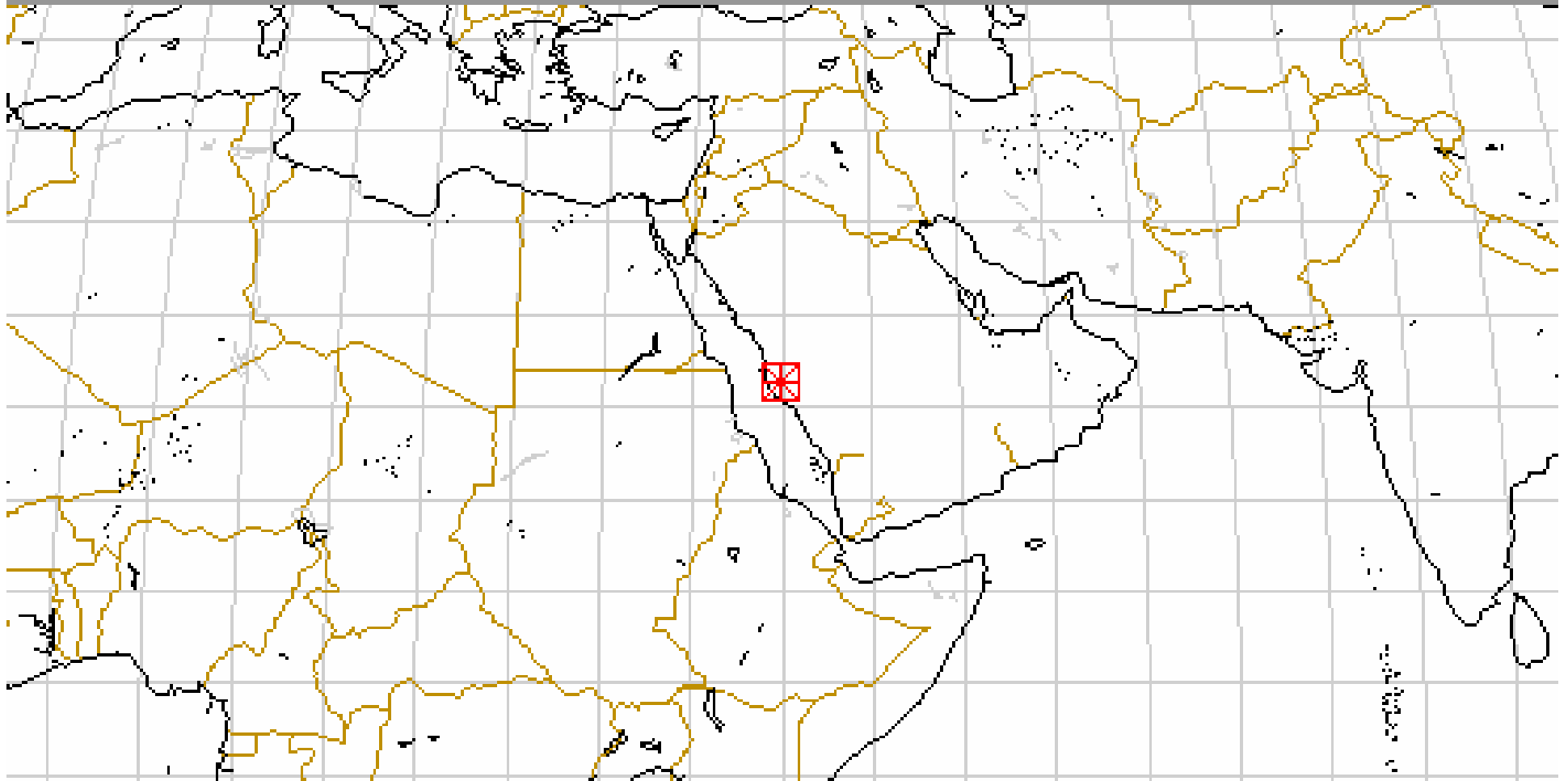# Qibla Maps

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

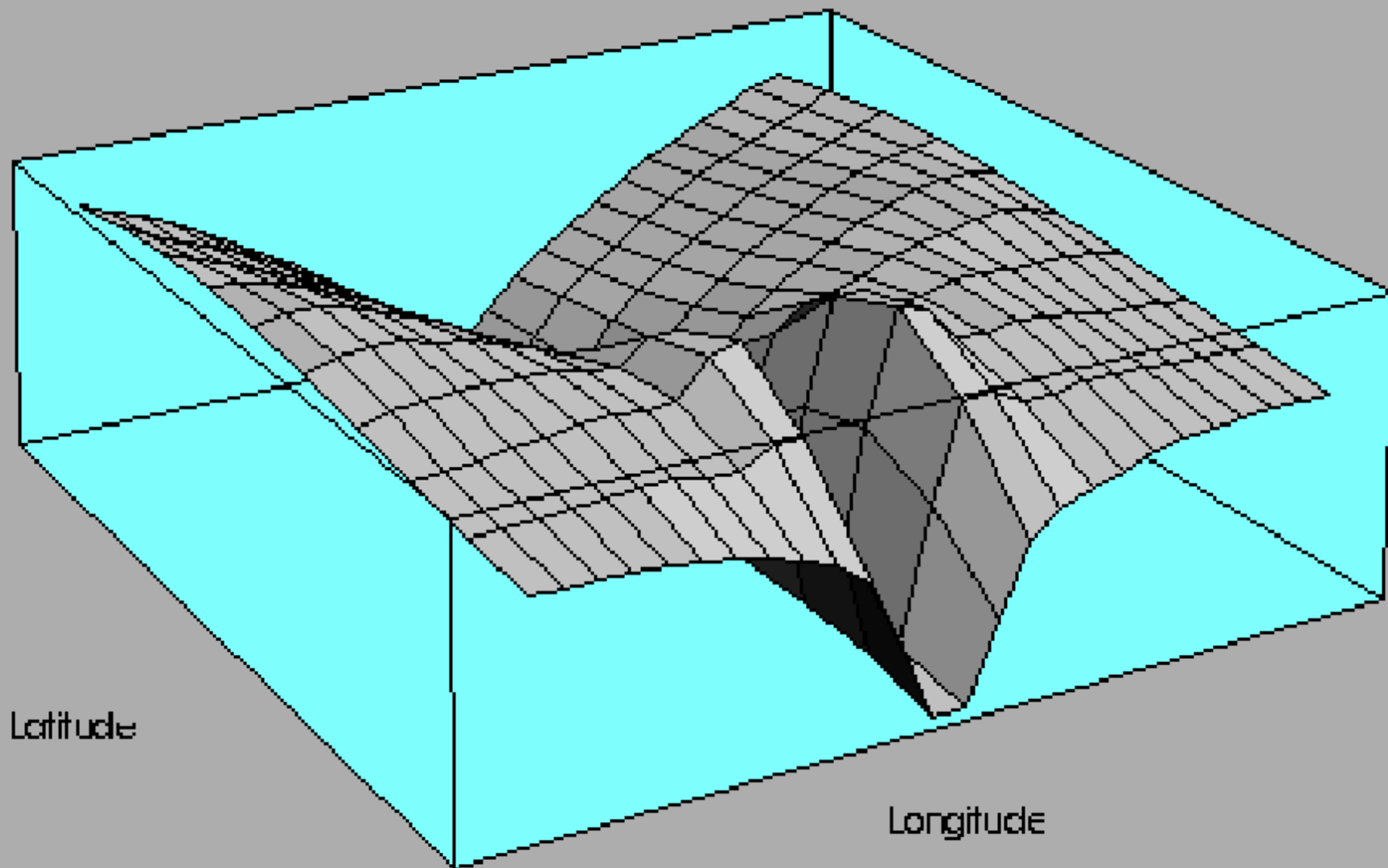Measure on a globe

Calculate using a formula

Use a map

Measure using a string on a globe

Calculate using a formula

$$\cot q = (\sin \varphi \cos \Delta\lambda - \tan \varphi_o \cos \varphi)/\sin \Delta\lambda$$

φ is latitude, φ_o is latitude of Mecca

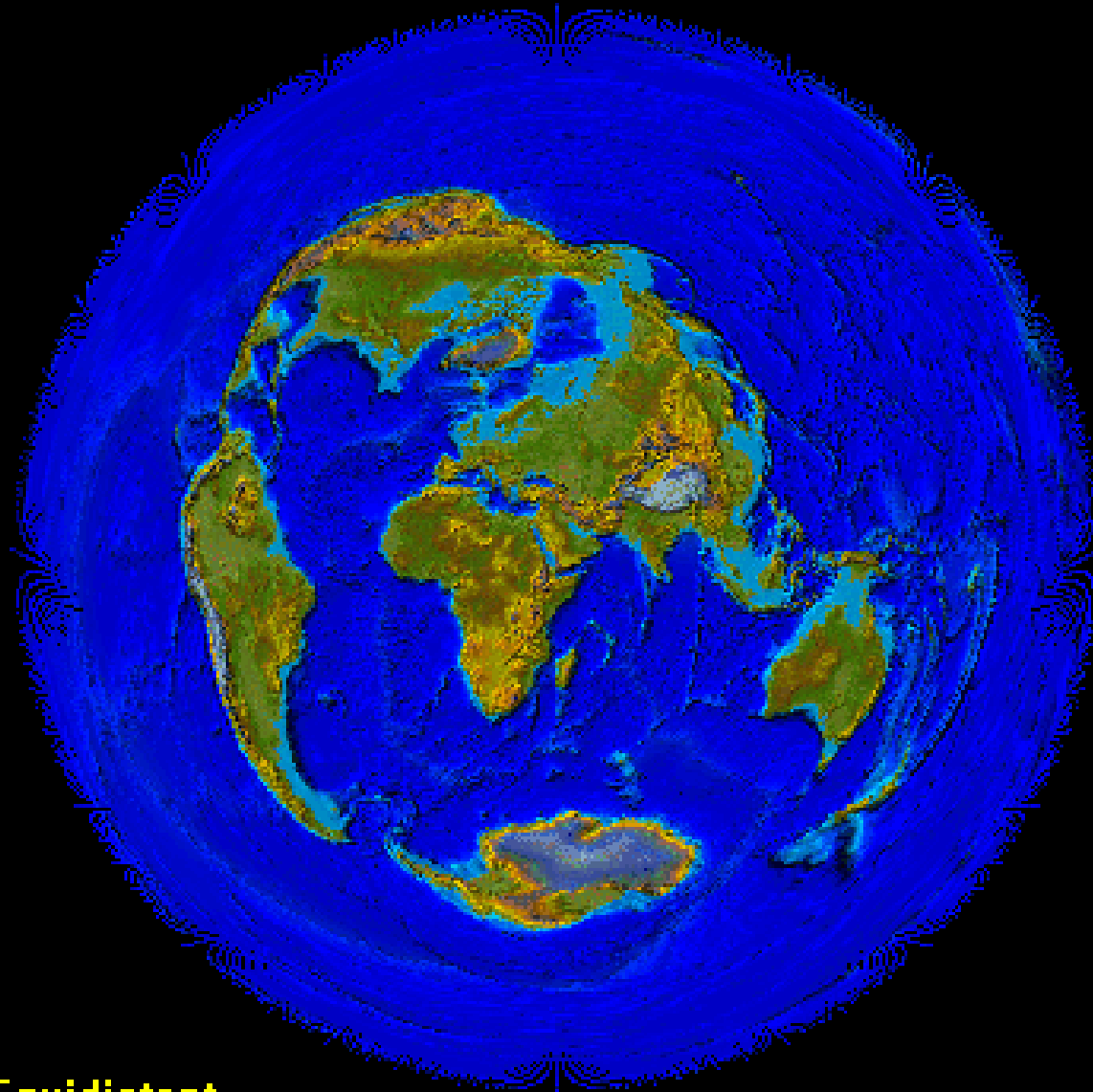$\Delta\lambda$ is $\lambda - \lambda_0$, λ_o is longitude of Mecca

Q as a function of latitude and longitude between 10N - 50N and 20W - 100E
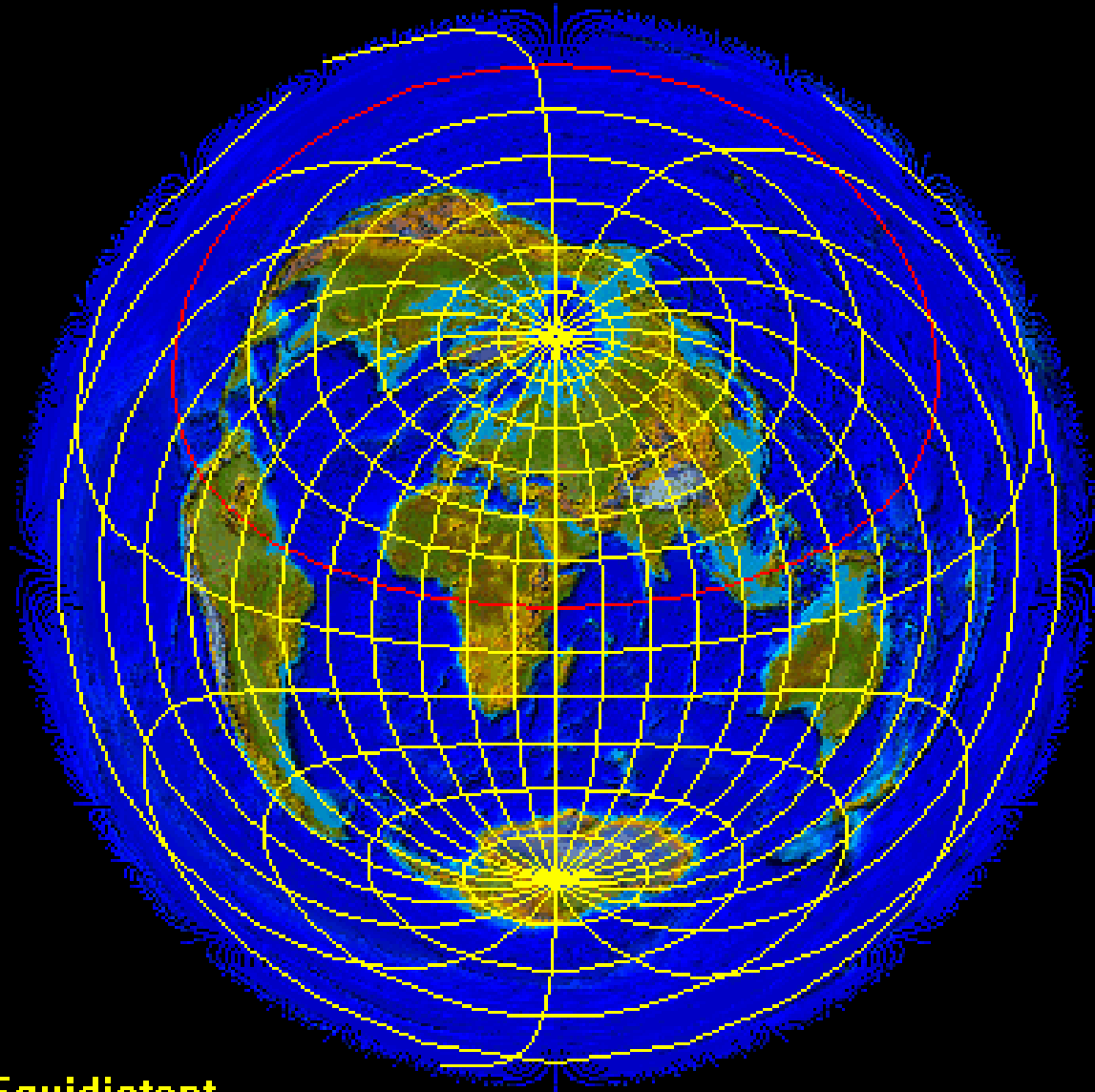
Or use a map.

World map centered on Mecca
Directions and distances From Mecca are correct

Azimuthal Equidistant

Directions FROM Mecca are correct

Azimuthal Equidistant

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.
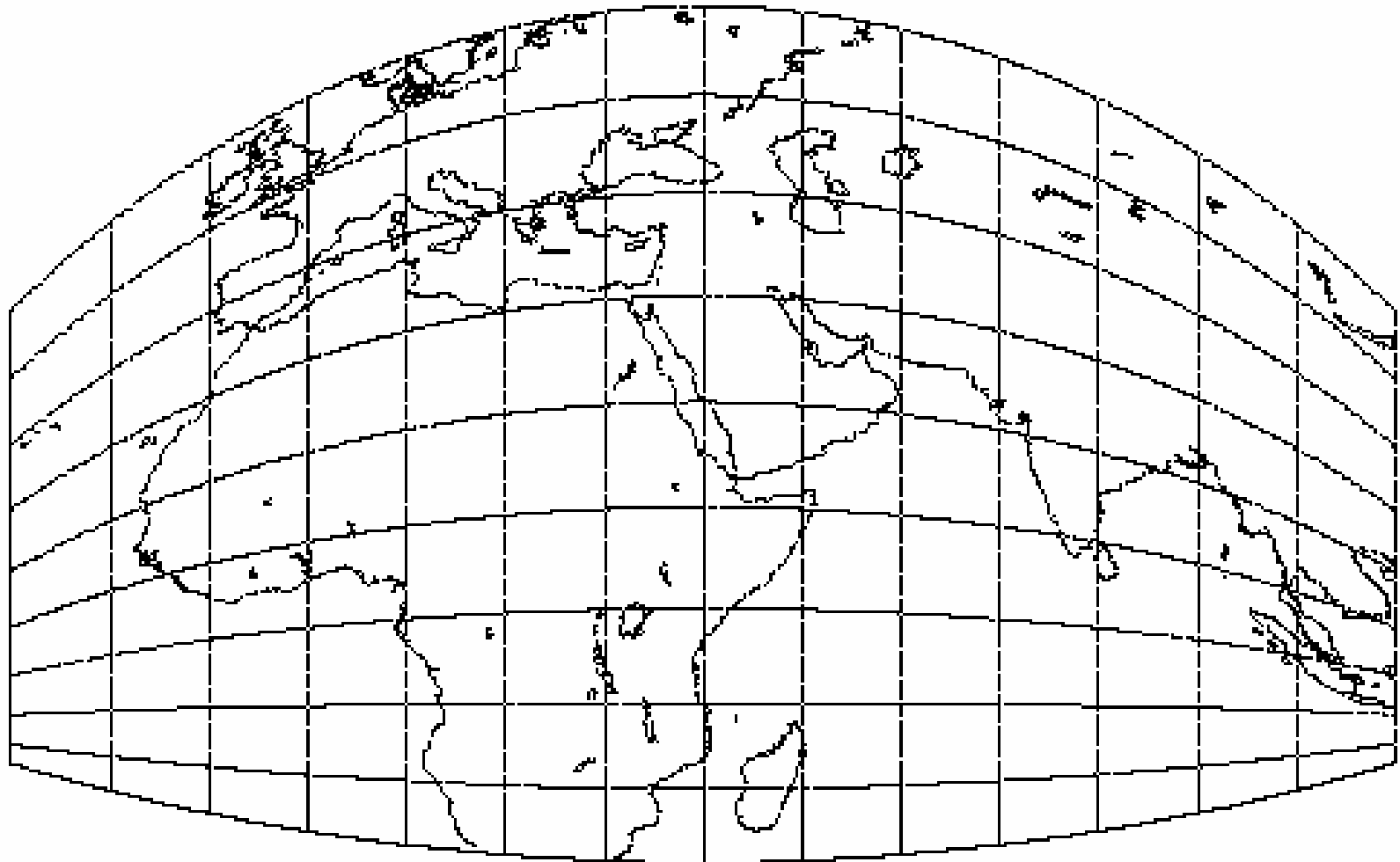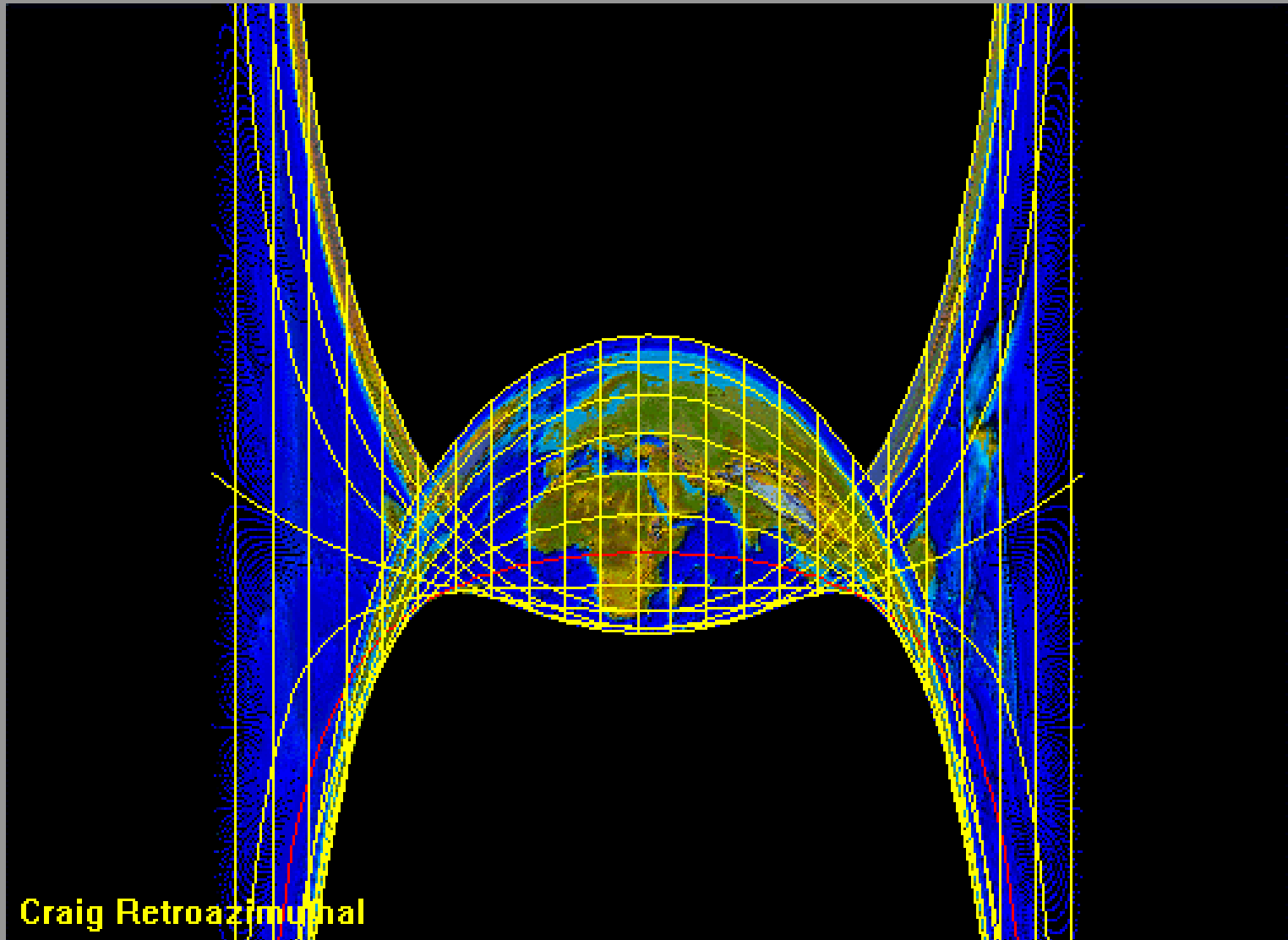
Craig's Retro-Azimuthal Map
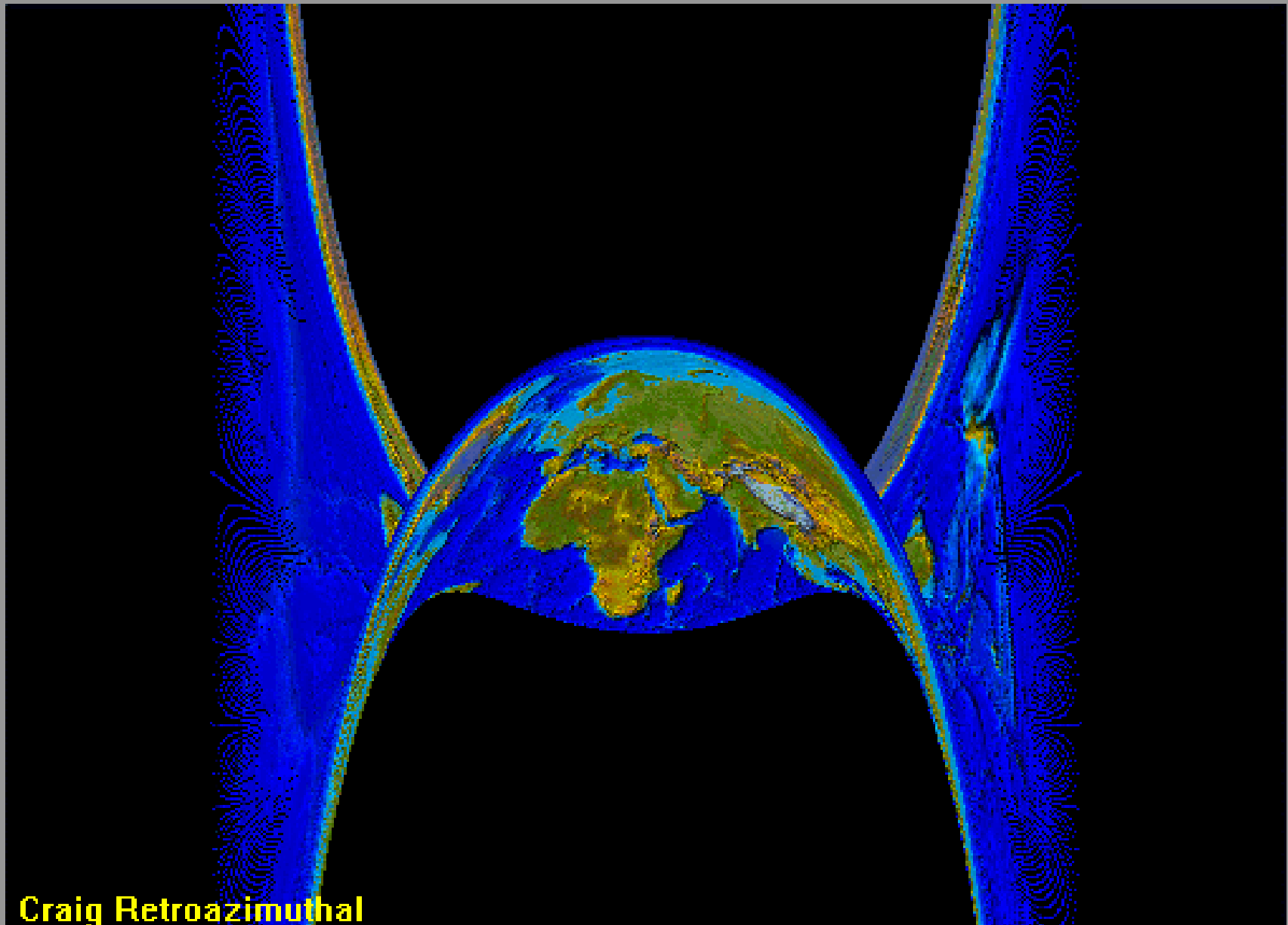
(squint at it)
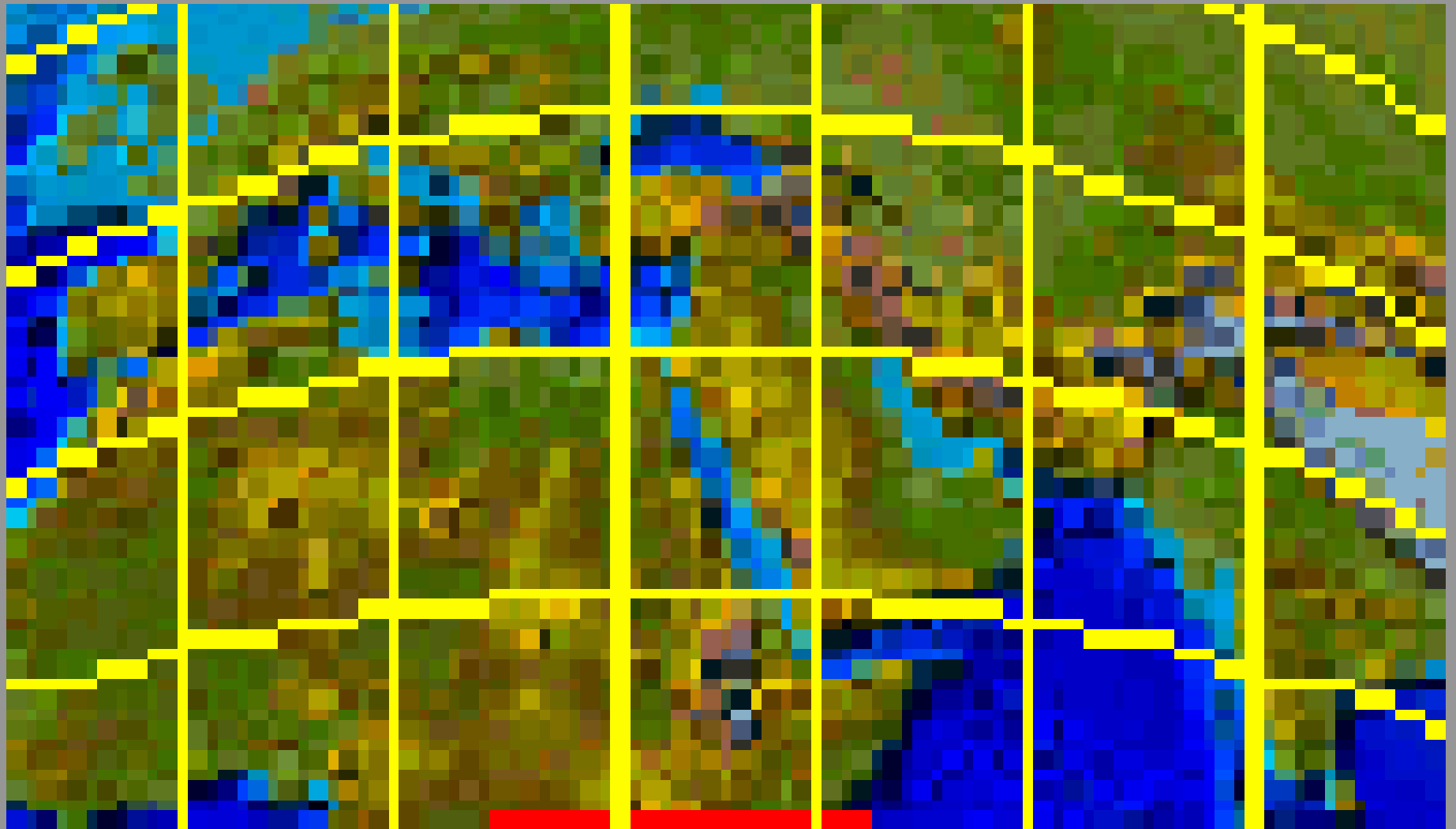
Craig's Retro-Azimuthal Map
Centered on Mecca

Expanded to the whole world this is Craig's retro-azimuthal map.
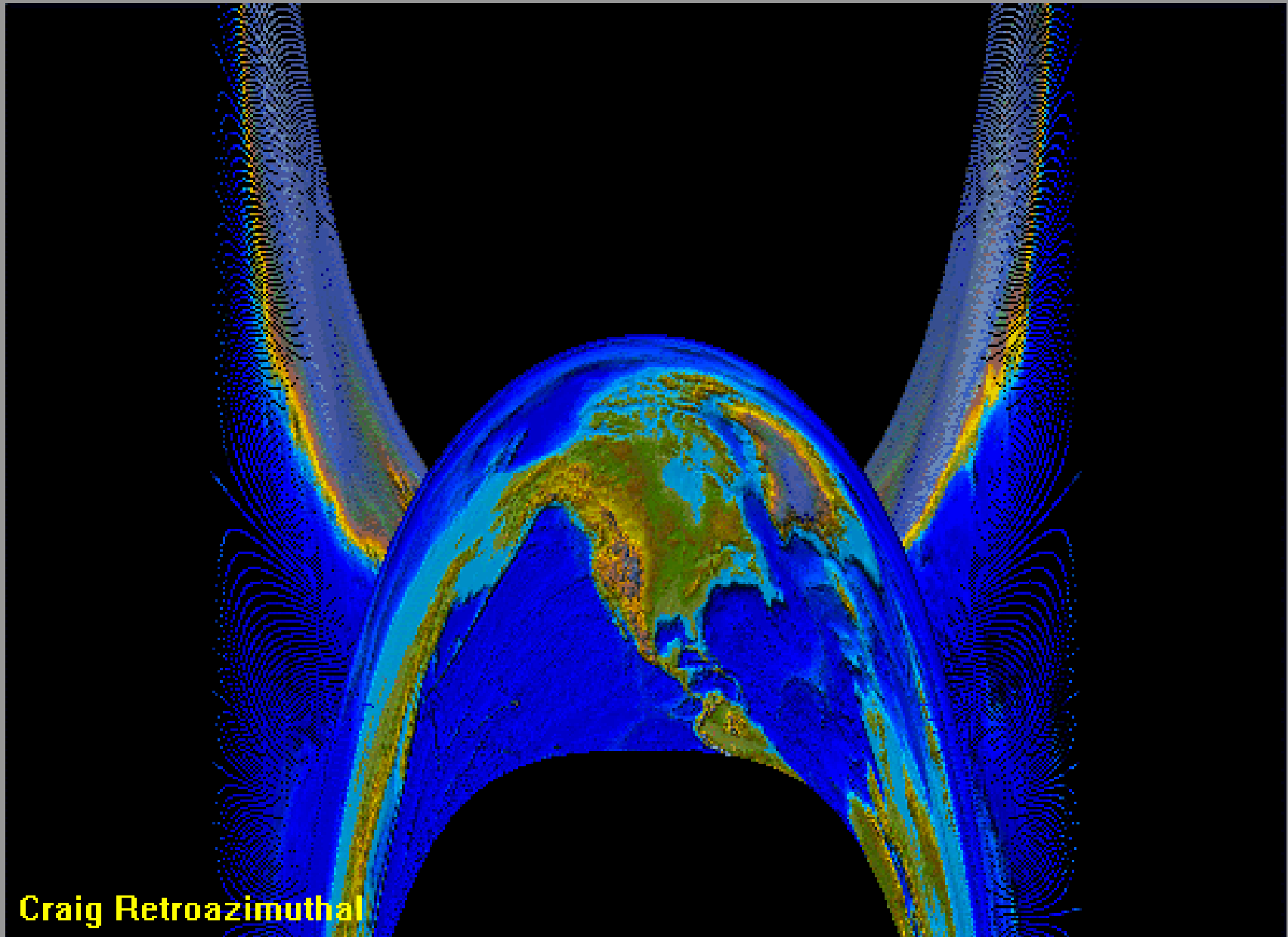

Craig Retroazimuthal
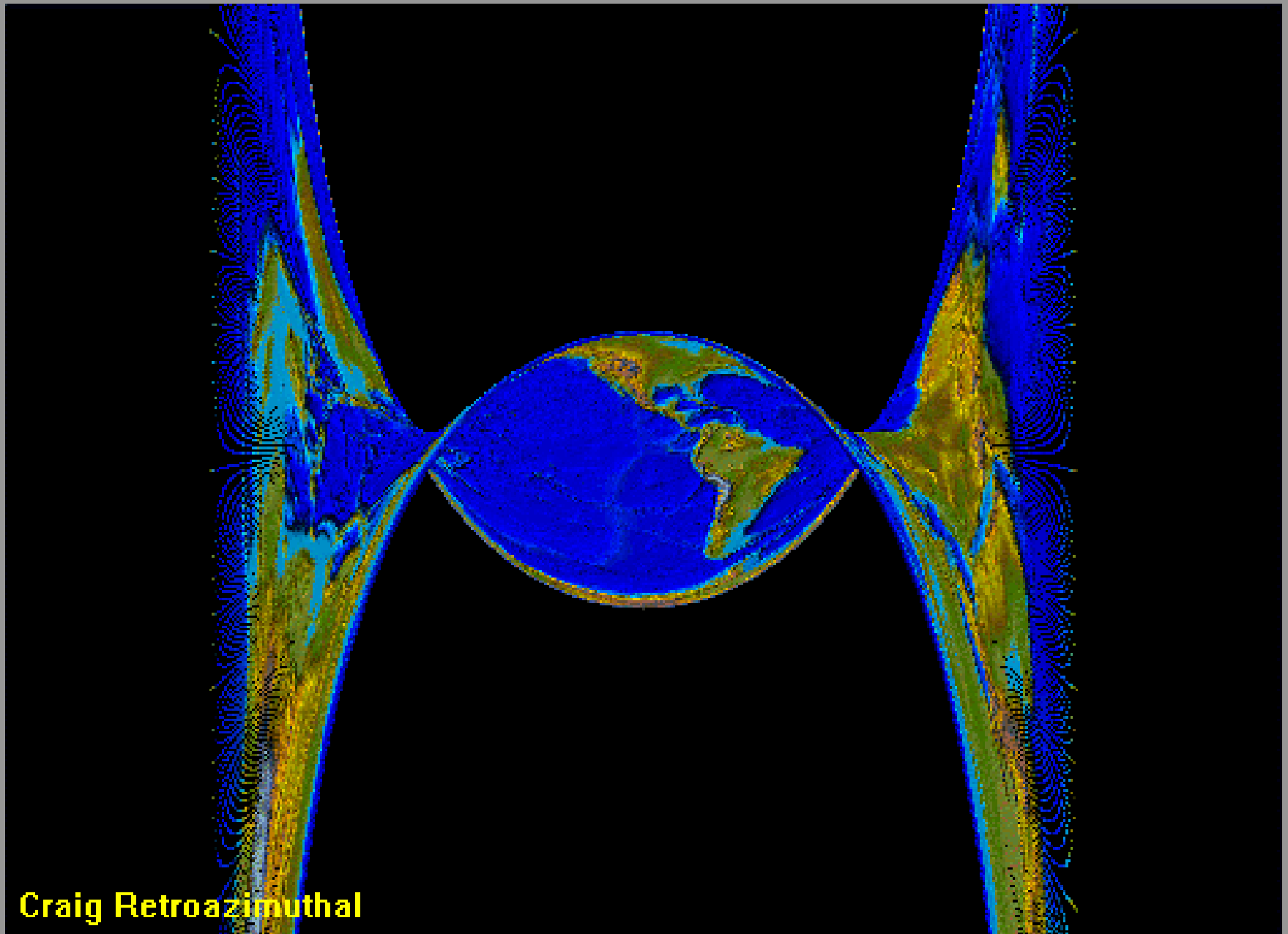
Here it is without the graticule.

Craig Retroazimuthal

Changing the latitude of the center changes the map.

Craig Retroazimuthal

Here the center is near the Equator

Craig Retroazimuthal

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.
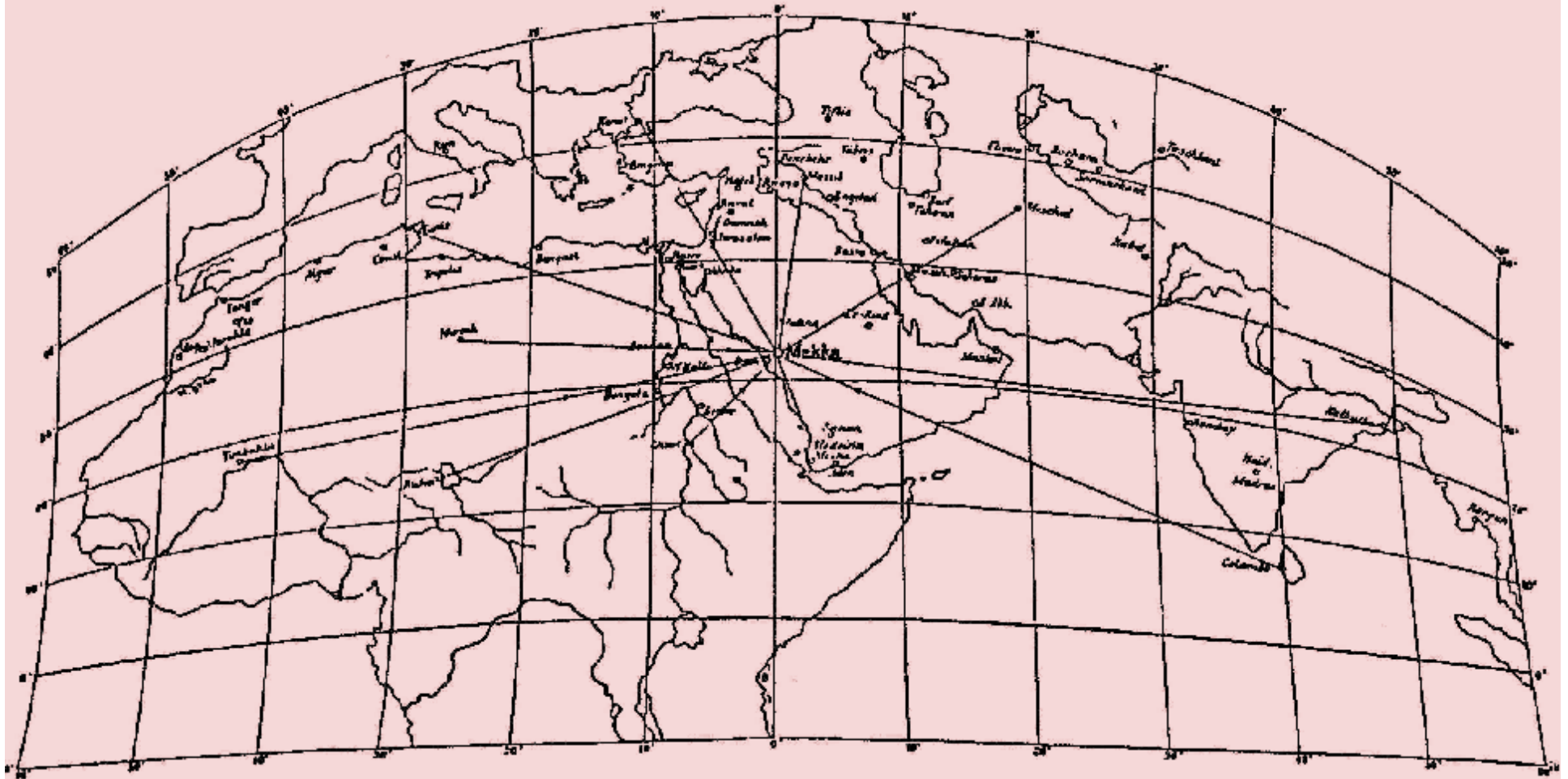
Hammer's Retro-Azimuthal Map

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
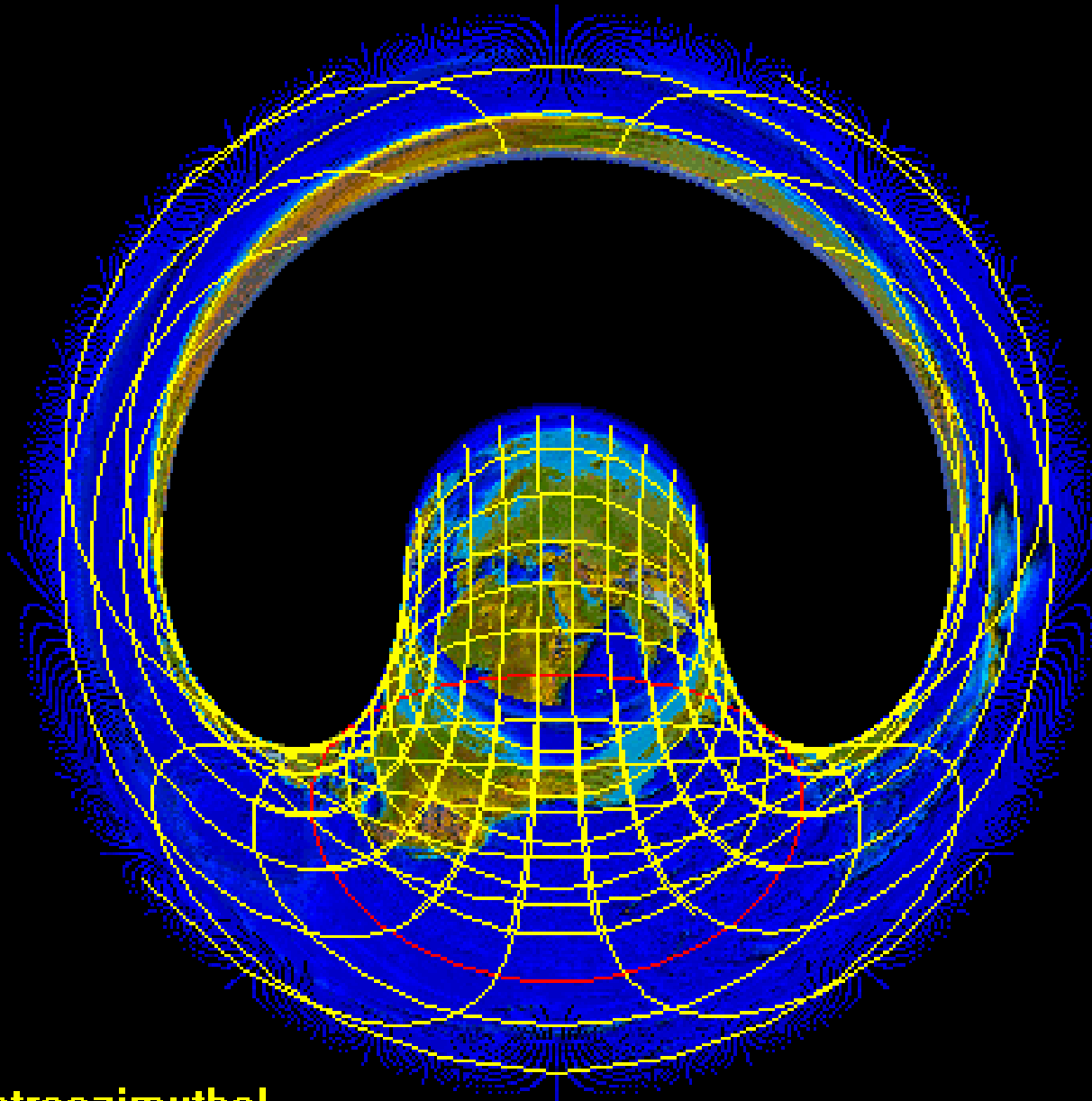degrees in longitudinal extent from the center).
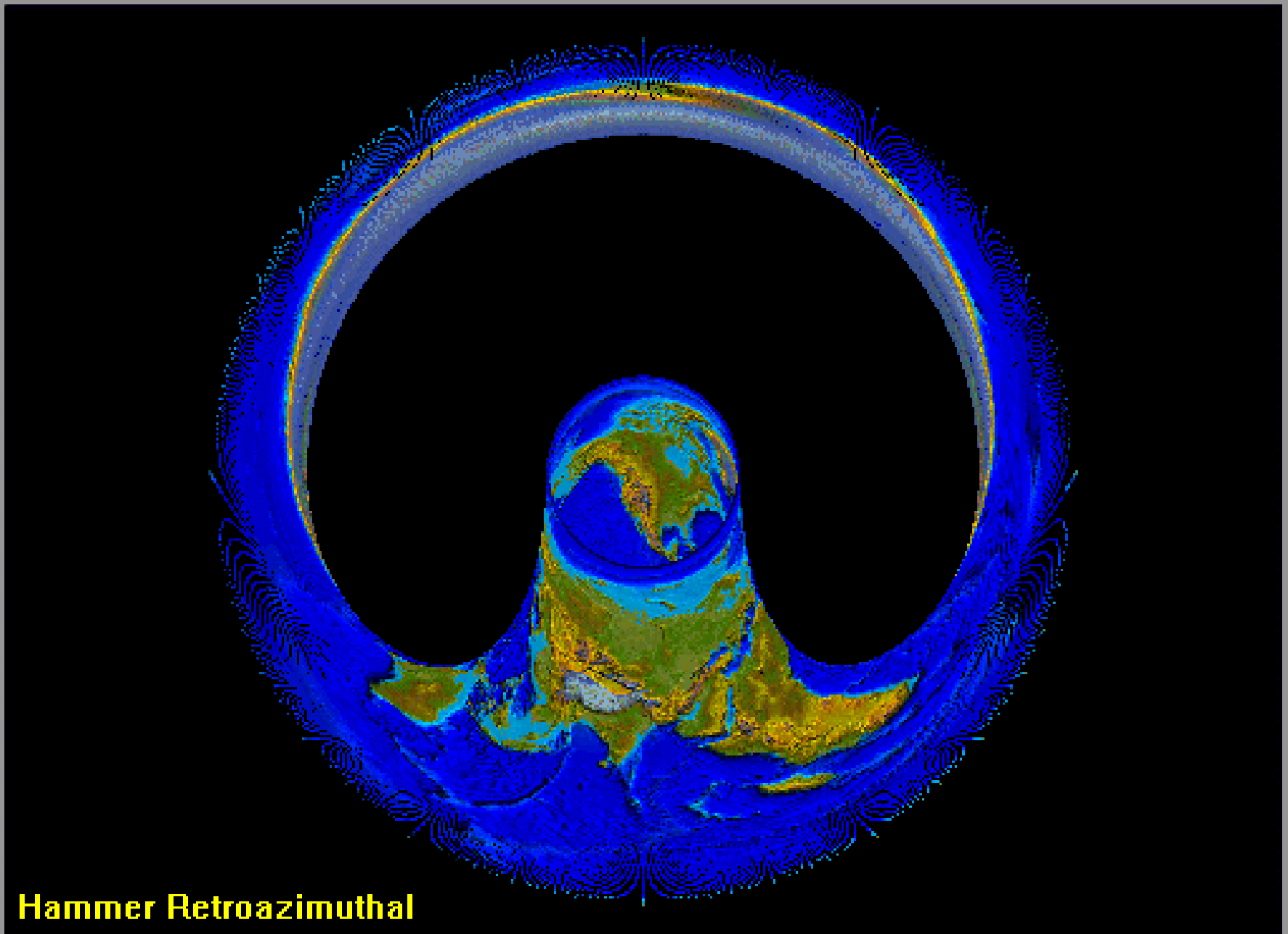
Map of the world centered on Mecca
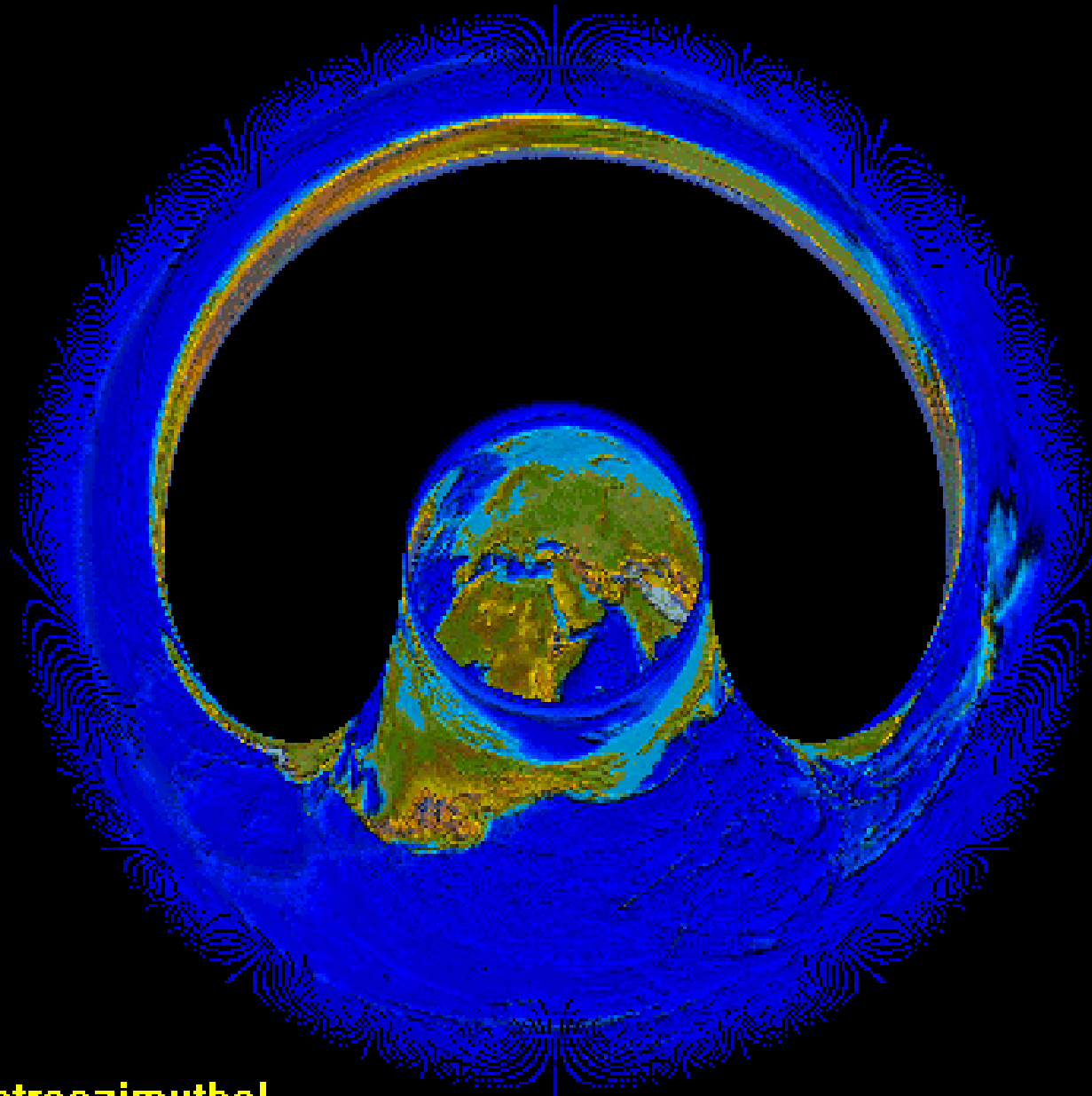
Hammer Retroazimuthal
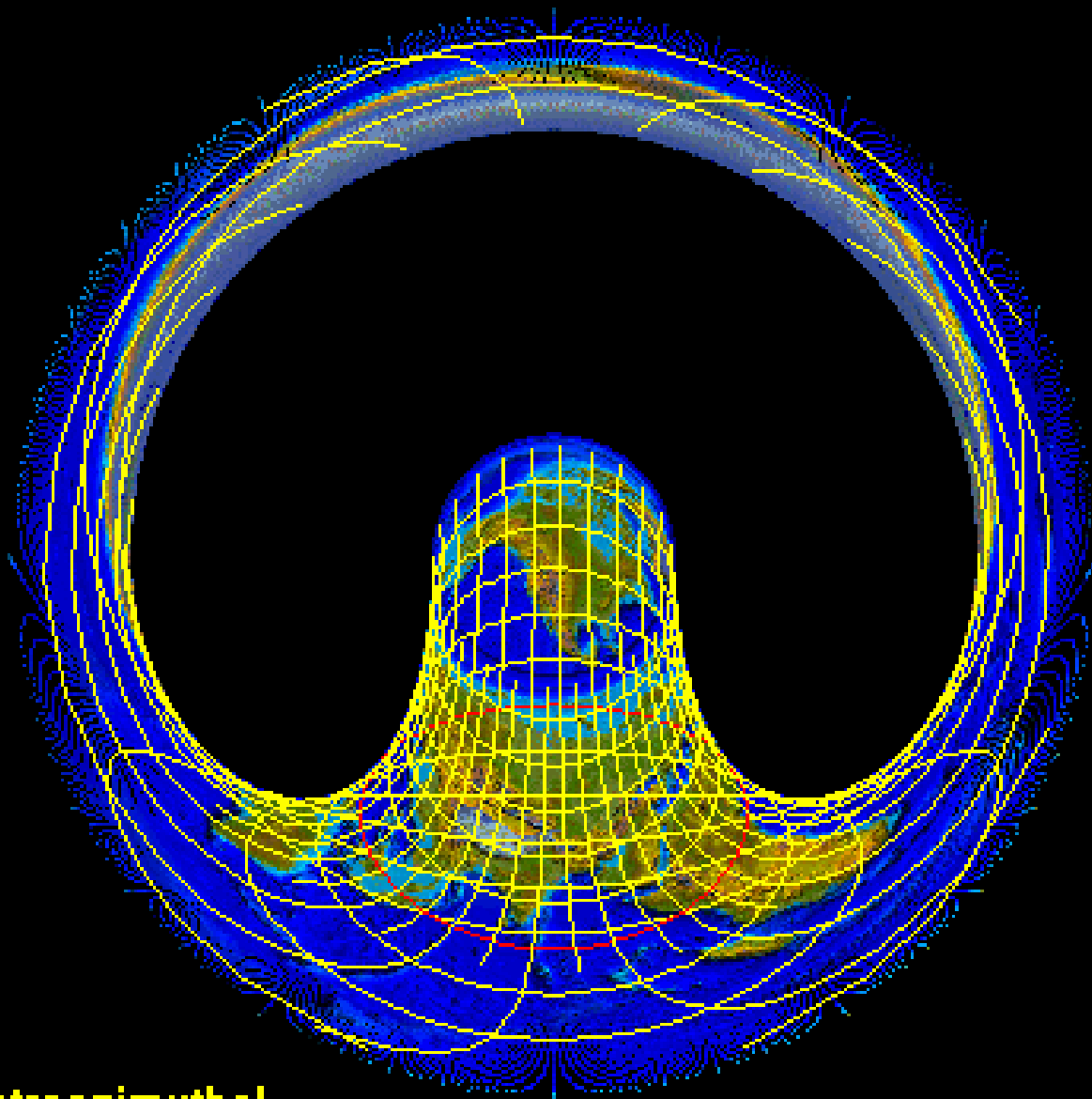
The same with the graticule.

Hammer Retroazimuthal

Changing the center modifies the hole and the overlap.

Hammer Retroazimuthal

Here is the new graticule.

Hammer Retroazimuthal

Another strange map
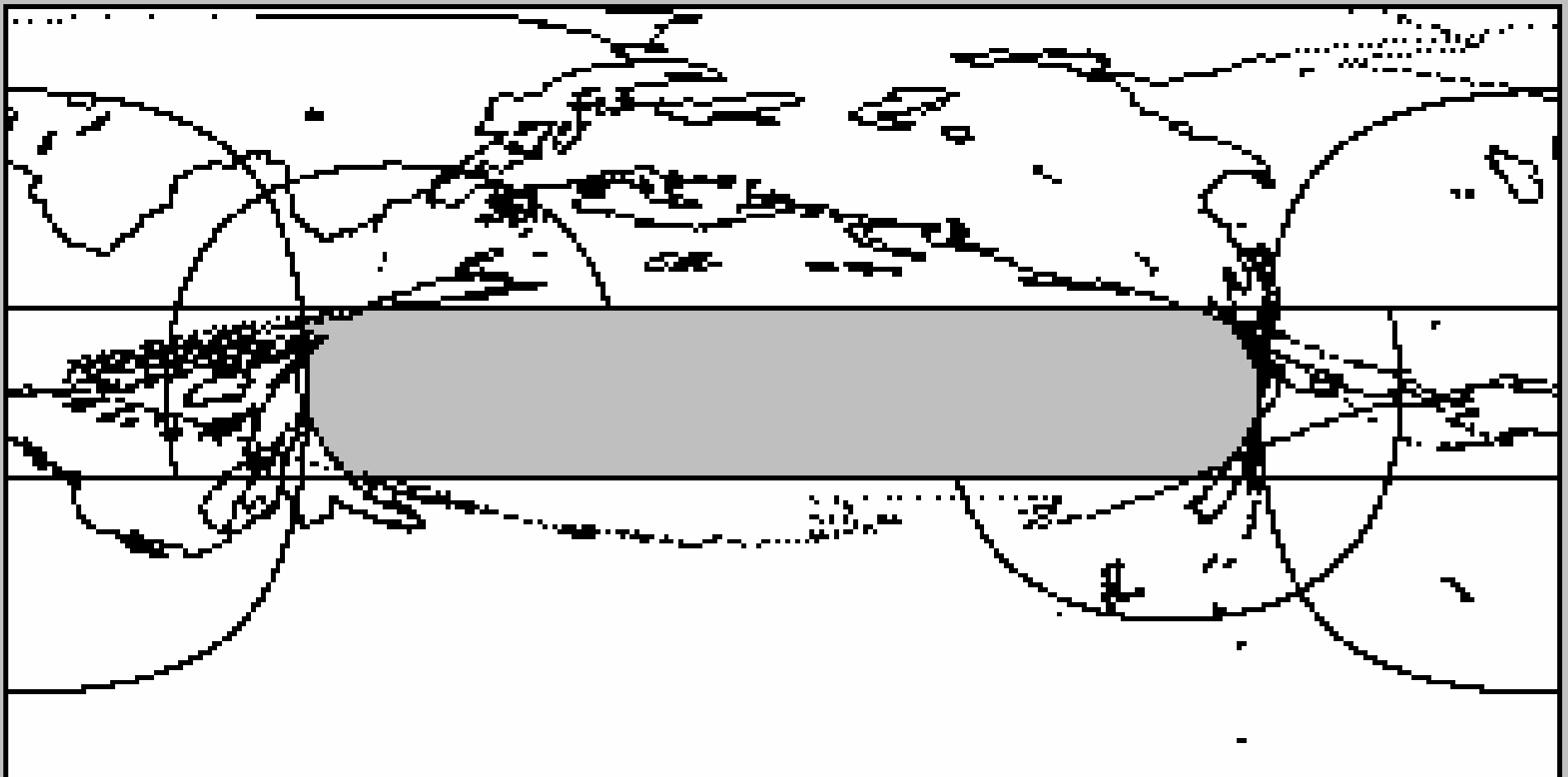
I have also invented a retro-azimuthal projection.

A new retro-azimuthal projection.
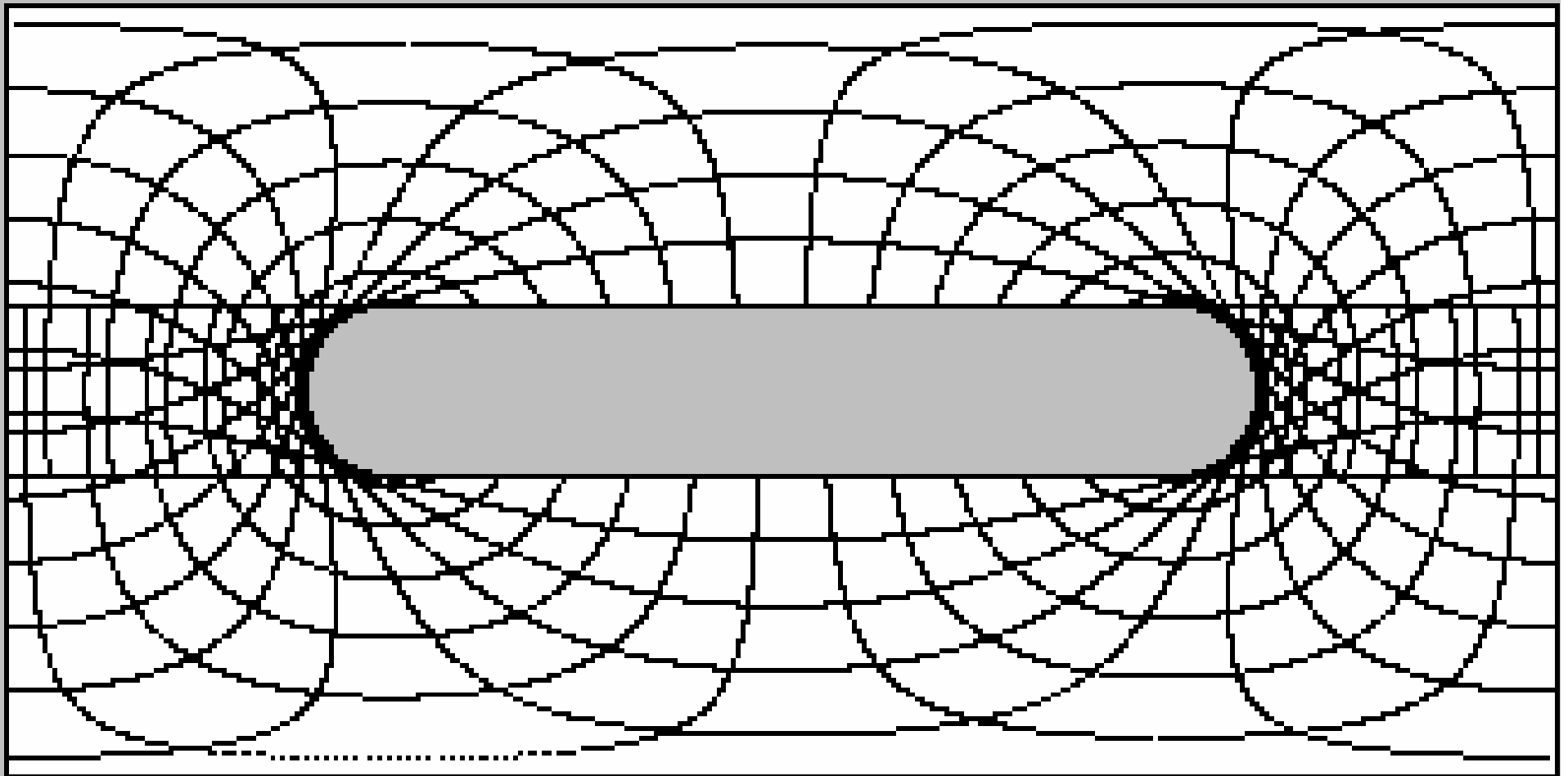## Direction **to** Mecca: Left to Right. Distance: Down.

Mecca Is the line across the top.

Find your location then measure from the left edge to get the direction. Measure up for distance.
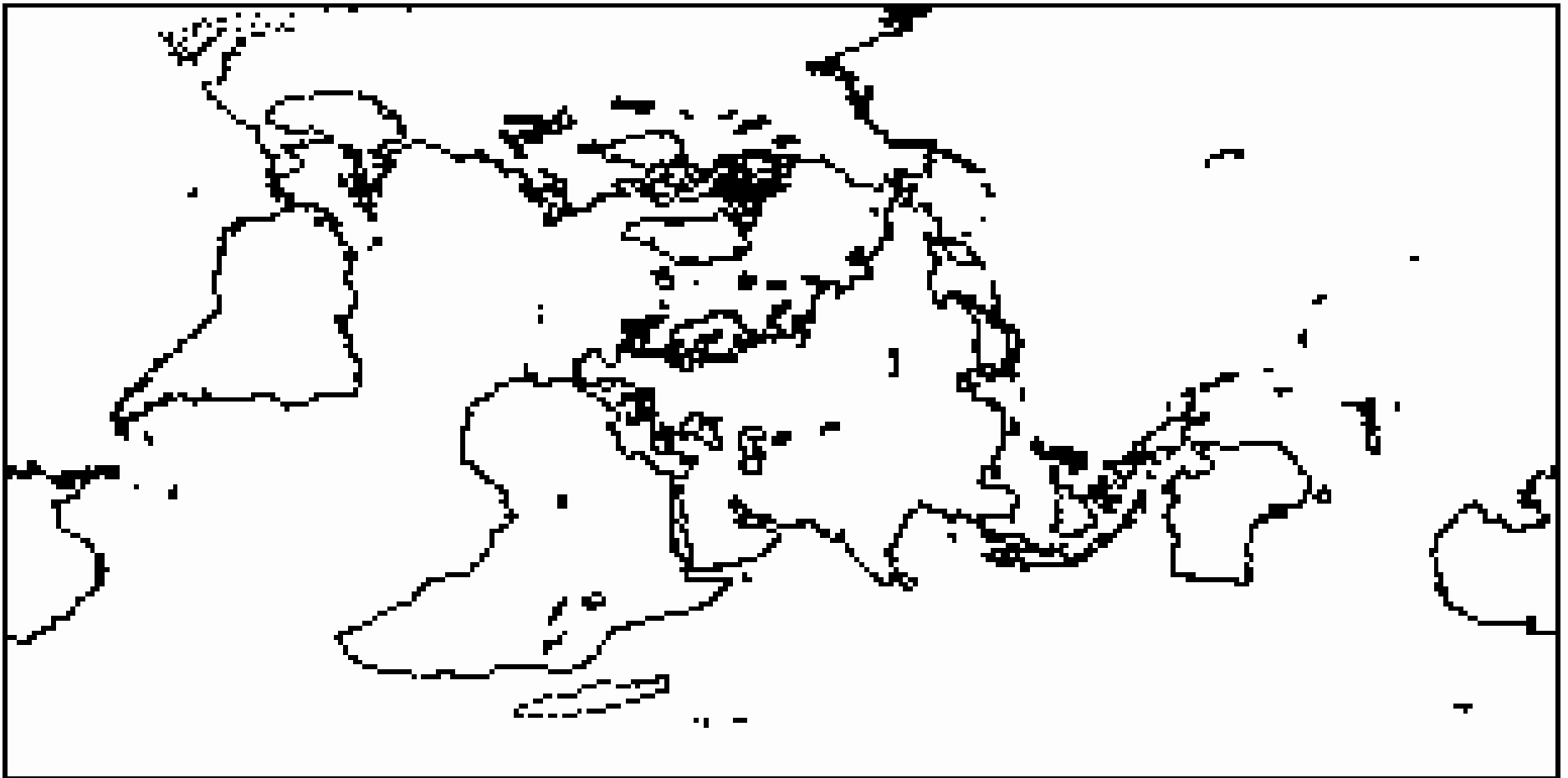
The Graticule
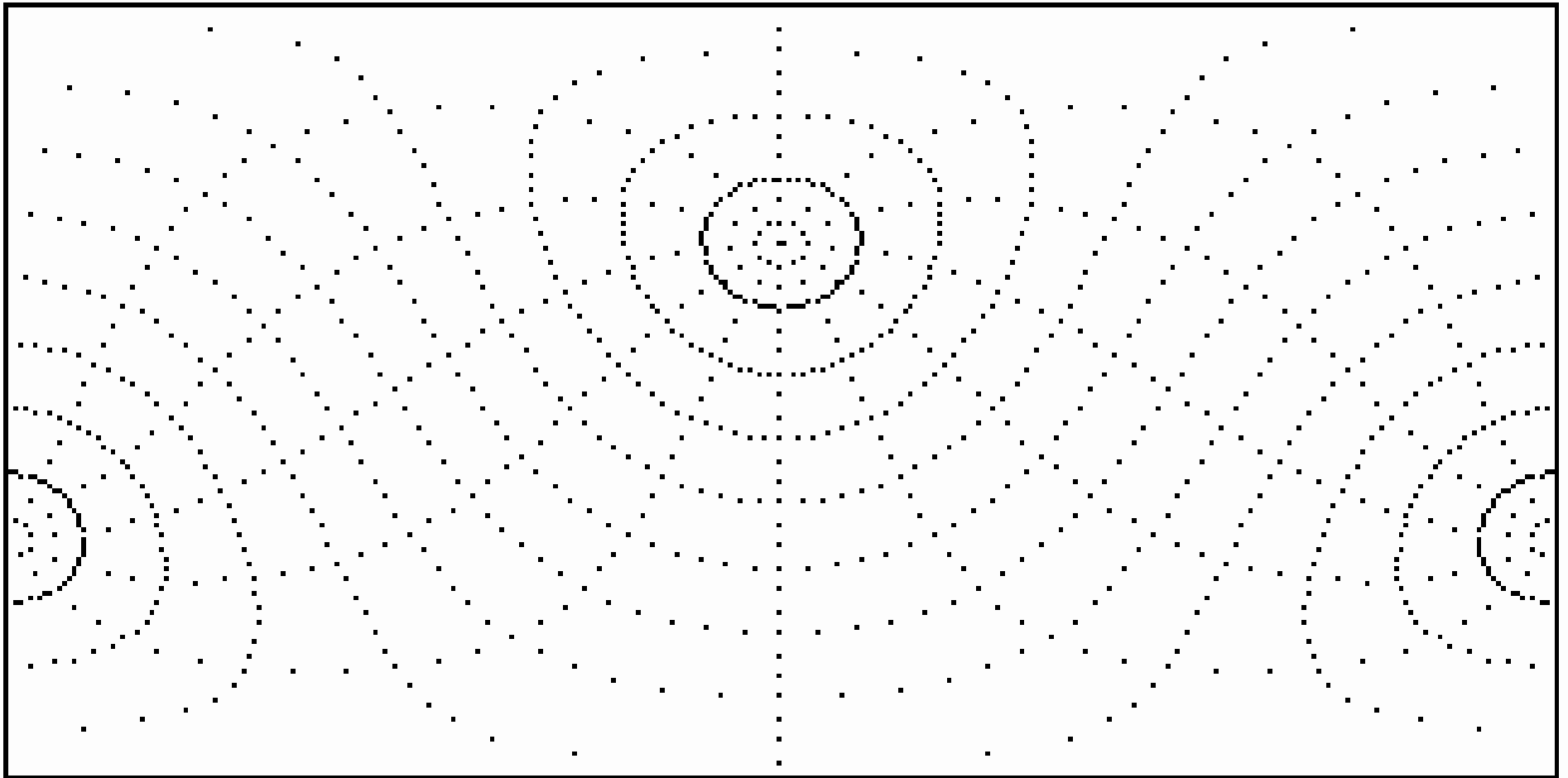## showing the hole and the overlap.

Distance-direction diagram **from** Los Angeles

Los Angeles across top, Distance down, Direction left to right

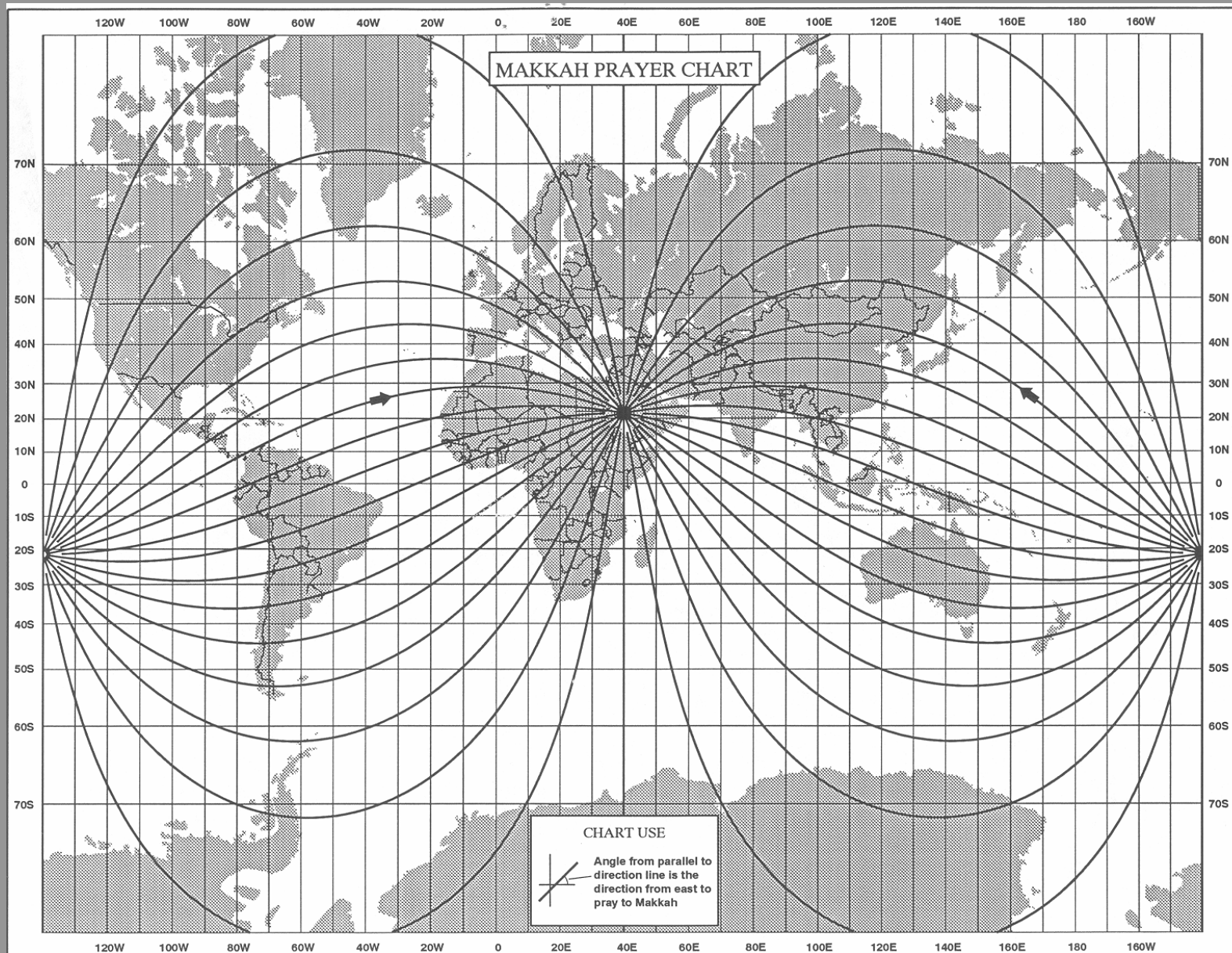# The graticule to accompany the previous map

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

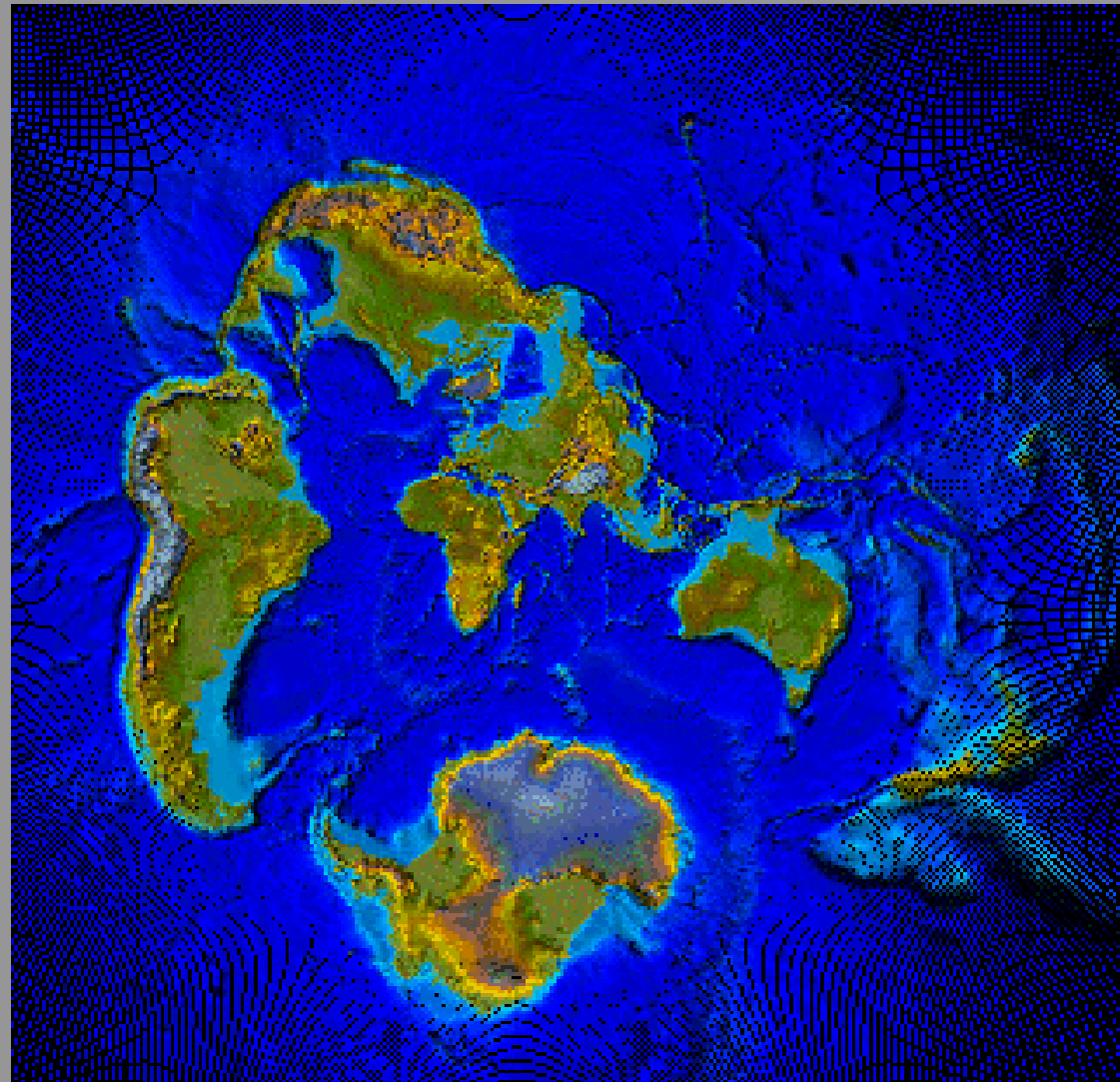# Lines of Equal Direction to Mecca

Mercator Projection

Or Use The Stereographic projection

Center near Mecca

Great circles from & to Mecca are straight lines. Local angles are preserved.
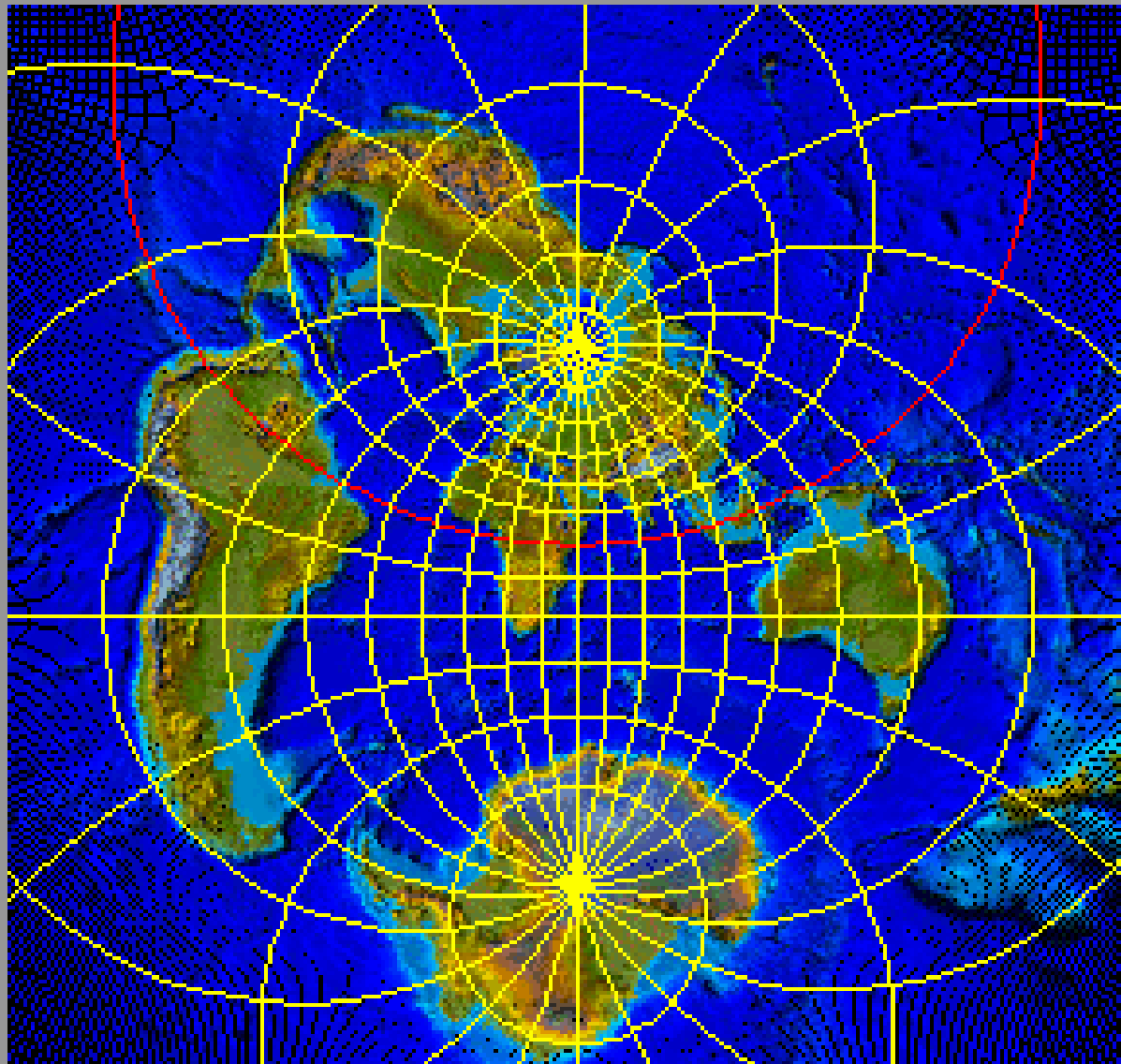
Distance rings about the center (Mecca) remain circles.

On The Stereographic Projection
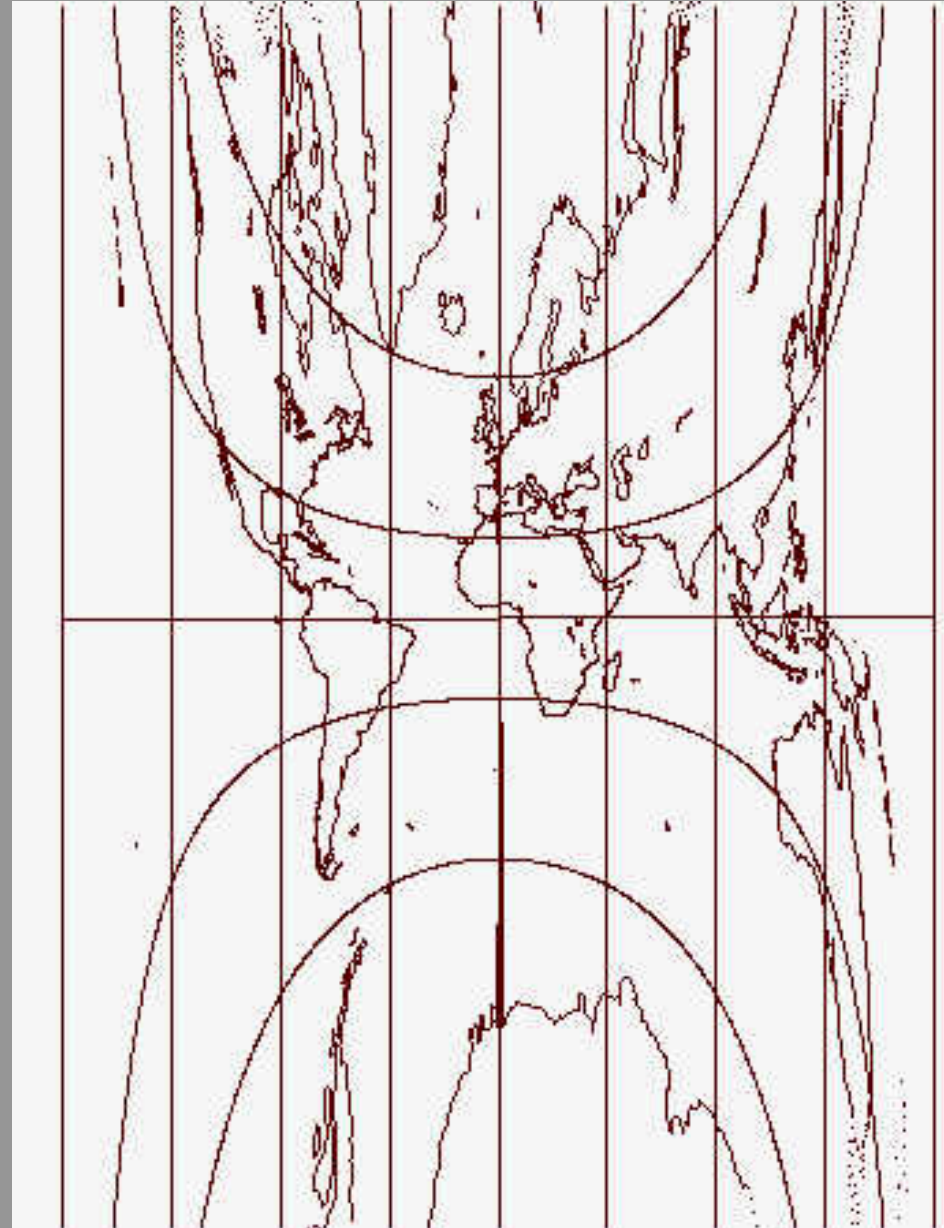
To get the direction to Mecca.

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

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.
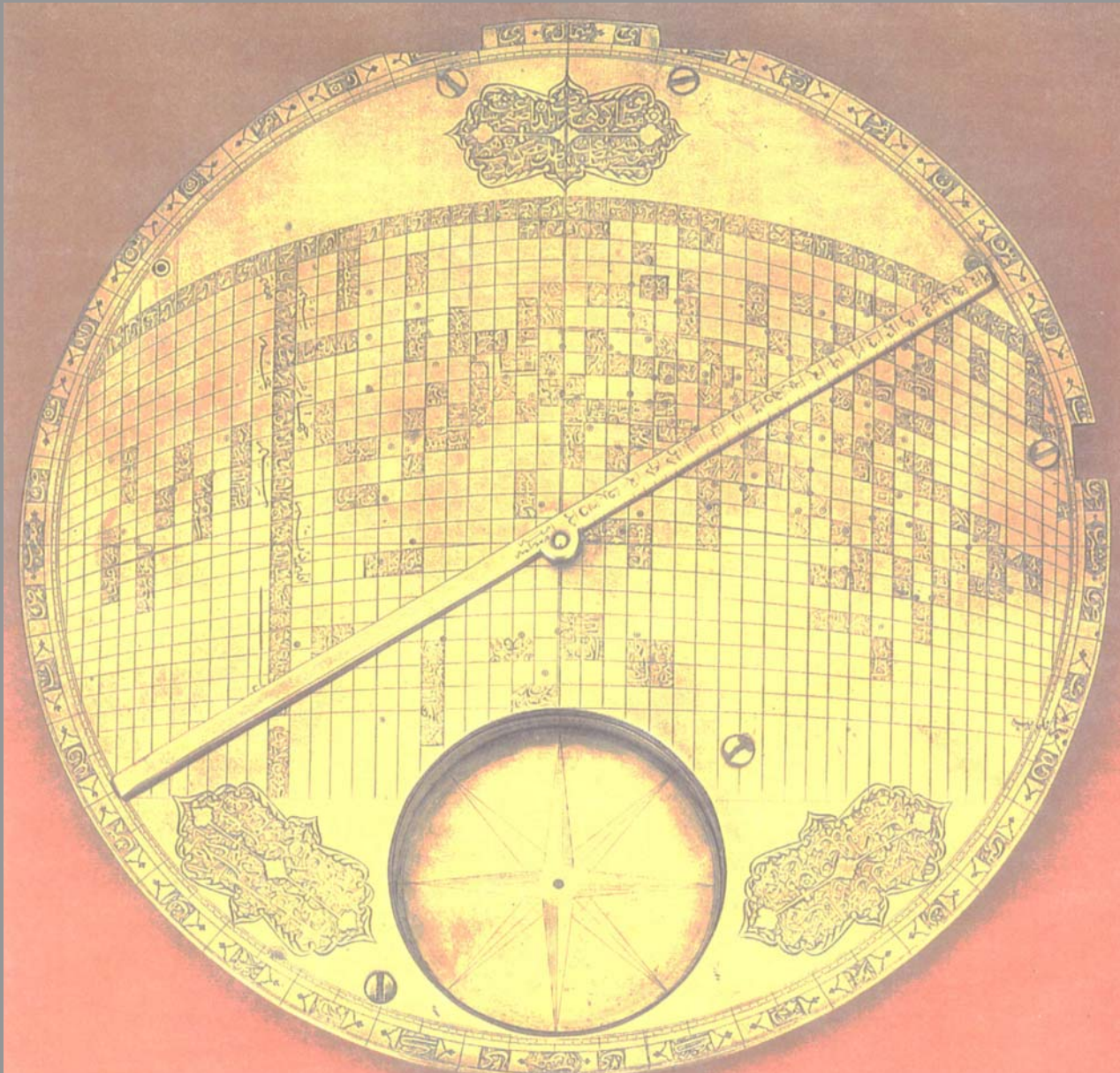
A remarkable demonstration of Arabic skill in mathematics as well as engraving.

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.
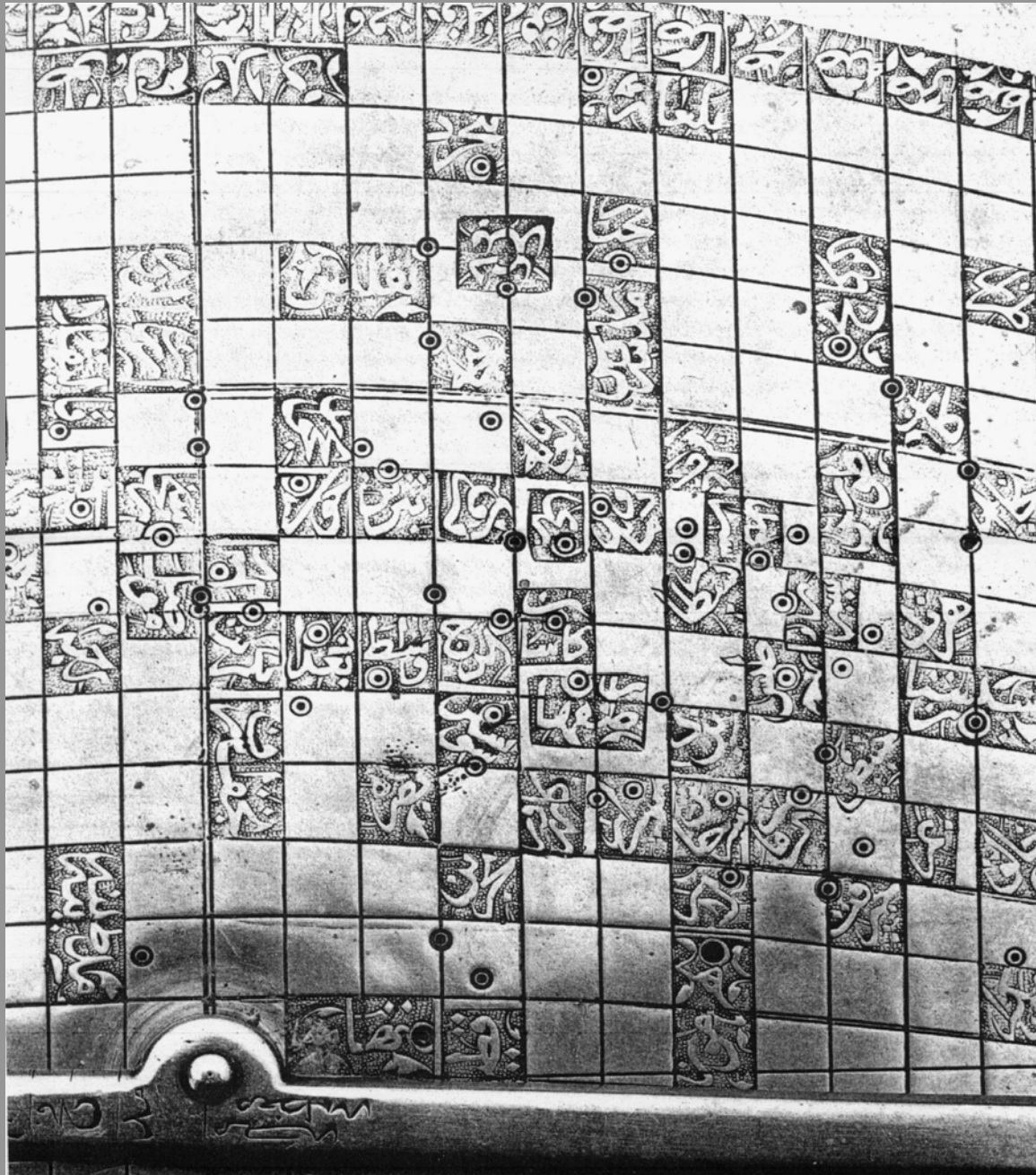
The meridians are parallel straight lines perpendicular to the base latitude and spaced according to the sine of the difference in longitude, modulated by the cosine of the center latitude.

The parallels should be elliptic curves that converge at 90°. Thus a world map again looks strange, with an overlap.
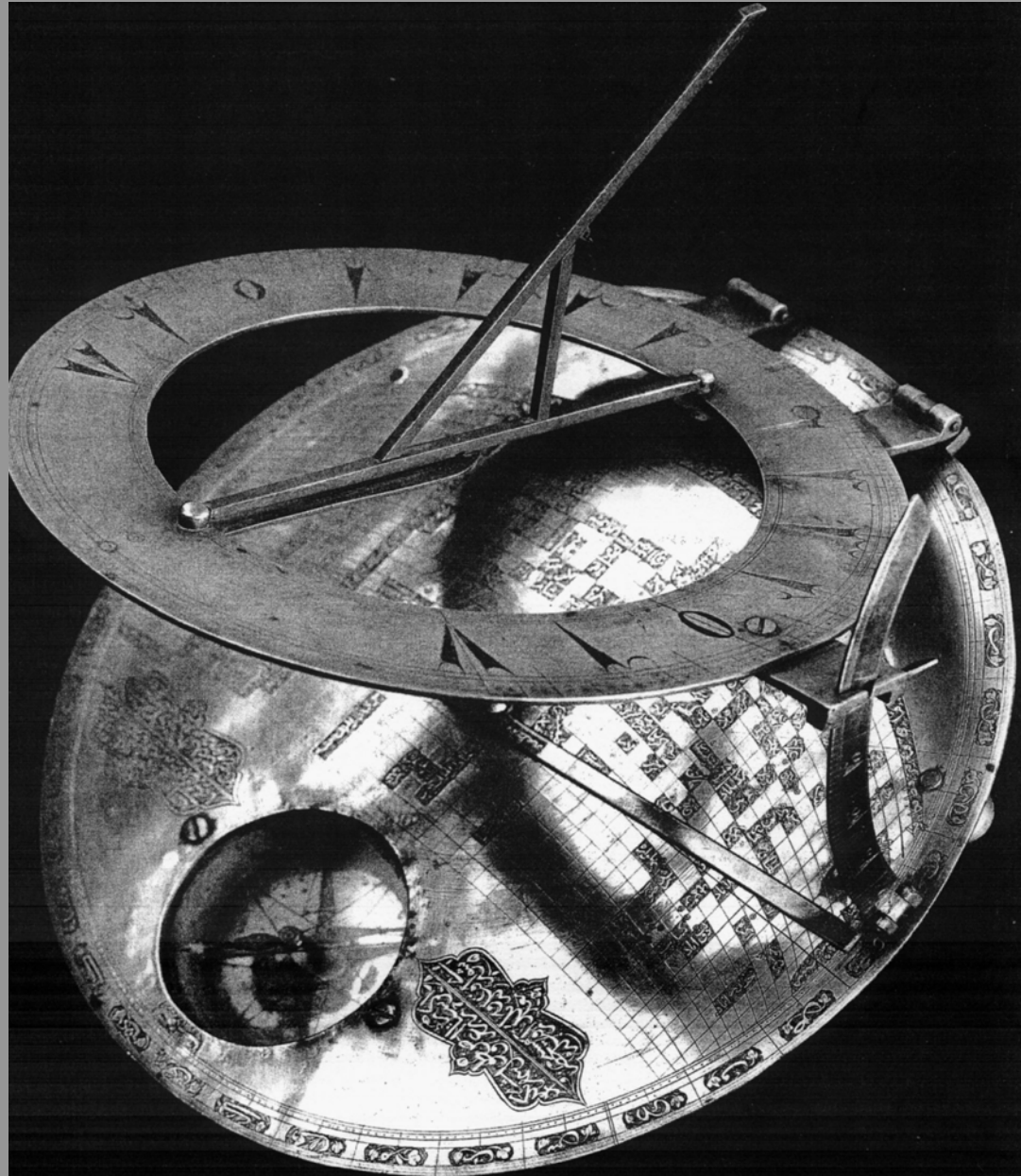
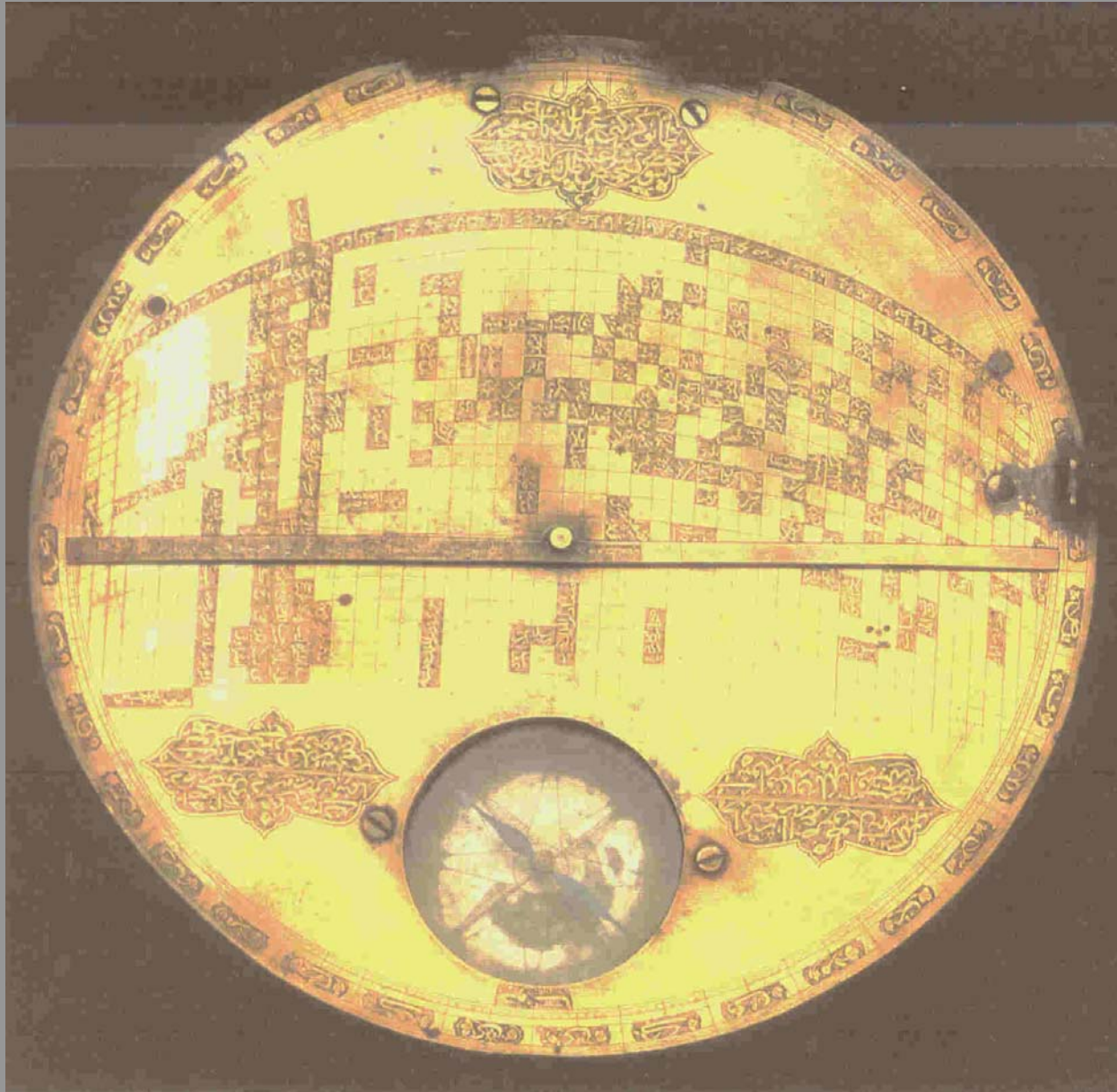# Detail of the Qibla Instrument
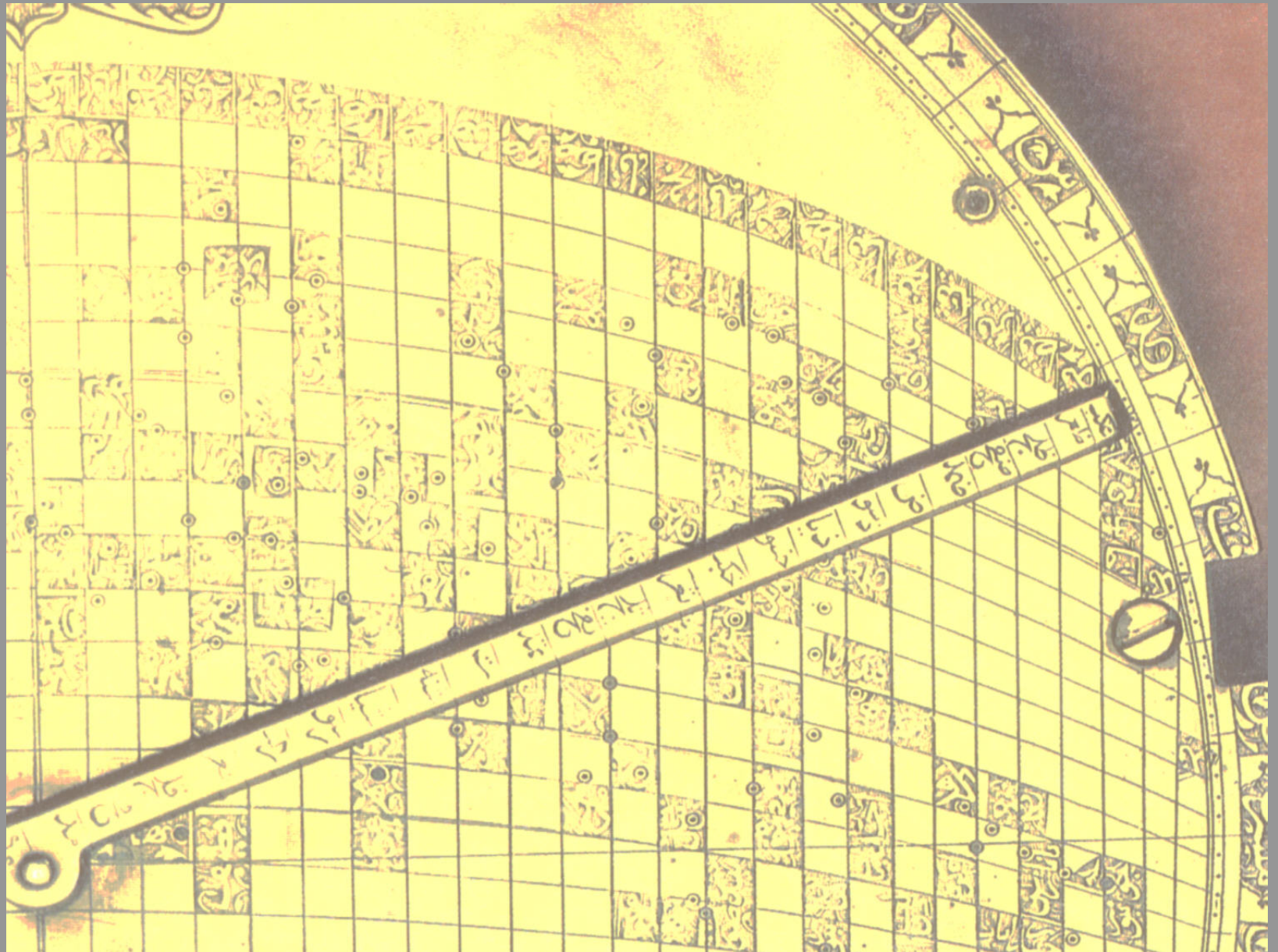
Better detail

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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University of California, Santa Barbara

California Map Society, Jan 20, 2001

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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.