The Petra Fallacy

Early Mosques face the Sacred Kaaba in Mecca, not Petra!

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Dan Gibson's book Early Islamic Qiblas (2017) prompted my reply "From Petra back to Mecca: from pibla back to qibla" (2017). His "Comparing two qibla theories" (2018) prompted the present response. I have appended a reaction to A. J. Deus' "Monuments of Jihad" (2018) on the orientations of Turkish mosques. The abundant reliable publications on the determination of the sacred direction toward the sacred Kaaba in Mecca are here listed for the first time. To understand why this or that early mosque was pulled down and rebuilt in a different direction, read on, but rest assured, it all has nothing to do with Petra.

Since these exchanges, I have made available on my Academia webpage a 1,350-page monograph entitled "Historical Mosque Orientations" (2023) with explanations of the orientations of hundreds of mosques towards the Kaaba, using the methods described in medieval texts. In 2023, Dan Gibson published a book entitled Let the Stones Speak, demonstrating for his revisionist readers, that the foundations of early mosques face Petra, so that the origins of Islam and its early history were deliberately falsified. He devoted an entire chapter devoted to show that my ideas were false.

Introduction

For over 1,400 years, Islamic civilization has taken the orientation of sacred space more seriously than any other civilization in human history. The sacred direction towards the sacred Kaaba in Mecca is called qibla in the languages of the Muslim commonwealth. How Muslims have determined the qibla over the centuries is a complicated story, but several facts are known:

- The Arabs before Islam had an intricate system of what we now call 'folk astronomy' based on what one can see in the heavens.
- The Kaaba has a rectangular base which is astronomically aligned; its major axis points toward the rising of Canopus, the brightest star in the southern sky, and its minor axis is defined by summer sunrise and winter sunset. Its four corners point roughly in the cardinal directions.
- The Muslims developed a sacred geography in which, over the centuries, various schemes were developed in which segments of the perimeter of the Kaaba corresponded to sectors of the world which had the same *qibla*, defined in

terms of astronomical risings and settings.

- By the 9th century, the Muslims had accessed the geographical and mathematical knowledge of their predecessors, which meant that for the first time they could calculate the *qibla* using (medieval) geographical coordinates and mathematical procedures.
- From the 7th to the 9th century and also occasionally thereafter until the 19th century, Muslims used astronomical alignments to lay out the *qibla*. From the 9th century to the present Muslims have also used mathematical methods to calculate the *qibla*.

Few people know anything about this these days. Indeed, most Muslims think that all mosques face Mecca. Yet if they would investigate just a few medieval mosque orientations they would be surprised. For medieval mosques face the Kaaba rather than Mecca. There is a subtle, but highly significant difference. How can they 'face' a distant edifice that is not visible? How these mosques actually 'face' the Kaaba is something we moderns have to learn.

Over the past 50 years, I have attempted to document—for the first time—the way in which Muslims over many centuries have used astronomy in the service of their religion:

- to regulate the lunar calendar through the sighting of the crescent;
- to organize the times of the five daily prayers;
- to determine the sacred direction or *qibla.*

To do this I did not just sit down and write about these subjects, I spent many years looking at thousands of medieval Arabic manuscripts and hundreds of scientific instruments in libraries and museums around the world. Since nobody had ever looked at these manuscripts for hundreds of years, I inevitably found things that were new. Some of my results took some Muslim colleagues by surprise. Western colleagues are, I find, becoming less and less interested in anything do with classical Islamic Studies. And that field is plagued by revisionists who think no medieval Arabic texts are trustworthy and who eagerly rewrite a chapter of Islamic history relying instead on the ramblings of some early Christian bishop in Armenia (I exaggerate).

Some of my publications include studies of the following subjects:

a) the methods with which Muslims from the earliest period could have determine the *qibla* by simple folk astronomy;

b) the notion of a sacred geography about the Kaaba, with sectors of the world having the same *qibla* defined by astronomical horizon phenomena;

c) the methods by which the Muslim scientists could calculate the *qibla* for a given locality;

d) the geographical tables showing longitudes and latitudes of hundreds of localities from al-Andalus to China together with their qiblas in degrees and minutes;

e) the medieval discussions of the orientations of religious architecture in various cities (notably Córdoba, Cairo and Samarqand);

f) the extraordinarily sophisticated mathematical tables displaying the *qibla* for any locality with which the user enters its longitude and latitude in the table and reads the value of the *qibla*;

g) the remarkable cartographical grids produced by Muslim scientists enabling the user to reading off the *qibla* on a circular scale and the distance to Mecca on a diametrical scale.

I have left it to others to write on such controversial topics as the conflict regarding the *qibla* – is it south-east or north-east? – amongst Muslims in North America. Frequently over the years folk have introduced the factor that the Earth is not a sphere into the *qibla* discussion, which is not helpful.

In 1999 I published a book dealing with the way Muslims have determined the sacred direction over for some 1,400 years. This presented an overview of the earliest procedures of using astronomical alignments to face an astronomically-aligned Kaaba, with different means of calculating the *qibla* using geographical coordinates and trigonometric or geometric methods. But the book focusses on the mathematical tables that were devised giving the *qibla* as an angle in degrees and minutes for the whole Muslim world; the geographical tables giving for the principal localities in the Muslim world the *qibla* and distance to Mecca; and the cartographical Mecca-centred grids which enable the user to read off the *qibla* and distance to Mecca for any locality in the world.

None of these materials was known 50 years ago. And inevitably none of them are mentioned in uninformed popular accounts of the *qibla* such as one finds in Wikipedia. I never thought while preparing all my research that some day somebody would come along and announce that all early mosques are oriented toward a location other than Mecca. No Muslim would ever have thought that mosques could be deliberately oriented somewhere other than Mecca. If they had, they would rightly be considered to be deranged.

Revisionist fascination with N. W. Arabia

Some 50 years ago some over-enthusiastic London-based Arabists – John Wansbrough and his students Michael Cook & Patricia Crone – came up with the idea that Islam began not in Mecca but somewhere unspecified in N.W. Arabia. One of the principal and most convincing arguments for this bold assertion was the 'fact' that the earliest mosques in Egypt and Iraq did not face Mecca, but rather some locality in N. W. Arabia. Some 25 years ago I pointed out the folly of this assertion, explaining that the earliest mosque in Egypt faces winter sunrise and the earliest mosque in Iraq faces winter sunset, so, of course these mosques do not face Mecca. Nor were they deliberately aligned towards anywhere in N.W. Arabia. They face the Kaaba. The earliest Muslims in Egypt and Iraq used winter sunset and winter sunrise, respectively, for the qibla, not because they were stupid, but because they were smart. How else to face an edifice they could not see: all savvy ancient peoples have used astronomical alignments for one reason or another.

My present intention is simple: it is to warn the unsuspecting reader that the only other person ever to have written generally on the subject of mosque orientations

a) has no qualifications to correctly interpret the available data;

b) has no understanding of the fact that **MODERN** directions from one place to another cannot be used to investigate the reasons underlying the orientation of **PRE-MODERN** architecture;

c) seems oblivious to the fact that there is well-established discipline called archaeoastronomy and has no understanding of astronomical alignments;

d) has erred monumentally in his interpretation of mosques that were built on pre-existing religious architecture or to fit with pre-Islamic city plans;

e) has no understanding of how mosques were laid out over the centuries; and

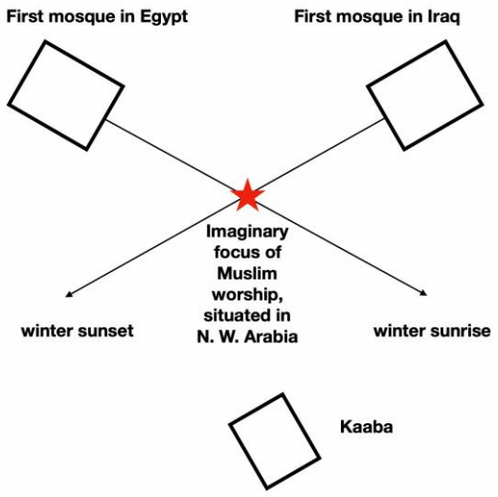
f) has no control over any of the numerous medieval Arabic sources—legal, astronomical, folk astronomical, and mathematical—relating to the determination of the qibla.

Worse still, he

g) has settled on a locality as the focus of early Islam where there were no Arabs, no Muslims, no Jews, and there was no life.

And worse than that,

h) behind Gibson's apparently innocent adventures in a field he does nor master there lies a pernicious ulterior motive that I personally find odious.



The fallacy propounded by Cook & Crone. They observed that the earliest mosques in Egypt and Iraq appeared to be aligned with a place in N.W. Arabia rather than with Mecca. This, they thought, confirmed their (incorrect) theory that the origins of Islam were somewhere in N.W. Arabia. In fact, the mosques are aligned with the Kaaba in Mecca by means of astronomical horizon phenomena, namely, winter sunrise and sunset, The first generation of Muslims knew what they were doing with regard to mosque orientations and later generations over many centuries developed remarkable and more sophisticated means for finding the sacred direction. We moderns just have to learn how they dealt with the need to align mosques in the sacred direction toward the sacred Kaaba in Mecca. It is not something one can imitate or investigate with an iPhone

Enter Dan Gibson with his Early Islamic Qiblas (2017)

I refer to Dan Gibson, an amateur Canadian Near East archaeologist with no formal academic training but with strong Christian missionary connections who has convinced himself that Islam started in Petra rather than Mecca and Medina.

He is certainly very creative: for example, he is able to find numerous references to Petra in the *Qur'ān* that nobody before him had ever noticed. The prominent Arabist Arthur Jeffrey in his book *The foreign vocabulary of the Qur'ān* (1938) documented numerous Aramaic words but no specifically Nabataean words. Also, although the Nabataeans may have been Arabs, it should be

remembered that classical Arabic developed in Mecca, not in Petra.

With the arrogance of the uninformed Gibson claims to be able to interpret the orientations of any early mosque. He presents as 'proof' of his Petra theory the 'fact' that the earliest 50-odd mosques are oriented to within a degree or two with Petra in sight, not Mecca. And, Gibson claims, the real Kaaba was originally in Petra anyway. All this happily confirms his theory that Islam started in Petra, not Mecca. But this is all poppycock (كلام فارغ , *kalām fārigh*), not least because it contradicts everything we know about early Islam and contemporaneous Petra, let alone the sacred direction or *qibla*, but mainly because it is based on the most obvious false premises. Since Gibson has no idea how the first generations of Muslims might have determined the direction of anywhere – Petra or Mecca – he compares the orientation of mosques laid out well over 1,200-1,400 years ago with **MODERN** directions of Petra and Mecca.

Let me say at the outset that I believe that Gibson is sincere even though he is misguided; he really believes what he has discovered is new and exciting, substantiated by the evidence, which he is the first person to present. (Certainly nobody before Gibson has presented this dazzling array of mosque orientations.) But he cannot believe there is another explanation to all of his orientations which does not involve Petra at all. As they say in new-speak, he just doesn't get it.

Nabataean orientations before Gibson

If Gibson is ill-informed about Muslim practice, he appears to be quite clueless about earlier Nabataean practice in Petra and elsewhere. He apparently does not know that even his favourite Nabataeans used astronomical alignments—the cardinal and solstitial directions—for orienting their religious architecture and their tombs.

Accurate mosque orientations towards Petra

To give credence to his Petra theory Gibson needs to rewrite the history of science, a subject about which he is singularly uninformed. He wants us to accept that when the first generation of Muslims expanded out of Petra (!) they knew all about astrolabes (!) and spherical trigonometry (!) and the like. When they wanted to build mosques around the world from al-Andalus to China facing the Kaaba in Petra they used these advanced mathematical techniques to calculate the pibla toward Petra and they were able to do this to within a degree or two. More poppycock (كلام فارغ)! In fact, they used simple astronomical alignments, and there was no need for any mathematical system. (However, as part of the Graeco-Roman world, the Nabataeans long before the advent of Islam did have such devices as sundials.)

Mosque orientation before Gibson

Gibson's claim about Petra deliberately ignores everything that modern scholarship has uncovered about the notion of sacred direction in Islam. His first book *Qur'ânic Geography* (2011) had not a single reference to any serious book or article on the *qibla*. His later works have been padded with a few references to my works but they deliberately omit any reference to four articles which presented an overview of what was known before Gibson appeared on the scene:

- "On the astronomical orientation of the Kaaba" (with Gerald S. Hawkins) (1982);

- "Astronomical alignments in medieval Islamic religious architecture" (1982);
- "The orientation of medieval Islamic religious architecture and cities" (1995);
- "The earliest Islamic mathematical methods and tables for find¬ing the direc¬tion of Mecca" (1996); and
- "The sacred geography of Islam" (2005).

For myself, I am fairly confident that Islam started in Mecca and Medina, and that all early mosques were deliberately aligned to face the astronomically-aligned Kaaba in Mecca. These orientations were achieved by the early Muslims with a considerable amount of success within the limits of their capabilities, mainly using astronomical alignments or building on earlier foundations that were inevitably also astronomically aligned. Later mosques were aligned either in *qiblas* calculated from geographical data using mathematical procedures, although the old procedures continued to be used.

In each major centre in the medieval Islamic world there was a palette of several qibla-directions accepted by one interest group or another. There might be a *qiblat al-ṣaḥāba*, a direction chosen by the first generation of Muslims who settled in that locality, usually an astronomically-defined direction, and favoured thereafter; there might be different directions favoured by the individual legal schools; there might be a different astronomically-defined direction that was favoured by some; and there could be two mathematically-determined *qibla*-directions, one based on an approximate methods and the other based on an exact procedure. In addition, there is the modern *qibla*, which is irrelevant to the investigation of any historical mosque.

I consider it necessary to respond to Dan Gibson's latest pronouncements for two main reasons:

- People seem to forget that the sacred direction in Islam is not toward Mecca but toward the Kaaba in Mecca. There is a significant difference between facing an edifice that one cannot see but which one knows is astronomically aligned and facing a distant city. People need to be reminded of this, because what was obvious to a medieval mind is not obvious to us moderns. All of Gibson's mosques are aligned toward the Kaaba in one way or another. Since the 9th century, when mathematical geography and mathematical methods became available, mosques have generally been aligned toward Mecca, usually, but not always, using mathematical methods. In major centres there was sometimes a quadrant of *qibla*-directions used different interest groups. Without knowing this, it is somewhat precarious to try to explain an early mosque orientation.
- There are very few people – Muslims, non-Muslims and independents – who know anything about medieval *qibla* determinations and even fewer who would be able to counter Gibson's 'new', basically absurd theories which appear to rely on 'scientific evidence'.
- I am well aware of the potential damage Gibson has done / can do to our field. But more seriously, Gibson's writings

are guaranteed to contribute to Islamophobia amongst those who have no idea about the one and only civilization which really took orientations seriously for over 1400 years.

Some basics

Before we begin to lose the reader through technicalities we mention a few basic notions that were self-evident to medievals but are not to some moderns.

The heavens above the observer appear to rotate about a celestial axis defined (more or less) by the Pole Star. The altitude of that star above the northern horizon is a measure of the latitude of the locality.

The cardinal directions north and south are defined as the intersections on the horizon with the meridian, the vertical circle passing through the Pole Star, intersects. The cardinal directions east and west are defined on the horizon by the vertical circle perpendicular to the first one. Or we may consider them as the points at which the sun rises and sets at the equinoxes, the days when the length of daylight equals the length of night.

The daily path of the sun is a circle perpendicular to the polar axis. At the equinoxes the day-circle passes through the east and west points. At the summer solstice, when the length of daylight is maximum, sunrise and sunset are substantially (for convenience say about 30°) to the north of east and west. At the winter solstice, when the length of daylight is minimum, sunrise and sunset are substantially to the south of east and west.

The expression 'astronomical alignments' relates here to buildings whose bases, mainly rectangular, are in the cardinal directions, or in directions defined by the rising or setting sun at the solstices. The risings and settings of various bright "qibla stars" might also be involved. These solar directions conveniently divide each quadrant of the horizon into three roughly equal parts.

To calculate the direction from any general locality toward another, specific locality, one needs to know the longitudes and latitudes of both localities and be familiar with an appropriate geometric procedure or trigonometric formula. These are adequately dealt with elsewhere. The latitudes used by medieval astronomers could be fairly accurate but the longitudes less so.

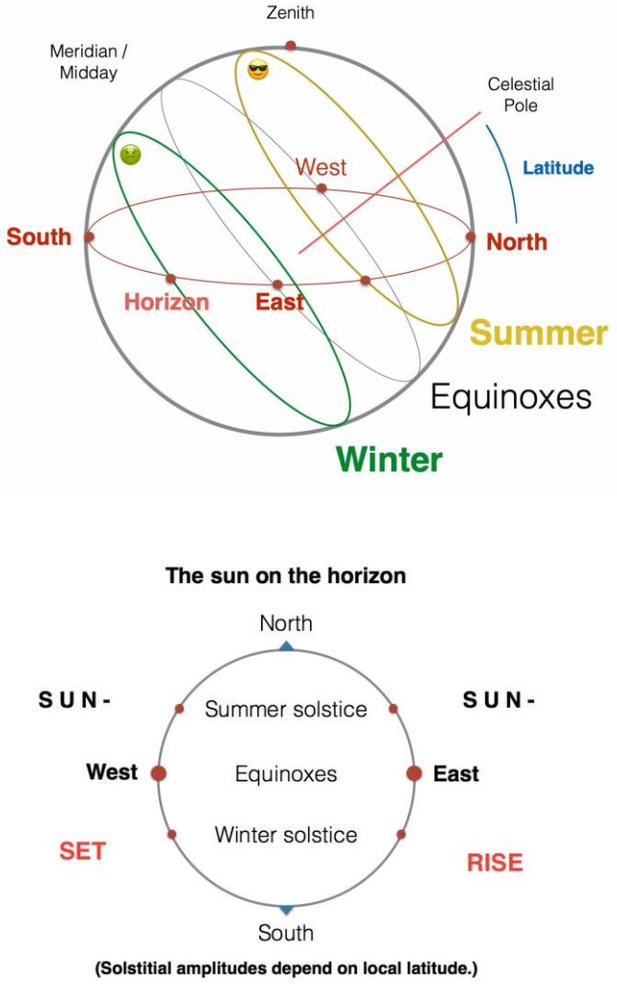


Fig. The sun's paths above and below the horizon at the equinoxes and the solstices

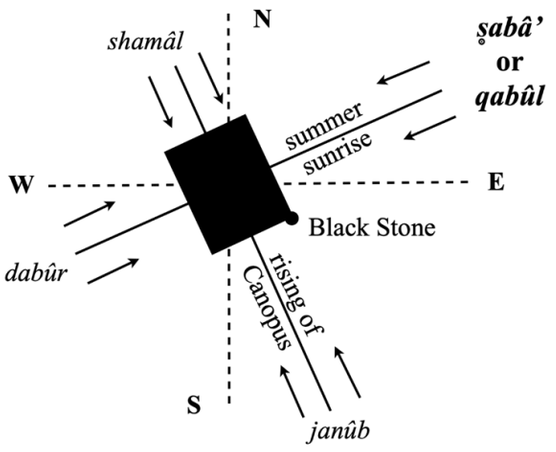
Gibson's "Comparing two qibla theories" (2018)

In this silly and desperate new article Dan Gibson attempts to compare what he and I have written on the *qibla* or sacred direction in Islam and the orientation of the earliest mosques (to ca. 800). He still seems to have no understanding of anything I have ever written on the subject of the *qibla* so he is hardly equipped to summarize my findings. He claims that I do not understand what he has discovered, which is very far from the truth, because I like numbers and can handle them (up to a point) and I can sometimes tell when people have been misled by numbers, as is the case with Gibson. And statistics are on my side this time.

Gibson has the audacity to present our respective credentials for conducting such an investigation, and I admit to being somewhat tickled by this. He modestly fails to mention the universities and subjects of his own "several undergraduate degrees". He states that he is assisted by "a small team of fellow researchers with degrees in history, astronomy, engineering, mathematics, and physics", but it is a pity that none of these have saved him from making a complete fool of himself in such areas, now well-documented, as ethnoastronomy and archaeoastronomy, for this is where our investigations belong, as well as in Islamic Studies and Nabataean Studies.

In discussing my credentials Gibson omits mention of the fact that my first degree was in mathematics (Cambridge, 1963), with a distinct penchant with respect to statistics. My graduate studies in Near Eastern Languages and Literatures and the History of Science came later (Yale, 1972). In discussing my professional experience Gibson simply omits the two decades (1985-2006) I spent as Professor of the History of Science at the Johann Wolfgang Goethe University in Frankfurt and Director of one of the two leading centres in Europe of research on the history of Islamic astronomy and mathematics (the other being the University of Barcelona). معليش .

Gibson states that my "location of data" is my article "Qibla" in the *Encyclopaedia of Islam*, the prestigious reference work on historical Islamic Studies with articles each written by leading international authorities, kindly adding "many books and articles on the subject" and referring to an old website of mine. However, in that overview article "Qibla", published in 1979, after presenting some of the methods and tables used by Muslim astronomers over the centuries, I briefly discussed mosque orientation in a few lines. Gibson is correct in stating that I have not personally measured mosque orientations (except in Samarqand). However, in the 1970s I did consult hundreds of published mosque plans in the library of the Institute of Fine Arts in New York. Only a small minority of studies of individual mosques or architectural complexes contained reliable statements concerning orientations and few plans had reliable indications of true north. I concluded that to publish a survey of orientations based on such plans would not be worthwhile ("Astronomical alignments", p. 310).



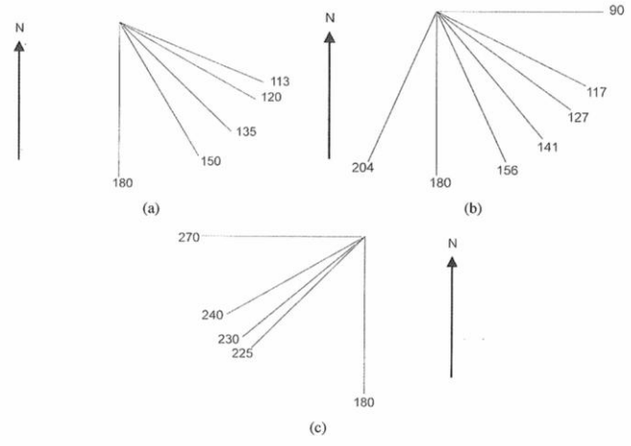
Orientation of the Kaaba mentioned in medieval texts and confirmed by satellite images, with consideration of the surrounding horizon.

Canopus (سهيل , *Suhayl*) is the brightest star in the southern sky. The direction of the rising of Canopus is perpendicular to the axis between summer sunrise and winter sunset for the latitude of Mecca.

In pre-Islamic folklore the walls of the Kaaba were associated with the four 'cardinal' winds. Note that if one standing in front of the SW wall one is facing (استقبل, *istaqbala*) the قبول *qabūl* wind, also called صبا *ṣabā*; in this position one is facing summer sunrise with (formerly) fortunate Yemen (اليمن, *al-Yaman*) on the right and ominous Syria (الشأم), *al-sha'm*) on the left.

Some revisionists have claimed that the orientation of the Kaaba may have been altered on one of the several occasions when the edifice was rebuilt after destructive floods. Revisionists have to be very innovative when confronted with an edifice that is as ancient as the Kaaba.

Various *qibla*-directions accepted in medieval cities of (a) Córdoba, (b) Cairo, and (c) Samarqand.



These include astronomical directions, cardinal and solstitial, and qiblas determined by approximate and/or accurate formulae.

In Córdoba there is no accurately-computed qibla attested, only one derived by an approximate formula (113°), which competed with winter sunrise (120°). The striking orientation of the Grand Mosque (150°) results from the street-plan of the Roman suburb where it was built, and it is happily 'parallel' to the main axis of the Kaaba. In the case of Cairo, the qibla of the Companions of the Prophet was winter sunrise (117°) and in the 10th century the *qibla* of the astronomers (127°) started to become popular. In Samarqand the *qibla* of the Companions was toward winter sunset (240°) but the *qibla* of the Shāfiʿīs was due south (since the Prophet had prayed due south in Medina) and that of the Ḥanafīs was due west (since the road to Mecca left Samarqand in a westerly direction).

Imagine trying to unravel this from mosque orientations alone.

Fortunately, we have medieval texts which explain it all.

The orientation of the Kaaba

It was the discovery of the astronomical alignment of the Kaaba – based on satellite images interpreted by Gerard Hawkins and a medieval Yemeni text extracted by myself – which in 1982 provided the key to the astronomical alignments of numerous early mosques. Such astronomical alignments were then confirmed not only by the mosques themselves but also by medieval texts mentioning the different mosque orientations in individual cities, notably, Córdoba, Cairo and Samarqand. These cities, with their mutually independent astronomical traditions, reveal remarkably similar arrangements of qibla-directions within a quadrant.

By 1987, when I published the *Encyclopaedia of Islam* article "Makka as centre of the world", as well as various articles on mosque orientations, I was able to present the first explanation of the reasons certain mosques face in directions that take us by surprise. Inevitably Gibson has never mentioned these articles. Some of them are reprinted in the 1993 volume Astronomy in the Service of Islam, which he now cites by title but does not mention its contents. These texts show

that a palette of different qibla directions was used in each major centre, that is, a set of directions within a quadrant. For some legal scholars the direction of the Kaaba was optimal (عين الكعبة , *ʿayn al-Kaʿba*) was optimal but any direction within the appropriate quadrant (جهة الكعبة *, jihat al-Kaʿba*) was acceptable. Gibson for the first time now mentions the orientation of the major axis of the Kaaba but he describes it as solstitial, whereas in fact it is aligned toward the rising of Canopus, the brightest star in the southern sky: it is the minor axis which faces winter sunset on one side and summer sunrise on the other. The astronomical orientation of the Kaaba is a topic that has not yet attracted any serious attention, either in the Muslim world or in the West.

Anybody who wants to understand mosque orientations should first consider the Kaaba and the astronomical orientations of its rectangular base, and then pose the question: how would one face an astronomically-aligned sacred edifice in a distant location, without much geographical knowledge and with little or no mathematics? The answer for the early Muslims was quite simple: one should face the same direction as one would when standing in front of the Kaaba at that wall or corner which corresponds to the location in question. No serious geography. No mathematics. It's called tradition.

The corners of the Kaaba were named since time immemorial after the directions they faced: Syria, Iraq, the Yemen and "the West". A rich tradition of sacred geography was developed over the centuries based on the notion of the alignments of the sacred edifice. Some 20 different schemes are now known from Arabic and Persian manuscript sources – treatises on geography, legal and practical texts on the *qibla* (كتب دلائل القبلة)), treatises on folk astronomy, encyclopaedias – in which the world is divided into sectors about the Kaaba, with the qibla for each sector defined in terms of astronomical risings and settings. This newly-discovered material was surveyed in the article "Makka as centre of the world" mentioned above, and was announced mainly to receptive audiences of ethno- and archaeo-astronomers. The Islamic tradition of orientation and sacred geography is the only aspect of ethnoastronomy and archaeoastronomy in human history for which we have documentation. Gibson would not like these manuscript sources of Islamic sacred geography because they are "late"; in fact, they date from the period between the 9th and the 16th century, which for me is still early.

Gibson's conclusions regarding orientations

Gibson's investigations of the orientations of some 50-odd early mosques and comparison of their orientations with the **MODERN** directions of Petra, Jerusalem and Mecca, have revealed to him that there were four *qiblas* in early Islam. In his words:

> "Gibson believes that early mosques faced one of four different qiblas. Originally they faced Masjid al-Haraam in Petra (Jordan). Then during a century of disagreement they faced Mecca, as well as a place between Mecca and Petra, and some were aligned to be parallel to a line drawn between Mecca and Petra."

So his first "*qibla*", attested for the majority of early mosques, is towards the Masjid al-Ḥarām in Petra (!), which, according to him, is the original Kaaba (!). I label this direction *pibla* because it should not be confused with the real *qibla*.

Other early mosques "during a(n imaginary) century of disagreement", faced Mecca, or a place between Mecca and Petra. If the mosques found by Gibson to be facing Mecca do indeed face Mecca, then it is by coincidence. To assert that mosques were deliberately built in between two directions is extremely naïve but saves Gibson from admitting that he does not know what is going on.

The fourth orientation is parallel to a line drawn between Mecca and Petra, which I label *fribla*, for 'frankly ridiculous'. There is no historical cultural tradition known to Man in which people aligned sacred buildings in a direction between two directions to two different places. Here Gibson trips over deliberate solstitial alignments, which for certain localities do indeed lie cunningly between the local directions of Petra and Mecca.

Some individual mosques

I have no intention of commenting here on the orientations of numerous mosques. I have done that already in "From Petra back to Mecca – From *pibla* back to *qibla*" (2017), and I have seen how some of my pronouncements there have been misunderstood and misrepresented and distorted. I may have written somewhere that this or that mosque faces Petra and this has been taken as a confirmation of Gibson's pronouncements, but I went on to say that in fact the mosque is actually aligned toward summer sunrise or whatever. Further, I now doubt that one can trust Gibson's values for mosque orientations derived from satellite maps. So I shall here restrict comments to six (rather important) mosques, although later I shall make some suggestions for serious research in the future.

Gibson claims that the **Umayyad Mosque in Damascus** faces Petra not Mecca. He further claims that it was deliberately laid out towards Petra, and accurately at that. He overlooks the important fact that it was built on a Byzantine basilica which had replaced a Roman temple that was cardinally aligned. This is why it appears to face Petra, since within the limits of the exercise, Petra is roughly due south of Damascus. The Muslims built their Mosque and were surely happy that it 'faced' the northern Syrian corner of the Kaaba, as indeed it does. (Later, Muslim astronomers calculated the qibla in Damascus as about 30° E of S according to medieval data.)

Similarly, the **Mosque of ʿUmar in Jerusalem** was built so that it is aligned with the Temple complex, which is roughly cardinally aligned. Gibson claims the Mosque faces Petra, but in fact it is happily facing roughly due south toward the Kaaba. (It was some time before the astronomers announced that the qibla in Jerusalem was about 45 E of S according to medieval data.)

The **Mosque of Guangzhou** in China, dated (by some) to 627 (but this is legendary), is oriented at 292°. Gibson maintains that it was deliberately aligned towards Petra at 295° rather than Mecca at 285°. Since it faces Petra to within 3°, Gibson thinks that those who built it must have used a correct mathematical procedure. More likely, it was oriented towards summer sunset at about 295°. One should keep in mind that the Mosque has been rebuilt several times, although tradition would probably have dictated that the basic layout by Companions of the Prophet not be changed. Also one can ask how Muslims from Petra might have reached China before the death of the Prophet and built a mosque toward Petra. Gibson believes they had ships; I have suggested flying

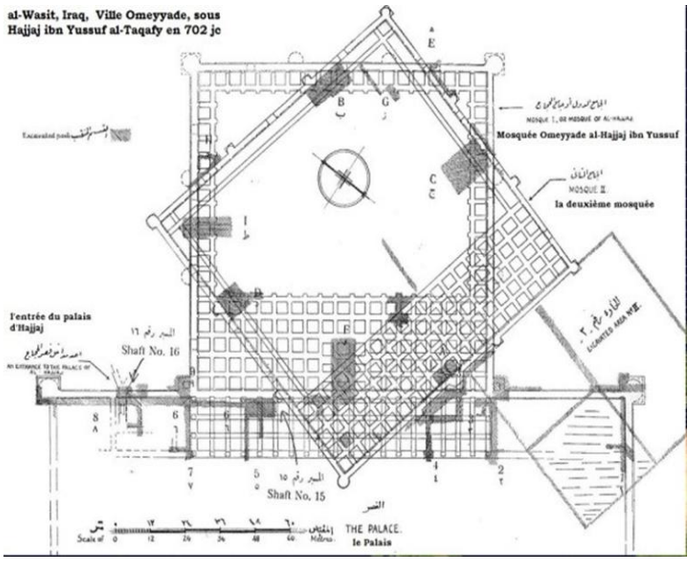
carpets. I repeat that the origins of this mosque are legendary.

The **Grand Mosque in Sanaa**, built in 705, is oriented at 334°. Now it happens that from Sanaa Petra is at 334°, Jerusalem is at 335°, and Mecca is 326°. Does this mean someone calculated the direction of Petra and got it right to the nearest degree? No it doesn't, because the major axis of the Mosque is 'parallel' to that of the Kaaba in Makka (and it even has a miniature Kaaba inside). Those who built the Mosque were thinking about facing the south-eastern wall of the Kaaba, not about "The rose-red city", of which they had probably never heard.

The **Great Mosque in Córdoba** faces the deserts of Algeria rather than the deserts of Arabia. Why? The suburb of Roman Corduba that was called Colonia Patricia and which slopes down to the River Guadalquivir has only in the past 20 years been excavated. The orthogonal street pattern is now seen to be standard Roman, with the minor axis solstitially aligned between summer sunrise and winter sunset. We now see that the Mosque was built exactly in accordance with that street-plan. And that is why it faces a direction perpendicular to the solstices. And that is very nice, not least because its major axis is 'parallel' to the major axis of the Kaaba. Some medieval schemes of sacred geography appropriately associate al-Andalus with the middle of the NW wall of the Kaaba. (Later, Andalusī astronomers proposed different *qiblas*, including winter sunrise and a direction derived by an approximate geometric procedure.)

Several early mosques in the Maghrib from Morocco to Tunisia face the same direction as the Mosque of Córdoba, thanks to the Romans, and thanks to the alignments of the Kaaba, and thanks to the late American Islamicist and historical geographer Michael Bonine, who discovered this. So much for Gibson's *fribla*, according to which the Mosque was built so as to be parallel to an imaginary line between Petra and Mecca. It is the *fribla* that is also imaginary.

The first **Mosque at al-Wāsiṭ** in the province of al-al-'Irāq was built in 706 and then demolished; a second Mosque was erected between 1009 and 1155 in a completely different direction, at about 50° further south. The first Mosque faces about 245° and the second Mosque faces about 195°. K. A. C. Creswell, the father of the history of Islamic architecture, wrote in the 1930s that the first Mosque faced Jerusalem; Crone & Cook inevitably said it faced an unidentified site in N.W. Arabia; Gibson now says it was first built deliberately facing "between Petra and Mecca''. In fact, it faces winter sunset, which was taken as the *qibla* by the first generations of Muslims in al-'Irāq. The second mosque was oriented in a *qibla* for Wāsiṭ that had been derived by someone familiar with (medieval) geographical coordinates and mathematics. The orientation of the two mosques has never been previously explained in modern times.



This plan of the first two mosques at Wāsiṭ was published by the Iraqi archaeologist F. Safar in 1934.

It tells us all that we need to know in order to understand about the general notions regarding early mosque orientations.

The first mosque there was erected in 706 towards winter sunset because that was the *qibla* (or one of the qiblas) of the early Muslims. Clearly this seemed like a good idea at the time and it was eminently sensible: the Kaaba was more or less in that direction, and its NE Wall also faced winter sunset.

Thus the *qibla*-wall of the mosque was 'parallel' to the NE wall of the Kaaba.

A few centuries later a replacement mosque was built on the same site in the direction that was computed for the local *qibla* using a mathematical formula and the available geographical data.

The modern *qibla* for Wāsiṭ is irrelevant to any discussion of this situation, because all this is not about 'us', it is about 'them'.

The orientations of both the first and second mosques in Wāsiṭ, like those of every mosque from the 7th to the 21st century, have nothing to do with Petra

Criticism of Gibson's methodology

My main complaint again Gibson's methodology is that he believes with all his heart that **MODERN** directions towards Petra and/or Mecca are somehow relevant to our understanding of the orientations of early mosques. There cannot be anybody on his team who knows about geography or mathematics (or better, the history of those disciplines) and who could have explained to him why this is problematic. The ancients and the medievals did not have access to **MODERN** geographical coordinates. Nor did they have access to exact procedures for finding the direction on one locality to another.

To use pre-modern coordinates in such an investigation is no task for an amateur like Gibson. Whatever he might have used in the way of ancient Greek (Ptolemaic) coordinates would be inaccurate—especially given that the Greek value for the length of the Mediterranean was in error—and the first coordinates in Muslim sources appeared in Baghdad ca. 825.

Another problem with his methodology is the following. He finds that many early mosques are oriented toward Petra accurately to with a degree or two. He then assumes that the early Muslims/Arabs/Petrans deliberately wanted their mosques to face Petra and that they achieved this with impressive accuracy.

Another problem I have with Gibson's interpretations of this data is that he desperately needs to rewrite the history of mathematical geography:

> "… the early Muslims had methods of accurately calculating *qiblas*. Just because we do not know for certain what method they used, does not make it impossible or even improbable that they managed to do this."

Elsewhere he has discussed all of the scientific means that must have been available to the first generations of Muslims. Did his Arab Muslims from Petra really know about Ptolemy's geographical coordinates (with its incorrect value of the length of the Mediterranean) as well as Greek and/or Indian trigonometry? Did they have astrolabes? I doubt that they did, and certainly the

first Muslim scientists known to have proposed exact methods, geometrical and trigonometric, for determining the *qibla*, date from ca. 825 (inevitably in Baghdad). Also, the earliest Islamic astrolabes, from the 8th and 9th centuries, have no means for finding the *qibla* anyway.

Why do we do this?

At my advanced age I have no time to waste writing about crackpot theories like that of Dan Gibson. Nevertheless, I feel I must write these few pages trying to show how crazy and potentially dangerous they are. There is quite a lot of repetition in these pages but I cannot stress enough the fallacious procedures Gibson has used and the fallacious conclusions he has reached.

In the late 1980s I had a strong motive to try to understand medieval Islamic orientations; it was purely academic, for I was constantly confronted with historians of Islamic architecture writing such nonsense as this or that mosque "does not face Mecca properly" or "is not correctly aligned towards Mecca" or marking a mosque-plan with a directional indicator toward Mecca on a *qibla*-wall when the mosque doesn't face Mecca at all (by modern standards). These colleagues had no idea about medieval *qibla* determinations and would not want to hear about these from an outsider anyway. In fact, I can count on the fingers of one hand those colleagues in the history of Islamic architecture over the past 50 years who have even mentioned what scientific and legal texts tell us about the qibla. So my colleagues in the history of Islamic art and architecture generally still tend to write *n'importe quoi* (كلام اي) when confronted with a curious orientation and continue to publish whole books about medieval cities or about architectural complexes without mentioning orientations at all.

Gibson has an even stronger motive to push his Petra thesis. He concludes his book *Early Islamic Qiblas* (2017) with the smug advice to Muslims to decide for themselves whether they should carry on praying in (what he calls) the false *qibla* toward Mecca or switch to the correct *qibla* toward Petra (which I call *pibla*). There is another revisionist enthusiast in London, an English historian not well-versed in the development of the prayer ritual in Islam, who has recently claimed that Muslims have been praying at the wrong times for 1400 years. This kind of ammunition is very useful for those who campaign against Islam and Muslims.

An example of the way in which the Christian lunatic fringe has been able to use Gibson's theory is the video entitled "The earliest mosques don't face Mecca! Gibson's new research". This features a conversation between a total innocent Al Fadi and one Jay Smith. The latter is an assertive Christian evangelist, apologist and polemicist; since 1983, he has been a full-time missionary with the Brethren in Christ Mission with a focus on apologetics and polemics among the Muslims of London. In the video Smith makes a complete fool of himself by talking about the way some early mosques, for example, in India and China face Petra to within a degree or two. But I myself showed in the 1980s that many mosques, not just early ones, faced the Kaaba – not the city of Mecca – using astronomical alignments. This is because, as Gibson seldom mentions, and as Smith would not want to know, the Kaaba itself is astronomically aligned.

There is no easy explanation of the orientation of medieval mosques. But we have laid the foundations for understanding this complicated subject. Then along comes Dan Gibson, completely untrained in Islamic studies, mathematical geography, and the history of science, and measures the orientation of some 50-odd early mosques using satellite images. His conclusion is that their orientations all have some connection to Petra, not Mecca. But he does not realize that these early mosques were not intended to face Mecca: they were intended to face the sacred Kaaba in Mecca, a building whose rectangular base is astronomically aligned. Since they had limited geographical knowledge and no mathematical knowledge the earliest Muslims adopted a very sensible expedient to enable them to face the Kaaba: they used astronomical risings and settings.

Of course these early mosques do not face Mecca. They face the Kaaba, according to the limitations of the time. They do not face Petra or any other specific locality. No civilization before *ca.* 825 (when the Muslims controlled both the geography and the mathematics) could orient edifices toward a specific locality because no civilization had the means – geographical and mathematical – to do that. To assert as Gibson does, that the Muslims in the 7th and 8th centuries could find the direction of Petra **EXACTLY** from al-Andalus to China is ridiculous. The reader should keep in mind that Gibson's conclusions are most welcome to certain partisan religious interest groups. See below and also the Appendix!

Critiques of critiques

Most people are either numerate, which means that they like numbers and know how to handle them, or innumerate, in the sense that they don't like numbers and shy away from them. Such people shudder when confronted with a direction such as 292°, because they have no idea that modern usage measures directions from 0° clockwise to 360° = 0°; these people might prefer to read 22° N of E. Gibson's book is all about numbers, some real (measurements of mosques) and some irrelevant (modern directions of Petra and Mecca). Alas, most reviews of Gibson's *qibla* extravaganza have been made by people not well versed in numbers.

In the acknowledgements to his *Early Islamic qiblas* Gibson thanks two scholars Rick Oakes and Ahmed Amine whom we shall mention below. (He also thanks one of the leading archaeoastronomers of the Near East, and of Petra, my friend Juan Antonio Belmonte, who was even more surprised than I was to find his name in Gibson's acknowledgements, for Gibson knows nothing about ethno- or archaeoastronomy.)

It is important to consider Gibson's approach to mosque orientations in light of his methodology. For he uses **MODERN** geographical coordinates to calculate directions of buildings to Petra or Mecca or Jerusalem when those who erected these buildings did not have access to such coordinates. Nor did they have **EXACT** mathematical procedures for calculating directions of one place to another. So when Gibson writes that a given mosque faces Petra, not Mecca, this is not to be taken seriously. If I were to say this or that mosque faces Mecca not Petra, that might be equally absurd. If either of us says that a given mosque faces exactly Petra or Mecca so that those who built it must have had the geographical and mathematical knowledge to determine the *pibla*/*qibla* accurately, this would be nonsense. For

mosques in the earliest period were laid out in directions that were not calculated at all.

In my first critique of Gibson's Petra thesis I deliberately stated that I would not demonstrate his error for all of the mosques he had misinterpreted but would present enough examples to demonstrate that not only are his interpretations erroneous, but also that the whole idea of assessing the "errors" of medieval orientations by comparing them with **MODERN** directions is flawed. Some later commentators didn't get this.

Rick Oakes, an independent American scholar, has posted his evaluation of my critique of *Early Islamic Qiblas* on the blog of the International Qur'anic Studies Association (IQSA), an outfit based in Atlanta claiming to be "devoted to the study of the Qur'an from a variety of academic disciplines". Oakes' focus here is not on the science, mathematics, or astronomy that was (or, rather, was not) available to early Muslims, nor is it with how they could have pointed any of their earliest mosques in any particular direction. But rather, he focusses on the 17 mosques that Gibson says face Petra. He does not argue whether or not they were pointed toward Petra intentionally. He does not argue that Gibson's mosque orientation measurements are accurate, but that these Gibson's conclusions based on these orientations deserve confirmation or refutation. He repeats from his non-critical review of Gibson's first book:

> "Gibson's evidence is just begging for a response. … Certainly, Gibson deserves a thoughtfully-considered book that responds to his analysis of the evidence with a different explanation."

I can only feel ashamed that my response was not "thoughtfully considered"; maybe the present essay will help. Oakes begins by naming five mosques whose orientations I did not even mention. He seems so convinced (and happy?) about Gibson's finding that 17 early mosques point toward Petra that he challenges other scholars to offer better explanations. Oakes correctly observes that my explanations of why the mosques in Amman, Fustat, Jericho, and Khirbat al-Minya (only these!) are preferable to Gibson's explanation that they point to Petra. While he is correct in mentioning that I wrote that the Sanaa Mosque points at Petra, he missed the fact that this does not mean that it was deliberately laid out to face Petra. For I also said that it was 'parallel' to the main axis of the Kaaba, so that the *qibla*-wall is 'parallel' to the SE wall of the Kaaba. His best quote is priceless:

> "Jericho – Khirbat al-Mafjar – King says that "All of these mosques are trying to tell us that they face south." Nonetheless [!], (this mosque) faces 180°, only 1° away from Petra's 181° [!!].
>
> "Khirbat al-Minya – King says that "This complex was obviously intended to face due south." Nonetheless, it faces 183°, only 1° away from Petra's 182°".

In brief, Oakes has unfortunately overlooked what I wrote about the absurdity of using modern directions to investigate orientations of buildings that were built well over 1,200 years ago and the folly of ignoring cardinal and solstitial directions in interpreting orientations that were laid out toward astronomical horizon phenomena or on pre-Islamic foundations that were cardinally aligned.

Another revisionist historian of early Islam, the French fundamentalist priest Édouard-Marie Gallez, has fallen for Gibson's thesis, as they say, 'hook, line and sinker'. He also fell for the nonsense that the first generations of Muslims must have been scientifically advanced. He further believes implicitly in Cook & Crone's 1977 *Hagarism* thesis. His own pet people are the so-called Judéo-Nazaréens, of whom most people, including the Hagarenes, have never heard. When he read my critique of Cook & Crone and Gibson on mosque orientations he went bananas and wrote an outrageous and venomous rejoinder quite unworthy of a man of the cloth, which in turn merited an appropriate response from an independent.

A rather curious book appeared in 2018. It was authored by Ahmed Amine, an independent researcher trained in medicine and studying the history of religions in late Antiquity. It is entitled *L'islam de Petra* … and was intended as a response to the thesis of Dan Gibson. The author had no prior knowledge of the *qibla* or its determination in Islamic history but simply launched into Gibson and his 'findings'. He then discussed my criticism of Gibson's theories. It is clear that he had little understanding either of what Gibson had been trying to do, or why I saw this as problematic. Sadly, Amine's book will probably be read with enthusiasm by unsuspecting French-speaking Muslims, although it is incomprehensible without access to the original writings of Gibson and myself, both in English and not properly explained by Amine. Sadly also, such readers will not find any serious writings in French (or any other language) on the determination of the qibla in past centuries because these have been omitted from Amine's bibliography. Some seven pages of references contain an important article by Saifallah *et al.* and a few lesser articles of mine, otherwise nothing whatsoever of consequence on the *qibla*. Amine's conclusion after 226 pages is that

> *"la thèse de Pétra demeure en l'état, comme une simple hypothèse de travail qui nécessite des preuves supplémentaires plus décisives."*

Here a valuable opportunity has been lost, but one may well ask what was the goal. Gibson's Petra thesis, Amine says, "remains at project stage like a simple working hypothesis which requires additional and more decisive proofs". It was a mistake in the first place for the author (AA) to approach a book based on totally false assumptions (DG) together with a harsh criticism thereof (DAK) without any understanding of the subject at hand. And it was a mistake for this author (DAK) to innocently try to help that author (AA) try to understand anything.

But all is not lost. I can recommend the article by Mark Anderson of the Zwemer Center for Muslim Studies: it is entitled "Is Mecca really the birthplace of Islam?". This should be required reading for anyone interested in the Petra fallacy. (Unfortunately I am reported to have said that the earliest Muslims "calculated" the *qibla* but this is what Gibson falsely claims for directions to Petra, whereas in fact I had stated that they "determined" the direction of the Kaaba using astronomical alignments: they calculated nothing.) Anderson's study considers seven of Gibson's arguments for Petra and the match ends with a score **Mecca 7, Petra 0**. I doubt that any serious scholar in the History of the Near East, Nabataean Studies or Islamic Studies, or the History of Science would contest this.

Dan Gibson's "qibla tool"

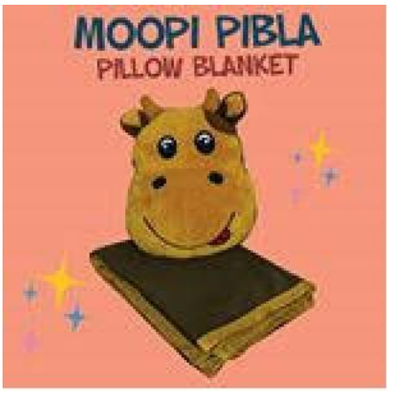
Gibson's publisher (CanBooks) has in the past few days (early November, 2018) released a new "Qibla Tool" (available at http://thesacredcity.ca/data/index.html). This is most useful and will put an end to some of the often silly controversy that has been raging about early mosque orientations. A Google Maps image of the whole medieval Muslim world shows the location and orientation of all of the earliest mosques. Click-on, rather confused insets then give further details, which happily do not conceal the 'map'. Gibson explains that this tool uses the latest Google Maps, which sometimes is "not the best" and that it is not intended to be a highly accurate investigative tool. Rather, it is an illustrative tool, so users can quickly view and compare various mosques, and make their own conclusions about the patterns that Gibson sees in early mosque construction.

What is obvious from the map is the following:

- The overwhelming majority of mosques in Jordan and Palestine are astronomically aligned to face south.
- The majority of mosques in Syria are astronomically aligned to face south.
- Virtually all mosques in al-Andalus and the Maghrib face a curious direction around south south east.
- The Mosque in Sanaa is aligned roughly north-north-west, 'parallel' to the mosques in al-Andalus and the Maghreb. How can that be?
- There are not many mosques in Egypt on the one hand and in Iraq, Iran & Central Asia on the other with a clearly defined general orientation.
- The conclusions that can be drawn from these observations are the following:
- In Palestine the early Muslims favoured south for the qibla. (This makes the mosques all seem as though they are facing Petra, which is not far to the south.)
- In Greater Syria the early Muslims favoured south for the qibla. South means south or (for latitudes less than 36°) the rising or setting of Canopus. (Their mosques appear to point between Petra and Mecca because Syria is more to the east than Palestine and further from Petra than Palestine.)
- As already established by Michael Bonine in the 1990 & 2008 (Maghrib) and myself in 2016 (Córdoba), the mosques in the Islamic West were built in accordance with Roman city-plans that had their minor axis solstitially aligned (summer sunrise and winter sunset). This was considered acceptable by the Muslims because, as luck would have it, the mosques are 'parallel' to the main axis of the Kaaba. (They are indeed 'parallel' to a line between Petra and Mecca, but this is of no historical consequence.)
- The solitary Mosque in Sanaa is aligned 'parallel' to the axis for the Kaaba because people wanted that, not because there was any Roman city. (From Sanaa, Petra is sort of behind Mecca so the mosque appears to be aligned towards both.)

- We have to look more carefully at orientations in places like Egypt, Iraq and Central Asia. I can recommend my studies on Cairo (1983/2004) & and Samarqand (1984/2012) for a start. In each location, the cardinal directions and winter sunrise and sunset played a significant role, and for each locality there were more than one calculated qibla direction.

Only general observations are appropriate here because Gibson is using a **MODERN** map. The directions it shows for mosques are supposedly **MODERN** *qiblas*. (I do not know how directions left, right and centre are supposed to be preserved on such a map as this.) As far as I know, nobody ever calculated the direction of Petra before Dan Gibson; what are shown on his new "*qibla* tool" are, he thinks, the **MODERN** *piblas*. The problem with Gibson's new map is that his directional indicators show the orientations of the mosques but do not point correctly at the places he would like them to point because of the nature of the map projection and, inevitably, because of the curvature of the earth. I love the way some of his straight lines indicating mosque orientations swish across the world and end up in or around Petra or Mecca. Flat maps always have limitations of one sort or another. On a rectangular Mercator map of the whole world the *qibla* in North America appears to be toward south-east. However, when you fly out of New York's JFK Airport on Saudia towards Jedda you fly north-east over Greenland (or what's left of it), not towards the south-east as some folk might think. And you probably fly over Petra too. In the case of Gibson's map, parallels of latitudes and meridians (longitudes) are not shown; instead there is an unlabelled square (orthogonal) grid which curiously does not expand when one enlarges the map. Since the grid is orthogonal it does not correspond to that of a map that would preserve direction (necessarily toward a central point). It is just as well for Gibson that he has not included distant places (such as New York or Guangzhou) on his map; he might be in for quite a surprise. In any case, pictures speak louder than words, and Gibson's map speaks louder than mere numbers. Just be very careful how you use it.



Suggestions for future research

Fortunately, nowadays one would not have to travel the length and breadth of the Muslim world to have a new look at mosque orientations. What concerned investigators might want to do in the future with the major mosques of the medieval period (7th-15th centuries) is the following:

1) determine which mosques were built on the authority of the Prophet or his Companions;

2) determine which mosques were built on the foundations of, or in line with pre-Islamic religious architecture which happened to be cardinally aligned (such as in Jerusalem and Damascus);

3) determine which mosques were built according to the street-plans of pre-Islamic

cities which happened to be solstitially aligned (such as Córdoba, Tlemcen, Tunis, Kairouan);

4) determine which mosques were built toward winter sunrise (taken as one *qibla*-direction from Egypt to al-Andalus), and toward winter sunset (taken as one *qibla*-direction from Iraq to Central Asia), or toward some other astronomical horizon phenomenon;

5) determine which mosques face due west in India and due east in N. Africa;

6) determine which mosques face more or less due south in Jordan and Syria and more or less due north in Yemen and E. Africa.

Mosques which do not conform to these norms can possibly be explained by means of information on the local *qibla* in treatises on folk astronomy and sacred geography (**astronomically-defined directions**) or treatises on mathematical astronomy (*qiblas* calculated from available medieval geographical data using **exact or approximate mathematical methods**). Local topography or hydrography may also have played a role. In all such investigations, no conclusions should be drawn based on *qibla*-directions calculated from **MODERN** geographical data using some kind of **EXACT** mathematical procedures.

To any interested parties, I would recommend looking at the five articles mentioned above, not least my article on the earliest mathematical methods and tables for finding the *qibla*. I am confident that such simple approximate methods had far more influence in mosque alignment than any complicated exact methods and tables. But one cannot use any of these without knowing what geographical coordinates were available over the centuries. The complexity of Islamic geographical tables giving longitudes and latitudes, and the basic reference work by E.S.&M.H. Kennedy, *Geographical coordinates of localities from Islamic sources* (Frankfurt, 1987), presents 14,000 sets of longitudes and latitudes from some 80 Arabic and Persian astronomical and geographical sources.

In investigating the orientation of a historical mosque it is important to take into consideration the original surrounding street-plan and the various *qibla*-directions that were favoured in that region at the time. Without such information it is not a little arrogant to suppose that one can make any sensible pronouncement regarding the reason behind the orientation of an edifice that was built over a millennium ago. Woe betide anyone who claims to explain any medieval mosque orientation without realizing how complicated is the subject of orientations.

New light on orientations in Turkey

In 2018 two studies appeared on the orientation of mosques in Turkey. The first was an eminently sensible analysis of selected mosques of major importance (ulu camis) based on sound historical criteria and the kind of modern investigative methods now standard in archaeoastronomy, and it was published in an academic journal. The authors were Profs. Mustafa Yilmaz and Ibrahim Tiryakioglu from the Department of Geomatics, Faculty of Engineering, Afyon Kocatepe University in Afyonkarahisar, Turkey, and the title was "The astronomical orientation of the historical Grand mosques in Anatolia".

The second 'study', by A. J. Deus, an economist by training, was a completely off-the-wall attack on Turkish history based on a nutty idea that the

diverse mosque orientations resulted from deliberate attempts to align the mosques not toward the *qibla* but (exactly, of course) toward the sites of contemporaneous military campaigns in Ukraine, Iran, Somalia, to Tunisia. Instead of places of worship the mosques, for Deus, become – اعوذ بالله – "monuments of jihad". Oy weh!

Deus is inevitably innocent of any idea about Ottoman astronomy, mathematics, geography, and instruments for finding the *qibla*, and has no idea how the Ottoman astronomers actually determined the *qibla*. Proof of this is his premise that they could compute the MODERN *qibla* (and **MODERN** directions to Ottoman military hot-spots hundreds of miles away) whenever and wherever they wanted to, which they most certainly could not. To be sure, their favourite method was approximate anyway (this is well documented) and their geographical data was not accurate, so if they came up with a direction similar to the **MODERN** *qibla* it would be by chance.

Deus published this 'study' online "in collaboration with" a dubious revisionist outfit called "Inarah – Institute for Research on Early Islamic History and the Koran" based in Saarbrücken, Germany, and known for some very strange and misguided pronouncements about early Islam. If this is the best that Inarah (انارة , *ināra*, 'enlightenment', from نور , *nūr*, 'light') can do with mosque orientations, it is rather sad but hardly surprising. Deus' 'study' will doubtless be swallowed whole by clueless *revisionistas* and other uninformed, innumerate souls. I have addressed this outrageous and pernicious nonsense elsewhere. The principal monuments amongst Deus' 200-odd mosques can be interpreted with reference to the *qibla* that was accepted at the time they were built (which is of course not the **MODERN** *qibla*), and they all face the Kaaba in one way or another, in ways that Deus shows himself incapable of understanding. There is no need for any overzealous, uninformed revisionism.

Concluding remarks

For the time being, practicing Muslims can happily ignore Gibson's outrageous suggestion that they start praying towards Petra again, as he thinks they did in the earliest days. He thinks they should have been praying towards Petra for over a millennium. اعوذ بالله .

My humble opinion is that Muslims should simply carry on praying towards the Kaaba as they have been doing for over 1,400 years.

As for the Kaaba itself, nobody in its vicinity could guess or test its astronomical alignments now because of all of the skyscrapers surrounding the Mosque complex. And by 2019, according to numerous news reports in 2017, the whole area around the Kaaba will supposedly be covered by a retractable roof. These reports were inevitably neither confirmed nor denied by the Saudi authorities. If they are true, then the focal point of Islam, the Kaaba, symbol of the divine presence, will no longer be visible even from space.

The author

David A. King is a British orientalist and historian of science who has spent 50 years researching the history of astronomy and mathematics in Islamic civilization from the original sources. In particular, he has documented the ways in which astronomy was used in medieval Islamic society for the purposes of religious obligations: the calendar regulated by the visibility of the lunar

crescent, the sacred direction (*qibla*) toward the Kaaba in Mecca, and the astronomically-defined times of prayer. These writings, which include a dozen books and 250 articles, notably *In Synchrony with the Heavens* (*ca.* 2,000 pages, 2004/05), are based mainly on his researches on several thousand Arabic scientific manuscripts and hundreds of astronomical instruments which he has studied in libraries and museums around the world. King has also published on an ingenious medieval Cistercian number-notation and on the cult of the most misunderstood saint in Christian history, as well as on the Latin acrostic which provided the inspiration for Piero della Francesca's enigmatic "Flagellation of Christ" (2007). His first book was *Mathematical Astronomy in Medieval Yemen* (1983) and his most recent works are "Astronomy in medieval Jerusalem" (2017) and "Two medieval spherical astrolabes from Tunis and Istanbul" (2018).

Bibliography of books, articles and websites on *qibla* determination

Notes: No general bibliography on *qibla* determinations has ever been prepared before. References to specific medieval Islamic legal works on the *qibla* are to be found in the writings of Neumann, Dallal, King, Rius and Schmidl. See also the article "Ḳibla (legal aspects)" by A. J. Wensinck in *Encyclopedia of Islam*, 2nd edn. ••••For the latest, see Gibson 2023 and King 2023.

Early Western works

The first modern scholar to turn his attention to mathematical *qibla* determinations was the German historian of Islamic mathematics and astronomy **Karl Schoy** (1877-1925), on whom see the obituary by J. Ruska in *Isis* 9 (1927), pp. 83-95. His collected papers are available as *Beiträge zur arabisch-islamischen Mathematik und Astronomie*, 2 vols., Frankfurt, 1988. The next was **Edward S. Kennedy** (1912-2009), the leading scholar of the history of Islamic astronomy in the 2nd half of the 20th century, on whom see the obituary and bibliography in *Suhayl* 9 (2009-2010), pp. 185-214. His collected papers are published in *Studies in the Islamic Exact Sciences*, Beirut, 1983.

For numerous writings by **the two next generations of specialists in the history of Islamic astronomy and mathematics** on mathematical methods for finding the *qibla* – especially Richard P. Lorch, Julio Samsó, Jan P. Hogendijk, J. Lennart Berggren, Ahmad Dallal and DAK – see www.staff.science.uu.nl/~gent0113/islam/qibla.htm. Reprints by Variorum of various studies by DAK are the following: *Islamic Mathematical Astronomy* (1986/1993)*; Islamic Astronomical Instruments* (1987/1995); *Astronomy in the Service of Islam* (1993); and *Islamic Astronomy and Geography* (2012). All publications of DAK are available at davidaking.academia.edu.

General works on Islamic astronomy (selected)

Carlo Alfonso Nallino, "[Islamic Astronomy]", in *Encyclopaedia of Religion and Ethics*, James Hastings, ed., 12 vols., Edinburgh: T. & T. Clark, vol. 12 (1921), pp. 88-101.

DAK, "Islamic astronomy", in Christopher Walker, ed., *Astronomy before the Telescope*, London: British Museum Press, 1996, pp. 143-174, repr. in *Islamic Astronomy and* Geography, I, also available on www.muslimheritage.com/article/islamic-astronomy.

Robert G. Morrison, "Islamic astronomy and astrology", in Robert Irwin, ed., *New Cambridge History of Islam*, vol. 4, Cambridge, etc.: Cambridge University Press, 2010, pp. 589-613.

Kennedy *et al.*, *Studies*: E. S. Kennedy, Colleagues and Former Students, *Studies in the Islamic Exact Sciences*, David A. King and Mary Helen

Kennedy, eds., Beirut: American University of Beirut, 1983.

Kennedy *Festschrift*: *From Deferent to Equant: Studies in the History of Science in the Ancient and Medieval Near East in Honor of E. S. Kennedy*, David A. King and George Saliba, eds., *Annals of the New York Academy of Sciences* 500 (1987).

DAK, "Science in the service of religion: The case of Islam", *impact of science on society* (UNESCO), no. 159 (1991), pp. 245-262 (available in several languages, but not Arabic), repr. in *Astronomy in the Service of Islam*, I, available at http://unesdoc.unesco.org/images/0008/000885/088535eo.pdf.

– , *In Synchrony with the Heavens – Studies in Astronomical Timekeeping and Instrumentation in Islamic Civilization*, vol. 1: *The Call of the Muezzin*, & vol. 2: *Instruments of Mass Calculation*, Leiden, *etc.*,: Brill, 2004-05.

Clive N. Ruggles, ed., *Handbook of archaeoastronomy and ethnoastronomy*, 3 vols., New York, *etc.*,: Springer, 2015, contains the following articles: King, "Astronomy in the service of Islam', pp. 181-196; Clemency Montelle, "Islamic mathematical astronomy'', pp. 1909-1916; Tofigh Heidarzadeh, "Islamic astronomical instruments and observatories'', pp. 1917-1926 (more references below).

Encyclopaedia of Islam, 2nd edn., 13 vols., Leiden: E. J. Brill, 1960-1980, especially articles "Anwā' (pre-Islamic calendrical system)"; "Asṭurlāb (astrolabe)"; "Hay'a (astronomy); "Ḳibla (sacred direction)", "Layl wa-nahār" (simple timekeeping); "Makka as centre of the world" (sacred geography), "Mīḳāt" (astronomical timekeeping and times of prayer)", "Mizwala (sundials)", "Rubʿ (quadrant)", "Nud̲jūm" (star-lore); "Ru'yat al-hilāl (lunar crescent visibility)", "Shakkāziyya (universal projections)", and "Ṭâsa (magnetic compass)"; and "Zīd̲j (astronomical handbooks and tables)".

BEA: Thomas Hockey *et al.*, eds., *The Biographical Encyclopedia of Astronomers*, New York: Springer, 2007, available at http://islamsci.mcgill.ca/RASI/BEA/. (Standard reference on significant Muslim astronomers.)

DSB: *Dictionary of Scientific Biography*, 14 vols. and 2 supp. vols., New York: Charles Scribner's Sons, 1970-80. (Biographical articles are sometimes preferable to the corresponding ones in *BEA*.)

Lennart Berggren, *Episodes in the Mathematics of Medieval Islam*, New York, etc.: Springer, 1986.

E. S. Kennedy & Mary Helen Kennedy, *Geographical coordinates of localities from Islamic sources*, Frankfurt: IGAIW, 1987.

Islamic folk astronomy (selected)

There is no general survey. Various aspects are treated in the following works:

Paul Kunitzsch, *Untersuchungen zur Sternnomenklatur der Araber*, Wiesbaden: Otto Harrassowitz, 1961.

– , article "Ibn Qutayba", in *Dictionary of Scientific Biography*, XI, pp. 246-247 (no article in *BEA*!).

Fuat Sezgin, *Geschichte des arabischen Schrifttums*, VII: *Astrologie – Meteorologie und Verwandtes*, Leiden: E. J. Brill, 1979, pp. 336-370.

Charles Pellat, articles "Anwā'" and Layl wa-nahār", in *Encyclopedia of Islam*, 2nd edn.

Anton H. Heinen, *Islamic cosmology: A study of as-Suyūtī's al-Hay'a al-saniya fi-l-hay'a al-sunnīya*, Beirut, 1982 (a work for prime importance for understanding an independent, truly Islamic Arab cosmology, reviewed in *Journal of the American Oriental Society* 109 (1989), pp. 124-127).

Miquel Forcada, "Mīqāt en los calendarios andalusíes", *al-Qantara* 11 (1990), pp. 59-69.

– , "Astrology and Folk Astronomy: The *Mukhtasar min al-Anwā'* of Aḥmad b. Fāris", *Suhayl – International Journal for the History*

of the Exact and Natural Sciences in Islamic Civilisation 1 (2000), pp. 107-205

DAK, "Folk astronomy in the service of religion: The case of Islam", in Clive L. N. Ruggles & Nicholas J. Saunders, eds., *Astronomies and Cultures*, Niwot CO: University Press of Colorado, 1994, pp. 124-138, and *idem*, "Applications of folk astronomy and mathematical astronomy to aspects of Muslim ritual", *The Arabist (Budapest Studies in Arabic)*, 13-14 (1995): 251-274.

– , "A survey of arithmetical shadow-schemes for time-reckoning", in *idem*, *In Synchrony with the Heavens*, III: pp. 457-528, previously published in *Oriens* 32 (1990), pp. 191-249.

Petra G. Schmidl, *Volkstümliche Astronomie im islamischen Mittelalter. Zur Bestimmung der Gebetszeiten und der Qibla bei al-Aṣbaḥî, Ibn Raḥîq und al-Fârisî*, 2 vols., Leiden, *etc.*: Brill, 2007. (The first study of its kind, based on medieval Yemeni treatises on folk astronomy compiled by legal scholars and astronomers.)

Daniel M. Varisco, "Islamic folk astronomy", in Helaine Selin, ed., *Astronomy across cultures – The* [!] *history of non-western astronomy*, Dordrecht, *etc.*: Kluwer, 2000, pp. 615-650.

Clive N. Ruggles, ed., *Handbook of archaeoastronomy and ethnoastronomy*, 3 vols., New York, etc.,: Springer, 2015, contains the following articles (see also above): Petra G. Schmidl, "Islamic folk astronomy", pp. 1927-1934; Daniel Martin Varisco, "Folk astronomy and calendars in Yemen", pp. 1935-1940.

Danielle Adams, "Two Deserts – One Sky – Arab star calendars", at onesky.arizona.edu (accessed 2018) (a new website featuring aspects of Arab star-lore in a visual and reader-friendly fashion, at the same time respecting the original Arabic star-names).

Gerald R. Tibbetts, *Arab Navigation in the Indian Ocean before the coming of the Portuguese ...* , (Oriental Translation Fund, N.S. XLII), London: The Royal Asiatic Society of Great Britain and Ireland, 1971, repr. 1981. (It is often overlooked that Arab navigation is an aspect of Islamic folk astronomy, not of Islamic astronomy, which is based on observations and calculations.)

On archeoastronomy and ethnoastronomy

Clive L. N. Ruggles, ed., *Handbook of Archaeoastronomy and Ethnoastronomy*, 3 vols., New York, etc.,: Springer, 2015. (A work of monumental importance covering many relevant topics, with various chapters in Part II: Methods and Practices, and overviews by experts nof the situation in all parts of the world, although, alas for our present purposes, Central and South Arabia are not covered.) (This book is on a much more scholarly level than the 2005 publication by D. H. Kelley & E. F. Milone entitled *Exploring ancient skies: An encyclopedic survey of archaeoastronomy*, which does not even mention the Islamic phenomenon of orientations.)

Selected works on the determination of the qibla

General

DAK, "The sacred direction in Islam: A study of the interaction of religion and science in the Middle Ages", *Interdisciplinary Science Reviews* 10 (1985), pp. 315-328.

– , "The determination of the sacred direction in Islam", in *World-maps for finding the direction and distance to Mecca*, Leiden: Brill & London: Furqan Foundation, 1999, ch. 2, pp. 47-127.

– , "The sacred geography of Islam", in *Mathematics and the Divine – A Historical Study*, T. Koetsier and L. Bergmans, eds., Dordrecht: Elsevier, 2005, pp. 161-178, repr. in *Islamic Astronomy and Geography*, VIII.

Jerusalem and Mecca

M. S. M. Saifullah, M. Ghoniem, ʿAbd al-Rahman Robert Squires & M. Ahmed, "The Qibla of early mosques: Jerusalem or Makkah? '"(2001), available at www.islamic-

awareness.org/History/Islam/Dome_Of_The_Rock/qibla.html (consulted 2016).

Angelika Neuwirth, "From the Sacred Mosque to the Remote Temple – Sūrat al-Isr 'ābetween text and commentary'', in Jane Dammen McAuliffe & Barry D. Walfish & Joseph W. Goering, eds., *With Reverence for the Word – Medieval scriptural exegesis in Judaism, Christianity, and Islam*, Oxford: Oxford University Press, 2003, pp. 376-407.

Simon Shtober, ""Lā yajūz an yakūn fī al-ʿālam li-Llāhi qiblatayn": Judaeo-Islamic polemics concerning the qibla (625-1010)", *Medieval Encounters: Jewish, Christian and Muslim Culture in Confluence and Dialogue* 5 (1999), pp. 85-98.

Uri Rubin, "Between Arabia and the Holy Land: A Mecca-Jerusalem axis of sanctity", *Jerusalem Studies in Arabic and Islam* 34 (2008), pp 345-362.

The orientation of the Kaaba

Gerald S. Hawkins & David A. King, "On the astronomical orientation of the Kaaba", *Journal for the History of Astronomy* 13 (1982), pp. 102-109, repr. in *Astronomy in the Service of Islam*, XII (the first announcement, based on investigations of satellite images by GSH & and medieval Arabic texts on folk astronomy by DAK).

DAK, "Faces of the Kaaba", *The Sciences* (The New York Academy of Sciences) 22:5 (May/June, 1982), pp. 16-20, and 22:6 (September, 1982), p. 2 (letter to the editor protesting an inappropriate and ridiculous subtitle added without author's knowledge).

Islamic sacred geography

DAK, "Makka. iv. As centre of the world [sacred geography and orientation of mosques]", *The Encyclopaedia of Islam*, 2nd edn., vol. VI, pp. 180-187, repr. in *Astronomy in the Service of Islam*, X.

– , "Some Ottoman schemes of sacred geography", *Proceedings of the II. International Symposium on the History of Turkish and Islamic Science and Technology, Istanbul, 1986*, 2 vols., Istanbul: Istanbul Technical University, 1986, I, pp. 45-57. (Helps explain the orientation of Turkish mosques.)

Petra G. Schmidl & Mónica Herrera Casais, "The earliest known schemes of Islamic sacred geography", in A. Akasoy & W. Raven, eds., *Islamic thought in the Middle Ages: Studies in text, transmission and translation in honour of Hans Daiber*, Leiden: Brill, 2008, pp. 275-300.

DAK, "The sacred geography of Islam", in *Mathematics and the Divine – A Historical Study*, T. Koetsier and L. Bergmans, eds., Dordrecht: Elsevier, 2005, pp. 161-178, repr. in *Islamic Astronomy and Geography*, VIII.

See also Schmidl, *Volkstümliche Astronomie*, for detailed analysis of some Yemeni schemes.

The following two works have very little to do with the sacred geography discussed here:

Annemarie Schimmel, "Sacred geography in Islam", in Jamie Scott & P. Simpson-Housley, eds., *Sacred places and profane spaces: Essays in the geographics of Judaism, Christianity, and Islam*, New York Greenwood, 1991, pp. 163-175.

Thomas Jøhnk Hoffmann, "Dis/integrating the centre – Space, narrative, and cognition with special reference to the hadjdj and the Ka'ba, *Temenos* 35-36 (1999-2000), pp. 25-38.

Studies of folk astronomical and legal texts on finding the *qibla*

DAK, "Al-Bazdawī on the *qibla* in early Islamic Transoxania", *Journal for the History of Arabic Science* 7 (1983/1986), pp. 3-38, repr. in *Islamic Astronomy and Geography*, IX (text, translation and analysis of a highly significant and informative Arabic text by the late-11th-century judge and Ḥanafī legal scholar Abu 'l-Yusr al-Bazdawī).

– , "Architecture and astronomy: The ventilators of medieval Cairo and their secrets", *Journal of*

the American Oriental Society 104 (1984), pp. 97-133 (based in part on the most significant legal work on the qibla, a treatise by al-Dimyāṭī, and historical records by al-Maqrīzī – see below).

Mònica Rius Piniés, *La Alquibla en al-Andalus y al-Magrib al-Aqsà*, Barcelona: Institut "Millás Vallicrosa" de Història de la Ciència Àrab, 2000. (This is the first investigation of determination of the *qibla* in al-Andalus and the Maghrib in the light of medieval folk astronomical and legal texts on the *qibla*.)

Petra G. Schmidl, *Volkstümliche Astronomie im islamischen Mittelalter. Zur Bestimmung der Gebetszeiten und der Qibla bei al-Asbahî, Ibn Rahîq und al-Fârisî*, 2 vols., Leiden, etc.: Brill, 2007. (The first study of its kind, based on medieval Yemeni treatises on folk astronomy compiled by legal scholars and astronomers.)

Ahmad Dallal, *Islam, science, and the challenge of history*, New Haven CT: Yale University Press, 2010 (features the legal discussions surrounding the disputed mosque orientations in Fez).

Andreas Neumann, "Die Orientierung in Gebetsrichtung (*istiqbāl al-qibla*) in der islamischen Rechtswissenschaft. Entwurf eines Papers erstellt für Sonja Brentjes auf Basis von Enzyklopädien des fiqh", June, 2011, available at www.academia.edu/29820776/ (accessed 2018) (not for beginners).

Orientations of mosques and religious architecture (by region)

Note: Numerous works by historians of Islamic architecture leave out mention of the *qibla* and mosque orientations altogether. Those who do not but who ignore locally-accepted *qibla*-directions are not included here.

General

George Sarton, "Query: Orientation of the mihrab in mosques", *Isis* 20 (1933), pp. 262-264, see also *ibid.*, 24 (1935), pp. 109-11; 34 (1942), p. 2; 35 (1944), p. 176; & 38 (1947), pp. 95-96. (An interesting exchange which took place before any serious work had been done on the history of *qibla* determinations. Mainly concerned with the situation in the Maghrib.)

DAK, "Astronomical alignments in medieval Islamic religious architecture", *Annals of the New York Academy of Sciences* 385 (1982), pp. 303-312, repr. in *Astronomy in the Service of Islam*, XIII.

– , "The orientation of medieval Islamic religious architecture and cities", *Journal for the History of Astrono*my 26 (1995), pp. 253-274 (a new version is in *In Synchrony with the Heavens*, VIIa).

Suliman Bashear, "Qibla musharriqa and early Muslim prayer in churches", *The Muslim World* 81 (1991), pp. 267-282.

Robert G. Hoyland, *Seeing Islam as others saw it – A survey and evaluation of Christian, Jewish and Zoroastrian writings on early Islam*, Princeton NT: Darwin Press, 1997, pp. 560-573 (a fresh approach to the *qibla* in early Islam).

Iran

Michael E. Bonine, "The morphogenesis of Iranian cities'', *Annals of the Association of American Geographers* 69 (1979): 208-224 (a study of singular importance).

Central Asia

DAK, "Al-Bazdawī on the qibla in early Islamic Transoxania", *Journal for the History of Arabic Science* 7 (1983/1986), pp. 3-38, repr. in *Islamic Astronomy and Geography*, IX.

Cairo

DAK, "Architecture and astronomy: The ventilators of medieval Cairo and their secrets", *Journal of the American Oriental Society* 104 (1984), pp. 97-133 (a revised version is in *In Synchrony with the Heavens*, VIIb) (the first serious study of the orientation of medieval Cairo and some of its major mosques).

al-Andalus

DAK, "Some medieval values of the qibla at Cordova", an appendix to "Three sundials from Islamic Andalusia", *Journal for the History of Arabic Science* 2 (1978), pp. 358-392, esp. pp. 370-387, repr. in *Islamic astronomical instruments*, XV.

Alfonso Jiménez, "La qibla extraviada'', *Cuadernos de Madīnat al-Zahrā'* 3 (1991): 189-209 (an important study, the first of its kind for any region of the medieval Muslim world, presenting the orientations of all mosques in the Iberian Peninsula).

Mònica Rius Piniés, *La Alquibla en al-Andalus y al-Magrib al-Aqsà*, Barcelona: Institut "Millás Vallicrosa" de Història de la Ciència Àrab, 2000. (This is the first investigation of mosque orientations in al-Andalus and the Maghrib in the light of medieval folk astronomical and legal texts on the qibla. The following three entries are representative of a dozen articles by the same author.)

– , "La qibla des mosquées andalouses", in *Les Andalousies de Damas à Cordoue*, Paris: Institut du Monde Arabe, 2000, p. 205

– , "La alquibla de Madinat al-Zahra y otras mezquitas andalusíes", in *Catálogo de la exposición El Esplendor de los Omeyas cordobeses*, Granada: Fundación Legado Andalusī, 2001, pp. 424-430.

– , "Qibla in the Mediterranean'', in Ruggles, ed., *Handbook of archaeoastronomy and ethnoastronomy*, 2015, pp. 1687-1694.

DAK, "The enigmatic orientation of the Great Mosque of Córdoba", *Suhayl – International Journal for the History of the Exact and Natural Sciences in Islamic Civilisation* (2018), to appear, preprint available on www.davidaking.academia since 2016 (shows how the street-plan of the Roman suburb of Colonia Patricia influenced the layout of the Mosque and how schemes of Islamic sacred geography confirmed that the Mosque was appropriately oriented with respect to the NW wall of the Kaaba).

The Maghrib

Marcel Philibert, *La Qibla et le miḥrāb. Differences constatées dans la direction des mosquées maghrébines, raisons possibles, orientation par des procedés modernes*, Algiers: privately distributed, 1972 (inspired and valuable).

Michael E. Bonine, "The sacred direction and city structure: A preliminary analysis of the Islamic cities of Morocco", *Muqarnas* 7(1990): 50-72 (fundamental).

– , "Romans, astronomy and the *qibla*: urban form and orientation of Islamic cities of Tunisia", in J. C. Holbrook & R. T. Medupe & J. O. Urama, eds., *African Cultural Astronomy – Current Archaeoastronomy and Ethnoastronomy Research in Africa*, Berlin (?): Springer, 2008, pp. 145-178 (fundamental).

Turkey

Frank E. Barmore, "Turkish mosque orientation and the secular variation of the magnetic declination", *Journal of Near Eastern Studies* 44 (1985), pp. 81-98.

– , "Some Ottoman schemes of sacred geography", *Proceedings of the II. International Symposium on the History of Turkish and Islamic Science and Technology, Istanbul, 1986*, 2 vols., Istanbul: Istanbul Technical University, 1986, I, pp. 45-57. (Helps understand the orientation of Turkish mosques.)

Mustafa Yilmaz & Ibrahim Tiryakioglu, "The astronomical orientation of the historical Grand mosques in Anatolia (Turkey)", *Archive for History of Exact Sciences* 72 (2018), pp. 565–590 (https://doi.org/10.1007/s00407-018-0215-1) (important).

Determination of the qibla by geometry or trigonometry

General overviews

Karl Schoy, article "Ḳibla. ii. Astronomical aspects" in *Encyclopedia of Islam*, 1st edn., Leiden: E. J. Brill, 1913-38.

DAK, "Ḳibla. ii. Astronomical aspects", in *The Encyclopaedia of Islam*, new edition, vol. V, fascs. 79-80, Leiden: E. J. Brill, 1979, pp. 83-88, repr. in Astronomy in the Service of Islam, IX.

– , "The sacred geography of Islam", in *Mathematics and the Divine – A Historical Study*, T. Koetsier and L. Bergmans, eds., Dordrecht: Elsevier, 2005, pp. 161-178, repr. in *Islamic Astronomy and Geography*, VIII.

A list of relevant literature is on the website www.staff.science.uu.nl/~gent0113/islam/qibla.htm by Robert van Gent.

Methods proposed by individual Muslim scientists

DAK, "The earliest Islamic mathematical methods and tables for finding the direction of Mecca", *Zeitschrift für Geschichte der arabisch-islamischen Wissenschaften* 3 (1986), pp. 82-149, with corrections listed *ibid.* 4 (1987/88), p. 270, repr. in *Astronomy in the Service of Islam*, XIV (analyzes materials from the 8th and 9th centuries, including simple approximate procedures and already sophisticated tables displaying the *qibla* as an approximate function of longitude and latitude difference from Mecca).

E. S. Kennedy & Yusuf 'Id, "A letter of al-Bīrūnī: Ḥabash al-Ḥāsib's analemma for the *qibla*", *Historia Mathematica* 1 (1973), pp. 3-11, repr. in Kennedy *et al.*, *Studies in the Exact Sciences*, pp. 621-629 (the first method associated with an individual astronomer)

Karl Schoy, "Abhandlung von al-Faḍl b. Ḥātim al-Nairīzī: Über die Richtung der Qibla ... " *Sitzungsberichte der Bayerischen Akademie der Wissenschaften, Math.-phys. Klasse*, 1922, pp. 55-68, repr. in *idem*, *Beiträge zur arabisch-islamischen Mathematik*, 2 vols., Frankfurt: IGAIW, 1988, I, pp. 252-265.

Jan P. Hogendijk, "Al-Nayrīzī's mysterious determination of the azimuth of the qibla at Baghdad", *SCIAMVS* 1 (2000), pp. 49-70.

Richard P. Lorch, "Naṣr ibn ʿAbdallāh's instrument for finding the qibla", *Journal for the History of Arabic Science* 6 (1982), pp. 123-131.

Takanori Suzuki, "A solution of the *qibla*-problem by Abu 'l-Qāsim Aḥmad ibn Muḥammad al-Ghandajānī", *Zeitschrift für Geschichte der arabisch-islamischen Wissenschaften* 4 (1987/88), pp. 139-148.

Karl Schoy, "Abhandlung des … Ibn al-Haitam (Alhazen) über die Bestimmung der Richtung der Qibla", *Zeitschrift der Deutschen Morgenländischen Gesellschaft* 75 (1921), pp. 242-253, repr. in *idem*, *Beiträge*, I, pp. 230-241. (Ibn al-Haytham had two different methods for finding the qibla.)

Ahmad Dallal," Ibn al-Haytham's universal solution for finding the direction of the qibla by calculation", *Arabic Science and Philosophy* 5 (1995), pp. 145-193. (This article describes Ibn al-Haytham's other method.)

Ali Moussa, "Mathematical methods in Abū al-Wafā"s *Almagest* and the qibla determinations", *Arabic Sciences and Philosophy* 21 (2011), pp. 1-56.

Kennedy, E. S., "Applied mathematics in the tenth century: Abū'l-Wafāʾ calculates the distance Baghdad – Mecca", *Historia Mathematica* 11 (1984), pp. 193–206.

– , E. S. Kennedy, *A Commentary upon al-Bîrûnî's Kitâb Tahdîd nihayât al-amâkin*, 1973, based on the translation by Jamil Ali, *The Determination of the coordinates of cities: al-Bîrûnî's [nihâyat] al-amâkin*, 1966 (the most important single work on the qibla by the leading scientist of medieval Islam).

J. Lennart Berggren, "A Comparison of four analemmas for determining the azimuth of the *qibla*", *Journal for the History of Arabic Science* 4 (1980), pp. 69-80.

— ,“ The Origins of al-Bīrūnī’s “Method of the *Zīj*es” in the theory of sundials”, *Centaurus* 28 (1985), pp. 1-16.

Julio Samsó & Honorino Mielgo, “Ibn Isḥāq al-Tūnisī and Ibn Muʿādh al-Jayyānī on the *qibla*”, 25 pp., first published in Samsó, *Islamic astronomy and medieval Spain*, Aldershot & Brookfield VT, 1994, VI.

Joan Carandell, “An analemma for the determination of the azimuth of the *qibla* in the *Risāla fī ʿilm al-ẓilāl* of Ibn al-Raqqām”, *Zeitschrift für Geschichte der arabisch-islamischen Wissenschaften* 1 (1984), pp. 61-72.

Jan P. Hogendijk, “The qibla table in the *Ashrafi Zij*”, in A. von Gotstedter, ed., *Ad Radices: Festband zum fünfzigjährigen Bestehen des Instituts für Geschichte der Naturwissenschaften der Johann Wolfgang Goethe-Universität, Frankfurt am Main*, Stuttgart: Franz Steiner, 1994, pp. 81-94.

Richard P. Lorch, “The qibla table attributed to al-Khāzinī”, *Journal for the History of Arabic Science* 4 (1980), pp. 259-264, repr. in *idem*, *Arabic Mathematical Sciences: Instruments, Texts, Transmission*, Aldershot & Brookfield VT: Ashgate, 1995.

Ahmad S. Dallal, *An Islamic Response to Greek Astronomy:* Kitāb Taʿdīl Hayʾat al-Aflāk *of Sadr al-Sharīʿa*, Leiden, *etc.*: E. J. Brill, 1995, esp. ch. 18 (pp. 296-309 & 448-451).

Randy K. Schwartz, “Al-qibla and the new spherical trigonometry: The examples of al-Bīrūnī and al-Marrākushī”, Paper presented at Tenth Maghrebian Colloquium on the History of Arabic Mathematics (COMHISMA10), Tunis, Tunisia, May 31, 2010. (al-Marrkushī’s method was not derived by spherical trigonometry.)

DAK, “al-Khalīlī’s *qibla* table”, *Journal of Near Eastern Studies* 34 (1975), pp. 81-122, repr. in *Islamic Mathematical Astronomy*, XIII, also available at http://muslimheritage.com/article/al-khalili-spherical-astronomy (describes a spectacular table from 14th-century Damascus showing the *qibla* in degrees and minutes for each degree of longitude and latitude in the entire Muslim world).

Glen Van Brummelen, “The numerical structure of al-Khalīlī’s tables”, *Physis* 28 (1991), pp. 667-697. (A brilliant investigation of al-Khalīlī’s universal auxiliary tables, concluding with suggestions about the way he compiled his universal *qibla* table.)

– , “Seeking the Divine on Earth: The direction of prayer in Islam”, *Math Horizons* 21:1 (Sept. 2013), pp. 15-17.

Cartographical solutions

Karl Schoy, “Die Mekka- oder Qiblakarte (Gegenazimutale mittabstandstreue Projektion mit Mekka als Kartenmitte)” (1917) (the first European map preserving direction and distance to Mecca at the centre).

DAK & Richard P. Lorch, “*Qibla*charts, *qibla*maps, and related instruments’’, in J. B. Harley & David Woodward, eds., *History of Cartography*, vol. 2, book 1: *Cartography in the traditional Islamic and South Asian societies*, Chicago & London: University of Chicago Press, 1992, pp. 189-205.

DAK, “Two Iranian world maps for finding the direction and distance to Mecca”, *Imago Mundi – The International Journal for the History of Cartography* 49 (1997), pp. 62-82 and 1 pl.

– , *World-Maps for finding the direction and distance to Mecca: Innovation and tradition in Islamic science*, Leiden: Brill & London: Al-Furqan Islamic Heritage Foundation, 1999, xxix + 638 pp.

– , “Safavid world-maps centred on Mecca – A third example and some new insights on their original inspiration”, in *idem*, *In Synchrony with the Heavens*, VIIc: pp. 823-846.

Jan P. Hogendijk, “Three instruments for finding the direction and distance to Mecca: European cartography or Islamic astronomy?”, text of a lecture available at www.jphogendijk.nl/talks/qib.pdf (accessed 2018) (shows that the inspiration is Islamic).

Instruments to find the qibla

DAK & Richard P. Lorch, "*Qibla*charts, *qibla*maps, and related instruments'', in J. B. Harley & David Woodward, eds., *History of Cartography*, vol. 2, book 1: *Cartography in the traditional Islamic and South Asian societies*, Chicago & London: University of Chicago Press, 1992, pp. 189-205.

King, *World-Maps for finding the direction of Mecca*, pp. 89-124, and *idem*, *In Synchrony with the heavens*, I: 94-99. (On *qibla*-indicators in general.)

Recent publications in languages other than English

Pierre Thuissier, "L'Islam et la science : le problème de la qibla", *La Recherche* 18:185 (février 1987), pp. 252-255 (based entirely on DAK).

Jan P. Hogendijk, "Middeleeuws islamitische methoden voor het vinden van de richting van Mekka", *Nieuwe Wiskrant* 12:4 (1993), pp. 45-52.

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