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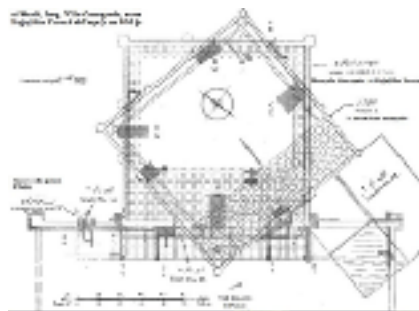


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The Petra fallacy

Early mosques do face the Sacred Kaaba in Mecca
but Dan Gibson doesn't know how



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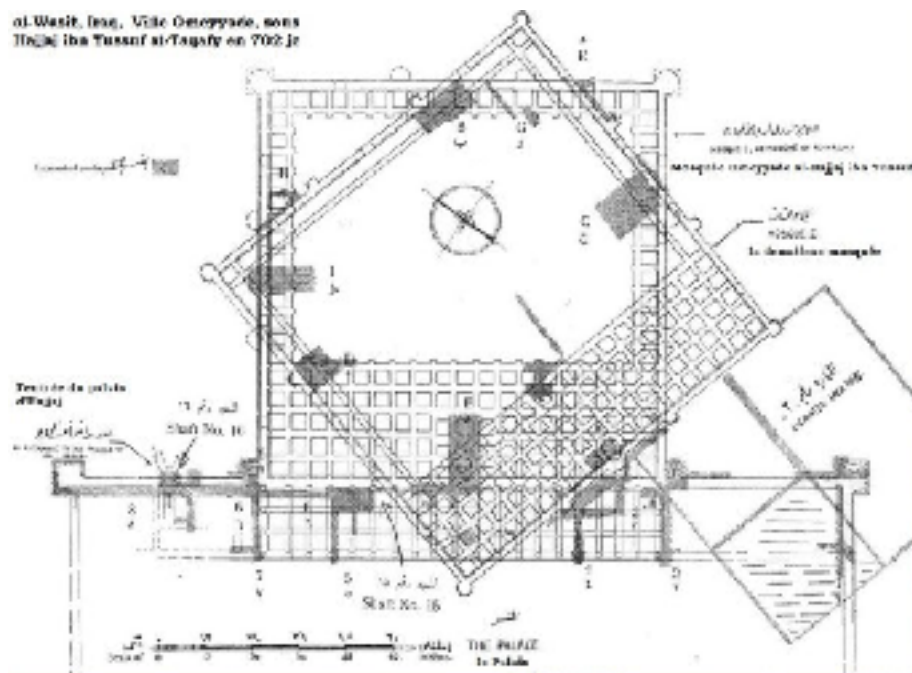
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Notes:

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) has prompted the present response. 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 early mosque in Iraq was pulled down and rebuilt in a different direction, read on ... , but rest assured, it all has nothing to do with Petra.



Keywords: Islam, Kaaba, Ka'ba, Mecca, Makkah, La Mecque, *qibla*, قِبْلَة , sacred geography, sacred direction, Petra, *pibla*, Nabataeans, astronomical alignments, mosque orientations, archaeoastronomy, ethnoastronomy, cardinal & solstitial directions, astronomical horizon phenomena, trigonometry, geometry, *qibla*-maps, *qibla*-indicators, Dan Gibson, revisionist, fallacy, Amod Jason Deus, A. J. Deus, Ottoman mosques, ...

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Introduction

“ما بين المشرق والمغرب قبلة” “What is between the east and the west is a *qibla*.”

Statement attributed to the Prophet Muḥammad.

“The Kaaba is the *qibla* for the Sacred Mosque, the Sacred Mosque is the *qibla* for the sacred precincts (of Mecca and its environs), and the sacred precincts are the *qibla* for the inhabitants of the whole world from where the sun rises to where it sets.” Ibn al-Qāṣṣ (ca. 975), كتاب دلائل القبلة , *Kitāb Dalā'il al-qibla*, quoted in King, *World-Maps for finding the direction of Mecca* (1999), p. 749.

“The most significant characteristic of the mosque is the direction that it faces.”
H. Masud Taj, “The influence of *qibla* in Islamic cities” (1999).

“None of the mosques which Gibson thinks were built facing Petra
has anything to do with Petra, ... ”.
DAK, “From Petra back to Makka” (2017).

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. The ways in which Muslims have determined the *qibla* over the centuries constitute 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. The first such schemes appear in Baghdad in the 9th century.
- By the early 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. (Of course, this would not mean that they could find the **MODERN** direction of Mecca.)

- 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 historical 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. And the matter of the *qibla* is not only about mosques: it is about every Muslim at home and abroad, in life and in death, who follows the prescriptions relating to the sacred direction of Islam.

One of my concerns over the past 50 years has been to attempt to document – mainly for the first time – the ways 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; and
- to determine the *qibla* or sacred direction toward the Kaaba.

To do this I first read what my teachers Karl Schoy (1877-1925) and Ted Kennedy (1912-2010) had written about these subjects using medieval Arabic sources. Particularly important were Kennedy's translations of and commentaries on the writings of al-Bīrūnī, the greatest scientist in early Islamic history, which dealt with the second and third of these topics.

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 most of these manuscripts for centuries, 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 to do with classical Islamic Studies. And that field is plagued by revisionists who think that 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, but not much).

Some of my publications in the history of Islamic astronomy include studies of the following subjects:

- the astronomical alignments of the rectangular base of the Kaaba;
- the methods with which Muslims from the earliest period could have determine the *qibla* by simple folk astronomy;
- the notion of a sacred geography about the Kaaba, with sectors of the world having the same *qibla* defined by astronomical horizon phenomena;
- the methods by which the Muslim scientists could calculate the *qibla* for a given locality;
- the geographical tables showing longitudes and latitudes of hundreds of localities from al-Andalus to China together with their *qiblas* in degrees and minutes;
- the extraordinarily sophisticated mathematical tables displaying the *qibla* for any locality with which the user enters its (medieval) longitude and latitude in the table and reads the value of the (medieval) *qibla*;
- the remarkable cartographical grids produced by Muslim scientists enabling the user to reading off the (medieval) *qibla* on a circular scale and the distance to Mecca on a diametrical scale.
- the medieval Arabic texts discussing the palettes of accepted directions for the *qibla* and for mosque orientations in specific localities, which partly explains the wide range of mosque orientations in these places (notably Córdoba, Cairo and Samarqand).

Over the past few decades numerous colleagues have published papers on various mathematical procedures proposed by individual Muslim scholars for finding the *qibla*, and some of my colleagues and former graduate students have written on the procedures involving folk astronomy and astronomical alignments. The interested reader can survey what has been written on historical *qibla*-determinations in the bibliography appended to this paper.

We 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 other 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 to the local meridian 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 (classical and medieval) 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 someone would come along and announce that all early mosques are oriented toward a location other than Mecca. No serious scholar, Muslim or non-Muslim, would ever have thought that mosques might have been deliberately oriented toward somewhere other than Mecca. If they had, they would rightly be considered to be deranged.

Revisionist fascination with N. W. Arabia

“Lies can become truth, if we do not stop them.” Warning on
CNN international, Nov., 2018.

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. This was a curious idea, not least because there were no obvious potential sites. One of the principal and most convincing arguments for their bold assertion was the ‘fact’ that the earliest mosques in Egypt and Iraq do not face Mecca, but rather some locality in N. W. Arabia. Some 25 years ago I pointed out to Michael Cook 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 (the **MODERN** direction of) Mecca. Nor were they deliberately aligned towards anywhere in N. W. Arabia. They were deliberately aligned to face toward the Kaaba. Cook reacted to this information by saying, most appropriately: “It’s a bit late”.

Yes, 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. From al-Andalus to Central Asia early mosques were built in astronomical directions later referred to as *qiblat al-ṣaḥāba* or *qiblat al-tābi‘īn*, “the *qibla* of the first or second generations of Muslims”.

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

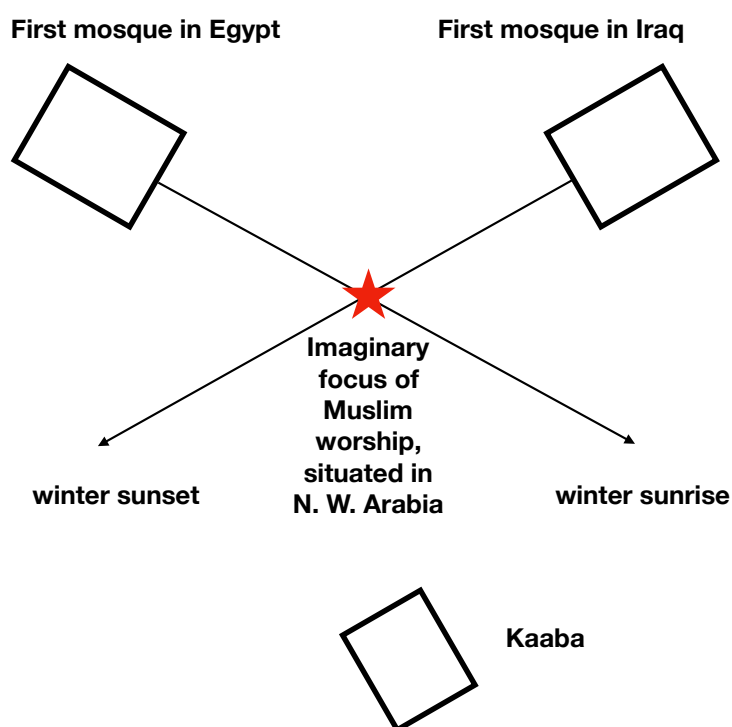
- (a) has no qualifications to correctly interpret the available data;
- (b) has no understanding of the fact that **MODERN** directions from one place to another cannot be used to investigate the reasons underlying the orientation of **PRE-MODERN** architecture;
- (c) seems oblivious to the fact that 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;
- (f) has no control over any of the numerous medieval Arabic sources – legal, astronomical, folk astronomical, and mathematical, geographical – relating to the determination of the *qibla*; and
- (g) prefers to refrain from citing the vast existing bibliography on the subject.

Worse still, he

- (g) has settled on a nice-enough locality, Petra, as the focus of early Islam where in the early 7th century there were no Arabs, no Muslims, and no Jews, and, in brief, there was not much going on.

And worse than that,

- (h) both his activities in a field which he does not master and his false conclusions have already contributed to somewhat dubious causes.



A schematic representation of the fallacy propounded by Cook & Crone. They observed that the earliest mosques in Egypt and Iraq appeared to be aligned toward a place in N. W. Arabia rather than toward Mecca.

This, they wrongly thought, confirmed their theory that the origins of Islam were somewhere in N. W. Arabia rather than in Mecca.

In fact, the mosques are aligned with the Kaaba in Mecca by means of astronomical horizon phenomena, namely, winter sunrise in Egypt and winter sunset in Iraq.

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, and no Google maps are going to help much.

Enter Dan Gibson with his *Early Islamic Qiblas* (2017)

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

He is certainly very creative: for example, he is able to find numerous implicit 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 I do not recall any specifically Nabataean words. (One of my first papers at graduate school was on the Aramaic loan-words in the *Qur'ān* for a course on Biblical Aramaic.) The Nabataeans may have been Arabs, and they have left us inscriptions in Nabataean, a dialect of Aramaic, but they spoke a form of Arabic. I leave this to the specialists. The problem for Gibson is that by the early 7th century they had left Petra.

Gibson claims to be able to interpret the orientations of any early mosque. He presents as 'proof' of his Petra theory the 'fact' that a good number of the 50-odd earliest 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. This 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 premisses. Since Gibson has no idea how the first generations of Muslims might have determined the direction toward anywhere – Petra or Mecca – he compares the orientation of mosques laid out well over 1,200-1,400 years ago with **MODERN** directions toward 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 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 regarding orientations, 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. Not a single historian of Nabataean history, language, religion, architecture or culture has come out with any item of information that would give credence to this breaking news about Petra. Which of course brings us back to Cook & Crone and their imaginary cradle of Islam in N. W. Arabia. Few would disagree that Petra is the nicest place in the entire region. But in the early 7th century it had long ceased to thrive and it appears to have been more or less deserted.

Accurate mosque orientations towards Petra

“ ... Turkish architects were not smart enough to read an angle off a table and draw a corresponding line on the ground [*sic*].” Deus, p. 7.

“ ... none of the mosques by Mimar Sinan point to Mecca [*sic*]” Deus, p. 19.

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* (my word) toward Petra and they were able to do this to within a degree or two. In fact, the ‘real’ Muslims used simple astronomical alignments to find the direction of the Kaaba, 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 ways Muslims over the centuries have determined the sacred direction. 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 five 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 finding the direction 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 the available 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. The modern *qibla*, based on accurate geographical data and derived by exact mathematical methods, is irrelevant to the investigation of the motivation behind the orientation of any historical mosque.

I consider it necessary to respond to Dan Gibson’s latest pronouncements for three 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 palette of *qibla*-directions – covering as much as a quadrant of the horizon – used by different interest groups.

Without knowing this, it is somewhat precarious to try to explain an early mosque orientation.

- The concept of the *qibla* is not just about legal scholars splitting hairs or mathematicians performing calculations or architects building mosques, it is about the millions and millions of faithful Muslims who for well over a millennium over a large part of this planet have exercised their utmost to pray towards the physical focus of their religion, a symbol of the presence of their God. This they do or have done in their mosques, but also in their homes and at work and whilst travelling. Also in death the faithful are laid to rest in the same direction in which they have been praying during their lives. No Muslim needs some ill-informed *Besserwisser* to announce to them that they and their forefathers have been praying in the wrong direction for over a millennium and that they should have been praying towards a city in Jordan that has absolutely nothing to do with early Islam.
- There are very few people – Muslims, non-Muslims and independents – who know anything about historical *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 1,400 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 & south are defined as the intersections on the horizon with the meridian, the vertical circle passing through the Pole Star. The cardinal directions east & 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 & sets at the equinoxes, the two days of the year 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 this day-circle passes through the east & west points. At the summer solstice, when the length of daylight is maximum, sunrise & sunset are substantially (for convenience say about 30°) to the north of east & west.

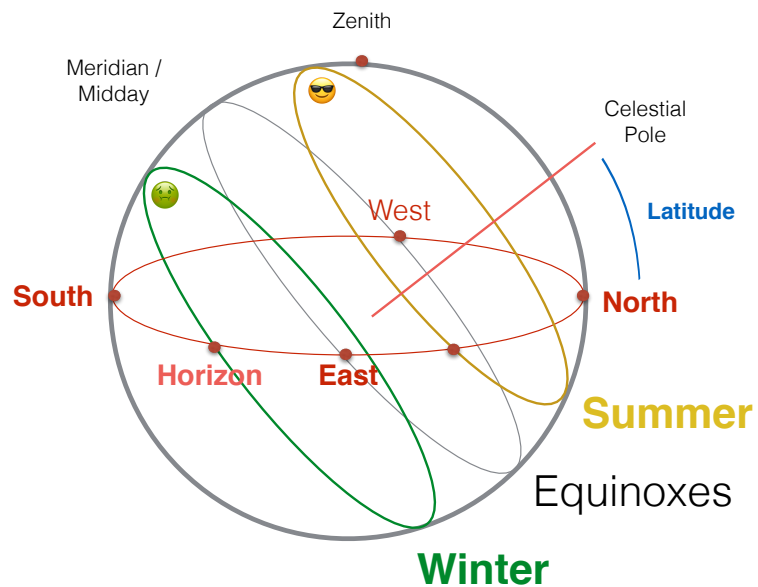
At the winter solstice, when the length of daylight is minimum, sunrise & sunset are substantially to the south of east & west. Directions toward distant localities can be envisaged as points on the local horizon.

However, before one can get involved with directions to distant localities it is necessary to first determine the north-south line or meridian. By far the most popular medieval procedure involved using the so-called "Indian circle". On a flat surface one erects a vertical gnomon at the centre of a circle of radius similar to the length of the gnomon, and during the course of the morning observes the shadow cast by the gnomon when the sun has reached a certain altitude. One then repeats this during the afternoon when the sun has the same altitude. The line bisecting the angle between the two shadows or, equivalently, the line bisecting the line between the two intersections with the circle is the meridian. More sophisticated methods were available if greater accuracy was required. Using a magnetic compass to determine the meridian was not a good idea. In the 15th century the deviation of magnetic north from true north was measured by an Egyptian astronomer, but knowledge of this complex issue remained limited until the introduction of modern geodetics.

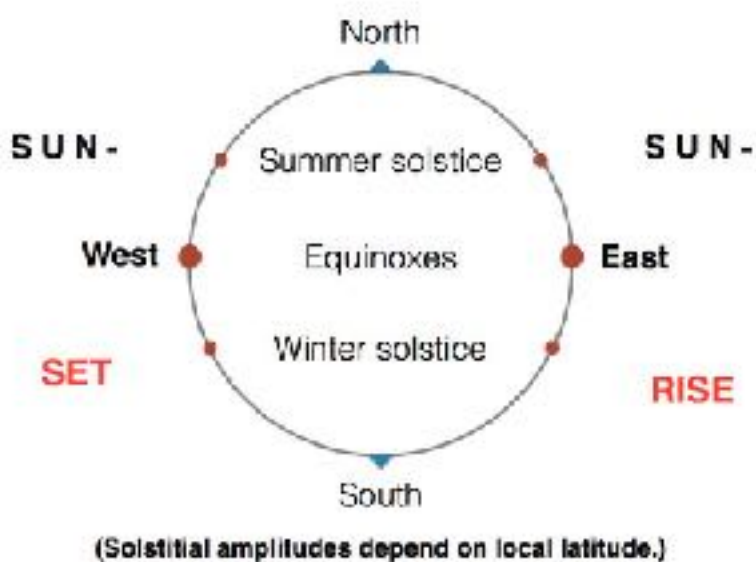
The expression 'astronomical alignments' relates here to buildings whose bases, mainly rectangular, are in the cardinal directions, or in directions defined by the rising or setting sun at the solstices. These solar directions conveniently divide each quadrant of the horizon into three roughly equal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

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 can be exact or approximate, and are adequately dealt with elsewhere. The latitudes used by medieval astronomers could be fairly accurate but the longitudes less so. In all, the possibility of error confronted mosque architects in determining the meridian, in determining the *qibla* using erroneous geographical data and approximate mathematical methods, and more besides. None of this was necessarily their fault. But it should be reasonably obvious to a savvy modern that the mosques they built centuries ago, whilst they might face the *qibla* accepted at the time, will not be facing the **MODERN** *qibla*, and that certainly is not their fault.

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



The sun on the horizon



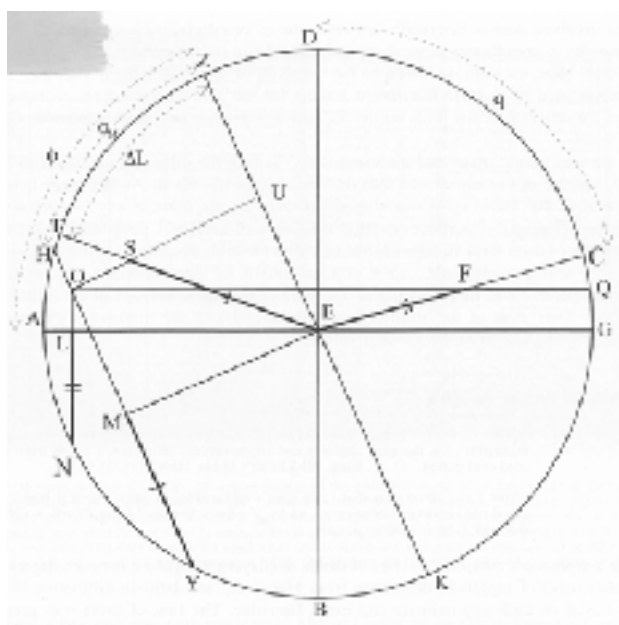
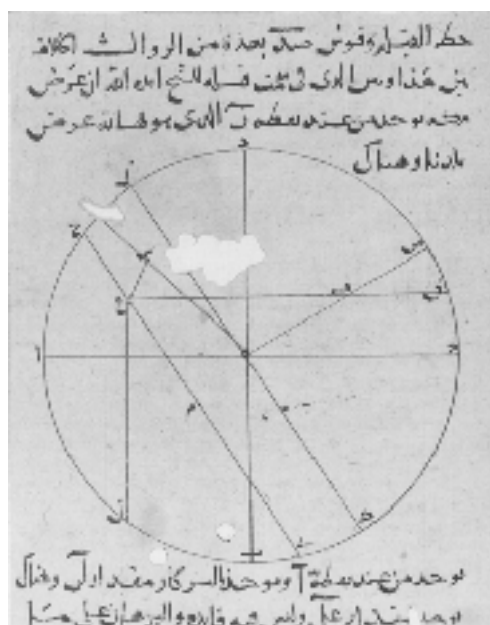
Excursus: A formula for determining the *pibla* to Petra

The following is one of several equivalent modern formulae for finding for any locality the direction of Petra, that is, the *pibla* p , from the longitudes and latitudes of the locality (x,y) and of Petra (x_P, y_P) (with $\Delta x = x \sim x_P$):

$$p(\Delta x, y) = \text{arc cot} \{ [\sin y \cos \Delta x - \cos y \tan x_P] / \sin \Delta x \}.$$

Methods of aligning early mosques toward Petra within a degree or two necessarily would have involved the equivalent of this level of sophistication, unless, of course, the mosques were oriented by the methods of folk astronomy (alignments with astronomical horizon phenomena) or, as Gibson suggests, by observing carrier pigeons let loose in Petra.

A brilliant equivalent procedure to find the *qibla* to Mecca was derived by the astronomer Habash in Baghdad *ca.* 850.



Habash's analemma construction for finding the *qibla*, from which the modern formula can be derived.

See further Kennedy & Id, "Habash al-Hāsib's analemma for the *qibla*" (1973), & King, *World-Maps for finding the direction of Mecca* (1999), p. 68.

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

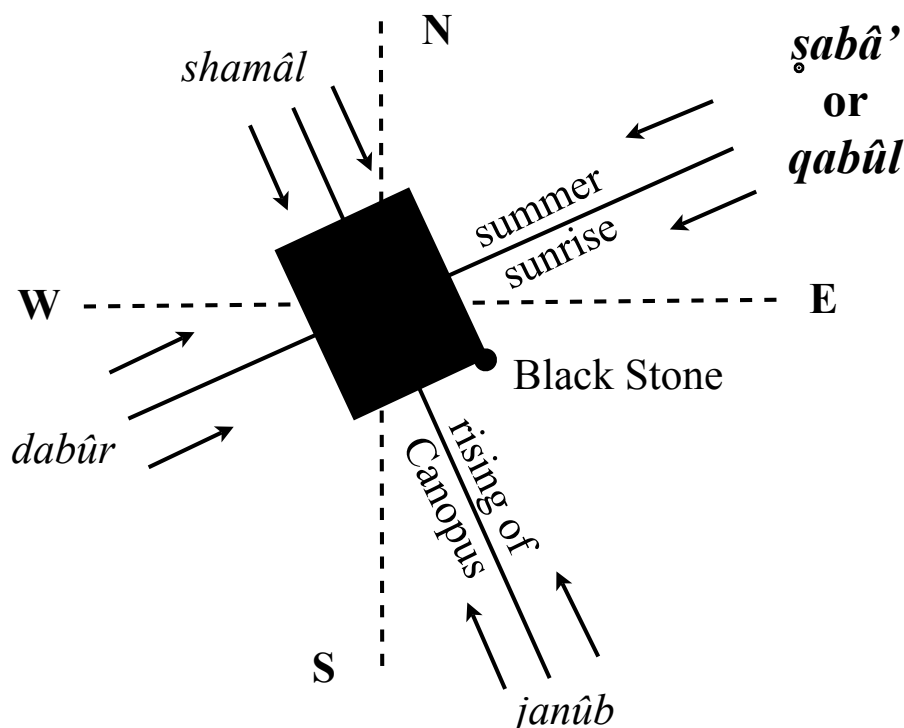
In this rather desperate new article Dan Gibson attempts to compare what he and I have written on the *qibla* or sacred direction in Islam and the orientation of the earliest mosques (to *ca.* 800). He still seems to have no understanding of anything I have ever written on the subject of the *qibla* 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 ignoring such fields, 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 (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 (1972). In discussing my professional experience Gibson simply omits the two decades (1985-2006) I spent as 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).

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).

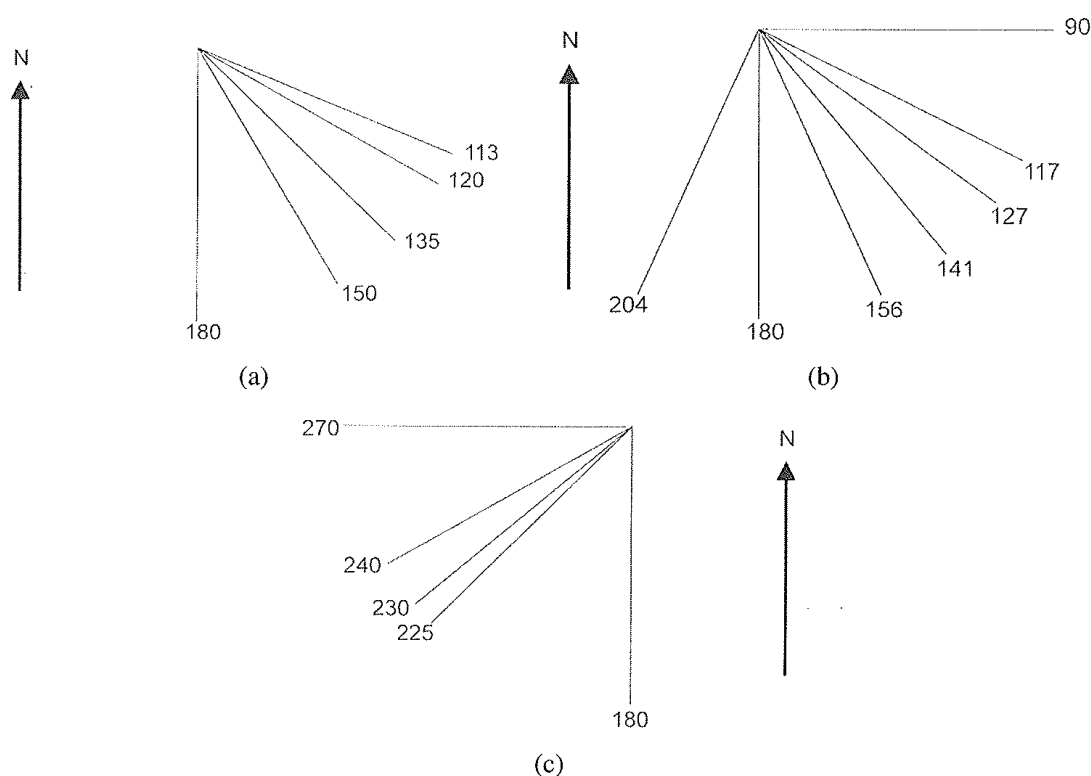


The orientation of the Kaaba mentioned in medieval texts and confirmed by satellite images, taking into consideration the surrounding skyline.

Canopus (سهييل, *Suhayl*) is the brightest star in the southern sky. The direction of the rising of Canopus is conveniently 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 *qabûl* wind, also called صبا *şabâ’*; in this position one is facing summer sunrise with (formerly) fortunate Yemen (اليمن, *al-Yaman*) on the right and ominous Syria (الشام, *al-sha’m*) on the left.

Some revisionists have claimed that the orientation of the Kaaba (with *al-ḥijr*!) 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 and mosque orientations accepted in medieval cities of (a) Córdoba, (b) Cairo, and (c) Samarqand. These include astronomical directions, cardinal and solstitial, and *qiblas* determined by mathematical procedures.

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 '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 some suburbs any direction between the rising and setting of the star Canopus (156°/204°), favoured as a south indicator, was used.

In Samarqand the *qibla* of the Companions was toward winter sunset (240°) but the *qibla* of the Shāfi'īs 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, يعني .

The orientation of the Kaaba

It was the discovery of the astronomical alignment of the Kaaba – using satellite images interpreted by Gerard Hawkins and a medieval Yemeni text discovered 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 discussing the way in which an individual should stand in prayer, facing the Kaaba directly was optimal (عين الكعبة , *ayn al-Kaʿba*) 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 for Islamicists 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 have labelled 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 Gibson finds facing toward (the **MODERN** direction of) 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 known historical cultural tradition 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 of 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. Further, I now doubt that one can trust Gibson’s values for mosque orientations derived from satellite maps. Also, I have found that the *qibla*-directions for various cities given on different internet sites are not always the same. 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 (the **MODERN** direction of) Petra not (the **MODERN** direction of) 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 geographical data.)

Similarly, the **Mosque of ‘Umar in Jerusalem** was built so that it is aligned in a southerly direction like the Temple complex, which itself 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 Muslim astronomers announced that the *qibla* in Jerusalem was about 45 E of S according to medieval geographical 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 toward (the **MODERN** direction of) Petra at 295° rather than toward (the **MODERN** direction of) Mecca at 285°. Since it faces (the **MODERN** direction of) Petra to within 3°, Gibson thinks that those who built it must have used a correct (mathematical?) procedure. More likely, it was oriented toward 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 (the **MODERN** direction of) Petra. This would be possible in a world of fantasy.

Gibson believes they had ships; I have suggested flying carpets. I repeat that the origins of this mosque are legendary.

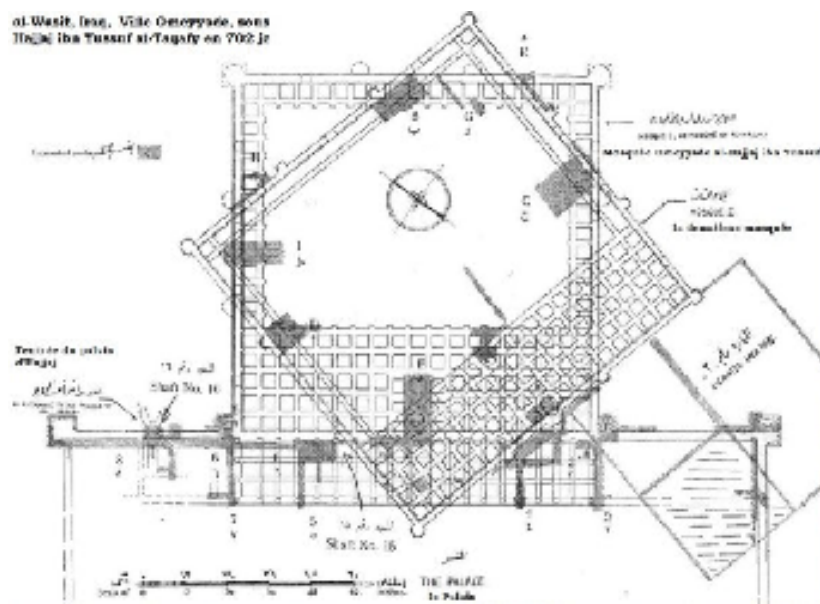
The **Grand Mosque in Sanaa**, built in 705, is oriented at 334° . Now it happens that, from Sanaa, (the **MODERN** direction of) Petra is at 334° , (the **MODERN** direction of) Jerusalem is at 335° , and (the **MODERN** direction of) Mecca is 326° . Does this mean someone calculated the direction of 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 Mecca (and it even has a miniature Kaaba inside). Those who built the Mosque were perhaps thinking about facing the south-eastern wall of the Kaaba, which they knew about, not about facing "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 sloped down to the River Guadalquivir from the cardinally-aligned central part of the city has only in the past 20 years been excavated. The suburban 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 suburban 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 south south-easterly 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. Gibson's *fribla* is also imaginary.

The first **Mosque at al-Wāsiṭ** in the province of al-'Irāq was built in 706 and later 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 N. E. Wall also faced winter sunset.

Thus the *qibla*-wall of the mosque was ‘parallel’ to the N. E. 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 newly-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 I have with Gibson's interpretations of this data is that he desperately needs to rewrite the history of mathematical geography, albeit with a cop-out:

“ ... 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 7th-century Petra (who didn't exist anyway) 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 surviving Islamic astrolabes, from the 8th and 9th centuries, have no means whatsoever for finding the *qibla* anyway.

(The Wikipedia article “Qibla”, by the way, also does no justice whatsoever to the Muslim scholars of yesteryear, ignoring all of their activities, let alone their major achievements. The only medieval means of finding the *qibla* that is mentioned is the astrolabe!)

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 inappropriate procedures Gibson has used and the unfortunate and totally false 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* and mosque orientations. So my colleagues in the history of Islamic art and architecture generally still tend to write *n’importe quoi* (اي كلام) 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, the English popular historian Tom Holland, self-styled “leading writer on the ancient world” (www.tom-holland.org), alas 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 1,400 years. This kind of ammunition is extremely useful for those who campaign against Islam and Muslims.

An example of the way in which certain folk have 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. In the video Smith, “an assertive Christian evangelist, apologist and polemicist”, talks about the way some early mosques, for example, in India and China face (the **MODERN** direction of) 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 and all mosques are, by means that Gibson has not mastered, aligned towards it.

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. This would be completely new to Nabataean Studies, which he claims to know something about, and no serious specialist on Nabataean culture is claiming any such an Islamic connection for Petra. He simply 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 abilities and 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 (**MODERN**) direction toward Petra **EXACTLY** from places between al-Andalus and China is ill-advised.

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 $360^\circ = 0^\circ$; these people might prefer to read 22° N of E. Now 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 colleague Juan Antonio Belmonte, who was even more surprised

than I was to find his name in Gibson's acknowledgements, for Gibson never mentions 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 (the **MODERN** direction of) Petra, not (the **MODERN** direction of) 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 understand this.

Rick Oakes is an American scholar of theology concerned with the history of the *Qur'ān* and of early Islam. He 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 naïvely focusses on the 17 mosques that Gibson says face (the **MODERN** direction of) Petra. He does not argue whether or not they were pointed toward (the **MODERN** direction of) 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 overlooks my refutation of all of them, so he repeats this appeal 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 feel only shame that my response was not “‘thoughtfully considered” ; maybe the present essay will help. Oakes begins by omitting that I first published my review of Gibson on my own website and later on the Muslim Heritage site. He writes that I “revised” my review after a petty response by Gibson, when, in fact, I just removed a comment about his missionary connection. Oakes then identifies five mosques whose orientations I did not even mention: the Masjid al-qiblatayn in Medina and four other very minor mosques I had never heard of. He seems so convinced about Gibson’s finding that 17 early mosques point toward (the **MODERN** direction of) Petra that he challenges other scholars to offer better explanations than that this was deliberate. It all becomes a game: who gets it right and who gets it wrong. 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 toward (the **MODERN** direction of) Petra. While he is correct in mentioning that I wrote that the Sanaa Mosque points toward (the **MODERN** direction of) Petra, he missed the fact that this does not mean that it was deliberately laid out to face Petra: I also said that the axis of the Mosque was ‘parallel’ to the main axis of the Kaaba, so that the *qibla*-wall is ‘parallel’ to the SE wall of the Kaaba. Oakes’ best quote about mosques that were built in the cardinal directions 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. He is apparently ready to believe Gibson’s claims about Petra if somebody can confirm them.

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 perhaps even 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 is saying,

"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. So be it.

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. Anderson's study considers seven of Gibson's arguments for Petra and the comparison ends with a score **Mecca 7, Petra 0**.

* Unfortunately I am reported to have said that the earliest Muslims "calculated" the *qibla*, whereas in fact I had stated that they "determined" the direction of the Kaaba using astronomical alignments: they calculated nothing.

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>). At first sight, this is most useful and could 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. Be careful, though, for this is a two-dimensional representation of a substantial swathe of the Earth's surface. 'Click-on', rather confused insets then give further details. Gibson explains that this tool uses the latest Google Maps, which he admits sometimes is "not the best" and that it is not intended to be a highly accurate investigative tool. Rather, he says, 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, the only sensible conclusion being that Gibson is right and King is wrong, though, to Gibson's credit, this is not stated.

What is obvious from the map is the following (remember it serves only early mosques):

- The map may show the orientations of mosques but producing the principal axis of the mosques as straight lines halfway around the world, nay, across the flat world, is in itself ridiculous and can only lead to more confusion. This is not a map that preserves directions in the way Gibson would like.
- The overwhelming majority of early mosques in Jordan and Palestine are astronomically aligned to face south.
- The majority of early mosques in Syria are astronomically aligned to face south.
- Virtually all early 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 early 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:

- The map will appeal to innumerate and cartographically innocent *revisionistas*, who will think it proves Gibson's theories.

- The map is guaranteed to confuse folk who have no idea about the mathematics of cartography so that they will believe in the 'directions' they see on the map.
- 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 also 'parallel' to a line between Petra and Mecca, but, *contra* Gibson, 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. The *qibla*-wall of the Mosque is 'parallel' to the NW wall of the Kaaba. (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 was more than one accepted *qibla* direction.

Only general observations are appropriate here because Gibson is using a **MODERN** map. The directions it shows for mosques are supposedly **MODERN** *piblas* or *qiblas*. As far as I know, for over 2,000 years nobody ever calculated the direction toward 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 eventually 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 mysteriously does not expand when one enlarges the map. Since the grid is orthogonal it does not 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.

New light and new darkness on orientations of mosques in Anatolia and beyond

" ... Turkish architects were not smart enough to read an angle off a table and draw a corresponding line on the ground [*sic*]." Deus, "Monuments of Jihad", p. 7.

" ... none of the mosques by Mimar Sinan point to Mecca [*sic*]" Deus, "Monuments of Jihad", p. 19.

In 2018 two studies appeared on the orientation of mosques in Anatolia (and beyond). 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. 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", published in an academic journal. Unfortunately the authors were unaware of an Ottoman table of the calculated *qiblas* for some 90 cities in the Ottoman Empire which I published some 20 years ago, but nevertheless their study, being within the context of the history of Islamic astronomy and mathematical geography as well as *qibla*-determinations, is one that can be built upon and expanded.

The second 'study', by A. J. Deus, an economist by training, is a completely off-the-wall attack on Turkish history based on a nutty idea that the diverse mosque orientations in the world of the Ottoman Turks resulted from deliberate attempts to align the mosques not toward (the **MODERN** direction of) Mecca but (exactly, of course) toward (the **MODERN** directions of) the

sites of contemporaneous Ottoman military campaigns in Ukraine, Iran, Somalia, to Tunisia. Instead of places of worship the mosques, for Deus, become – اعوذ بالله – “monuments of jihad”. Oy veh!

Deus is inevitably innocent of any idea about Ottoman astronomy, astrology, mathematics, geography, cartography, and instruments for finding the *qibla*, and has no idea how the Ottoman astronomers actually determined the *qibla* or how the Ottoman astrologers predicted events. Proof of this is his false premises that they could compute accurately the (**MODERN**) direction of Mecca if they wanted to, but they mainly did not, as well as that they were able to compute the (**MODERN**) directions from the location of any mosque toward Ottoman military hot-spots hundreds of miles away, whenever and wherever they wanted to. They most certainly could do neither of these. To be sure, as far as determining the *qibla* mathematically was concerned, their favourite method was an approximate one 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 has also overlooked an Ottoman geographical table listing the *qiblas* for 90 cities in the Empire, which I published in my book on Mecca-centred world-maps 20 years ago and which I have now published again on my academia.edu site.

Deus published his ‘study’ online “in collaboration with” a revisionist outfit called “Inarah – Institute for Research on Early Islamic History and the Koran” based in Saarbrücken, Germany, and known for some very strange 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 on my academia.edu site. 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, but in ways that Deus shows himself incapable of understanding. His overzealous, uninformed revisionism is hardly what Ottoman mosques need.

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 more or less due south in Jordan and Syria;
- (6) determine which mosques face due west in India and due east in N. Africa; and
- (7) determine which mosques 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. Also, measurements and calculations to the nearest degree are adequate for investigative purposes; any attempt at greater 'accuracy' is unrealistic.

To any interested parties, I would recommend looking at the five articles which I 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.

Concluding remarks

“Every mosque in the world is a segment of a circle whose centre is the Kaaba. **The most significant characteristic of the mosque is the direction that it faces.** Hence it is the building’s abstract orientation and not its most visible elements – dome, minaret, mihrab, *etc.* – that determines its identity.” H. Masud Taj, “The influence of qibla in Islamic cities” (1999), p. 173 (emphasis is mine, and the intended audience are all those who work on Islamic religious architecture ignoring its orientation and especially those who compare mosque orientations with the modern directions of Mecca and then spout nonsense).

As for the Kaaba, a symbol of the presence of God and the physical focal point of Islam, nobody in its vicinity now could guess or test its astronomical alignments because of all of the skyscrapers surrounding the Mosque complex. And by 2019, according to numerous news reports in 2017, the entire 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 Kaaba will sometimes no longer be visible even from space. If they are not true, فأحسن , so much the better.

Gibson thinks that Muslims should have been praying toward Petra for the past millennium, as he thinks they did in the first two centuries of Islam. For the time being, though, practicing Muslims can happily ignore Gibson’s outrageous suggestion that they start praying towards Petra again. They also don’t need to worry about Deus’ pronouncements that their mosques have never been oriented toward Mecca.

This independent observer suggests that Muslims should simply carry on praying towards the Kaaba as they have been doing for over 1,400 years.

Bibliography of books, articles and websites on historical *qibla* determinations

There is an enormous amount of literature in the Muslim sources on the sacred direction or *qibla* toward the sacred Kaaba in Mecca. Here we are concerned **only** with modern studies of historical literature which discussed the ways in which one can actually determine the *qibla*. Essentially, the *qibla* directions used in early times were often derived using astronomical horizon phenomena such as the cardinal and solstitial directions – north, south, east & west, or summer or winter sunrise & sunset, or the risings and settings of specific *qibla*-stars – as outlined in the little-known genre of folk astronomical and legal literature labelled *كتب دلائل القبلة*, *kutub dalā'il al-qibla*, “books on the (non-mathematical) means of finding the *qibla*”. The mathematically-derived *qiblas* (9th century onwards) were calculated from medieval geographical coordinates, using either simple approximate techniques or complicated trigonometric or geometrical procedures. In most major centres there was a palette of different *qibla*-directions favoured by one group or another, documented in the medieval sources, which partly accounts for the wide diversity of orientations of historical mosques in any given region.

Since the mathematically-derived *qiblas* depend on geographical coordinates, the *qibla* directions derived by Muslims centuries ago with (by modern standards, inaccurate) coordinates are obviously not going to be identical with modern *qibla* directions such as one can now access for any location on earth by means of the internet. If one is interested in investigating orientations of historical mosques it is advisable to first try to understand how Muslims dealt with the determination of the *qibla*, keeping in mind that modern *qibla*-directions are less relevant than one might first think.

No general bibliography on *qibla* determinations has been prepared before. **The author will appreciate information on any relevant works that have been inadvertently omitted.**

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 “*Qibla* (legal aspects)” by A. J. Wensinck in *Encyclopedia of Islam*, 2nd edn.

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 the American scholar **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 – International Journal for the History of the Exact and Natural Sciences in Islamic Civilisation* 9 (2009-2010), pp. 185-214. His collected papers are published in *Studies in the Islamic Exact Sciences*, Beirut, 1983. It is planned to put this volume online as well as his publications on various works by two of the most significant Muslim scientists, al-Bīrūnī and al-Kāshī, as well as the monumental *Geographical coordinates of localities from Islamic sources*.

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.

This bibliography does not include the standard references to the primary manuscript sources for the history of Islamic science, namely, the works of Heinrich Suter, Carl Brockelmann, Charles A. Storey, Fuat Sezgin, Ekmeleddin İhsanoğlu *et al.*, & Boris A. Rosenfeld *et al.* See further <https://ismi.mpiwg-berlin.mpg.de> (2018).

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), 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; Tofiq 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)"; "Asturlāb (astrolabe)"; "Hay'a (astronomy)"; "Kibla (sacred direction)"; "Layl wa-nahār" (simple timekeeping); "Makka as centre of the world" (sacred geography); "Mikāt" (astronomical timekeeping and times of prayer); "Mizwala (sundials)"; "Rub' (quadrant)"; "Nudjūm" (star-lore); "Ru'yat al-hilāl (lunar crescent visibility)"; "Shakkāziyya (universal projections)"; "Tāsa (magnetic compass)"; and "Zidj (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/> and now <https://ismi.mpiwg-berlin.mpg.de/biographies-list> (2018) (This is the standard reference work on the most 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'" & "Layl wa-nahār", in *Encyclopedia of Islam*, 2nd edn.

Anton H. Heinen, *Islamic cosmology: A study of as-Suyūṭī's al-Hay'a al-saniya fi-l-hay'a al-sunnīya*, Beirut, 1982 (a work of 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, "Miqāt 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-Aṣḥabī, Ibn Raḥīq und al-Fārisī*, 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.)

Archaeoastronomy 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 on the situation in most parts of the world, although, alas for our present purposes, Central and South Arabia are not covered.)

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 *idem*, *Islamic Astronomy and Geography*, VIII.

Jerusalem and Mecca

- M. S. M. Saifullah, M. Ghoniem, 'Abd 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-Isrā' between 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-‘ālam 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 *idem*, *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 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 *idem*, *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 hadj 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 *idem*, *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-Maqrizī – 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).

Determination of the *qibla* by geometry or trigonometry

General overviews

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

DAK, "Qibla. 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 *idem*, *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 *idem*, *Islamic Astronomy and Geography*, VIII.

al-Bīrūnī and his monumental work on mathematical geography

al-Bīrūnī's treatise كتاب تحديد نهايات الاماكن, *Tahdīd nihāyāt al-amākin*, on mathematical geography and the determination of the *qibla* is available in the critical edition of P. Bulgakov in مجلة معهد المخطوطات العربية, *Majallat Ma'had al-makḥṭūṭāt al-'arabiyya* (Cairo) 8

(1962); Jamil Ali, transl., *The Determination of the Coordinates of Cities ... by al-Bīrūnī*, Beirut: American University of Beirut Press, 1967; and E. S. Kennedy, *A Commentary upon al-Bīrūnī's treatise Tahdīd nihāyāt al-amākin – An 11th century treatise on Mathematical Geography*, Beirut: American University of Beirut Press, 1973. (This book, compiled in Ghazna ca. 1025, is arguably the most significant work on the subject ever compiled, but it was not widely circulated and survives in a unique manuscript. Published materials on al-Bīrūnī are accessible through www.jphogendijk.nl/biruni.html.)

Methods to determine the meridian

E. S. Kennedy, *The Exhaustive treatise on Shadows by Abu al-Rayhān ... al-Bīrūnī – Translation and commentary*, 2 vols., Aleppo: Institute for the History of Arabic Science, University of Aleppo, 1976, II, pp. 135-172.

- , “Bīrūnī 's graphical determination of the local meridian”, *Scripta mathematica* 24 (1959), pp. 251-255, repr. in *idem et al., Studies in the Islamic exact sciences*, pp. 613-617.
- , “al-Bīrūnī on determining the meridian”, *The Mathematics Teacher* 56 (1963), pp. 635-637, repr. in *idem et al., Studies in the Islamic exact sciences*, pp. 618-620.

The use of the magnetic compass

Petra Schmidl, “Two early Arabic sources on the magnetic compass”, *Journal of Arabic and Islamic Studies* 1 (1997-98), pp. 81-132.

DAK, article “Ṭāsa [= magnetic compass]” in *Encyclopaedia of Islam*, also *idem*, *World-maps*, pp. 107-124, and *In Synchrony with the Heavens*, X: 94-101.

Qibla-methods proposed by individual Muslim scientists

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

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 *idem*, *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).

- , King, “al-Khwārizmī and new trends in mathematical astronomy in the ninth century”, *Occasional Papers on the Near East* (New York University, Hagop Kevorkian Center for Near Eastern Studies) 2 (1983), 43 pp., esp. pp. 12-16.
- , “Too many cooks ... – A newly-rediscovered account of the first Islamic geodetic measurements”, *Suhayl – International Journal for the History of the Exact and Natural Sciences in Islamic Civilisation* (Barcelona) 1 (2000), pp. 207-241, repr. in *idem*, *Islam and Science*, IV, pp. 451-485, and E-X. (One of the objects of the exercise was to determine, for the first time, the qibla at Baghdad.)

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. Ḥatīm 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 'Abdallāh'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-Wafā' calculates the distance Baghdad - Mecca", *Historia Mathematica* 11 (1984), pp. 193-206.
- , E. S. Kennedy, *A Commentary upon al-Bīrūnī's Kitāb Tahdīd nihayāt al-amākin*, 1973, based on the translation by Jamil Ali, *The Determination of the coordinates of cities: al-Bīrūnī's [nihāyat] al-amākin*, 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 Zījes" in the theory of sundials", *Centaurus* 28 (1985), pp. 1-16.
- Julio Samsó & Honorino Mielgo, "Ibn Ishāq al-Tūnisī and Ibn Mu'ādh 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 'ilm 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 *Ashrafī Zīj*", in Anton 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 Ta'dīl Hay'at al-Aflāk of Sadr al-Sharī'a*, 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-Marrākushī's method was not derived by spherical trigonometry.)

DAK, "al-Khalilī'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-Khalilī's tables", *Physis* 28 (1991), pp. 667-697. (A brilliant investigation of al-Khalilī'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 for finding 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.)

Lists of historical *qibla*-values* for different localities

DAK, *World-Maps for finding the direction of Mecca*, pp. 71-124 & 453-638. (Investigation of tables by the 12th-century scientist al-Khāzinī for 250 localities derived from a world-map based on the geographical tables of the 11th-century polymath al-Birūnī; the monumental anonymous 15th-century Timurid geographical table from Kish with *qiblas*

and distances to Mecca for 274 localities; and various smaller Egyptian, Syrian and Iranian tables in manuscripts or engraved on instruments, as well as an Ottoman table of *qiblas* for 90 localities – see below.)

- , “Mathematical geography in 15th-century Egypt – An episode in the decline of Islamic science”, *Islamic Thought in the Middle Ages – Studies in Text, Transmission and Translation, in Honour of Hans Daiber*, Anna Akasoy & Wim Raven, eds., (Islamic Philosophy, Theology and Science, Texts and Studies, Hans Daiber, ed., vol. LXXV), Leiden & Boston: Brill, 2008, pp. 319-344, repr. in *idem*, *Islamic astronomy and geography*, XII. (An analysis of a 15th-century Egyptian geographical table for 425 localities.)
- , “An Ottoman list of *qibla*-values for cities in the Ottoman Empire”, on www.davidaking.academia.edu (2018) (serves 90 localities, previously published in *World-Maps ...*).

* The reader should keep in mind that modern *qibla*-values (based on modern geographical coordinates) are different.

Procedures for determine the meridian (incl. “the Indian circle”)

Note: Determining the meridian or local north-south line is a prerequisite to laying out the *qibla*.

E. S. Kennedy, *The Exhaustive treatise on Shadows by Abu al-Rayhān ... al-Bīrūnī – Translation and commentary*, 2 vols., Aleppo: Institute for the History of Arabic Science, University of Aleppo, 1976, II, pp. 135-172.

- , “Bīrūnī’s graphical determination of the local meridian”, *Scripta mathematica* 24 (1959), pp. 251-255, repr. in *idem et al.*, *Studies in the Islamic exact sciences*, pp. 613-617.
- , “al-Bīrūnī on determining the meridian”, *The Mathematics Teacher* 56 (1963), pp. 635-637, repr. in *idem et al.*, *Studies in the Islamic exact sciences*, pp. 618-620.

Jamil Ali, trans., *The Determination of the Coordinates of Cities ... by al-Bīrūnī*, pp. 255-256, and E. S. Kennedy, *A Commentary upon Bīrūnī’s Taḥdīd*, pp. 214-215.

Simple procedures for architects to lay out mosques

Note: These existed in abundance, but no survey has been undertaken.

Jamil Ali, trans., *The Determination of the Coordinates of Cities ... by al-Bīrūnī*, pp. 255-256, and E. S. Kennedy, *A Commentary upon Bīrūnī’s Taḥdīd*, pp. 214-215. (Six procedures for Ghazna proposed by al-Bīrūnī.)

DAK, “The Ottoman mosques fallacy” (see below) (examples based on al-Bīrūnī).

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. 109-111; 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 Astronomy* 26 (1995), pp. 253-274 (a new version is in *In Synchrony with the Heavens*, VIIa: 741-771).
- Suliman Bashear, "Qibla musharriqa and early Muslim prayer in churches", *The Muslim World* 81 (1991), pp. 267-282.
- Michelina di Cesare, "A qibla mušarriqa for the first al-Aqṣà Mosque? A new stratigraphic, planimetric, and chronological reading of Hamilton's excavation, ... ", *Annali, Sezione orientale* 77 (2017) 66-96.
- 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).
- H. Masud Taj, "Facing the city: the influence of qibla on street-line orientation in Islamic cities", *Proceedings of Symposium on Mosque Architecture, College of Architecture & Planning, King Saud University, 1419H - 1999*, 38 (1999), pp. 173-181.
- Magdalena Pinker, "Supernatural motifs in chronicled descriptions of the foundation of early Arabic-Islamic towns", *HEMISPHERES* 32 (2017), pp. 79-90.

Hejaz

- V. V. Bartold = Васи́лий Влади́мирович Барто́льд = Wilhelm Barthold, "Zur Orientierung der ersten muhammedanischen Moscheen", *Der Islam* 18 (1929), pp. 245-250, repr. in *idem*, *Собрание сочинений* = *Collected works* (*Собрание сочинений*, 9 vols., Moscow: Oriental Literature Publishing House = Издательство Восточной литературы), 1963-1977, vol. 6 (1966), pp. 537-542.

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 *idem*, *Islamic Astronomy and Geography*, IX.

Cairo

- Christel M. Kessler, "Mecca-oriented architecture and urban growth of Cairo", in *Atti del terzo congresso di studi arabi e islamici* (Ravello, 1-6 September 1966), Naples: Istituto Universitario Orientale, 1967, p. 425.
- , "Mecca-oriented urban architecture in Mamluk Cairo: The Madrasa-Mausoleum of Sultan Shaʿban II", in Arnold H. Green, ed., *In Quest of an Islamic Humanism: Arabic and Islamic Studies in Memory of Mohamed al-Nowaihi*, Cairo: American University in Cairo Press, 1984, pp. 97-108.
- , "Mecca-oriented architecture within an urban context: On a largely unexplored building practice of medieval Cairo", in Antony Hutt, ed., *Arab Architecture: Past and Present*, An exhibition presented by the Arab-British Chamber of Commerce at the Royal Institute of British Architects, London, 1984, Durham: Centre for Middle Eastern and Islamic Studies, University of Durham, 1983, pp. 13-20.

- , “Mecca-oriented building in mediaeval Cairo”, in *Focus on Arab Architecture, Past . . . and Present*, A Record of a Four-week Exhibition and Associated Functions, London, 24 January-17 February 1984, London: Arab-British Chamber of Commerce, 1984, pp. 44-52.
 - , “The ‘Imperious Reasons’ that flawed the minaret-flanked setting of Sultān Ḥasan’s Mausoleum in Cairo -- Another note on medieval Cairene on-site planning according to street-alignments and Mecca-orientations”, *Damaszener Mitteilungen* (German Archaeological Institute, Damascus) 11 (1999), pp. 307-316, pls. 40-41.
- DAK, “Architecture and astronomy: The ventilators of medieval Cairo and their secrets”, *Journal of the American Oriental Society* 104 (1984), pp. 97-133; with a revised version in *In Synchrony with the Heavens*, VIIb: 741-771) (the orientation of astronomically-aligned medieval ventilators reveals the secret of the orientations of the street-plan of Fatimid Cairo and Fatimid & Mamluk religious architecture in Cairo).

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 *idem*, *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 surviving historical mosques in the Iberian Peninsula).
- Mònica Rius Piniés, *La Alquibla en al-Andalus y al-Maghrib 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 andalusies”, in *Catálogo de la exposición El Esplendor de los Omeyas cordobeses*, Granada: Fundación Legado Andalusi, 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 mihrāb. Differences constatées dans la direction des mosquées maghrébines, raisons possibles, orientation par des procédés 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).

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*.)

Abbey Stockstill, "A tale of two mosques: Marrakesh's Masjid al-Jami' al-Kutubiyya", *Muqarnas – An Annual on the Visual Cultures of the Islamic World*, Gülru Necipoğlu, ed., 35 (2018): 65-82. (Marks a new era in the history of Islamic architecture.)

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).

The Balkans

Milutin Tadić & Zlatko J. Kovačić, "Orientation of the fifteenth and sixteenth century mosques in the former Yugoslavia", *J. Geogr. Inst. Cvijic* (= *Journal of the Geographical Institute "Jovan Cvijic" SASA*, (Belgrade) 66:1 (2016), pp. 1-17,

Greece

George Pantazis and Evangelia Lambrou, Investigating the orientation of eleven mosques in Greece", *Journal of Astronomical History and Heritage* 12:2 (2009), pp. 159-166.

Miscellania

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.

DAK, "Kibla. Aspects astronomiques", and "Makka. Comme centre du monde", in *Encyclopédie de l'Islam*, Leiden: Brill, 1955-2005.

- , "La science au service de la religion : le cas de l'Islam", *Impact : science et société* (UNESCO, Paris) no. 159 (1991), pp. 283-302 (also available in English and several other languages, but not Arabic; this French version available at <http://unesdoc.unesco.org/images/0008/000885/088535fo.pdf>).

- , "Astronomie et société musulmane : *qibla*, gnomonique, *mîqât*", in Rushdi Rashed, ed., in collaboration with Régis Morelon, *Histoire des sciences arabes*, 3 vols., Paris: Éditions du Seuil, 1997, I, pp. 173-215.

- , "Astronomie im Dienste des Islam", in Anton von Gotstedter, ed., *Ad radices – Festband zum fünfzigjährigen Bestehen des Instituts für Geschichte der Naturwissenschaften Frankfurt am Main*, Stuttgart: Franz Steiner, 1994, pp. 99-124.
- , "Astronomie und Mathematik als Gottesdienst: Das Beispiel Islam", in Jochen Brüning and Eberhard Knobloch, eds., *Die mathematischen Wurzeln der Kultur – Mathematische Innovationen und ihre kulturellen Folgen*, Munich: Wilhelm Fink, 2005, pp. 91-123.
- , "La scienza al servizio della religione: il caso dell'Islâm", in Clelia Sarnelli Cerqua, & Ornella Marra & Pier Giovanni Pelfer, eds., *La civiltà islamica e le scienze, Atti del Simposio Internazionale, Firenze, Palazzo Panciatichi, 23 Novembre 1991*, Florence: CUEN, 1995, pp. 129-150.
- , قبله یابی در اسلام , *Finding Qibla in Islam*, translated into Persian by Hossein Nahid, Tehran, 1379 HS, 90 pp.

Miscellaneous non-historical writings

- Mohammad Ilyas, *A Modern Guide to astronomical calculations of Islamic calendar, times & qibla*, Kuala Lumpur: Berita Publishing, 1984, pp. 169-174.
- , "Qibla and Islamic prayer times", in: Helaine Selin, ed., *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*, Dordrecht: Kluwer, 1997, pp. 834-836.
- Denis Roegel, "An extension of al-Khalilî's qibla table to the entire world", *HAL archives ouvertes.fr* (research report) 2008, pp. 1-779, at <inria-00336090>. (Why?)
- Waldo Tobler, "Qibla, and related, map projections", *Cartography and Geographic Information Science* 29 (2002), pp. 17-23.
- S. Kamal Abdali, "The Correct Qibla" (1997), available at <http://nurlu.narod.ru/qibla.pdf> (accessed 2018). (Deals mainly with the dichotomy on the *qibla* in North America between those Muslims who favour south-east and those who favour south-west. Weak on historical matters and on relevant bibliography.)

Enter the revisionists

Note: Recent works which investigate historical mosque orientations using **MODERN** directions of Mecca inevitably come up with false conclusions. Here two examples.

Dan Gibson and the aftermath

- Dan Gibson, *Qur'ânic Geography: a survey and evaluation of the geographical references in the Qur'ân with suggested solutions for various problems and issues*, Saskatoon, Canada: Independent Scholars Press, 2011 (several reviewers, none informed about orientations).
- , *Early Islamic Qiblas: A Survey of mosques built between 1AH/622 C.E. and 263 AH/876 C.E. (with maps, charts and photographs)*, 296 pp., Vancouver BC: Independent Scholars Press, 2017 (several reviewers, none informed about orientations).
- DAK, "From Petra back to Mecca – From *pibla* back to *qibla*" (2017), available at www.davidaking.academia.edu, also www.muslimheritage.com/article/from-petra-back-to-makka (critique of Gibson, *Early Islamic Qiblas*).
- Gibson's responses in 2017 to King: www.researchgate.net/publication/321708416, also www.academia.edu/34514746/.

Édouard-Marie Gallez's critique (2017): "King et Khan : Crone et Cook ont-ils renié leur travail ?", at www.academia.edu/35454474/

DAK reply to Père Gallez: "Gibson & Gallez - False *piblas* and fake *calumnias* - Did the elusive "Judéo-Nazaréens" use astrolabes to negotiate the narrow Siq of Petra?" at davidaking.academia.edu, currently (2018) at www.academia.edu/35868755/.

Rick Oakes, "Evaluation of Dr David King's book review of Dan Gibson "Early Islamic Qiblas"" (2018), available at www.academia.edu/37676717/.

Gibson, "Comparing two qibla theories" (2018), at <http://thesacredcity.ca/Comparing%20Two%20Qibla%20Theories.pdf>.

- , "Qibla Tool" (2018), available at <http://thesacredcity.ca/data/index.html>.

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