Qibla Maps

I have recently become interested in this subject after reading a book by David A. King

Qibla, in Arabic, asks for the geographic direction to the “cube”, or Ka’ba, in Mecca
Mecca in Western Saudi Arabia
The objective of al Hajj is the Ka’ba

The holy pilgrimage to Mecca is known as the Hajj. The Ka’ba is contained within a Mosque in Mecca. The building is forty by thirty-five feet in size, fifty feet high, covered with a new Egyptian cloth every year.

One history is it was earlier a sanctuary of a pagan God. Another that the building was constructed by Abraham & his son Ismail.
The Ka’ba in Mecca
The Need for Directional Information

The Muslim is expected to prostrate towards the Ka’ba when praying, five times a day.

Mosques are also expected to face Mecca.

There are other rules, like being buried with ones head in the direction of Mecca, do not expectorate or relieve nature towards Mecca, etc.

All of these activities require knowledge of the Qibla.
So what direction is it from here?
Ways of discovering the Qibla

Measure on a globe

Calculate using a formula

Use a map
Measure using a string on a globe
Calculate using a formula

\[ \cot q = \frac{(\sin \varphi \cos \Delta \lambda - \tan \varphi_0 \cos \varphi)}{\sin \Delta \lambda} \]

\( \varphi \) is latitude, \( \varphi_0 \) is latitude of Mecca
\( \Delta \lambda \) is \( \lambda - \lambda_0 \), \( \lambda_0 \) is longitude of Mecca
$Q$ as a function of latitude and longitude between 10N - 50N and 20W - 100E
Or use a map.
World map centered on Mecca
Directions and distances From Mecca are correct
Directions FROM Mecca are correct
Retro-azimuthal for Mecca

Instead of directions from Mecca

We want directions to Mecca
Given the circular appearance of the azimuthal map projection with direction **FROM** Mecca, we expect a somewhat similar looking circular map with Mecca at the center when requiring directions be **TO** Mecca.

Sorry! It is radically different
James Craig of the Survey of Egypt introduced the class of retro-azimuthal map projections in 1910.

A unique feature of Craig’s projection is that the meridians are equally spaced straight lines perpendicular to the base. The parallels of latitude must be made concave down to make the projection show correct directions to the center. As a consequence they converge and thus the map’s extent must be limited.
Craig’s Retro-Azimuthal Map
(squint at it)
Craig’s Retro-Azimuthal Map
Centered on Mecca
Expanded to the whole world this is Craig’s retro-azimuthal map.
Here it is without the graticule.
Changing the latitude of the center changes the map.
Here the center is near the Equator
This is not the end of the story

Just as there are many azimuthal projections: orthographic, equal area, equidistant, conformal, gnomonic, etc.

There can be many retro-azimuthal projections.

The most useful seems to be the equidistant retro-azimuthal, first described by Hammer in 1910 immediately after Craig’s publication.
Hammer’s Retro-Azimuthal Map

Shows both directions and distances to Mecca. Observe that the parallels are again concave down, with the same consequence as before.

The meridians are no longer straight. When restricted to a small area the map does not appear excessively strange. The strangeness again appears when the entire earth is depicted.
Equidistant Retro-Azimuthal Centered at Mecca. It covers only the principal Muslim countries (60 degrees in longitudinal extent from the center).
Map of the world centered on Mecca
The same with the graticule.
Changing the center modifies the hole and the overlap.
Here is the new graticule.

Hammer Retroazimuthal
Another strange map

I have also invented a retro-azimuthal projection.
A new retro-azimuthal projection.

Direction to Mecca: Left to Right. Distance: Down.

Mecca Is the line across the top.

Find your location then measure from the left edge to get the direction. Measure up for distance.
The Graticule showing the hole and the overlap.
Distance-direction diagram from Los Angeles
Los Angeles across top, Distance down, Direction left to right
The graticule to accompany the previous map
Another method

The direction to Mecca can also be shown as lines of equal direction on a map.

Courtesy of Professor Jon Kimerling of Oregon State University at Corvallis
Lines of Equal Direction to Mecca
Mercator Projection

MAKKAH PRAYER CHART

CHART USE
Angle from parallel to
direction line is the
direction from east to
pray to Makkah
Or Use The Stereographic projection

Center near Mecca

Great circles from & to Mecca are straight lines. Local angles are preserved.
Distance rings about the center (Mecca) remain circles.
On The Stereographic Projection
To get the direction to Mecca.
Draw a straight line to the center and measure the angle with respect to the meridian.
Here Is A New Azimuthal Projection

A novel azimuthal projection can be designed using Craig’s suggested parallel equidistant meridians.

Back to the Arab World

The previous materials all stem from the twentieth century.

The Arabs are known for their skill in engraving astronomical instruments such as an astrolabe.

An example is shown on the next slide.
Astrolabe by al-Khujandi of Baghdad, A.D. 985
Arab scholars had an interest in astronomical subjects.

Consequently they had solved the Qibla problem analytically as early as the tenth century. That is, they knew the equation for the Qibla and constructed tables of the direction to Mecca for the Muslim world.
An extract of a Qibla table from circa A.D. 1360.
Previously only tables and treatises were extant, no maps.

In 1989 a map-like instrument from circa A.D. 1700 was discovered.
The Brass Qibla instrument

Diameter 22.5 cm. (~9 inches).
It is missing the compass, and probably a sundial.
Estimated to have been made in Iran about A.D. 1700.
Centered on Mecca and indicates the Qibla to that city.
The coverage is from 10 N to 50 N and 60 degrees on either side of Mecca.
A remarkable demonstration of Arabic skill in mathematics as well as engraving.
The map projection resembles that of Craig from 1910.
Sold at auction in London in June of 2000 for $70,500.
A second, similar, instrument was discovered in 1995.
The Iranian Qibla Instrument Found in 1989
Some details

The cells are two degrees by two degrees.
Cities are shown by circular dots with their names.
Coastlines are not indicated.
The qibla can be read from the markings at the edge of the upper latitude.
The distance rule is graduated according to the sine of the spherical distance.
The meridians are parallel straight lines perpendicular to the base latitude and spaced according to the sine of the difference in longitude, modulated by the cosine of the center latitude.
The parallels should be elliptic curves that converge at 90°. Thus a world map again looks strange, with an overlap.
Detail of the Qibla Instrument
Better detail
The second instrument, found in 1995
The second instrument with sundial removed
Some References


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California Map Society, Jan 20, 2001

http://www.geog.ucsb.edu/~tobler
http://www.geog.ucsb.edu/~tobler

Publications (78 reprints at last count)

Reference to autobiography (in English and French)

Recent power point presentations on
  Map projections, Migration, etc.
  The world is shriveling as it shrinks
  Exploring geography cartographically
  The care and feeding of vector fields
  and so on.