were done to the reliefs in 1957 and may have included applications of natural beeswax. By 1967 the modern plaster in the joints was disintegrating and falling off after air-conditioning was installed in the gallery. In 1983 the old plaster and other fill materials were removed with scalpels and the reliefs were cleaned with a foam made from a strong soap (potassium methyl cyclohexyl oleate) in a mixture of water and ethanol. While still wet, the surfaces were poulticed with wet attapulgus clay (hydrated aluminum-magnesium silicate) in an effort to remove dirt from the stone's pores. It is difficult to know if any pigment was removed in this process, but traces of the attapulgus clay were detected in analysis done to determine a subsequent salt efflorescence. After cleaning, the reliefs were coated with a synthetic microcrystalline wax. New fills were made with pigmented epoxy and acrylic resins. In 2003 the presence of whitish efflorescence along joins in the relief panels led to analysis of fill materials and the efflorescent salts.[45] The results indicated that magnesite cement used in fills migrated as magnesium chloride, possibly from its initial application or from the poultice treatment. In addition, magnesium carbonate and magnesium sulfate were detected, salts that may have been caused by interactions with the alabaster (hydrous calcium sulfate) and plaster (also hydrous calcium sulfate). This summary of treatments of the Assyrian reliefs serves as a cautionary tale when searching for traces of ancient pigments on ancient stones.

The grey and brown alabaster surfaces of the Nimrud reliefs at Yale University have a saturated, waxy appearance. The carved lines and inscriptions have a whitish appearance for several reasons: many low areas are un-waxed and so appear lighter; some may have excess wax that has now blanched white; it is possible that traces of paper fiber were left by "squeezes;" there may also be traces of the poultice material used in the 1983 treatment; and in a few isolated places there is what appears to be ancient material, possibly a white gesso-type substance[46] that may have been used under some areas of applied color. The proper left foot of the human attendant in relief number 1854.2.1 shows traces of a light ochre-colored material on the skin and toenails in addition to the black and red pigments on the footwear. It is possible that more traces of pigment could be found across the reliefs under microscopic examination.

IV The Assyrian Reliefs from Nimrud: Examination and Analysis of Pigments

In 2002 the Center for Materials Research in Archaeology and Ethnology at the Massachusetts Institute of Technology studied pigments on a select number of reliefs from Assurnasirpal's palace: two reliefs from Williams College, six reliefs from the Metropolitan Museum, and three reliefs from the Yale University Art Gallery.[47] The following pigments were identified: white calcium carbonate and calcium sulfate, bone black and charcoal, hematite red, cinnabar red, and cobalt blue[48]. Raman spectroscopy, Polarized light microscopy and scanning electron microscopy with an energy dispersive x-ray spectrometer (SEM-EDS) were the techniques used to identify these pigments. New methods of digital imaging now allow for the detection of Egyptian blue even when this pigment is no longer visible on the ancient substrate. The most recent museum study conducted on Yale's Assyrian reliefs sought to apply these new techniques and thereby learn more about their original coloration.

Egyptian blue is a synthetic pigment that has the identical chemical composition ($CaCuSi_4O_{10}$) of the rare natural mineral cuprorivaite. Essentially a kind of blue frit, this calcium copper tetrasilicate (Hatton [e. a.] 2008, Ingo [e. a.] 2013) is produced by heating quartz, lime, and a copper compound with the addition of an alkali flux. Grinding the frit into a powder produces the pigment that has been used since the third millennium BCE. Ranging from pale to bright, royal blue in color, this pigment is highly stable. Re-firing pulverized Egyptian blue produces

45 YUAG archives, July 15, 2003 report from John Twilley, Analysis of fill materials and efflorescence on Assyrian reliefs from the Yale University art museum (*sic*).

46 Assyrian and Babylonian kings describe whitewashing the walls of their palaces and temples with *gaṣṣu* "gypsum" in their inscriptions (see CAD G, 54 f. *gaṣṣu* B for references).

47 YUAG archives, October 4, 2002 report by Elizabeth Hendrix, 'Some bas-relief pigments from the palace of Assurnasirpal II at Nimrud': 1–16. For Mesopotamian polychromy see Tomabechi (1986, 43–44 fn. 6) and Nunn [e. a.] (2015) and the references therein.

48 This is probably modern according to Hendrix, perhaps a restoration effort (*ibid.* 9). The use of cobalt blue pigment *is* attested in the ancient world, for instance, on Egyptian pottery from the Amarna period (Lee/Quirke 2006, 111).

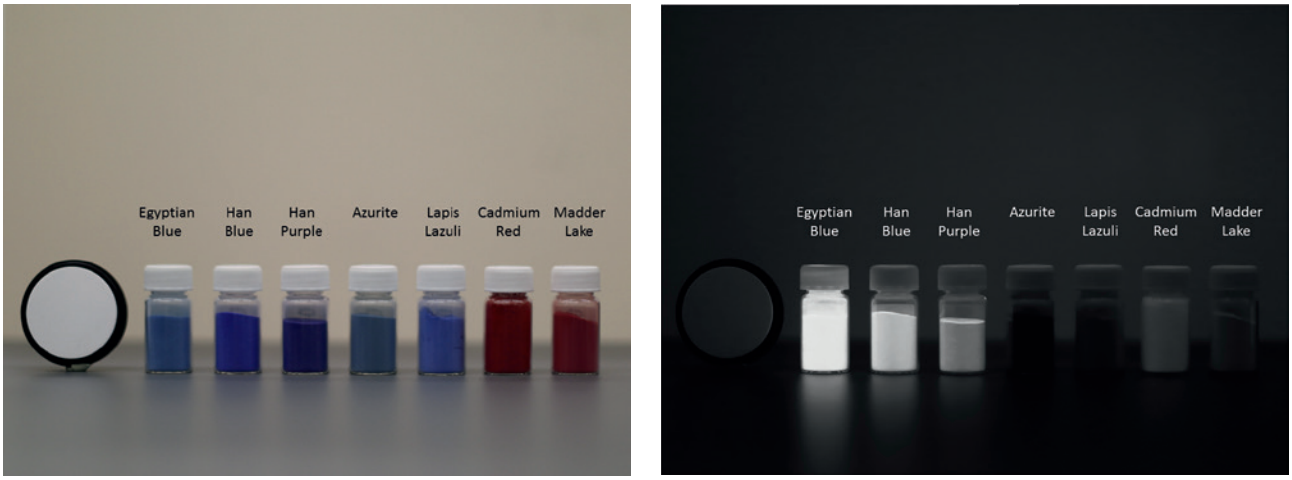

Fig. A2: Visible light photograph and visible-induced infrared luminescence image of several pigments

a more intense shade of blue, which resembles lapis lazuli. The latest use of Egyptian blue is often dated to the end of the Roman period but recently the pigment was found on an 11th century Spanish altarpiece (Lluveras [e. a.] 2010) and even a 16th century Italian painting (Bredal-Jørgensen [e. a.] 2011). The historical use of this pigment and its properties have been reviewed by Riederer (1997) and Scott (2002). The coloring mechanism of the pigment and the local chemical environment of Cu^{2+} ions have been investigated by x-ray absorption fine structure (XAFS) analysis (Pagès-Camagna [e. a.] 2006).

Egyptian blue exhibits a strong luminescence in the near infrared (IR) region when illuminated with light from the visible part of the electromagnetic spectrum. The spectral bands for absorption (500–670 nm, full width half maximum) and emission (850 -980 nm, full width half maximum), as well as luminescence lifetime (~100 μs) and quantum yield (~10 %) have been reported (Pozza [e. a.] 2000, Accorsi [e. a.] 2009, Johnson-McDaniel [e. a.] 2012). These properties make this substance an ideal candidate for spatial mapping on cultural heritage objects with infrared imaging.

Visible (light)-induced infrared luminescence imaging—sometimes abbreviated VIL—is a technique borrowed from the biomedical field. It has been used in art conservation for over fifty years and was initially applied to spatially map restoration work done with cadmium-based pigments (Bridgman/Gibson 1963). The excitation source has to be visible light with little or no infrared component, which can be achieved with either a digital projector (Smith [e. a.] 2009) or LED light sources (Verri 2009). A consumer digital camera that has the standard internal IR filter in front of the sensor removed may be used to record the infrared luminescence image.

Visible light is blocked by the introduction of a long-wave pass filter on the lens, which only permits the transmission of radiation in the near infrared range with wavelengths larger than ~800 nm. Since the sensor of consumer cameras are silicon based and only sensitive to about 1100 nm, the recorded image captures radiation roughly between 800 and 1100 nm. Figure A2 shows the visible-induced infrared luminescence of Egyptian Blue, Han Blue ($BaCuSi_4O_{10}$), Han Purple ($BaCuSi_2O_6$), cadmium red, and madder lake. Azurite and lapis lazuli do not exhibit infrared luminescence (Figure A2).

The spatial characterization and imaging of Egyptian blue and related pigments has been pioneered by Verri in his work on the Nebamun wall paintings at the British Museum (Verri 2008) and with a description of the methodology including several case studies (Verri 2009). Verri and colleagues also investigated the colors on a Neo-Assyrian wall relief from Khorsabad (Verri [e. a.] 2009). More recently, the infrared luminescence of Egyptian blue was mapped in microscopic cross sections of paint layers (Aramini [e. a.] 2013), from Etruscan Sarcophagi (MFA Boston 2012), and Roman Egyptian portraits and panels from Tebtunis (Ganio [e. a.] 2015).

An Egyptian limestone relief depicting Maat[49] (1391–1353 BCE) served as a trial for the imaging equipment and procedure. Figure J1 compares the regular photograph with the VIL image (Figure J1).

The visibly blue areas on the relief and the vial containing the Egyptian blue reference material on the left render bright white in the infrared image because of the strong luminescence.

49 YUAG 1936.45, gift of Walbridge S. Taft, B. A. 1907.

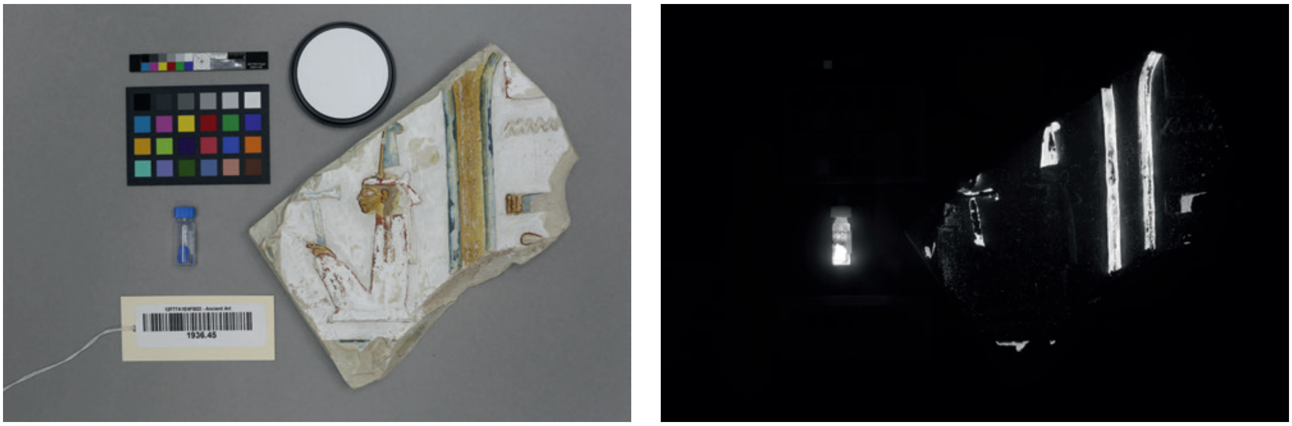

Fig. J1: Comparison of regular photography and VIL imaging of an Egyptian relief (YUAG 1936.45)

In addition, small but brightly luminescing grains of Egyptian blue are visible in the white areas of the relief as well, where blue pigment has been used to create a cooler, brighter shade of white, capable of standing out against the limestone substrate.

A similar use of Egyptian blue is found on the Yale Assyrian relief "Human-headed genius beside sacred tree" (1854.1). The infrared image shows Egyptian blue particles luminescing in the eye of the genius where the thick, textured application of white material (calcium sulphate, $CaSO_4$) is still present and visible to the naked eye (Figure J2). In her ground-breaking study of painted ornamental motifs in Assyrian palaces, Albenda (2005) discerned great variety in technique, style and artistic choice in the rendering of polychrome plaster decoration that would have been positioned above wall reliefs in ancient times; however, a characteristic feature of this type of decoration was the preference for a minimal palette—red, blue, black and white were the recurring colors—and a relatively flat application style (*ibid*. 30–31). To color a translucent stone like alabaster, other methods were clearly required: certain details, such as the eyeballs of the figures, were painted using a heavy application of calcium sulphate, tinted with finely ground Egyptian blue. A thin, smooth application of lime (calcium carbonate, $CaCO_3$), another type of white pigment, was used for the tree in relief 1854.3 (Hendrix 2002, 6), probably to serve as a ground, while a delicate application of cinnabar-based paint creates almost a stained effect for the crimson sole of the genius' sandal.

Egyptian blue particles also appear along the curve of the nostril where the mustache begins and in the beard (Figure J2).

The UV-induced visible fluorescence image shows the modern repair on the right side in light blue and the wax on the surface in light green from a previous treatment of unknown date, which accounts for why so little paint remains in these contexts. These features are also present in all the other UV images below. Originally, the blue pigment was probably mixed with black[50] to achieve a gleaming, dark color—this due to the translucent nature of alabaster—reminiscent of the hue and lustrous quality of lapis lazuli, which is often used as a simile in early Mesopotamian literature for alluring hair.

The area of the feet of genius is the only part of the relief where pigment is still visible to the naked eye. In addition to the black (bone black or charcoal) and red-brown (cinnabar, darkened over time) paint the infrared image reveals that Egyptian blue is present in larger quantities as well (Figure J3).

Luminescence was detected in the lines separating the soles from the rest of the sandals, the exposed foot, and the background above the foot. The UV image shows that there is no wax present for most areas of the foot, again a possible explanation for why more pigment is preserved here as opposed to around the genius's face. Modern color reconstructions of the Nimrud reliefs (Paley 2008, for instance) follow Layard's notes from the mid-19th century, which described the sandals as "black, edged with red; in those of Khorsabad, striped blue and red" (Layard 1849, vol. 2, 312) because both the visible traces of paint and chemical analysis of samples seemed to confirm his observations. In light of the new VIL-images, this color scheme must be re-evaluated: red and blue pigments have been detected together on the soles of the sandals, indi-

50 According to Layard's notes on the reliefs at the British Museum, the hair, beard and eyebrows of the winged genii were black (Layard 1849, vol. 2, 312). Black paint is still visible in such contexts on the reliefs from Nimrud at the British Museum and the Louvre.

Fig. J2: Detail of the head of the human-headed genius beside sacred tree (1854.1): Visible light photography, VIL infrared image, and UV-induced visible fluorescence image

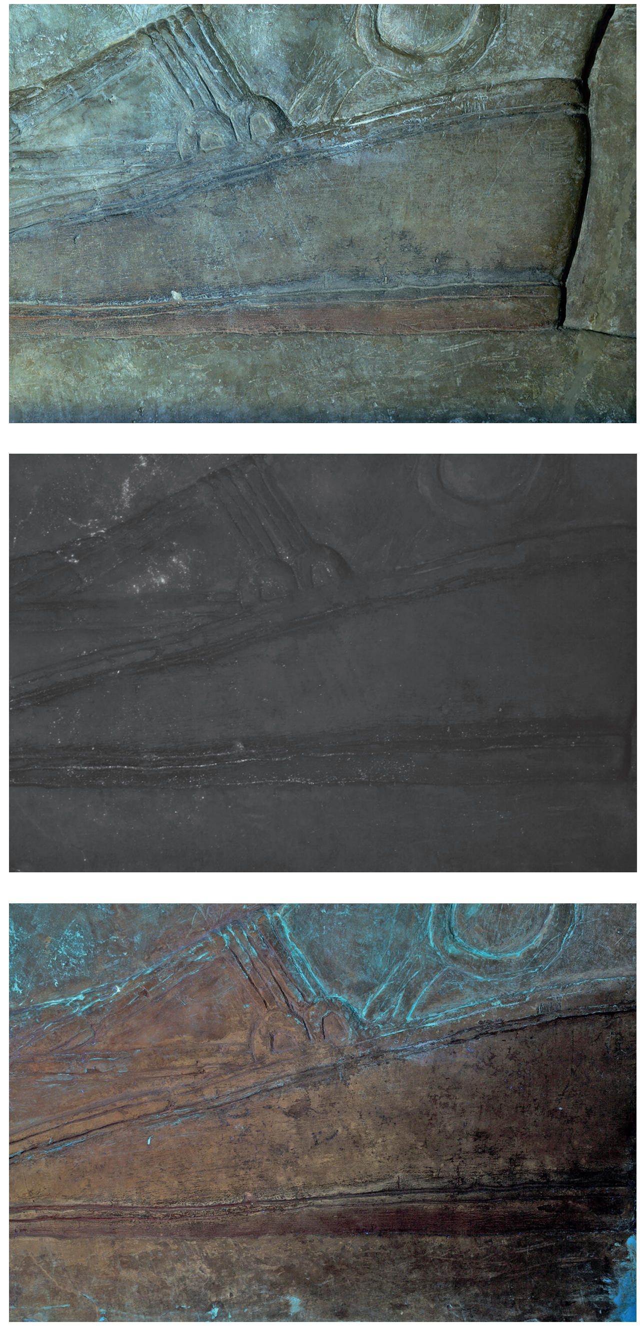

Fig. J3: Detail of the foot of the human-headed genius beside sacred tree (1854.1): Visible light photography, VIL infrared image, and UV-induced visible fluorescence image

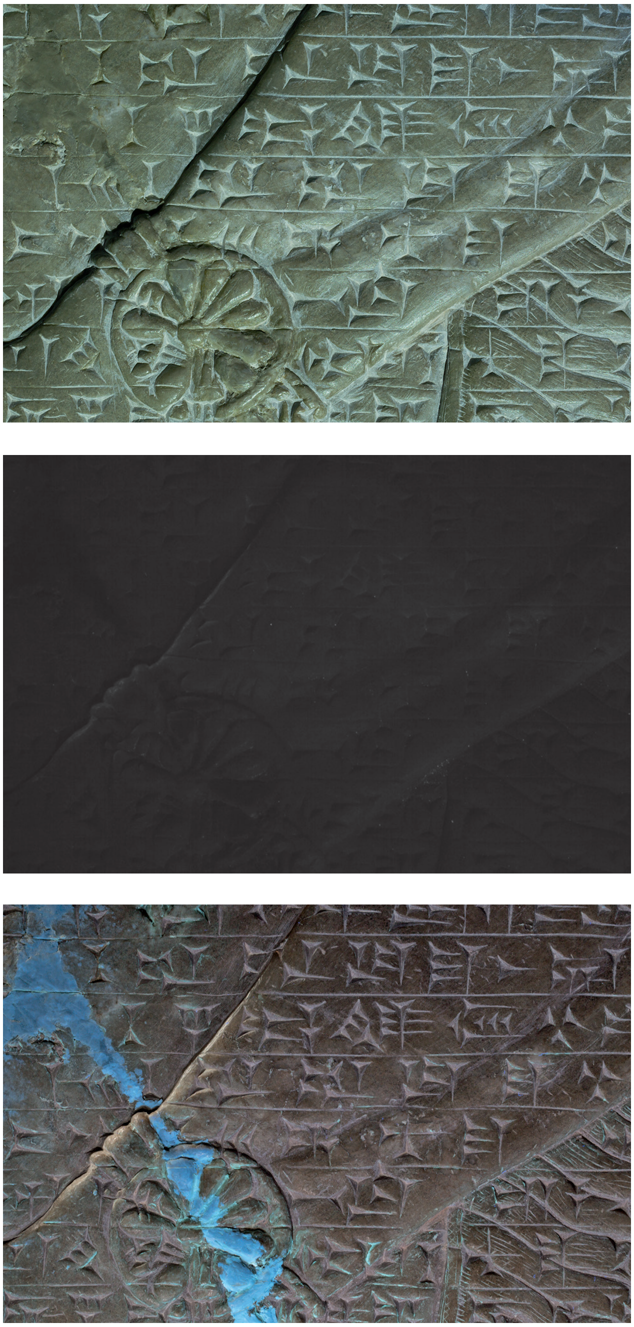

Fig. J4: Detail of the wrist of human-headed genius beside sacred tree (1854.1): Visible light photography, VIL infrared image, and UV-induced visible fluorescence image

cating that they were once colored a shade of purple. The straps and the edges of the sandals might have been dark blue (Egyptian blue + bone black/charcoal) or dark purple (cinnabar + Egyptian blue + bone/charcoal black).

The infrared detail of the wristband has some stray light illuminating the relief from the left. It shows up as a streak of light on the upper edge of the arm and is not related to any material aspect of the object (Figure J4).

This imperfection in the recording of the image can however be clearly distinguished from the small particle luminescence that is caused by the Egyptian blue pigment in the depressions of the wristband and on the lower edge of the arm. The recesses of the cuneiform inscription, the so-called 'Standard Inscription' of Assurnasirpal II, also contain some Egyptian blue particle luminescence.

Similar findings can be reported on the relief "Human Attendant Carrying a Bow, Arrows, and a Mace" (1854.2.1). As with 1854.1, the white of the eye, hair, and feet were painted using Egyptian blue. Figure J5 shows an abundance of luminescing particles inside the cuneiform inscription. The dagger too was colored with paint containing Egyptian blue (Figures J5 and J6).

In Layard's time, the bright blue pigment laid into the cuneiform signs, which he calls "pure oxide of copper," was apparently still visible:

> The interior of the Assyrian palace must have been as magnificent as imposing ... Battles, sieges, triumphs, the exploits of the chase, the ceremonies of religion, were portrayed on the walls, sculptured in alabaster, and painted in gorgeous colors. Under each picture were engraved, *in characters filled up with bright copper*, inscriptions describing the scenes represented (Layard 1849, vol. 2, 265. Italics added).

The innovative use of Egyptian blue to highlight the written word might be what Assurnasirpal boasts of in the following passage, where the bands of text on the wall reliefs are described as images:

> Praises of my heroism, that I had traversed highlands, lowlands and seas, my conquests of all foreign lands, I engraved with *zagindurû* in their walls, I had bricks glazed deep, lustrous blue, I set (them) above its doors.[51]

The additional presence of white and black paint in the 'Standard Inscription' from reliefs in other museums suggests the intriguing possibility that cuneiform inscriptions, much like Egyptian hieroglyphs, were color-coded in ancient times (Figure J7).

If so, color may have served as an added dimension for 'reading' Assyrian relief sculpture such that even illiterate visitors of the imperial palace may have known, partially at least, what information the text imparted and how they relate to the images.

51 ND 1104; RIMA I, 289: 30–32: *ta-na-ti qar-du-ti-a* ⸢*šá*⸣ *pi-rík ḫur-šá-ni* KUR.KUR.MEŠ *u* A.AB.BA.MEŠ *at-tal-la-ku ki-šit-tu šá* KUR.KUR.MEŠ DÙ-*ši-na ina za-gi-in-du-re-e ina* É.SIG$_4$.MEŠ-*ši-na e-ṣir* [na4]*a-gúr-ri ina* [na4]ZA.GÌN *ú-šab-šil a-na e-le-na* KÁ.MEŠ-*ši-na ú-ki-ni*

Fig. J5: Detail of the cuneiform inscription of the human attendant carrying a bow, arrows, and a mace (1854.2.1): Visible light photography, VIL infrared image, and UV-induced visible fluorescence image

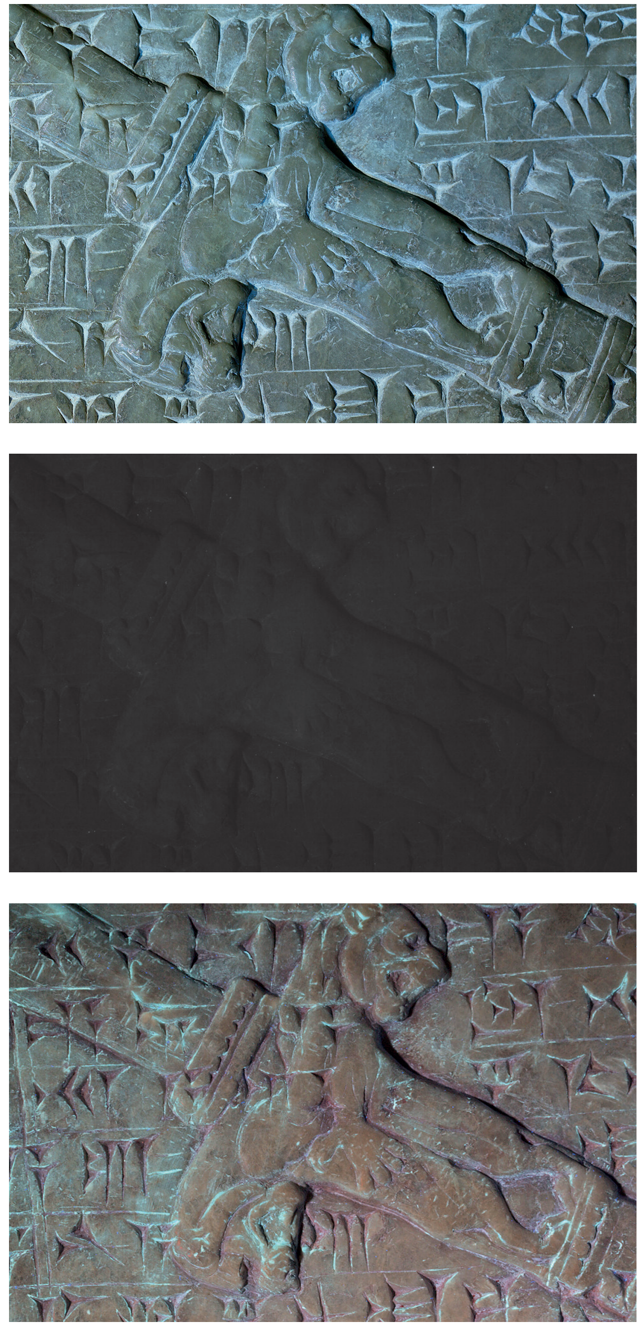

Fig. J6: Detail of the dagger of the human attendant carrying a bow, arrows, and a mace (1854.2.1): Visible light photography, VIL infrared image, and UV-induced visible fluorescence image

Fig. J7: Black and white pigment inside the cuneiform inscription in the Nimrud reliefs at the Louvre (AO 19847 and AO 19845)

The practice of inlaying writing carved in stone with pigment is attested in Egypt and Mesopotamia as early as the third millennium BCE. Nunn, Jändl and Gebhard report the use of carbon-based black pigment to emphasize the writing on the statue of a sitting woman dating to the Ur-III period (c. 2100 BCE) and the presence of white (cerussite, a lead carbonate mineral $PbCO_3$) pigment inside the cuneiform wedges on the statue of Ur-Ningirsu (c. 2100 BCE).[52] In their view, the inscriptions on statues constructed out of limestone and gypsum were highlighted with black paint, while on darker stones such as diorite white pigment was used (Nunn [e. a.] 2015, 200). Alabaster vessels with multilingual inscriptions from the Achaemenid period[53] offer much later examples of the same technique, while numerous instances of alabaster canopic jars and storage vessels with hieroglyphs filled with Egyptian blue may be found in Egypt. Traces of Egyptian blue were likewise recovered from the paper squeezes of the monumental inscription of Darius from Naqsh-e Rustam (Nagel 2010, 146 fn. 123).

52 Berlin, Vorderasiatisches Museum, VA 4856 and VA 8790 (Nunn [e. a.] 2015, 195 fn. 23. 196 fn. 26).

53 Oslo, Schøyen Collection MS 4536/3 dates to the reign of Xerxes (485–465 BCE) and MS 4536/4 to Artaxerxes (464–424 BCE). The pigment on these two vessels has not been analyzed. A comparable vessel from the reign of Darius (550–486 BCE) currently in the Bible Lands Museum, Jerusalem (BLMJ 1979) made of white calcite has purple stains on the surface. According to the published chemical analysis, aluminum, silicon and oxygen with some iron were detected, suggesting that the pigment used in ancient times may have been kaolnite mixed with hematite (Westenholz/Stolper 2002, 1–13).

Chemical Analysis of Pigment

The luminescence intensity of particles on the Assyrian reliefs was compared to an Egyptian blue reference and found to be similar. Further chemical analysis was then conducted to confirm the presence of Egyptian blue.

Elemental mapping using SEM-EDS on a luminescing sample removed from the relief 1854.1 produced the three maps of copper (Cu), silicon (Si) and calcium (Ca) (Figure J8).

An obvious correlation is not visible because calcium is ubiquitous: the gypseous alabaster support contains mostly calcium sulfate ($CaSO_4$) and additional silicon containing phases. But comparing an EDS spectrum of a copper-containing particle (Figure J9, blue top line) to a spectrum from a reference sample (black bottom line) shows great similarity. The copper (Cu), calcium (Ca), and silicon (Si) signals are clearly visible in both spectra and signals have similar ratios. Additional sulfur (S) in the sample from the objects stems again from the gypseous alabaster ($CaSO_4$) support, magnesium and aluminum from alabaster impurities (Figure J9).

IV Conclusion

The awareness that color was an essential feature of Mesopotamian statues, reliefs and monumental architecture has generated much discussion in recent scholarship, especially as new methods that permit the detection and identification of ancient pigment have been developed. This 're-discovery' of color calls for a reexamination of ancient Near Eastern aesthetics and has likewise stimulated research in hitherto understudied topics such as

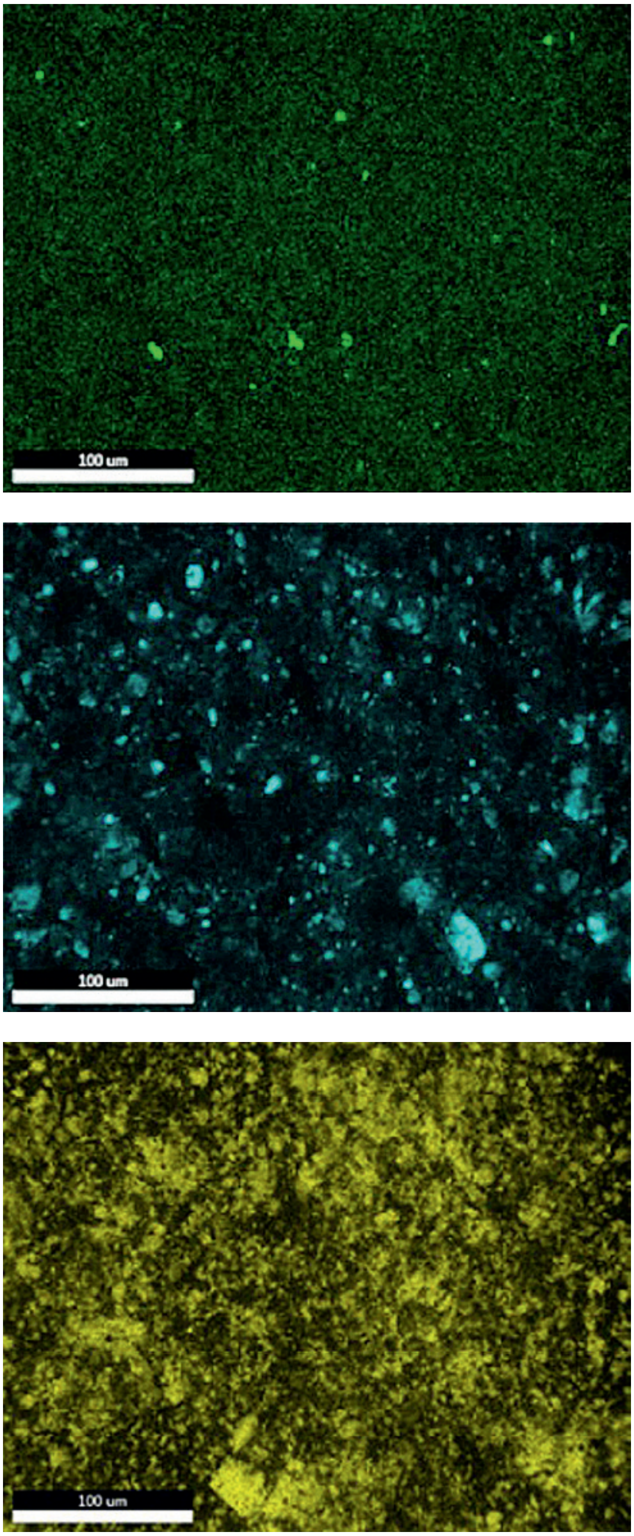

Fig. J8: SEM-EDS elemental maps from left to right: Copper (Cu, green), silicon (Si, blue), and calcium (Ca, yellow)

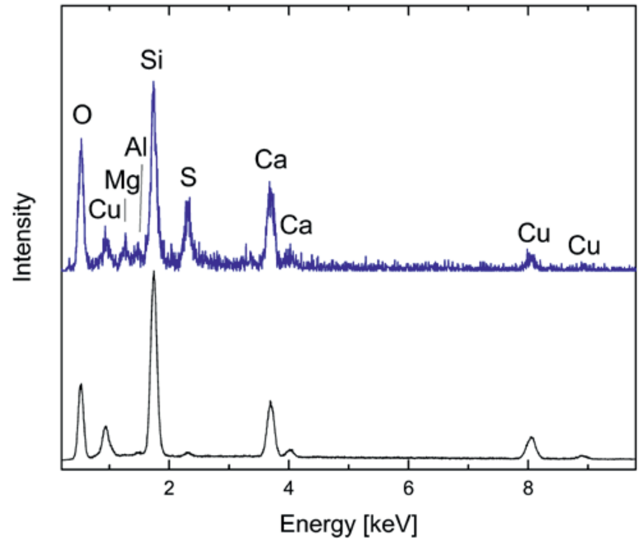

Fig. J9: SEM-EDS spectra of an Egyptian blue reference sample (bottom black line) and a sample from the relief (top blue line)

color technology (the manufacture of pigments, dyes and glass), terminology and symbolism. Focusing on the single yet key pigment Egyptian blue, this paper has attempted to draw attention to the importance of color as a sensory experience in Assyrian palatial spaces. The results of the multispectral imaging study conducted at Yale University indicates that the original polychrome decorative program of the Northwest Palace in Nimrud included bands of colored text that would have appeared on the walls as well as upon the throne base, brightly painted colossal statues of bulls and lions standing adjacent to doorways and on inscribed slabs placed in wall niches and thresholds. Like a cylinder seal impression rolled endlessly along the walls, polychrome text and image would have given continuous presence to the king's statements: about his military triumphs, his control over enemy lands and resources, his reverence for the gods and their protection and approval of him. In Assyrian palaces, the experience of color was always an experience of power.

V Appendix

Experimental Procedure

The images in this publication were recorded with a Canon EOS 5D Mark III DSLR with the internal filter in front of the sensor removed. The infrared luminescence was imaged with the visible light blocked by placing an X-Nite830 (MaxMax.com) filter in front of the lens. A combination of digital projector and LED light source was used in order to maximize excitation power. Ultraviolet-induced visible fluorescence images were captured with the same camera but using both a visible light band pass filter (X-NiteCC1, MaxMax.com) and a UV block filter (Tiffen Haze 2E). For regular visible light photography just the visible band pass was used.

The infrared images were shot at f8, ISO 100 and 30 seconds exposure in raw format (CR2). After processing each photograph with Camera Raw (version 9.1.1) and converting it to grayscale in Adobe Photoshop (version CS6, 13.03.1), the final image was saved in tiff format. UV and visible light images were recorded and processed with the same parameters except for omitting the greyscale conversion and using a shutter speed of 1/100 second for visible light imaging.

Several microsamples were removed from the reliefs and analyzed with Raman spectroscopy, Fourier transform infrared spectroscopy (FTIR) and scanning electron microscopy coupled with energy dispersive x-ray fluorescence spectrometry (SEM-EDS). For Raman analysis a Bruker Senterra spectrometer was used to acquire spectra with a 633 nm, 532 nm and 785 nm laser excitation at 2–5 mW nominal laser power. The FTIR spectra were acquired in transmission, flattened on a diamond window with a Thermo Continuum infrared microscope coupled to a Nicolet 6700 bench-top spectrometer. For SEM-EDS data, the samples were placed onto conductive double-sided adhesive tape on an aluminum stub and studied in a Zeiss EVO 15 MA variable pressure SEM equipped with a tungsten filament emission system. The images were recorded at a chamber pressure of 45 Pa with the backscattered electron detectors after which elemental analysis was performed using and EDAX energy dispersive x-ray spectrometer with an Octane silicon drift detector (SDD) operated using the TEAM software.

Bibliography

Abusch, T./ D. Schwemer (2011): Corpus of Mesopotamian anti-witchcraft rituals. AMD 8/1. Leiden/Boston

Accorsi, G. [e. a.] (2009): The exceptional near-infrared luminescence properties of cuprorivaite (Egyptian blue), Chemical Communications, 3392–3394

Albenda, P. (2005): Ornamental wall painting in the art of the Assyrian empire. Cuneiform monographs 28. Leiden

Aramini, F. [e. a.] (2013): L'identificazione del blu egiziano nelle sezioni stratigrafiche mediante fotoluminescenza. (Identifying Egyptian blue in cross-sections by means of photoluminescence), Bollettino ICR 27, 20–24

Arkhipov, I. (2012): Le vocabulaire de la métallurgie et la nomenclature des objets en métal dans les textes de Mari. ARM 32. Leuven

– (2010): Zagidrûm, NABU 2010/2, 1

Baines, J. (1985): Color terminology and color classification: ancient Egyptian color terminology and polychromy, American anthropologist 87, 282–297

Berlin, B./P. Kay (1969): Basic color terms: their universality and evolution. Berkeley

Biggam, C. P. (2012): The semantics of colour: a historical approach. Cambridge

– (1997): Blue in Old English. An interdisciplinary semantic study. Costerus new series 110. Amsterdam

Bredal-Jørgensen, J. [e. a.]. (2011): Striking presence of Egyptian blue identified in a painting by Giovanni Battista Benvenuto from 1524, Analytical and bioanalytical chemistry 401, 1433–1439

Brenner, A. (1982): Colour terms in the Old Testament. Journal for the study of the Old Testament supplement series 21. Sheffield

Bridgman, C./L. Gibson (1963): Infrared luminescence in the photographic examination of paintings and other art objects, Studies in conservation 8.3, 77–83

Fincke, J. C. (2000): Augenleiden nach keilschriftlichen Quellen. Würzburger medizinhistorische Forschungen 70. Würzburg

Fischer, W. (1965): Farb- und Formbezeichnungen in der Sprache der altarabischen Dichtung. Wiesbaden

Foulger, S. (2006): Die Grundfarben im Sumerischen. Unpublished MA thesis. Bern

Gage, J. (1999): Color and culture: practice and meaning from antiquity to abstraction. Los Angeles

Ganio, M. [e. a.] (2015): Investigating the use of Egyptian blue in Roman Egyptian portraits and panels from Tebtunis, Egypt, Applied physics A 121.3, 813–821

Guichard, M. (1993): Flotte crétoise sur l'Euphrate? NABU/53, 44–45

Hatton, G. D. [e. a.] (2008): The production technology of Egyptian blue and green frits from second millennium BC Egypt and Mesopotamia, Journal of archaeological science 35, 1591–1604

Henderson, J. (2013): Ancient glass. An interdisciplinary exploration. Cambridge

Heyer, R. (1981): *pû* 'SPREU' als Pferdefutter, BagM 12, 83–86

Ingo, G. M. [e. a.] (2013): Egyptian blue cakes from the Ayanis fortress (eastern Anatolia, Turkey): micro-chemical and -structural investigations for the identification of manufacturing process and provenance, Journal of archaeological science 40, 4283–4290

Kay, P. (1975): Synchronic variability and diachronic change in basic color terms, Language in society 4, 257–270

Kay, P./L. Maffi. (1999): Color appearance and the emergence and evolution of basic color lexicons, American anthropologist 101, 743–60

Landsberger, B. (1967): Über Farben im Sumerisch-Akkadischen, JCS 21, 139–173

Lassen, A. W. (2014): Wool in Anatolia in the Old Assyrian period, in: C. Breniquet/C. Michel (ed.), Wool economy in the ancient Near East. Oxford, 255–263

Layard, A. H. (1849): Nineveh and its remains. London. 2 volumes

Lee, L./S. Quirke. (2006): Painting materials, in: P. T. Nicholson/ I. Shaw (ed.), Ancient Egyptians materials and technology. Cambridge, 104–120

Lluveras, A. [e. a.]. (2010): Evidence for the use of Egyptian blue in an 11th century mural altarpiece by SEM-EDS, FTIR AND SR XRD (Church of Sant Pere, Terrassa, Spain), Archaeometry 52, 308–319

Marchetti, N. (2009): Texts quoting artworks: the banquet stele and the palace reliefs of Assurnasirpal II, RA 103, 85–90

Mayer, W. (2013): Assyrien und Urarṭu I. Der achte Feldzug Sargons II., im Jahr 714 v. Chr. AOAT 395/1. Münster

Merrill, S. (1875): Assyrian and Babylonian monuments in America, Bibliotheca sacra 32, 320–349

Meuszyński, J. (1981): Die Rekonstruktion der Reliefdarstellungen und ihrer Anordnung im Nordwestpalast von Kalhu (Nimrud). BagF 2. Mainz am Rhein

Michel, C. (2001): Le lapis-lazuli des Assyriens au début du IIe millénaire av. J.-C., in: W. H. van Soldt (ed.), Veenhof anniversary volume. Studies presented to Klaas R. Veenhof on the occasion of his sixty-fifth birthday. PIHANS 89. Leiden, 341–359

Moorey, P. R. S. (1999): Ancient Mesopotamian materials and industries. Winona Lake

Nagel, A. (2010): Colors, gilding and painted motifs in Persepolis: approaching the polychromy of Achaemenid Persian architectural sculpture, c. 520–330 BCE. Unpublished PhD thesis. Ann Arbor

Oppenheim, A. L. [e. a.]. (1970): Glass and glassmaking in ancient Mesopotamia. The Corning Museum of glass monographs 3. New York

Pagès-Camagna, S. [e. a.] (2006): New insights into the colour origin of archaeological Egyptian blue and green by XAFS at the Cu K-edge, X-Ray spectrometry 35, 141–145

Paley, S. M. (2008): Creating a virtual reality model of the north-west palace, in: Curtis, J. E. [e. a.] (ed.), New light on Nimrud. Proceedings of the Nimrud conference 11th–13th March 2002. London, 195–208

Paley, S. M./R. P. Sobolewski (1987–1992): The reconstruction of the relief representations and their positions in the north-west palace at Kalhu (Nimrud) II–III. BagF 10. 14. Mainz am Rhein

Payne, E. E. (2007): The craftsmen of the Neo-Babylonian period. A study of the textile and metal workers of the Eanna temple. Unpublished PhD thesis. New Haven

Polvani, A. M. (1980): La pietra ZA.GÌN. Mesopotamia 15, 73–92

Pozza, G. [e. a.]. (2000): Photoluminescence of the inorganic pigments Egyptian blue, Han blue and Han purple, Journal of cultural heritage 1, 393–398

Reade, J. E. (1963): A glazed-brick panel from Nimrud, Iraq 25, 38–47

Richardson, S. F. C. (2006): Gir$_3$-gen-na and Šulgi's "library": liver omen texts in the third millennium BC (I), Cuneiform digital library journal 2006:3, 1–9

Richardson, S. F. C. (2010): On seeing and believing: liver divination and the era of warring states (II), in: A. Annus (ed.), Divination and interpretation of signs in the ancient world. Chicago, 225–266

Riederer, J. (1997): Egyptian blue, in: E. W. Fitzhugh (ed.), Artists' pigments: a handbook of their history and characteristics 3. Washington, D. C., 23–45

Sallaberger, W. (2000): Das Erscheinen Marduks als Vorzeichen, ZA 90, 227–262

Sallaberger, W. (2007): Benno Landsbergers 'Eigenbegrifflichkeit' in wissenschaftsgeschichtlicher Perspektive, in: C. Wilcke [e. a.] (ed.), Das geistige Erfassen der Welt im Alten Orient: Beitrage zu Sprache, Religion, Kultur, und Gesellschaft. Wiesbaden, 63–82

Schenkel, W. (2010): Color terms in ancient Egyptian and Coptic, in: E. R. MacLaury [e. a.] (ed.), Anthropology of color. Interdisciplinary multilevel modeling, Amsterdam and Philadelphia, 2007. Amsterdam, 211–228

Schuster-Brandis, A. (2008): Steine als Schutz- und Heilmittel: Untersuchung zu ihrer Verwendung in der Beschwörungskunst Mesopotamiens im 1. Jt. v. Chr. AOAT 46. Münster

Scott, D. (2002): Copper and bronze in art: corrosion, colorants, conservation. Los Angeles

Smith, G. D. [e. a.]. (2009): Inexpensive, near-infrared imaging of artwork using a night-vision webcam for chemistry-of-art courses, Journal of chemical education 86.12, 1382

Smith, J. P. (1903): A compendious Syriac dictionary. New York

Soden, W. von (1936): Leistung und Grenze sumerischer und babylonischer Wissenschaft. Die Welt als Geschichte II, 411–464

Stearns, J. B. (1961): Reliefs from the palace of Ashurnasirpal II. AfO Beih. 15. Graz

Streck, M. P. (1999): Die Bildersprache der akkadischen Epik. AOAT 264. Münster

Tomabechi, Y. (1986): Wall paintings from the northwest Palace at Nimrud, AfO 33, 43–54

Veldhuis, N. (2014): History of the cuneiform lexical tradition. Guides to the Mesopotamian textual record 6. Münster

Verderame, L. (2004): I colori nell'astrologia mesopotamica, in: H. Waetzoldt (ed.), Von Sumer nach Ebla und zurück. Heidelberg, 327–332

Verri G. (2008): The use and distribution of Egyptian blue: a study by visible-induced luminescence imaging, in: K. Uprichard/ A. Middleton (ed.), The Nebamun wall paintings: conservation, scientific analysis and display at the British Museum. London, 41–50

– (2009): The spatially resolved characterization of Egyptian blue, Han blue and Han purple by photo-induced luminescence digital imaging, Analytical and bioanalytical chemistry 394, 1011–21

Verri, G. [e. a.] (2009): Assyrian colours: pigments on a Neo-Assyrian relief of a parade horse, The British Museum technical research bulletin 3, 57–62

Villard, P. (2010): Les textiles néo-assyriens et leurs couleurs, in: C. Michel/M.-L. Nosch (ed.), Textile terminologies in the ancient Near East and Mediterranean from the third to the first millennia BC. Oxford, 388–399

Vogelsang-Eastwood, G. (2000): Textiles, in: P. T. Nicholson/I. Shaw (ed.), Ancient Egyptian materials and technology. Cambridge, 268–298

Waetzoldt, H. (2010): The colours and variety of fabrics from Mesopotamia during the Ur-III period, in: C. Michel/ M.-L Nosch (ed.), Textile terminologies in the ancient Near East and Mediterranean from the third to the first millennia BC. Oxford, 201–209

Warburton, D. A. (2010): Basic color term evolution in the light of ancient evidence from the Near East, in: E. Robert [e. a.] (ed.), Anthropology of color. Interdisciplinary multilevel modeling, Amsterdam and Philadelphia, 2007. Amsterdam, 229–246

– (2012): Colorful meaning: terminology, abstract and the Near Eastern Bronze Age, in: N. Johannsen [e. a.] (ed.), Excavating the mind: cross-sections through culture, cognition and materiality. Aarhus, 183–208

– (2016): Ancient color categories, in: L. Ronnier (ed.), Encyclopedia of color science and technology. New York, 1–9

Westenholz, J. G./M. W. Stolper. (2002): A stone jar with inscriptions of Darius I in four languages, Achaemenid research on texts and archaeology 2002.005, 1–13

Wierzbicka, A. (1990): The meaning of color terms: semantics, culture, and cognition, Cognitive linguistics 1, 99–150

– (2006): The semantics of colour: a new paradigm, in: C. P. Biggam/C. J. Kay (ed.), Progress in colour studies I: language and culture. Amsterdam and Philadelphia, 1–24

– (2008): Why there are no colour universals in language and thought, Journal of the royal anthropological institute 14, 407–25

Conservation Blog at the Museum of Fine Arts Boston

Conservation in action: Etruscan sarcophagi (http://www.mfa.org/collections/conservation/conservationinaction_etruscansarcophagi/october2012)