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

 $\cot q = (\sin \phi \cos \Delta \lambda - \tan \phi_0 \cos \phi) / \sin \Delta \lambda$

φ is latitude, $φ_o$ is latitude of Mecca Δλ is λ - λ₀, λ_o 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 retroazimuthal 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.



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



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.

James I. Craig, *Map Projections*, 1910, Cairo, Ministry of Finance.



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

بالمناعض المغض الم	الناعض فحق لطعن ا
	The It I was
المنظر معرفة بالعديد ومدكو عدم هو واعجيب	حقور صوب لد جرير جرو فا طود د م عطر
الم الحاصة مع العام عن المربع الم	ط فله لط صفرة بل فا ند فد نه عط ب فد ج عر مة
کاللام صداف راهد جر تو به مج د فر مدع مے	ي ديد مايج مد فاج مد جمط ه ده بطعز ج
ازاما جو تو له عدب فر له عب الح بدع ٣	يا علم مجودك حف ك ذك ترع يو فه بو هو ح
مالکہ صب قرب جو اس ملط عن کے ملک ما	بيد تله مي صب مل لب عط له فد لب عز كب فو تل عدي
مجالا مح ما قرب ما قول کے مدسط من قط مز سن لط	جل الكا مج ما فل ند تح مد فد مح عو كه فو ما عد خ
بدانتها مارج ۲۷ مد نج ند مح ۲۷ فط مط سو کب	بد نظمد می مد کنور ن موجوعه که فو زیچ ج
به تط مد فط ج لط سط کب نظ مک سز بد فط مح سه ۲	به تطمه نط قد مه عو لج قو ما عد کا فو له عا نب
اوح موح ط ۲ مح به ط تراسه ند فط < عج له	بوج ا موقح فو ط عد بنافز ن عج بد لح ج ع ع
لا تراس من نظ کا سو با فط کا سدیکہ مح کہ سب ہ	بزور مرفز فو لوعد موفر له عب ه مح لب لعل
ع آبوع فو فط عسد کل مح تر سب سافت مح س فو	تح بولی فو مرجع لد ج مربط اتح ۲
يا ايد ما فد فط لح سو معالم که ساخت فر کا مح مب	بط ^{نه} ط فه فر له عبیط خ در سط فر ط ل سوله
کانیدان مدلح نوسب کرفر نا نط مرفو مرانو بنب	ڪ نيدن قد فن نع نح نح ند سر باذا نظ سدند
کالچ نا بچ کخ کس منه فرح نز کا فو یک ند مخ	کا بح الج في بوسط دن نظ در سويد نظ کا بح ما
کمانیہ ت فن فن نائے سے فورد نہ کہ فد جز نب نہ	الم تسل ف ف مح مع مطفط بخ سد له فط ۲ سا ع
کچ تیا ج فا فریط ہو یا فوج بچ کا فد نو ن مہ	ج قابح فاضط سوب فط مرسب له مح خرط م
لك عدف مد بخ نه ونه كانا ف ف بط مح بز ف مد معط فوي نا هو فد مدمج كالج ما مه مط	کی بے ند ق مط لز سد د فط یک س کج فر نز نز ا
كولخ او مح فد لدخ مب فر بط مد مو في ٢ مح .	کوٹے نوعے فط کونظ کہ تج کھ نہ کج نوب نا نہ
و از ار عز فد ار مد ما في لح سب مو ف ح مرح	پر دستر عربح نزنو کرافر کر نہ کہ تو بوجے کر
مج توح عو فد کسب که ف فالط که فا کو کر ۲	لح قراح عوالح مز لح مك فن مر مع لله الله مر مه لله
ط ته ط عه از مج ج ف يطلو د ف ج ج م	الها * الماعة قر فن معان قو كم مه ما قد م مب
لماند سعد في اله ه فا لدلب فوف طلب تر	ل ندس عد فز مومه ند فه نوما مح فد كالح ن
۲ بجر ما عد فر من في كما عط در فوكا	۲ لا ال الم عوفو ندما كا فه كا لز بد فح سلو ه
ابت معدفا خروج ف ندل تلح ک هد م	للسفيسيعيا فو ڪلو ۽ ذن مو لين بو لي کل
جانا مجاها ف مد کا لز عطح بط مجاعز مح خ ن	لح ال محمد ال د مَد لم کو از مسل کو ز
	لد ق دع فه طلح بخ في لا حَل فا مرتع بز له ه سه سه فد جابو ف ت تج تر فا د يسكو
<u>[2] - () > 1+ 0 0 20 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 </u>	لو ج سو مج في مع اج ح ح ف بط و

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

 D. A .King, 1997, Two Iranian World Maps for Finding the Direction and Distance to Mecca, *Imago Mundi*, 49:62-82 + plate facing page 88.

M. Houstsma, ed., 1927, *Encyclopaedia of Islam*, Leiden, Brill. Articles in volume II on "Hadjdj" (196-201, by Wensinck), "Ka'ba" (584-592, by Wensinck), "Kibla" (985-989, by Schoy).

 W. Tobler, 2002, "Qibla, and related, Map Projections", Cartography & Geographical Information Science, 29 (1):17-23.

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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.