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Using Geometric Analysis to Challenge Colonial Perspectives: Understanding Marīnid *Zillīj* Patterns through Multidisciplinary Insights

Uso del Análisis Geométrico para Desafiar Perspectivas Coloniales: Comprendiendo los Patrones de *Zillīj* Marīnid a Través de Perspectivas Multidisciplinarias

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Abstract

This study argues that analysing Islamic geometric art requires a deep understanding of the patterns' cultural origins and challenges tied to specific societal needs. In particular, Marīnid *zillīj* patterns highlight the dynasty's search for power legitimacy, fostering an intellectual environment harmonising Mālikī law and Sufi mysticism, *ẓāhir* and *bāṭin*. Through decolonial and geometric analyses, I propose moving beyond colonial and Orientalist categories to fully appreciate each unique geometric pattern within its original cultural and symbolic context.

Keywords Marīnid – *Zillīj* – *Ẓāhir* and *Bāṭin* – Geometry – Decolonial studies

Resumen

Este estudio sostiene que el análisis del arte geométrico islámico requiere comprender profundamente los orígenes culturales de los patrones y desafíos específicos de cada sociedad. En particular, los *zillīj* de los Marīnidas subrayan la búsqueda de legitimidad dinástica, fomentando un entorno intelectual que armonizaba la ley mālikī y el misticismo sufí, *ẓāhir* y *bāṭin*. A través de análisis decoloniales y geométricos, se propone superar categorías colonialistas y orientalistas para valorar plenamente cada patrón en su contexto cultural y simbólico original.

Palabras clave Marīnidas – *Zillīj* – *Ẓāhir* y *Bāṭin* – *Geometria* – Decolonialismo

Introduction

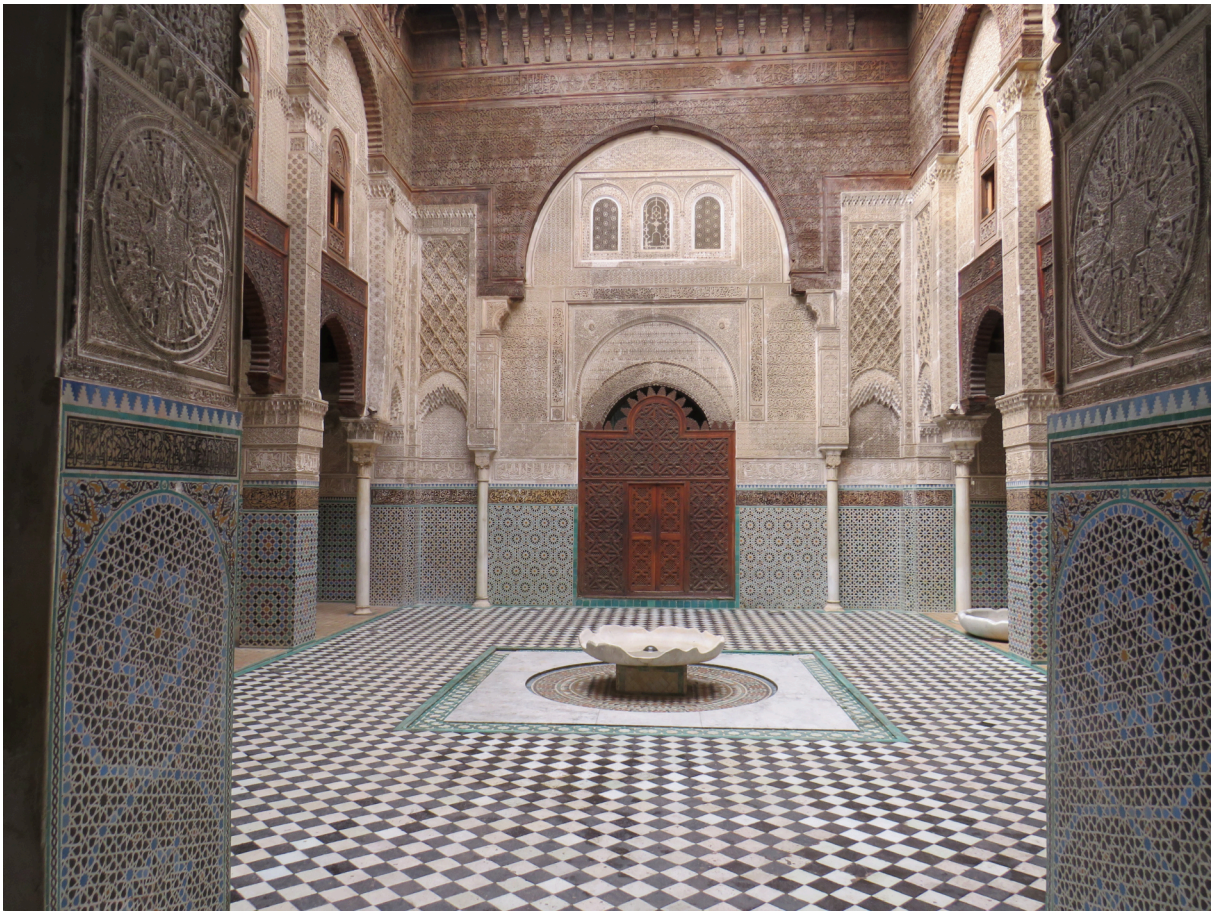

Image 1. al-ʿAttārīn, 1323–25, M. Antonieta Emparán F. (photographer)

In post-Almohad North Africa, the Marīnid dynasty rose to power in a region fractured by competing dynasties: the Hafsids in Ifriqiya, the Zayyanids in Tlemcen, the Nasrids in Granada, and the Marīnids in Morocco. As a Berber Zanata tribe, the Marīnids found themselves in need of legitimising their rule over the city of Fez, where a proud urban and intellectual society posed a complex challenge to their authority. Consequently, the Marīnids employed a nuanced validation strategy that resonated with Fez's scholarly and spiritual landscape, embracing Mālikīsm for religious orthodoxy, Sufism for mystical connection, and Sharifism to recognise the descendants of the Prophet Muḥammad. Central to this strategy was the construction of madrasas, which symbolised and supported the Marīnid integration into Fez's intellectual fabric, serving not only as educational institutions but also as subtle mechanisms of cultural and political alignment with the Fessi elite.

The madrasas of Fez emerged as pivotal centres for advanced studies, spanning a range of disciplines including theology, mathematics, rhetoric, astronomy, and astrology. Entirely state-sponsored through specific taxes, these institutions provided

housing and sustenance for students, many of whom travelled to Fez to pursue their studies. These students enjoyed a privileged social position, identifiable within society by distinctive clothing and supplementary income from astrological consultations and amulet creation. Sultan Abū Saʿīd ʿUthmān (r. 1310-1331) notably expanded these educational facilities, attaching the Madrasa al-ʿAttārīn (image 1) to the revered al-Qarawīyīn Mosque, itself among the oldest operational institutions of learning. This addition, alongside nearby Miṣbāhiyya and al-Ṣaffārīn madrasas, formed a university-like campus surrounding al-Qarawīyīn, further reinforcing the Marīnids' commitment to scholarly patronage. Subsequently, Abū ʿInān Fāris (r. 1348-1358), Abū Saʿīd's grandson, added to this legacy with the Madrasa ʾAbū ʿInānīya (1351) (image 2), the largest in Fez, complete with a mosque and a dedicated library.

The visual and intellectual milieu of these madrasas, however, was accessible only to the Fessi intellectual elite, comprising madrasa scholars, the sultan, *fuqahāʾ*, and prominent intellectuals in the city. This rarefied setting invites an analysis of the interplay between *ẓāhir* (outer) and *bāṭin* (inner) in Marīnid architecture and geometric ornamentation, where visible surfaces and hidden structures symbolically engage with Sufi discourses and the complexities of Islamic metaphysics. Within this context, *zillīj*[1]—the intricate geometric tilework accessible primarily within the madrasas—embodies a multilayered aesthetic, interweaving the visible and the concealed. By

Image 2. Bū ʿInānīya, 1350–55, M. Antonieta Emparán F. (photographer)

[1] *zəllīj* in Moroccan dialectal voice, see: (Premare et al., 1993: vol.5). From Arabic *zulaīj* (Wehr, 1994), from which the Spanish word *azulejo* derives, coming from the Arabic-Hispanic (RAE, online) with the integrated article.

focusing on the construction and symbolic interplay of geometric forms, it is possible to interpret the *zillīj* as both an aesthetic and intellectual expression of Marīnid power and legitimacy, grounded in the integration of Fez's theological and intellectual ideals.

1. The Problem of Perspective

1.1 *Situated Knowledge*

During my doctoral defence, while presenting my research on the unique pentagonal geometries in Islamic art, it was commented that my approach appeared overly emotional, potentially undermining my argument's academic rigour.[2] I start this article with a personal reflection to clarify my rationale for embracing what Escobar denominated as *sentipensar*—feeling-thinking.

In Latin American scholarship, there's a growing recognition that political theories of development cannot stand alone; they must engage with elements like "civilisation," "worldview," and "epistemic difference," which enrich our understanding of culture as more than symbolic structure (Escobar, 2014, p. 17). This shift supports studies that acknowledge a *pluriverse* perspective, resisting homogenising approaches (Escobar, 2014: 20). Escobar's insight applies not only to Indigenous or rural communities but to diverse groups, cultures, and historical periods. Embracing this standpoint allows for a more empathetic and culturally situated analysis.

In this way, researching Marīnid Islamic geometric art from an epistemologically decolonised academic foundation[3] allows for a richer, more nuanced understanding of its aesthetic and intellectual contexts. Considering that, as Donna Haraway stated, "all knowledge is a condensed node in an agonistic power field." (Haraway, 1988, p. 577). Therefore, it is imperative to acknowledge the cultural parameters under which a defined scientific work is performed; in this case, what is my situated knowledge and what are the tools that enable me to improve the analysis of the Marīnid *zillīj*.

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[2] In response to the questions and considering a statement by Ernst Herzfeld (cf. Infra), I provided a brief explanation of the existence of quasicrystalline geometry in Isfahan, Iran of the 15th century. I highlighted the complexity of this type of geometry by comparing it to the 17 crystallographic groups (Emparán Fernández, 2018a). Due to its intricate nature, this form of geometry was only "discovered" in the 1960s by Sir Roger Penrose, after whom it is named. I elucidated the distinction between this geometry and radial symmetry geometry, which follows an entirely different constructive and geometric logic. Subsequently, I contextualised the decagonal geometric patterns found in the madrasas of al-ʿAttārīn and ʾAbū ʿInānīya within this framework. Surprisingly, this argument seemed emotional to the academic in question.

[3] Philosophy of Liberation, originating in Latin America in the 1960s and gaining academic momentum in the 1970s, sought to decolonise dominant epistemologies, providing a platform for marginalised perspectives. This was further developed by the Modernity/Coloniality/Decoloniality (MCD) group, whose members had been publishing since the 1960s and formally organised in the 1990s. For references, see (Ardiles et al., 1973; Mignolo & Escobar, 2013; Bauer, 2022)

1.2 *From Orientalism to the Semantic Shift of Arabesque*

In the *Encyclopaedia of Islam*, the concept of the arabesque in Islamic art history shows an evolution from Ernst Herzfeld's orientalist and colonialist perspective (Herzfeld, *EI* 1, online), through Ernst Kühnel's categorical denial of any symbolic meaning (Kühnel, *EI* 2, online), to Linda Komaroff's more recent historiographical account (Komaroff, *EI* 3, online).

> […] polygonal shapes or stars […] create order in the kaleidoscopic confusion […]. The systems most favoured are those founded on polygons or stars with an odd number of angles, e. g. pentagons or nonagons, or stars with seven or fifteen points. […] The development of ornamental […] was favoured by the prejudice against the large forms of art in general and against the representation of figures, which latter applied equally to the detailed work of the craftsman; the great wealth on the other hand created a desire for luxury, art and ornament. […] The arabesque in the art of the western group shows some characteristics approaching occidental taste.[4] (Herzfeld, *EI* 1, online).

> It seems unnecessary to emphasise that the arabesque never has any symbolic significance but is merely one ornament from a large stock which includes other vegetal forms such as palmettes, rosettes and naturalistic flowers, and abstract forms such as cloud-bands. (Kühnel, *EI* 2, online)

Komaroff focuses on mentioning the emergence of perennial and Sufi-associated interpretations without considering historical contexts. The resurgence of traditionalism, led by Keith Critchlow (Critchlow, 1999), initiated a widespread interpretation of geometric Islamic art under the framework of perennial philosophy. Nevertheless, a semantic shift has emerged; authors such as Yasser Tabbaa (Tabbaa, 2001) analyse the arabesque symbolically, associating it with Ashʿarism, as Gülru Neçipoğlu has done in her work *The Topkapi Scroll* (Neçipoğlu, 1995). Furthermore, Neçipoğlu's article "L'idée de décor dans les régimes de visualité islamiques," featured in the catalogue *Purs Décors?* (Neçipoğlu, 2007), reviews European theories on the concept of arabesque in contrast to the aesthetic theories of medieval Islam.

[4] The first volume of the Encyclopaedia Islamica, A-D, was published in 1913. This entry reflects both the German Orientalism-colonialism of the time and the Hellenophilia within which Herzfeld was educated. On these topics and the history of his introduction to the study of Islamic art, as well as his view that the Semites lack creativity, and instead remain in stagnation, see: (Kröger, 2005), (Leisten, 2005), (Hillenbrand, 2005), and (Hauser, 2005). On the origins of the German "Hellenomania", see (Bernal, 1999: 281–316). The author also recounts the contempt developed against Orient and the hatred towards Islam.

Similarly, Jamal J. Elias, in his book *Aisha's Cushion: Religious Art, Perception, and Practice in Islam* (Elias, 2012), critiques European paradigms for analysing Islamic art and its alleged iconoclastic character, offering a fresh perspective and aesthetic theory on non-figurative representation.

1.3 *The Rise of Alhambrism: From Traditional Art to Industrial Design*

As MacKenzie notes: "It is a commonplace to suggest that European attitudes to oriental art made a severe distinction between the applied and the fine arts." (1995, p. 105). This division reflects a Eurocentric bias that has roots in colonial narratives, which often undermined the intellectual and aesthetic richness of Islamic geometric art. Such attitudes contribute to the ongoing challenges when lacking essential knowledge in geometry, Arabic, and calligraphy, ultimately limiting a comprehensive understanding of this art form.

Nineteenth-century Orientalist painting reflects a passion for handcrafted Eastern goods. Decorative elements such as tapestry, woodwork, jewellery, ceramics, etc., are wonderfully depicted as well as traders in bazaars (MacKenzie, 2019, p. 26). The exoticized representation of the Orient in the 19th-century Western painting reveals an "inauthentic invention" intended to counter the traveller's disappointment and thus spare the viewer from a similar disillusionment (Bohrer, 2003, p. 12). Nevertheless, as Tabbal points out, was so hyper-realistic in its depiction that the paintings seemed to be a kind of scientific documentary rather than an imaginary production. In these paintings, workers and artisans were mostly depicted as lazy, sluggish and childish in opposition to Western industriousness (Tabbal, 2023, p. 34).

Rouphael observes by studying Victor Hugo, that the Orient is delocalised, since for the latter Africa is semi-Asiatic and Spain is semi-African, therefore, Spain is in the Orient (Rouphael, 2015, p. 49). Nevertheless, as Tabbal summarises, during the nineteenth century Morocco's situation was even more ambivalent; sometimes it belonged to the Orient and sometimes to the Occident. Colonialist rhetoric was established that brought the Maghreb closer to France under which Morocco's cultural identity was subjugated (Tabbal, 2023. p. 30).

The publication of Tales of the Alhambra by Washington Irving in 1832, attracted adventurous travellers to Granada. Nevertheless, Owen Jones and Jules Goury drew more attention to the Alhambra with their multi-fascicle work *Plans, Elevations, Sections and Details of the Alhambra*, published between 1836 and 1845 (Jones & Goury, 2013). However, the mass popularisation of Alhambrism reached its height with the Alhambra Court at Sydenham (Futter, 2019: 67). The influence of Owen Jones reached as far as Chile, but not as an Orientalism, rather, as a Europeism (Emparán Fernández, 2018b).

Image 3 & 4. Square Tiles, Late 19th century, Art Institute Chicago.

However, it was not until *The Grammar of Ornament*, 1855 (Jones, 2016), that an orientalist aesthetic of ornament was definitively established. This aesthetic that will be reproduced in all buildings inspired by the Alhambra is not, as was established in the conclusions of the international conference *The Power of Symbols. The Alhambra in a Global Context* (Zürich, September 16 - 17, 2016), simply Alhambrism, but Owen Jonesian. "[…] it was 'Moorish' design, loosely based on the Alhambra and popularized by Owen Jones, which was most frequently used." (MacKenzie, 2019, p. 90)

The value of Moroccan *zillīj*, therefore, as with all Oriental art, was subject to its historical "age-value," established during the nineteenth century and categorised by Alois Riegl. Its value lies in the "being there" prior to any scholarly knowledge or conventional education. (Bohrer, 2003, p. 2). The ornamental elements of the Alhambra[5] and Fez were transformed into technically reproduced decorative objects, that anyone with sufficient means could possess in their own home (Images 3 & 4) and the significance of the monuments diminished. Travelling to discover the monuments became less important, as did the effort to understand their culture of origin.

[5] The tiles of the Alhambra are known as alicatados. The cutting technique is similar to that of ẓillīj; however, alicatados feature a glazed layer over the enamel, whereas ẓillīj are only enamelled (Rubio Domene, 2008: 154–156). For further information on the geometry of the alicatados of the Alhambra, see: (Emparán Fernández, 2018a). Regarding the restoration process of the *alicatados* during the second half of the 19th century, see: (Orihuela, 2008).

In this regard, the Orientalist approach to studying geometric patterns of the Alhambra, Morocco, and the Mamluks—largely motivated by an interest in developing the architectural decoration industry—has since permeated academia. This approach, compounded by a lack of understanding of Euclidean geometry, has led to the misconception that regular pentagon and decagonal radiant patterns can be hand-drawn on graph paper.[6]

The issue of misunderstanding Islamic art is not confined to the Orientalist art of the nineteenth and early twentieth centuries; it also extends to contemporary academics and curators. In the catalogue for the exhibition *Inspired by the East. How the Islamic World Influenced Western Art*,[7] organised between the British Museum and the Islamic Arts Museum Malaysia, Mary Kelly fails to recognise the inscription found on the original frame of the artwork *La Prière* by Étienne Dinet (1861–1929). She acknowledges William Greenwood,[8] curator of the British Museum, for indicating that it is "a somewhat garbled rendering of the motto of the Nasrid Kingdom of Granada" (Kelly, 2019: 49). However, this inscription, known as the *gāliba*, is not confused in any way but rather reflected. In other words, a mould was used as a model for the creation of the frame, resulting in the inscription appearing in reverse. This not only illustrates the specialists' lack of knowledge regarding the Arabic language but also their unwillingness to make an effort to identify the script; the *gāliba* is a well-known and recognised element.

The issue of experts in Islamic and Orientalist art lacking fundamental competencies, such as knowledge of Arabic, does not end here. Following the publication of *Orientalism* by Edward Said, Linda Nochlin penned an article that was described as "purely polemic, and, at times, quite hysterical" (Warraq, 2010: online) concerning Orientalist art from the nineteenth century (Nochlin, 1983, Reprinted: 1989). In this article, Nochlin critiques the hyperrealist aspects of Orientalist painting, particularly regarding the details of architectural ornamentation. In this context, she specifically examines *Snake Charmer* (image 5) by Jean-Léon Gérôme to critique the epigraphic

[6] In a previous review, for a still unpublished text, it was suggested that there is no need to reconstruct the geometric patterns present in the *zillīj* of al-ʿAttārīn and ʾAbū ʿInānīya, stating that André Paccard's (Paccard, 1980) publication of *maʿallem* sketches already details the construction method. However, these sketches, created freehand on graph paper by the *maʿallem*, depict only simpler eight-fold symmetry patterns. In contrast, the geometric designs in both al-ʿAttārīn and ʾAbū ʿInānīya include more complex hexagonal and pentagonal patterns. Given the technical limitations of freehand work on a grid, it is impossible to accurately render regular hexagons or pentagons this way. Thus, Paccard's sketches do not and indeed could not provide a full geometric explanation of these intricate patterns. This gap underscores a key misconception in the scholar's comment and highlights the need for precise geometric reconstruction to understand these advanced designs.

[7] 10 October 2019 – 26 January 2020.

[8] He, describing the piece in the catalogue, mentions: "The script around *The Preyer* is garbled Arabic." (William Greenwood in: Greenwood & de Guise, 2019: 21).

Image 5. Jean-Léon Gérôme, Snake Charmer, c. 1879,The Clark Art Institute

bands. She states:

> A "naturalist" or "authenticist" artist like Gérôme tries to makes us forget that his art is really art, both by concealing the evidence of his touch, and, at the same time, by insisting on a plethora of authenticating details, especially on what might be called unnecessary ones. These include not merely the "carefully executed Turkish tile patterns" that Richard Ettinghausen pointed out in his 1972 Gérôme catalogue; not merely the artist's renditions of Arabic inscriptions which, Ettinghausen maintains, "can be easily read. (Nochlin, 1989, p. 38)

Regarding Ettinghausen (Ettinghausen, 1972, p. 18),[9] Nochlin notes in a footnote that Edward Said told her in conversation that the script, which resembles Arabic, is actually illegible (Nochlin, 1983, p. 57, note 7). Nochlin not only fails to verify whether the text is readable but also indirectly questions Ettinghausen's expertise. Although

[9] "That Gérôme was also interested in the settings and, specifically, in the accuracy of his observations is not only evident from the carefully executed Turkish tile patterns […] but also from the renditions of inscriptions in Arabic characters which often can be easily read." (Ettinghausen, 1972: 18)

some Arabic calligraphy styles may indeed be difficult even for skilled readers, all calligraphic forms follow strict rules where letter shapes depend on their position within words and sentences. Thus, while one might confirm that the cabochons lack coherent Arabic text, it is entirely possible to identify the epigraphic frieze as Surah Al-Baqarah, verse 256. Even the controversial, pro-Western Ibn Warraq points out the inconsistency in Nochlin's approach:

> It is simply a feature of Islamic calligraphic art, and in this case Gérôme was not inventing the writing. But even if Gérôme had invented the inscriptions, what conclusion would follow? Only that Gérôme did not know Arabic. But neither does Nochlin. If Gérôme's ignorance of Arabic is an obstacle to painting about the Orient, why isn't Nochlin's ignorance of Arabic (or Turkish) an obstacle to writing about Orientalism in art? (Warraq, 2010, online)

This leads us to consider the implications of lacking knowledge in Arabic calligraphy, Islamic geometry, or even Euclidean geometry when discussing Islamic art. As we revisit our initial inquiry, one might wonder how an academic, unaware that constructing a regular pentagon requires the use of a ruler and compass, can confidently claim expertise in geometrical ornamental Islamic art and Neo-Arab ornamentation. This raises important questions about the standards of expertise in the field and the importance of foundational knowledge in making informed assessments. As noted by MacKenzie, "[...] the West's appropriation of Eastern subjects, yet another tool in the establishment for power and authority" (MacKenzie, 2013, p. 117), has led to a continuous ignorance regarding the complexities of Islamic ornamentation, whether in its expression through calligraphy or geometry, that persists to this day.

2. Marīnid geometry versus "Moorish Style"

2.1 *Clarifying Geometry: Addressing Academic Misunderstandings*

Let us revisit Herzfeld's assertion and provide some pertinent clarifications: "The systems most favoured are those founded on polygons or stars with an odd number of angles, e.g. pentagons or nonagons, or stars with seven or fifteen points." (Herzfeld, *EI* 1, online).

The construction of regular heptagons (seven-sided polygons) and enneagons (nine-sided polygons) using only a straightedge and compass is mathematically impossible (Berggren, 2016, p. 87–94). This stems from a fundamental principle in geometry regarding constructible numbers. A regular polygon can be constructed with a straightedge and compass if and only if the number of its sides is a product of a

power of 2 and any distinct Fermat primes. Notably, neither 7 nor 9 fits this criterion (Cooke, 2013, p. 122–125, 286). Consequently, the geometrical constructions that result in purported heptagons or enneagons are invariably irregular and often lack the harmonious proportions one would expect from well-constructed geometrical figures. Thus, contrary to Herzfeld's assertion, the appearances of regular seven-pointed and nine-pointed stars are exceedingly rare and are frequently irregular, sometimes appearing disproportionate.

While it is indeed possible to construct a regular pentagon with a straightedge and compass, this process demands a high level of expertise and precision. The complexity involved is considerable; thus, historical mathematical treatises suggest that artisans often resorted to methods for creating approximate, irregular pentagons.[10] Consequently, any attempts to create such shapes yield irregular figures that lack harmonious proportions. Furthermore, notable contributions by Sir Roger Penrose in the latter half of the 20th century have elucidated patterns based on pentagons and decagons (Stewart, 2001, p. 82–85). As mentioned in a previous footnote,[11] his findings demonstrate that while pentagons can be constructed, the resulting patterns based on them are significantly more intricate than those derived from simpler polygons. This underscores the necessity for a nuanced understanding of both the mathematical principles involved and the historical context of geometric constructions within Islamic art.

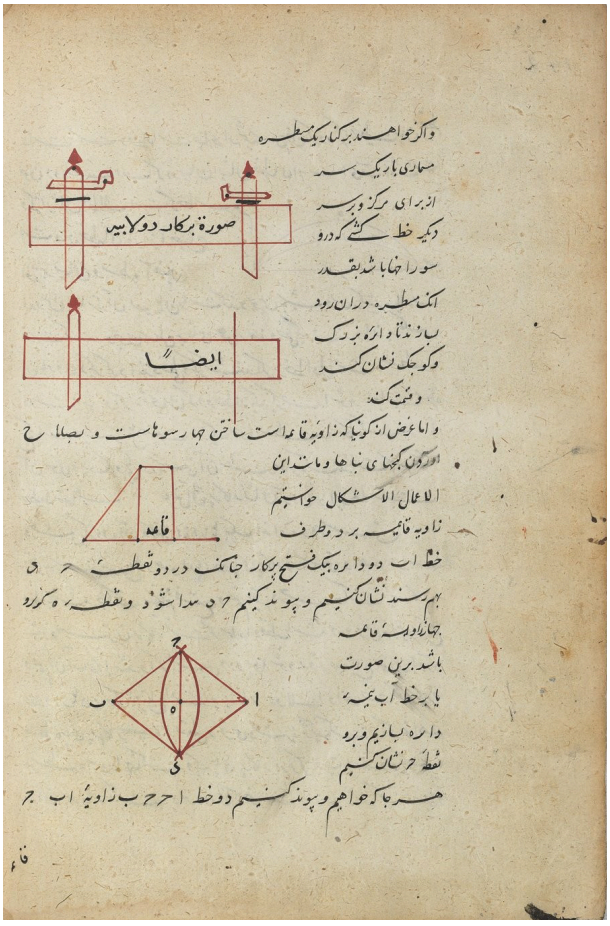

Image 6. Abu l-Wafāʾ al-Būzajānī (text author), Wheel compass, Bibliothèque nationale de France. Persan 169. Fol. 142v.

2.2 *Practical Geometry for Artisans: Simplified Methods for Constructing Complex Polygons*

Abū al-Wafā al-Būzhjānī (940 – 998 CE) at the beginning of his treatise for craftsmen, *Geometrical Constructions*, describes three types of compasses (Abu l-Wafāʾ al-Būzajānī, 2010). He begins by describing the basic

[10] Cfr. Infra.

[11] Cfr. Supra.

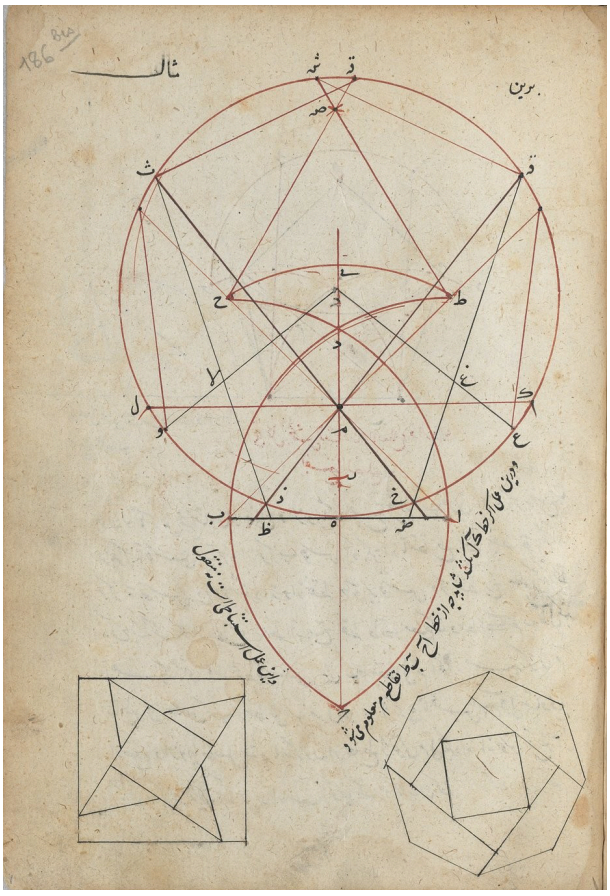

Image 7. Verging construction of a pentagon, Construction 21 Anonimous Compendium, Bibliothèque nationale de France, Ms. Persan 169, fol. 186r.

compass, the carpenter's compass. He then states that it is best for craftsmen to have the version of this compass with a wing nut so that the opening of the compass is kept fixed, and if any adjustment is needed, it is easy to do so to achieve precision work. However, these compasses are only reliable for drawing small circles, and for larger drawings Abū al-Wafā recommends the use of the wheel compass (Image 6), an earlier version of the beam compass. This compass was constructed using a straightedge as a bar. Two versions of this compass are mentioned: one in which both legs are movable, and the other in which the ruler is perforated with holes to obtain certain diameters, with one of the legs fixed.

The partial translations of Abū al-Wafā's work by Woepcke (Woepcke, 1855, 1860), from a Persian translation (Bibliothèque Nationale de Paris, MS. Persan 169 folios 141v-179v) into French, and Suter (Suter, 1922), from the original Arabic (Biblioteca Ambrosiana, Milan, Ms. Arab 68) into German, do not have this section. However, the Persian edition with French translation by Jafar Aghajani Chavoshi (Abu l-Wafāʾ al-Būzajānī, 2010), based on two Persian manuscripts (Ms. Persan 169 and the Tehran University, Central Library, Ms. 2876, folios 1-70) is complete.

However, Alpay Özdural (Özdural, 1996) notes that in the manuscript for the Ulugh Beg Observatory conserved in the Süleymaniye Library in Istanbul, Ms. Ayasofya 2753, Abū al-Wafā states that for craftsmen, the control of the legs of the compass was difficult. It is for this reason that he developed approximate constructions of the pentagon, as well as for other polygons employing the fixed compass in a single aperture, radius. Therefore, the chances of error were minimized.

Although the use of the golden triangle was "popular" during the thirteenth century for constructing pentagons (Chorbachi & Loeb, 1992), both the text of Abū al-Wafā,

Geometrical Constructions, and the *Anonymous Compendium*[12] (c. 1300) (Anonymous, 2017) are full of pentagon constructions with a fixed compass opening (Hogendijk, 2017; Kheirandish, 2017) (Image 7). These alternative constructions were created directly to satisfy the needs of craftsmen, who faced difficulties operating the compass. There are also options for constructing other polygons, including approximate construction of heptagons and nonagons. Abū al-Wafā clarifies that these vergent constructions are intended only for craftsmen (Abu l-Wafāʾ al-Būzajānī, 2010). Mathematicians, knowing the precise methods, prefer correct constructions over alternatives and confidently use a compass.

A comprehensive understanding of traditional geometry and the principles of Euclidean constructions is essential for historians studying Islamic geometric art. Beyond adding rigour to the analytical process, reconstructing geometric patterns enables scholars to appreciate the nuanced aesthetic dimensions embedded within these designs. Unlike an analysis based solely on final patterns, a geometrically informed approach reveals the underlying constructional steps—intermediary shapes, guiding circles, and other elements—that historical geometers and madrasa's scholars would have visualised as integral to the design process. This layered understanding enriches both the scientific and artistic appreciation of the geometer's achievements, underscoring the intellectual depth and skill required to construct such sophisticated patterns.

In addition, this methodology enhances aesthetic interpretation by exposing the symbolic potential of each geometric choice. For instance, a twelve-pointed star can be constructed through different geometric strategies, each carrying distinct aesthetic and numerological implications. Building a star through two overlapping hexagons, three squares, or four triangles, for example, creates distinct symbolic resonances, just as whether it is inscribed within a hexagon or a square. or Archimedean tessellation affects the overall composition and symbolic content. Consequently, the historian's lack of geometric knowledge or failure to reconstruct these patterns impedes their ability to conduct a thorough visual analysis and obscures deeper layers of meaning within the work. Moreover, constructing a twelve-pointed star may also be contingent upon its arrangement within a specific Archimedean tessellation (Grünbaum & Shepard, 1977), the application of a radial pattern (Necipoğlu, 1995, p. 32–33), or the use of a tiling unit that allows for infinite repetition within the framework of the 17 crystallographic groups (Chorbachi, 1989; Stewart, 2001: 74–79).

[12] *Fī tadākhul al-ashkāl al-mutashābiha aw al-mutawāfiqa – On What Is Needed by the Craftsman from Geometrical Construction.*

Image 8. Maʿallem sketches, in Traditional Islamic Craft in Moroccan Architecture, André Paccard, 1980, vol. 1, p. 226.

2.3 *Maʿallems: Craftsmanship Without Geometry*

Given the lack of manuals outlining the exact geometric construction of historical patterns, the reverse engineering process is invaluable, as geometry—being an exact science—allows us to deduce construction steps by observing the finished patterns. Even though multiple construction methods exist for shapes like pentagons (Euclid's approach, for example, is complex as it demonstrates a geometric proof rather than a simple drawing method[13]), the fundamental techniques for creating these forms have remained consistent since antiquity. For instance, constructing a square requires dividing a circle into four equal parts, a principle unchanged over time.

However, sketches from *maʿallem* artisans are not truly geometric manuals; they do not show mathematical exercises or constructive geometry but rather provide visual guides based on eight-fold symmetry. These sketches lack the creation of foundational grids, relying on pre-printed paper or templates, enabling replication rather than original geometric insight (Image 8). This is likely why current workshops seldom produce patterns based on hexagons or pentagons, focusing instead on designs built on multiples of four—a tendency observed following the decline of the Marīnid dynasty, with few exceptions seen only under the *Saʿdī* rule.

3. The Marīnid Dynasty and Its Legitimacy Problem

Lacking a political and religious foundation (Bel, 1940, p. 33–34) to legitimise their rule, the Marīnids relied on a combination of elements that were not inherently compatible: Mālikīsm, mysticism, and Sharifism (Gubert, 1996: 398).[14] Additionally,

[13] See Book IV, prop. II, and Book IV, prop. XI (Euclid, 1956).

[14] Fez was undergoing a revival of the Idrīs cult. This led to a major political problem for the Marīnids; the existence of anti- Marīnid sentiment as well as the threat of an Idrisid descendant taking power. See: (Shatzmiller, 1976, p. 110).

they fabricated a genealogy to establish legitimacy through claims of noble lineage (Bennison, 2014, p. 199; Ibn Marzūq, 1977, p. 95).[15]

To prove their merits, the Marīnid sultans turned to elements of Sufism, which held great prestige at the time (Bennison, 2014, p. 200). Consequently, the sultans invoked Sufi qualities such as piety and asceticism.[16] They also employed Sufi terminology, such as *mawla*, meaning lord or master (Bennison, 2014, p. 200; Gubert, 1996). Material and infrastructural support, gifts, invitations to the palace, visits and emoluments were provided to religious elites, including the *ʿulamāʾ*, the Sufis, and the descendants of the Prophet, known as the *shurafāʾ*. The sultans notably transformed the city of Fez through the construction of madrasas since the sultanate of Abū Yūsuf Yaʿqūb with the construction of al-Ṣaffārīn. Consequently, the establishment of madrasas became a central strategy for legitimising their power (Bennison, 2014: 203–204).

During the Marīnid period, Fez comprised two sections: the old city, Fās al-Bali, which had already been unified by the Almoravid Yūsuf ibn Tāshfīn (r. 1061–1106 CE), and the new city, *al-Madīnah al-Bayḍāʾ*, the White City (1276 CE), constructed by Abū Yūsuf (r. 1258–1286 CE). The colour white represented the dynasty[17] and would later come to be known as *Fās Jdid* (Tourneau, 1961, p. 15). *Fās Jdid* was a prominent military city (Tourneau, 1961: 27) that housed the sultan, his family, and the governmental apparatus,[18] as well as two military corps (Terrasse, 1975, p. 71–74). A unit of Syrian archers was established in the area now known as Mellah, which subsequently led to the neighbourhood being referred to as Homs. The second military corps consisted of both Castilian and Catalan Christians, and this quarter was known as the Christian suburb (Tourneau, 1961, p. 15–16).

While the new city had a predominantly military character, the old city was a commercial and intellectual hub (Terrasse, 1975, p 31), marked by a middle-class population already accustomed to urban life by the 14th century. This population consisted of people of Arab, Berber, Andalusian, and Kairawanian origin. Society in Fez was structured into three social classes. The elite, which constituted the middle class, was composed of three distinct groups: merchants, intellectuals, and government officials. The intellectual group included teachers and students from the

[15] Ibn Marzūq continues by describing the dispute over the Marīnid lineage, followed by recounting how the alleged ancestors arrived in the Maghreb.

[16] For a more comprehensive understanding of the narratives surrounding the sultans, one may consult the accounts of contemporary chroniclers and historians, including (Ibn-Khaldūn, 1956, p. 239–242, 1984, p. 81; Ibn Abī Zarʿ, 1964, p. 721–722; Ibn Marzūq, 1977, p., p. 22–23, 33, 48–49; Ibn-Baṭṭūṭa, 1994. p. 927–932); see also (Blanchère, 1928, p. 84; Bel, 1938, p. 292; Bennison, 2014, p. 208).

[17] In contrast with the red Nasrid dynastic colour and of their city, the al-Ḥamrāʾ (Vidal Castro, 2000: p.79). See: (Bennison, 2014, p. 209). On the interactions between the Marīnid and Naṣrid Sultanates, see: (Melo Carrasco, 2014; Vidal Castro, 2004).

[18] About the makhzen, see: (Terrasse, 1975, p. 69–71, Kably, 1986, p. 258–271).

Image 9. 10-fold pattern, al-Attarin, M. Antonieta Emparán F. (photographer)

various madrasas, which allowed students from rural areas to integrate into this social class (Tourneau, 1961, p. 28–29).

4. Decoding Geometric Patterns: Insights through Reconstruction

While a full geometric analysis of these patterns is beyond the scope of this article, a detailed construction process offers invaluable insights into both the symbolic and social implications embedded within Marīnid geometric designs.[19] However, a preliminary understanding of its complexity already reveals several key points. First, it underscores the creator's advanced expertise in geometry, suggesting an intentionality beyond decorative appeal. Second, it hints at a symbolic language embedded within the patterns—an intellectual code accessible mainly to madrasa scholars and students, thus positioning the patterns as a marker of knowledge and cultural refinement. Finally, this symbolic depth aligns with the dynasty's broader validation strategy, where Sufi elements and Islamic legal practices converge, embedding the patterns within both spiritual discourse and the social framework of the period.

This layered complexity showcases geometric design as both an aesthetic and an intellectual pursuit, deeply entwined with Marīnid identity and the scholarly life of Fez. To the untrained eye, the intricate *zillīj* mosaics may appear merely as visually appealing, complex webs, inviting only a surface-level aesthetic experience of endless loops and striking patterns. But for the madrasa's expert geometers, including students and masters, these patterns reveal a deeper reality, one embedded in the geometry's layered construction process and its intellectual resonance. They possess the ability not only to appreciate the *zillīj*'s aesthetic value but also to engage with its structural essence, the unseen dimensions that emerge through the geometry's underlying complexity and method of construction providing them a more

[19] Future work on preparation will cover this reconstruction in depth.

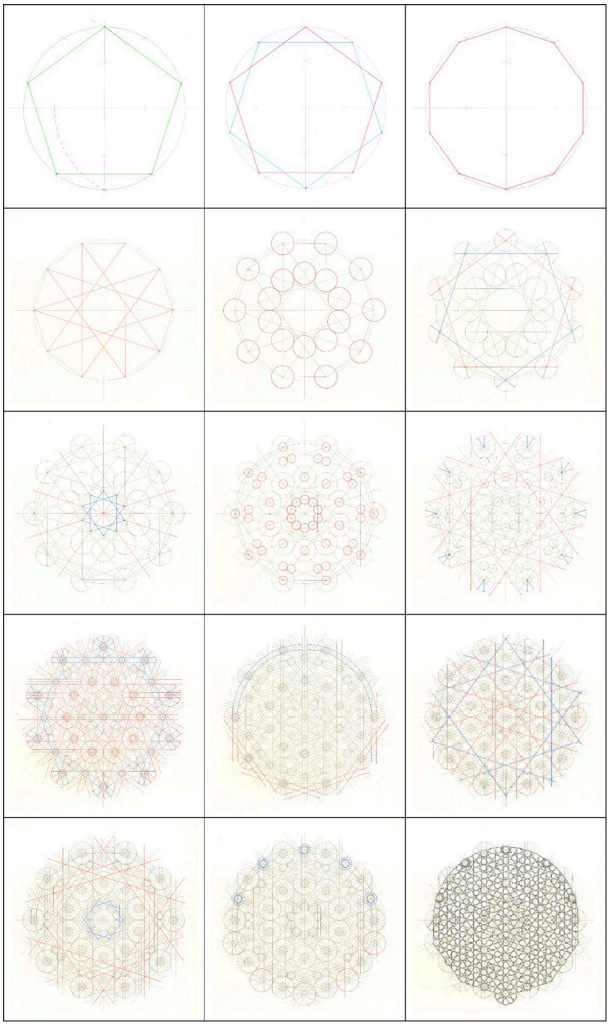

Image 10. M. Antonieta Emparán F., 10-fold pattern construction step-by-step, 2024.

deep and meaningful aesthetic experience. The *zillīj* at the threshold separating the central courtyard from the prayer hall in al-ʿAttārīn (Image 9) may initially appear to be a complex pattern; it is indeed regarded by contemporary traditional artists as the "jewel of al-ʿAttārīn." However, this apparent surface complexity is minor compared to the more than 25 geometric steps required for its full construction (Image 10). In this example, one can observe the various layers of design work accumulating one upon the other, each adding depth and intricacy.[20]

For these experts, each geometric form transcends the two-dimensional plane, activating a layered, almost three-dimensional vision of the wall before them. As these layers project into each other, the geometrical pattern evokes intellectual and spiritual realms familiar to the scholars of the madrasa, who interpreted the patterns through the lens of both mystical Sufism and Islamic legal scholarship as a graphic of their knowledge.

This connection to the divine and cosmic aligns with the intellectual lineage[21] of al-ʿAttārīn's first master, Ibn al-Bannāʾ al-Marrākushī (1256 – 1321 CE)—a sufi polymath proficient in geometry, astronomy, astrology, and occult science granted with a cosmological vision in his youth. Fez's madrasas fostered great minds like Ibn Khaldūn; it was there where Ibn Khaldūn, after his migration from Tunis, completed his studies. In addition to his distinction as a *faqīh*—a doctor of Islamic law—he was

[20] These drawings were originally made as part of the doctoral analysis of this *zillīj*. Step-by-step instructions for constructing this pattern, along with symbolic interpretations, can be found in the dissertation, currently undergoing editing for imminent publication.

[21] Due to space limitations, it is not possible to clarify all the genealogical relationships between the masters and disciples among the intellectuals mentioned here. All of them are genealogically connected within just three generations. A forthcoming article, currently in preparation, will address this intellectual genealogy along with the harmonization between the practice of law and mysticism, or *Ẓāhir* and *Bāṭin*.

a significant Sufi thinker, notably authoring a treatise on the debate within the Nasrid realm regarding whether the Sufi path required a guiding master or could be attained solely through texts. Similarly, the esteemed Sufi Ibn ʿAbbād al- Rundī (1333 – 1390 CE) pursued his studies at al-ʿAttārīn and ʾAbū ʿInānīya madrasas, ultimately formalizing the Shādhilīya order and serving as imam at the illustrious al-Qarawīyīn Mosque. These renowned madrasas also captivated Ibn al-Khaṭīb (1313 – 1374 CE), Ibn Khaldūn's friend, who, as a devout Sufi and prominent vizier to the Nasrid dynasty, recognized their profound significance. Even Ibn Baṭṭūṭa (1304 – 1369 CE), upon his return to Fez, was deeply impressed by the geometric beauty of these academic and spiritual centres. These patterns, thus, hold layered meanings—anchored not only in geometry but also in the social, intellectual, and mystical dimensions of Marīnid Fez—symbolizing a complex tapestry of dynastic legitimacy and intellectual pursuit.

Thus, it is fitting to conclude that the contemplation of these geometric patterns is imbued with what I term the "aesthetic of *ẓāhir* and *bāṭin*," where the evident, exoteric, and legal aspects balance with the hidden, esoteric, and mystical dimensions. Although this is not the place to delve deeply into these terms or the layered social and intellectual depths within Marīnid society,[22] it is clear that while the novice eye perceives only the exterior, the *ẓāhir*, the trained geometer's gaze penetrates into the inner, concealed essence—the *bāṭin*.

5. Summary and Conclusions

This study underscores the need to analyse Islamic geometric art through methods that both reconstruct the geometric intricacies and incorporate the socio-cultural framework of its origin. Marīnid *zillīj* patterns, particularly, reflect a layered synthesis of spiritual, legal, and political elements—evident in the dynasty's use of geometry to express the balance between Mālikī legal practice and Sufi mysticism, or *ẓāhir* and *bāṭin*. Moving beyond conventional Orientalist and colonialist perspectives, this approach advocates for a decolonial lens that appreciates each geometric pattern as a unique product of its cultural and symbolic landscape, deeply connected to the specific historical and intellectual needs of its societies. This combined approach offers a fuller understanding of Islamic geometric art, one that is as intellectually rich as the geometric patterns themselves. Through this lens, the *zillīj* can be seen as both an artistic and intellectual statement, intended not only for aesthetic appreciation but also as a form of scholarly engagement for students and teachers in the madrasas, reflecting both the mathematical skill of the geometers and the dynastic legitimacy sought by Marīnid patrons.

[22] Further exploration of *ẓāhir* and *bāṭin* aesthetics within Marīnid society and its broader social and intellectual implications will be provided in a forthcoming publication.

References

Abu l-Wafāʾ al-Būzajānī, M. I. (2010). *Ketâb al-nejârat* (J. A. Chavoshi, Trans.). Miras-e Maktoob.

Anonymous. (2017). On Similar and Complementary Interlocking Figures. In *The Arts of Ornamental Geometry* (pp. 179–375). Brill.

Ardiles, O., Assmann, H., Casalla, M., Cerutti, H., Cullen, C., De Zan, J., Dussel, E., Fornari, A., Gillot, D., Kinen, A., Kusch, R., Pró, D., de la Riega, A., Roig, A., & Scannone, J. C. (1973). *Hacia una filosofía de la liberación latinoamericana*. Bonum.

Bauer, C. F. (2022). *Analéctica latinoamericana: Un pensamiento descolonizador para el siglo XXI*. Prometeo Editorial.

Bel, A. (1938). *La religion musulmane en Berbérie: Vol. 1. Etablis*. Geuthner.

Bel, A. (1940). Le premiers Émirs Mérinides et l'Islam. *Mélanges de Géographie et d'orientalisme*, 34–44.

Bennison, A. K. (2014). Drums, Banners and Baraka: Symbols of Authority during the First Century of Marīnid Rule, 1250-1350. In A. K. Bennison (Ed.), *The Articulation of Power in Medieval Iberia and the Maghrib* (pp. 195–216). Oxford University Press.

Berggren, J. L. (2016). *Episodes in the mathematics of medieval Islam*. Springer.

Bernal, M. (1999). *Black Athena: Vol. 1. The fabrication of ancient Greece : 1785-1985*. Rutgers Univ. Pr. *Mémorial Henri Basset. Nouvelle études Nord-Africaines et Orientales* (pp. 83–89). Librairie Orientaliste Paul Geuthner.

Bohrer, F. N. (2003). *Orientalism and Visual Culture: Imagining Mesopotamia in Nineteenth-Century Europe*. Cambridge University Press.

Chorbachi, W. K. (1989). In the tower of Babel: Beyond symmetry in islamic design. *Computers Math. Applic.*, *17*(4), 751–789.

Chorbachi, W. K., & Loeb, A. L. (1992). An Islamic Pentagonal Seal. In *Fivefold Symmetry* (pp. 283–305). World Scientific.

Cooke, R. L. (2013). *The history of mathematics: A brief course*. John Wiley & Sons, Inc.

Critchlow, K. (1999). *Islamic Patterns an analytical and Cosmological Approach*. Inner Traditions.

Elias, J. J. (2012). *Aisha's Cushion. Religious Art, Perception, and Practice in Islam*. Harvard Univ. Press.

Emparán Fernández, M. A. (2018a). *Lo que olvidan los matemáticos. La asimetría cromática como representación simbólica en la Alhambra de Granada*. Editorial Académica Española.

Emparán Fernández, M. A. (2018b). Palacio de la Alhambra: Un orientalismo chileno del siglo XIX. In F. Giese & A. Varela Braga (Eds.), *The Power of Symbols* (pp. 355–

369). Peter Lang CH. https://doi.org/10.3726/b10940

Escobar, A. (2014). *Sentipensar con la tierra. Nuevas lecturas sobre desarrollo, territorio y diferencia*. Ediciones UNAULA.

Ettinghausen, R. (1972). In B. H. Evans (Ed.), *Jean-Léon Gérôme (1824-1904)*. Dayton Art Institute.

Euclid. (1956). *The Thirteen Books of The Elements* (T. L. Heath, Trans.; Vol. 2). Dover Publications.

Futter, C. L. (2019). "Beautiful as a Poet's Dream..." Islamic Influence on European Design. In L. de Guise & W. Greenwood (Eds.), *Inspired by the East: How the Islamic world influenced Western art* (pp. 16–29). The British Museum Press - Islamic Arts Museum Malaysia.

Greenwood, W., & de Guise, L. (Eds.). (2019). *Inspired by the East: How the ISlamic world influenced Western art*. The British Museum - Islamic Arts Museum Malaysia.

Grünbaum, B., & Shepard, G. (1977). Tilings by Regular Polygons. *Mathematics Magazine*, *50*(5), 227–247. https://doi.org/10.2307/2689529

Gubert, S. (1996). Pouvoir, sacré et pensée mystique: Les écritures emblématiques Mérinides (VII°/XIII°-IX°/XV° siècles). *Al-Qantara*, *XVII*(2), 391–427.

Haraway, D. (1988). Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies*, *14*(3), 575–599.

Hauser, S. R. (2005). History, Races, and Orientalism: Eduard Meyer, the Organization of Oriental Research, and Erns Herzfeld's Intellectual Heritage. In *Ernst Herzfeld and the Development of the Near Eastern Studies, 1900-1950* (pp. 505–559). Brill.

Herzfeld, E. (2012). *Arabesque*. Encyclopaedia of Islam. https://referenceworks.brill.com/display/entries/EI1O/SIM-0810.xml?rskey=6MHX4d&result=1

Hillenbrand, R. (2005). The One that Got Away: Ernst Herzfeld and the Islamic Architecture of Iran. In *Ernst Herzfeld and the Development of Near Eastern Studies, 1900-1950* (pp. 405–426). Brill.

Hogendijk, J. P. (2017). A Mathematical Classification of the Contents of an Anonymous Persian Compendium on Decorative Patterns. In *The Arts of Ornamental Geometry* (pp. 145–162). Brill.

Ibn Abī Zarʿ, ʿAlī Ibn-ʿAbdallāh. (1964). *Rawd al-Qirtas: Vol. II* (A. Huici Miranda, Ed. & Trans.).

Rawḍat al-Nisrīn fī Dawlat Banī Marīn (M. Á. Manzano, Trans.). Consejo Superior de Investigaciones Científicas.

Ibn Marzūq, M. I.-A. (1977). *El Musnad. Hechos memorables de Abū l-Ḥasan Sultan de los Benimerines* (M. J. Viguera Molins, Ed. & Trans.). Inst. Hispano-Arabe de

Cultura.

Ibn-Baṭṭūṭa, M. I.-ʿAbdallāh. (1994). *The travels of Ibn Baṭṭūṭa: Vol. IV* (C. Defrémery, B. R. Sanguinetti, & H. A. R. Gibb, Eds.; C. Defrémery, B. R. Sanguinetti, H. A. R. Gibb, & C. F. Beckingham, Trans.). Hakluyt Society.

Ibn-Khaldūn, ʿAbd-al-Raḥmān Ibn-Muḥammad. (1956). *Histoire des Berbères et des dynasties musulmanes de l'Afrique Septentrionale: Vol. IV* (H. Pérès, Ed.; L. B. de Slane, Trans.). Geuthner.

Ibn-Khaldūn, ʿAbd-ar-Raḥmān Ibn-Muḥammad. (1984). *Le voyage d'Occident et d'Orient: Autobiographie / Ibn Khaldûn* (A. Cheddadi, Trans.). Sindbad.

Jones, O. (2016). *The Grammar of Ornament*. Ivy Press.

Jones, O., & Goury, J. (2013). *Plans, elevations, sections, and detailsof the Alhambra, from drawings taken on the spot in 1834 by Jules Goury, and in 1834 and 1837 by Owen Jones 1842*. Isha Books.

Kably, M. (1986). *Société, pouvoir et religion au Maroc à la fin du "Moyen-Age" (XIVe—XVe siècle)*. Ed. Maisonneuve et Larose.

Kelly, M. (2019). Orientalism, Orientalist Art and the Making of Meaning. In W. Greenwood & L. de Guise (Eds.), *Inspired by the East: How the Islamic worldinfluenced Western art* (pp. 42–53). The British Museum Press - Islamic Arts Museum Malaysia.

Kheirandish, E. (2017). An Early Tradition in Practical Geometry: The Telling Lines of Unique Arabic and Persian Sources. In *The Arts of Ornamental Geometry* (pp. 79–144). Brill.

Komaroff, L. (n.d.). *Arabesque*. Encyclopaedia of Islam. Retrieved May 14, 2024, from https://referenceworks.brill.com/display/entries/EI3O/COM-23685.xml?rskey=yP2SpC&result=1

Kröger, J. (2005). Ernst Herzfeld and Friedrich Sarre. In *Ernst Herzfeld and the Developments of Near Eastern Studies, 1900-1950* (pp. 45–99). Brill.

Kühnel, E. (2012). *Arabesque*. Encyclopaedia of Islam. https://referenceworks.brill.com/display/entries/EIEO/SIM-0694.xml?rskey=k6wGik&result=1

Leisten, T. (2005). Mshatta, Samarra, and al-Hira: Ernst Hesrzfeld's Theories Concerning the Development of the Hira-Style Revisited. In *Ernst Herzsfeld and the Development of Near Eastern Studies, 1900-1950* (pp. 371–403). Brill.

MacKenzie, J. M. (1995). *Orientalism. History, Theory, and the Arts*. Manchester University Press.

MacKenzie, J. M. (2013). Orientalism in arts and crafts revisited: The modern and the anti-modern: The lessons from the Orient. In I. R. Netton (Ed.), *Orientalism Revisited. Art, Land and Voyage*. Routledge.

MacKenzie, J. M. (2019). The Orientalism Debate. In W. Greenwood & L. de Guise (Eds.), *Inspired by the East: How the Islamic world influenced Western art* (pp. 16–

29). The British Museum Press - Islamic Arts Museum Malaysia.

Melo Carrasco, D. (2014). Al-andalus y el Magreb: Nazaríes y benimerines; notas en torno a una "historia paralela." In J. J. Vagni & L. Calle (Eds.), *Marruecos y América Latina. Viejas y nuevas confluencias* (pp. 29–46). Centro Mohammed VI.

Mignolo, W. D., & Escobar, A. (2013). *Globalization and the Decolonial Option*. Taylor & Francis.

Neçipoğlu, G. (1995). *The Topkapi Scroll: Geometry and Ornament in Islamic Architecture*. The Getty Center for the History of Art and the Humanities.

Neçipoğlu, G. (2007). L'idée de décor dans les régimes de visualité islamiques. In *Purs décors? : Arts de l'Islam, regards du XIXe siècle*. Les Arts Decoratifs.

Nochlin, L. (1983). The Imaginary Orient. *Art in America*, 119–131, 187–191.

Nochlin, L. (1989). The Imaginary Orien. In *The Plotics of Vision. Essays on Nieteenth-Century Art and Society* (pp. 33–59). Harper & Row, Publishers.

Orihuela, A. (2008). La conservación de alicatados en la Alhambra durante la etapa de Rafael Contreras (1847-1890): ¿Modernidad o provisionalidad? In *La Alhambra: Lugar de la memoria y el diálogo* (pp. 125–152). Patronato de la Alhambra y Generalife / Centro de Estudios de al-Andalus y el Diálogo de Civilizaciones.

Özdural, A. (1996). On Interlocking Similar or Corresponding Figures and Ornamental Patterns of Cubic Equations. *Muqarnas*, *13*, 191–211.

Paccard, A. (1980). *Traditional Islamic craft in Moroccan architecture* (M. Guggenheim, Trans.; Vol. 1). éditions atelier 74.

Premare, A.-L. de, Canamas, J.-P., Comerro, V., Dallaporta, C., & Ealet, E. (1993). *Dictionnaire arabe marocain-français*. Editions l'Harmattan.

Rouphael, N. H. (2015). *L'orientalisme au XIXe siècle: De la fiction vers la réalité*. Connaissances et savoirs.

Rubio Domene, R. F. (2008). La Sala de las Camas del Baño Real de Comares de la Alhambra: Datos tras su restauración. *Cuadernos de La Alhambra*, *43*, 152–171.

Shatzmiller, M. (1976). Les premiers Mérinides et le milieu religieux de Fès: L'introduction des Médersas. *Studia Islamica*, *43*, 109–118.

Stewart, I. (2001). *What shape is a snowflake?* W.H. Freedman.

Suter, H. (1922). Das Buch der geometrischen Konstruktionen des Abuʾl Wefâʾ. *Beiträge Zur Geschichte Der Mathematik Bei Den Griechen Und Arabern*, 94–109.

Tabbaa, Y. (2001). *The Transformation of Islamic Art During the Sunni Revival*. University of Washington Press.

Tabbal, S. (2023). *Das Gelb Marokkos. Auf den Spuren der Orientmaler Fortuny und Regnault*. De Gruyter.

Terrasse, H. (1975). *Histoire du Maroc: Vol. II*. AMS Press.

Tourneau, R. L. (1961). *Fez in the age of the Marinides* (B. A. Clement, Trans.).

University of Oklahoma Press.

Vidal Castro, F. (2000). Formación y consolidación (1232-1302). In R. Menendez Pidal (Ed.), *Historia de España: Vol. VIII–3* (pp. 77–114). Espasa-Calpe.

Vidal Castro, F. (2004). Nazaríes y Meriníes, caminos entrecruzados: Al-Andalus y el Magreb al-Aqsa (Marruecos). In *Al-Andalus y el Norte de África: Relaciones e Influencias*. Fundación El Monte.

Warraq, I. (2010). *Linda Nochlin and The Imaginary Orient*. New English Review. https://www.newenglishreview.org/articles/linda-nochlin-and-the-imaginary-orient/

Wehr, H. (1994). *A dictionary of modern written Arabic (Arabic—English)* (J. M. Cowan, Ed.). Spoken Language Services.

Woepcke, F. (1855). Recherches sur l'histoire des sciences mathématiques chez les Orientaux, d'après des traités inédits arabes et persans. Troisième article. Sur une mesure de la circonférence du cercle, due aux astronomes arabes et fondée sur un calcul d'Aboûl Wafâ. *Journal Asiatique*, *5*, 218–256; 309–359.

Woepcke, F. (1860). Recherches sur l'histoire des sciences mathématiques chez les Orientaux, d'après des traités inédits arabes et persans. Troisième article. Sur une mesure de la circonférence du cercle, due aux astronomes arabes et fondée sur un calcul d'Aboûl Wafâ. *Journal Asiatique*, *15*, 281–320.

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