

MAP PROJECTIONS, COORDINATES, SCALES, AND NORTH

A review of Cartography, Map elements, Scales, and Projections.

Sources:

academic.emporia.edu/aberjame/map/h_map/h_map.htm
<http://en.wikipedia.org/wiki/Cartography>
http://en.wikipedia.org/wiki/Map_projection
<http://geography.about.com/>
http://www.colorado.edu/geography/gcraft/notes/mapproj/mapproj_f.html
<http://resources.esri.com/help/9.3/ArcGISEngine/dotnet/89b720a5-7339-44b0-8b58-0f5bf2843393.htm>
http://en.wikipedia.org/wiki/Lambert_azimuthal_equal-area_projection
http://en.wikipedia.org/wiki/Magnetic_declination

Cartography

From Wikipedia

(Greek *chartes* = map and *graphein* = to write)
is the art and science of making maps.

The oldest known *maps* are preserved on Babylonian clay tablets from about 2300 B.C.

Maps have an agenda and represent terrain of the mapped object on flat media. They combine science, technique, and cartographic elements in order to communicate spatial information effectively.

Attempt to eliminate distortion in one or several aspects of the map. The map maker must choose which distortions are less important than the others. They may choose to allow a little distortion in all four of the following aspects to produce the right type of map.

- **Conformality** - the shapes of places are accurate
- **Distance** - measured distances are accurate
- **Area/Equivalence** - the areas represented on the map are proportional to their area on the Earth
- **Direction** - angles of direction are portrayed accurately

Modern cartography is closely integrated with geographic information science and constitutes many theoretical and practical foundations of geographic information systems (GIS).



Printed map depicting Ptolemy's description of the *Oecumene*
(1482, Johannes Schnitzer, engraver).

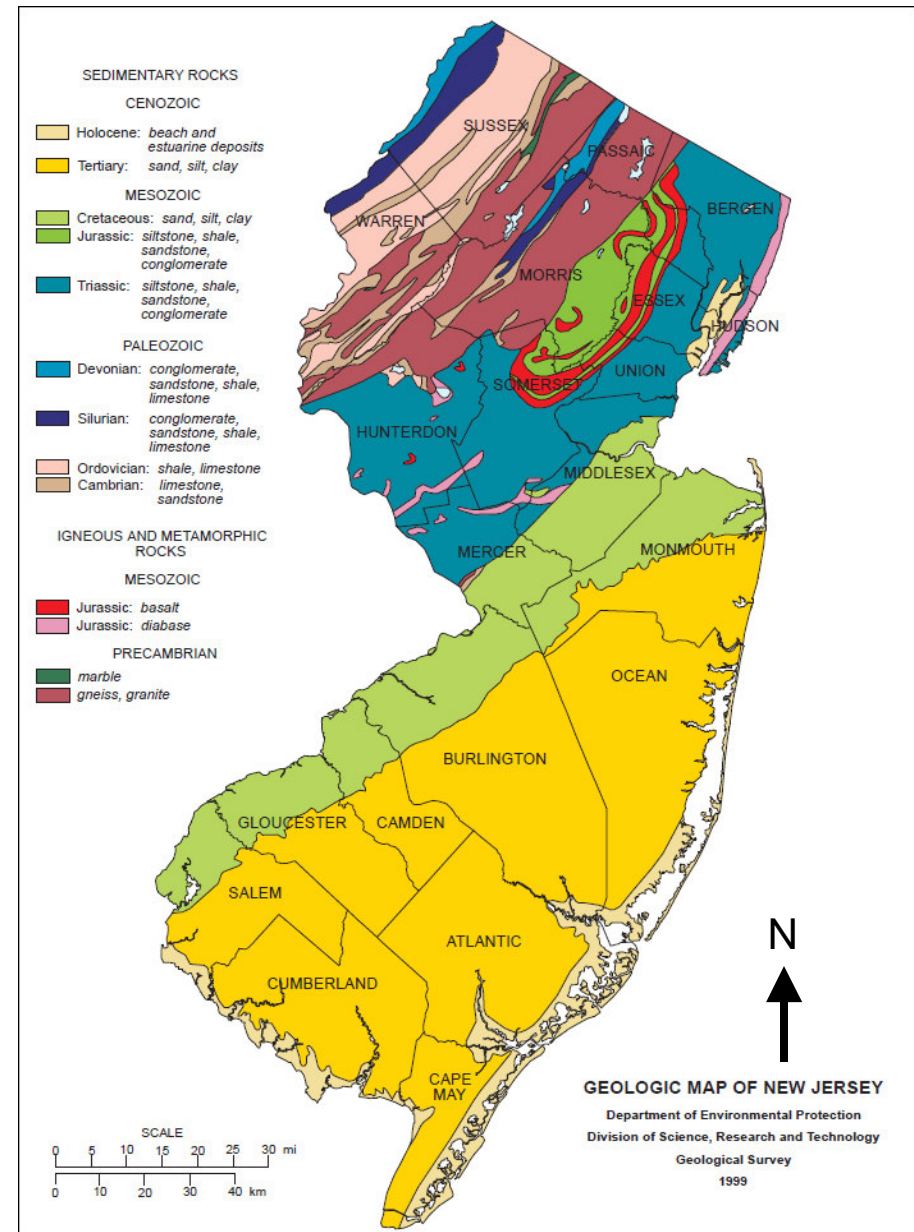
GEOLOGICAL MAPS

Geological maps have a **North arrow, or reference graticules, a scale, a legend, and commonly a base map** (topographic, photographic, or otherwise)

It is important to know the coordinate system, map units, and spatial projection of the maps that you use and create.

It is also important to make a map as simple but as elegant as possible, using the least amount of information needed to effectively communicate the purpose of the map.

Since it's inception in 1879, the US Geological Survey has prepared topographic base maps and atlas maps for use by the various states.



MAP SCALES

USGS 1:24,000 scale topographic maps are commonly used as base for geological maps in many parts of the US.

A scale of 1:24,000 means 1 inch = 24,000 inches or 2000 ft. This is a convenient scale when using feet and inches, and provides a basis for other scales that are useful for measuring distances:

IMPERIAL UNITS

SCALE	1 inch =
1:63,360	1 mile
1:12,000	1000 ft
1:6,000	500 ft
1:4,800	400 ft
1:2,400	200 ft
1:1,200	100 ft
1:600	50 ft
1:240	20 ft

Imperial scales are non-metric, and are virtually unique to the US.

Conversion to metric is underway, with 1:100,000 scale and 1:50,000 scale maps being the modern standard.

1:250,000 scale means 1 cm = 250,000 cm on the map, or

METRIC UNITS

SCALE	1 cm =
1:250,000	2.5 km
1:100,000	1 km
1:50,000	500 m
1:20,000	200 m
1:5,000	50 m
1:2,000	20 m
1:1000	10 m
1:500	5m
1:100	1m

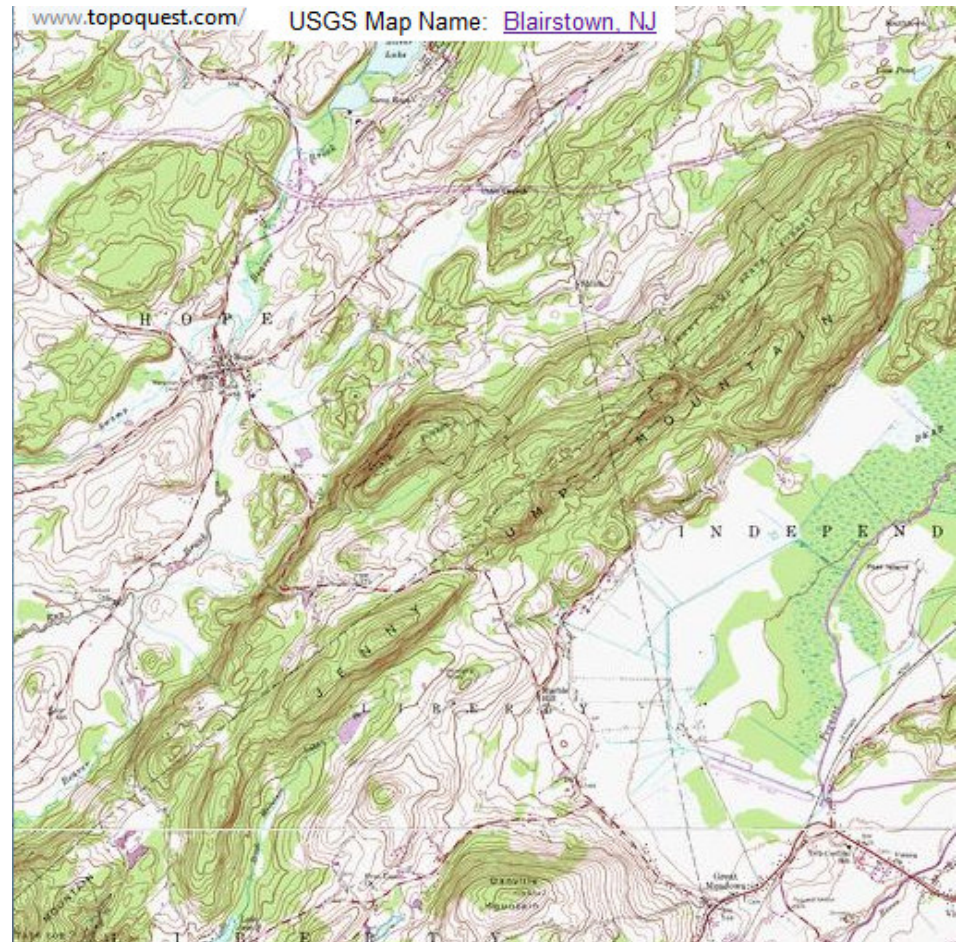
MAP SCALES

The 6" engineers protractor ruler is a useful mapping tool when working with USGS 1:24,000 scale topographic maps and cross sections.



The $1/10''$ graduations on the ruler are equal to 200 ft map distance, and can therefore be used for quickly determining distances and angles for mapping oriented geological features on $7\text{-}1/2'$ topographic quadrangle maps ($1/10'' = 20\text{ ft}$).

Topographic base maps are available from a number of on-line sources, including the USGS, as Digital Raster Graphic (DRG) images. Those covering the State of NJ are included on the Flash drive as monochromatic (2-bit) images

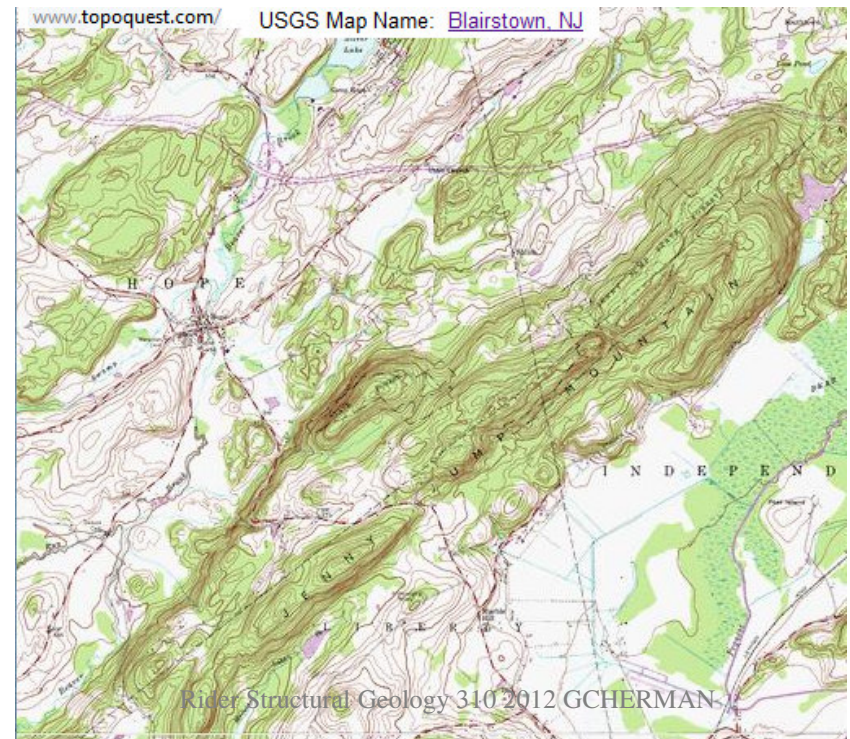
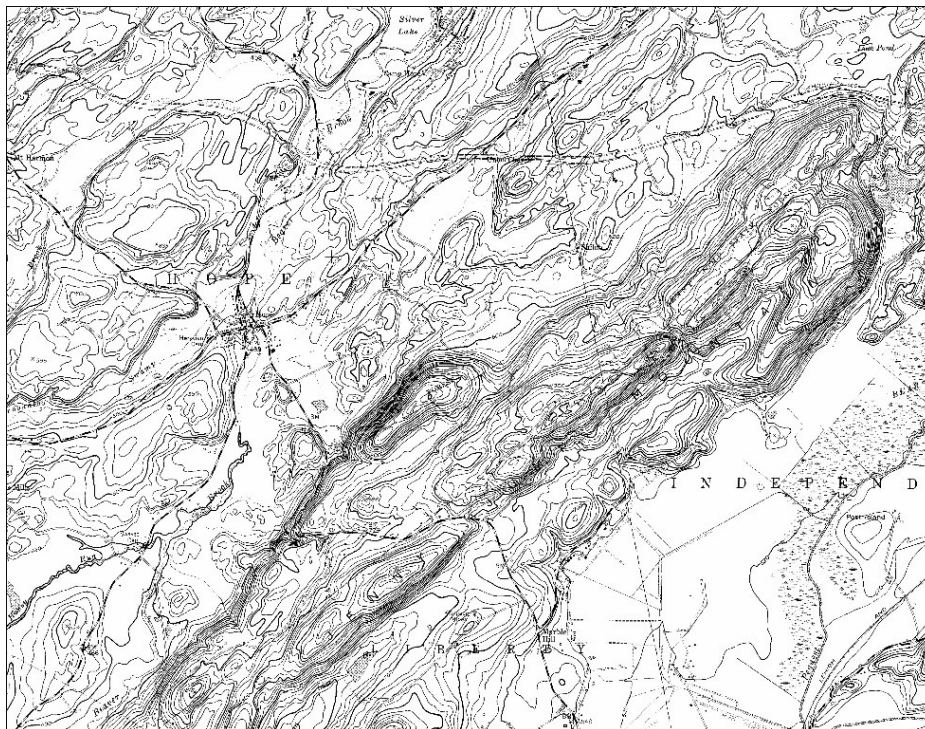


MAP IMAGES

The Flash drive contains a directory of monochrome (2-bit), 1:24,000 topographic images of the northern half of New Jersey (Quadrangles 1 – 92) in KMZ file (Google Earth) format. The images stem from NJ Geological Survey Digital Geodata Series DGS 99-1. Eight (8) out of 13 original index colors used to compile the topo maps were set to 0, and the remaining were set to 1. See the metadata for the DGS product for more details.

The FLASH DRIVE/NJTopos_MrSid/ directory contains the entire set of full-color US Geological Survey 7-1/2' Topographic quadrangles for the State of NJ in the Mr. Sid format, for use in GIS.

NJ Geological Survey Monochromatic version of the full-color USGS DRG TIFF image



GEOGRAPHIC COORDINATE SYSTEM

Sir Isaac Newton first brought to light the shape of the earth into public awareness in the early 18th century. He concluded that the earth was an oblate ellipsoid of revolution - an ellipse wider at the equator than at the poles. This theory was widely investigated.

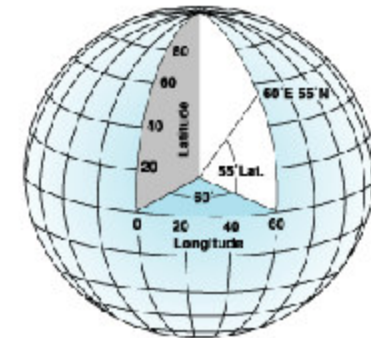
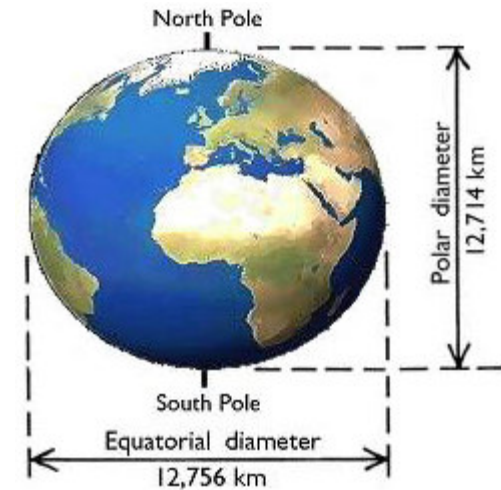
We delineate the earth and sky with meridians and parallels using angular units of measure to define longitude and latitude.

Scientists use several geometrical methods to measure angle - radians and x/y coordinates included - but the most accepted measure is the degree, which divides a full circle into 360 parts.

Longitude and latitude are angles measured from the earth's center to a point on the earth's surface. The angles often are measured in degrees (or in grads).

A geographic coordinate system (GCS) uses a three-dimensional spherical surface to define locations on the earth. A GCS is often incorrectly called a datum, but a datum is only one part of a GCS. A GCS includes an angular unit of measure, a prime meridian, and a datum (based on a spheroid).

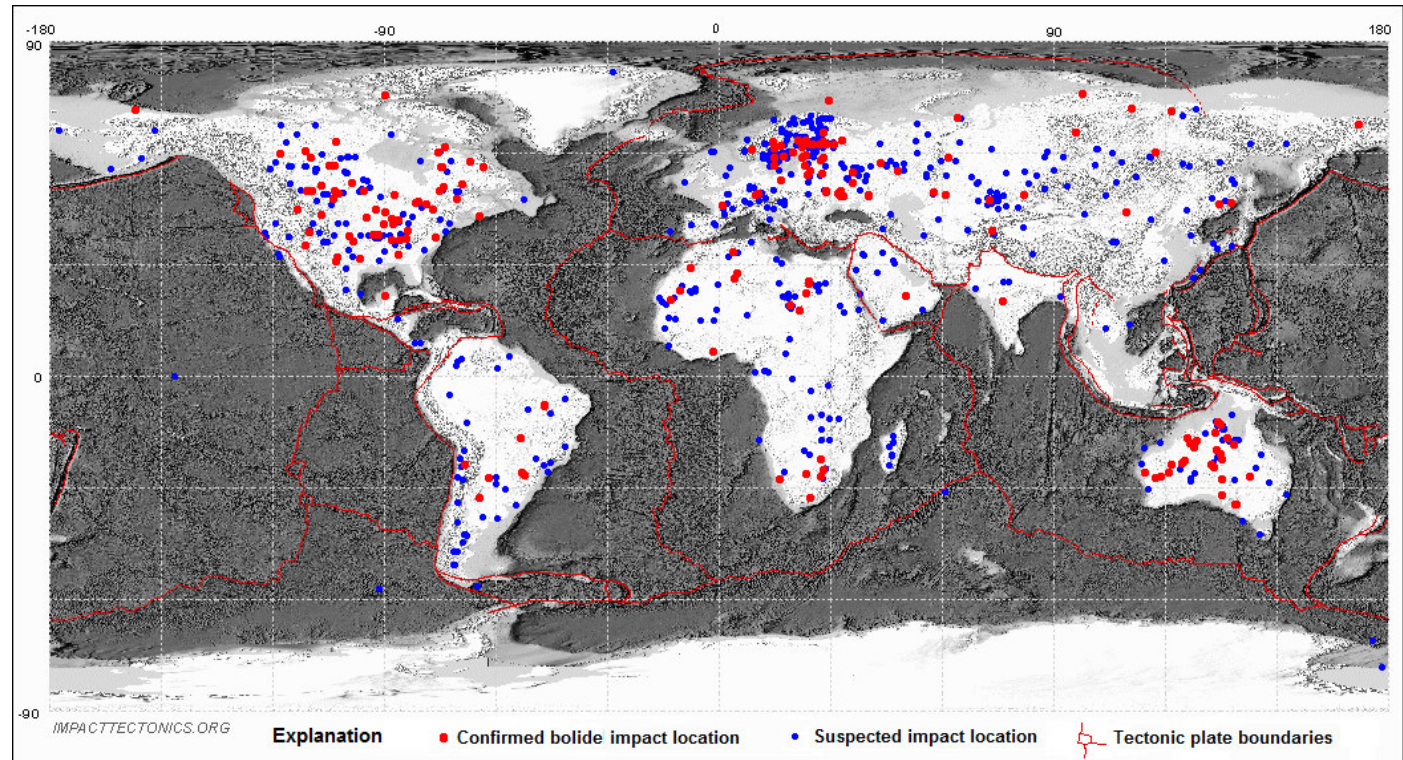
The spheroid defines the size and shape of the earth model, while the datum connects the spheroid to the earth's surface. A point is referenced by its longitude and latitude values.



GEOGRAPHIC COORDINATE SYSTEM

The line of latitude midway between the poles is called the equator. It defines the line of zero latitude. The line of zero longitude is called the prime meridian. For most GCSs, the prime meridian is the longitude that passes through Greenwich, England.

The origin of the graticule (0,0) is defined by where the equator and prime meridian intersect.



The Earth geographic showing world physiography, tectonic plate boundaries, and known and suspected bolide-impact sites. A Google Earth implementation of this map and the referenced source data are available at <http://www.impacttectonics.org/earth.html>.

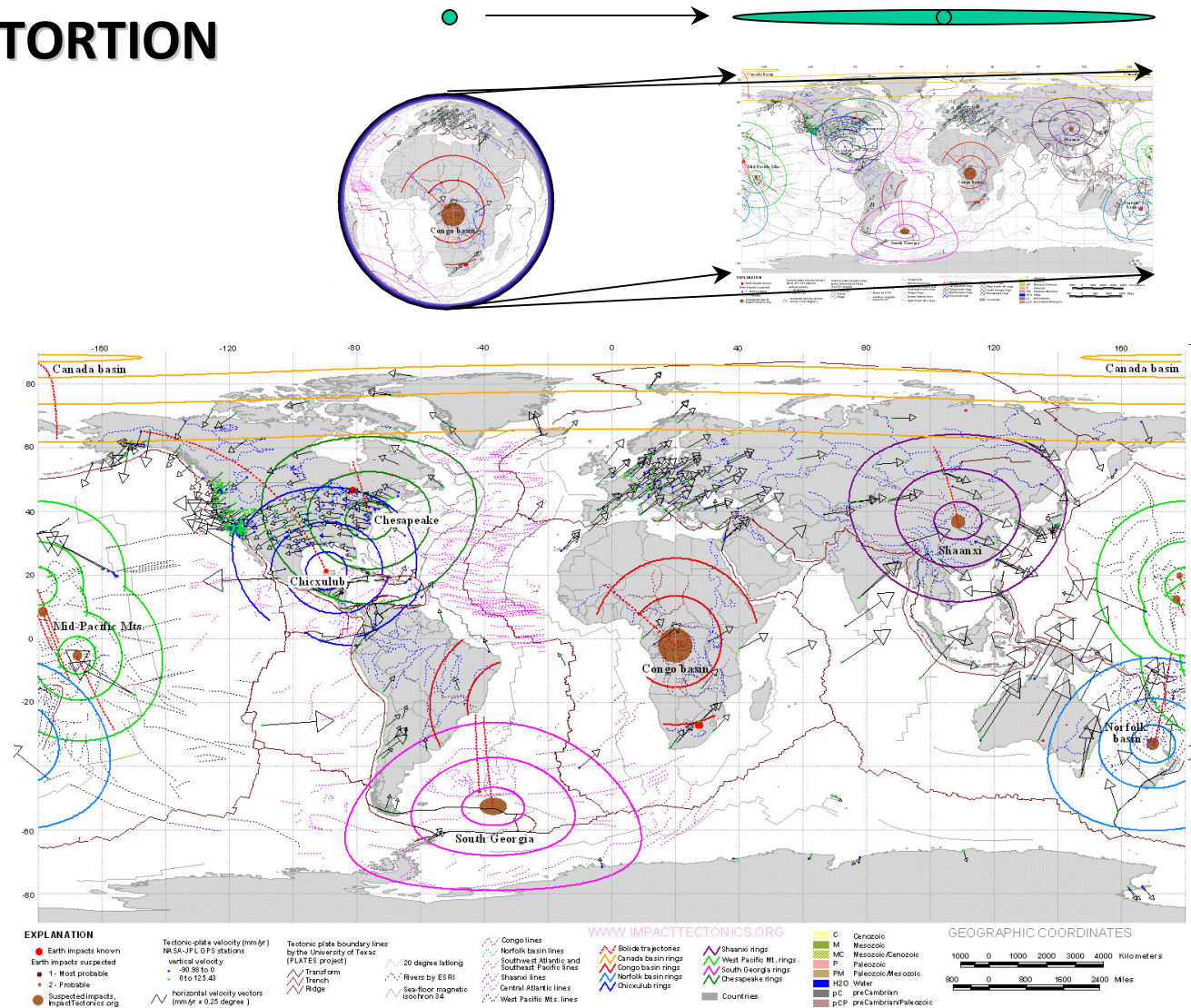
Latitude and longitude values are traditionally measured either in decimal degrees (e.g. lat 34.0234, lon -175.7765) or in degrees, minutes, and seconds (DMS). Latitude values are measured relative to the equator and range from -90° at the south pole to $+90^{\circ}$ at the north pole. Longitude values are measured relative to the prime meridian. They range from -180° when traveling west to 180° when traveling east. It may be helpful to equate longitude values with x and latitude values with y. Data defined on a geographic coordinate system is displayed as if a degree is a linear unit of measure. Google Earth uses geographic maps. Rider Structural Geology 310 2012 GCHERMAN 8

GEOGRAPHIC DISTORTION

Circles are distorted in geographic coordinate space as a result of stretching the tops and bottom points of the reference spheroid into a graticule. Circles become oblate and either stretched at the top toward the north of the equator or toward the bottom southward.

Circles generated in polar regions span geographic longitude because of the severity of the stretch. Circles at the equator are least distorted and appear circular.

This is an example of why it is necessary to use different map projections in order to map accurate distances, angles, and areas at various cartographic scales.



Geographic map showing 2 known and 5 suspected large-bolide impact sites on Earth, tectonic plate boundaries, and tectonic-plate motion vectors based on 12 years of GPS monitoring. A Google Earth implementation of this map and the referenced source data are available at www.impacttectonics.org/earth.html.

Rings of 660km, 1600 km, and 900 km were generated around each strike.

MAP PROJECTIONS and COORDINATES

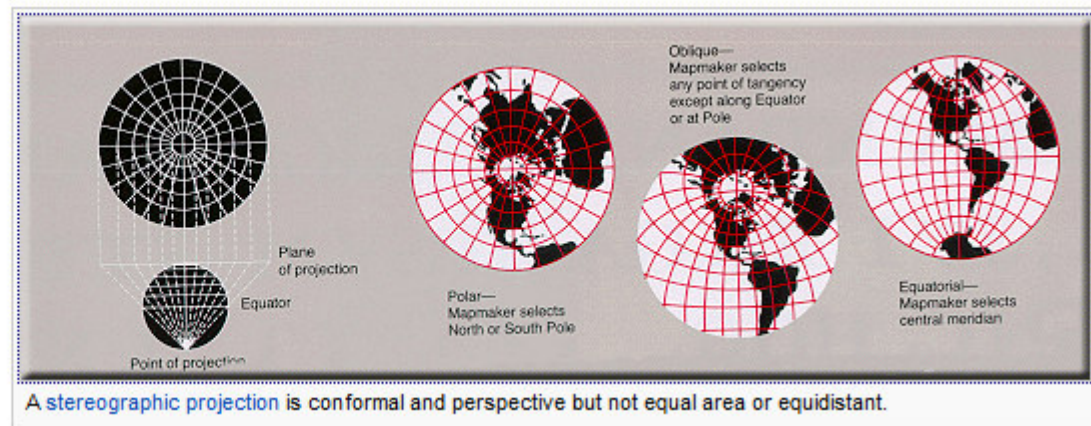
A map projection is any method of representing the surface of a sphere or other three-dimensional body on a plane. Map projections are necessary for creating maps. All map projections distort the surface in some fashion. There is no limit to the number of possible map projections.

Maps use different projections in order to portray spherical objects on a cartesian or rectilinear map space. Due to the many uses of maps and the vast range of scales at which they are created, no single map projection serves well for all purposes. Modern national mapping systems typically employ a transverse Mercator or close variant for large-scale maps in order to preserve conformality and low variation in scale over small areas. For smaller-scale maps, such as those spanning continents or the entire world, many projections are in common use according to their fitness for the purpose.

Conformal

Conformal map projections preserve angles locally. These are some conformal projections:

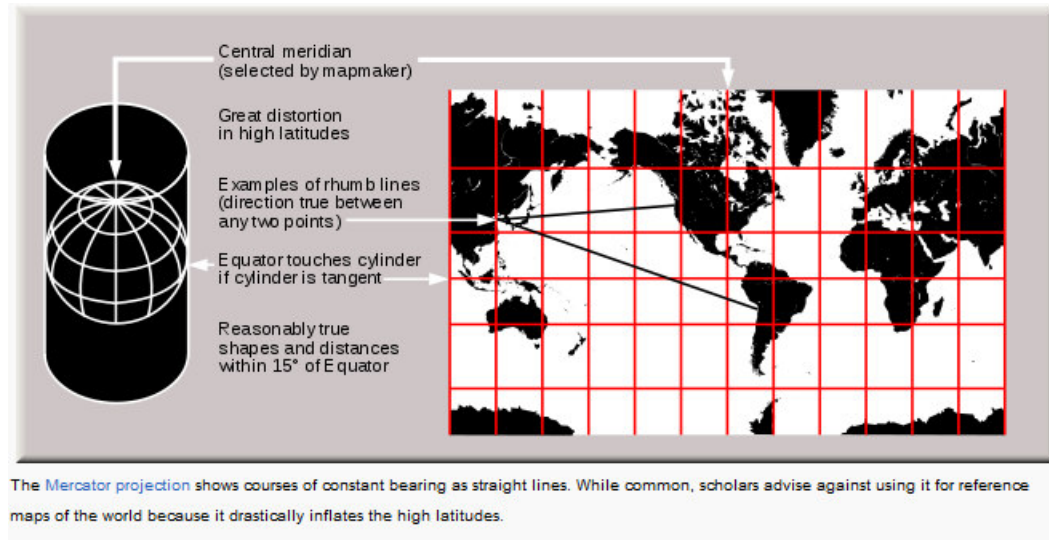
- Mercator – rhumb lines are represented by straight segments
- Transverse Mercator
- Stereographic - shape of circles is conserved



MAP PROJECTIONS and COORDINATES

Cylindrical - The Mercator projection shows courses of constant bearing as straight lines.

The term "normal cylindrical projection" is used to refer to any projection in which meridians are mapped to equally spaced vertical lines and circles of latitude (parallels) are mapped to horizontal lines.



Historically, several different projections have been used to depict the United States.

Early 19th century - simple polyconic projection was used first to map the US coast, then later was used by the USGS used to create thousands of topographic quadrangles until the 1950's.

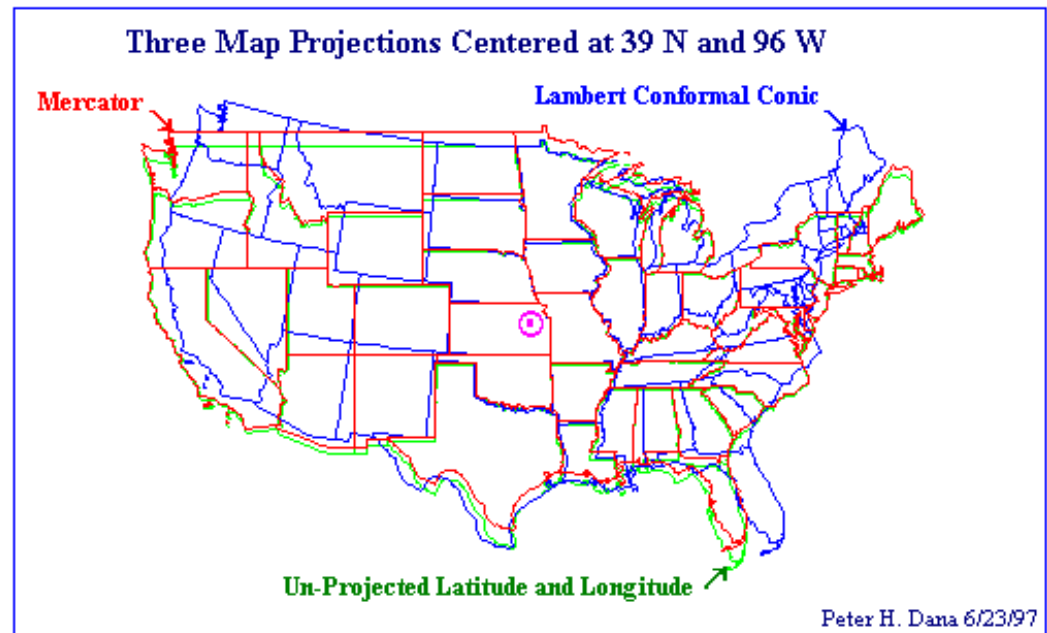
Other agencies used the Mercator cylindrical projection in the early twentieth century, then later in the century, some agencies converted to the Lambert conformal conic projection for maps of the entire country.

MAP PROJECTIONS and COORDINATES

After the 1950's, USGS quadrangles were based on the conformal State Plane Coordinate System (SPCS), which is not a projection but is based on two different projections depending on the shape of the region it describes. This system is broken down into grid zones. For states extending predominantly east-west, this system uses the Lambert conformal conic projection. For states extending predominantly north-south, the transverse cylindrical Mercator projection was adopted.

Another familiar grid system came into use during the same period - the Universal Transverse Mercator (UTM) grid system which extends across the entire world in zones 6 degrees longitude wide. This system, like SPCS, is not a true projection but is based solely on the transverse cylindrical Mercator projection.

In 1970, the Albers equal-area conic projection came into use for maps of the entire country.

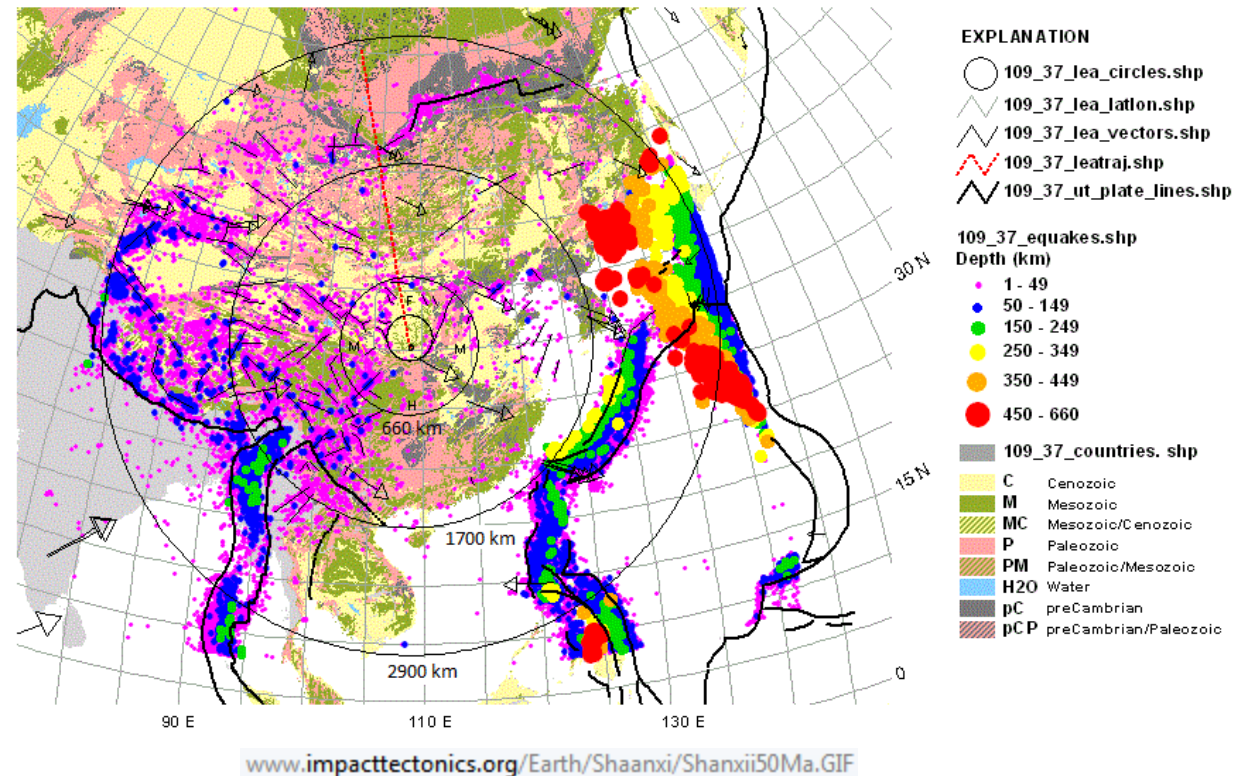


www.colorado.edu/geography/gcraft/notes/mapproj/mapproj_f.html

MAP PROJECTIONS and COORDINATES

Lambert Equal-Area Azimuthal projections – Equidistant Preservation of Area.

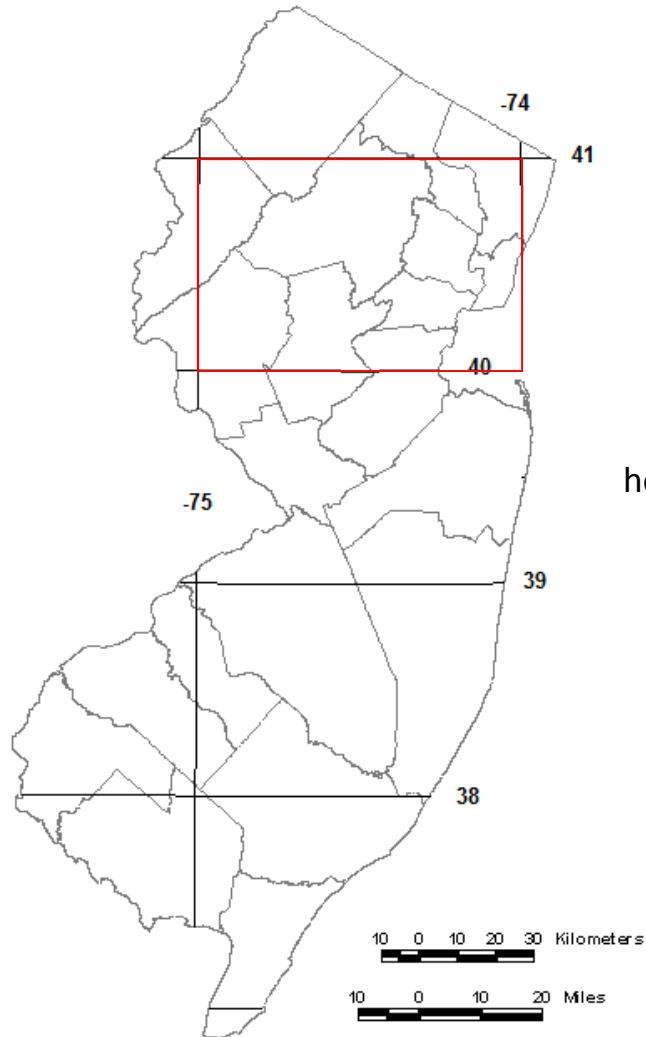
The Lambert azimuthal equal-area projection maps part of a spherical surface to a map disk (that is, a region bounded by a circle). It accurately represents area in all regions of the sphere, but it does not accurately represent angles. It is named for the Swiss mathematician Johann Heinrich Lambert, who announced it in 1772.



The Lambert azimuthal projection (for short) is a useful map projection in cartography. For example, the National Atlas of the US uses a Lambert azimuthal equal-area projection to display information in the online Map Maker application, and the European Environment Agency recommends its usage for European mapping for statistical analysis and display. It is also used in scientific disciplines such as geology for plotting the orientations of lines in three-dimensional space (using Schmidt net graphing paper) .

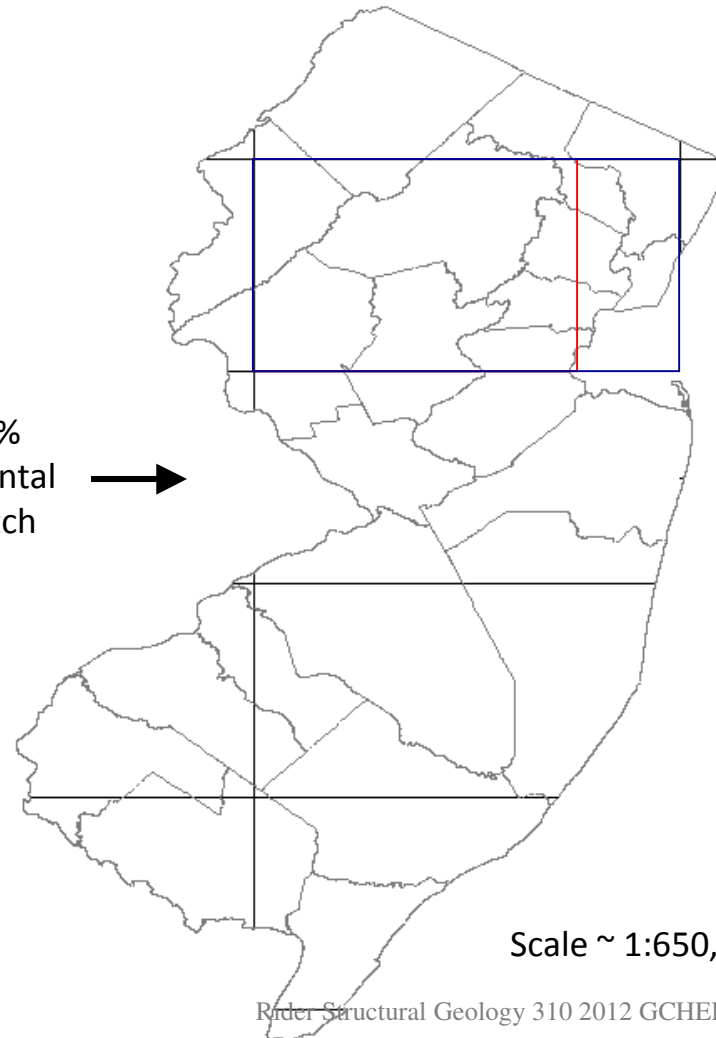
NEW JERSEY IN STATE PLANE FEET and GEOGRAPHIC DEGREES

1983 North American Datum
NAD83 NJ State Plane Feet



1984 World Geodetic System
WGS84 Geographic Decimal Degrees

~21%
horizontal
stretch →



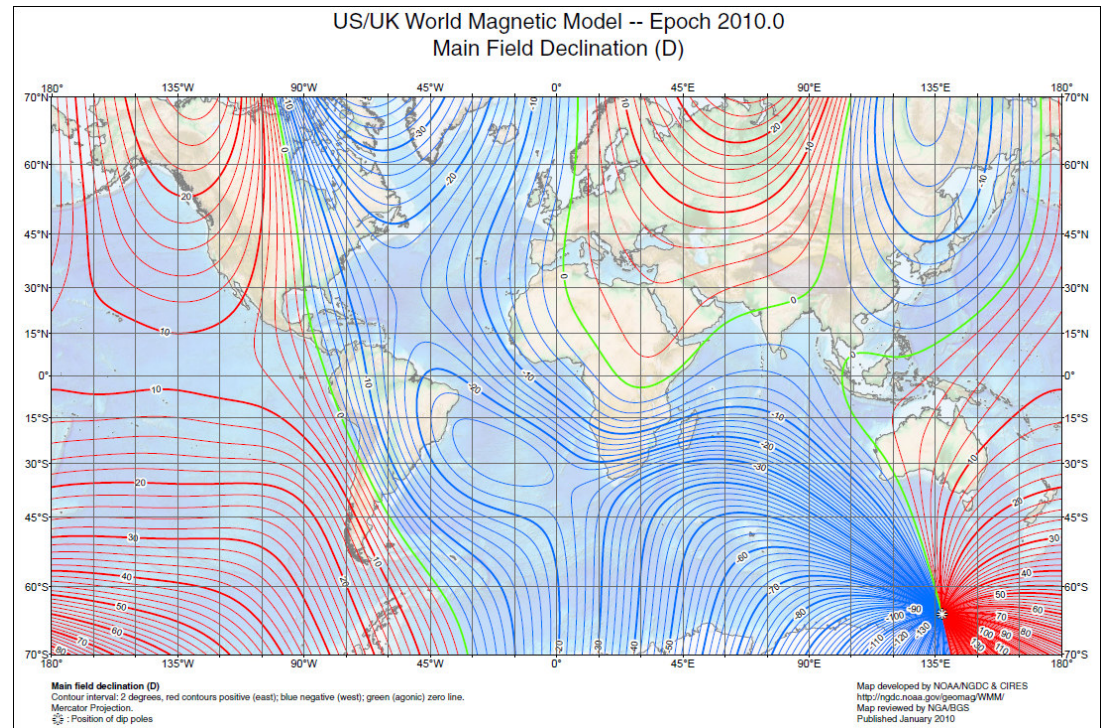
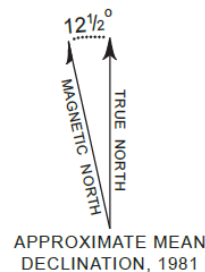
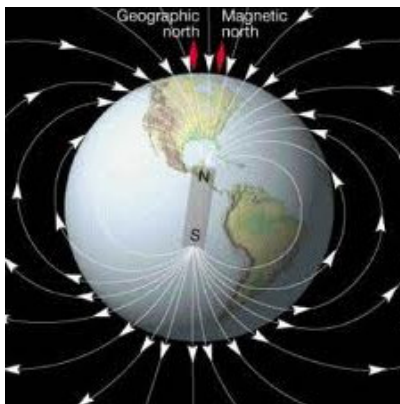
Scale ~ 1:650,000

MAGNETIC AND TRUE NORTH

Magnetic declination is the angle between magnetic north (the direction the north end of a compass needle points) and true north. The declination is positive when the magnetic north is east of true north. The term magnetic variation is a synonym, and is more often used in navigation. Isogonic lines are where the declination has the same value, and the lines where the declination is zero are called agonic lines.

On most maps intended for wilderness or navigational use, including the topographic maps of the USGS, a diagram on the map legend shows the relationship between magnetic north in the area concerned and true north.

Different conventions are used, such as a five-pointed star at the top of True North, or labeled lines, and another label stating the size of the declination in degrees or mils, or both.



upload.wikimedia.org/wikipedia/commons/d/d4/World_Magnetic_Declination_2010.pdf