U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

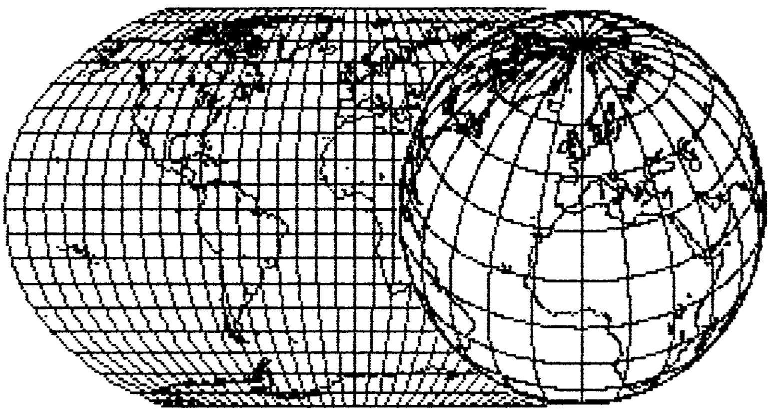
To Beginning Animation

Map Projections

By

Tau Rho Alpha* and daan Strebe#

Open-File Report 91 - 553 A



Go Home

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To stack outline

Description

The purpose of this HyperCard guide is to describe a few of the common map projections that can be used to present thematic data. This description of map projections enables a compiler of thematic data to select a map projection that will portray the data effectively, and it allows the map reader to identify the map projection so that there is a mutual understanding as to how to obtain information from the thematic map. In regional mapping, the choice of a map projection is usually based on convention or availability rather than on how well the map projection portrays a particular set of data. The best projection for portraying thematic data about people, countries, agriculture, geology, and so on (all areal phenomena) is a map projection that preserves areal relationships..

Many map projections are derived on a developable surface (see glossary, page 4) producing a basic grid system of longitude and latitude known as the earth's graticule. From the graticule, a map projection can be defined. In this manual, four main types of map projections are described. Projections onto (1) Planes (Azimuthal), (2) Cones, (3) Cylinders, and (4) a miscellaneous category. Each of these main types has some variations, and this guide will show some of these variations. Eighteen map projections commonly used to present thematic data are briefly described and illustrated. Also included are several examples of the map projections used by the U. S. Geological Survey for thematic maps. This guide consists of descriptive material only and does not contain a program for creating map projections.

Requirements for the diskette version of this report are: Apple Computer, Inc., HyperCard 2.0™ software (not supplied) and Apple Macintosh™ Plus, Classic, SE, or II. The date of this Open-File Report is 10/04/1991. OF91-533-A, paper copy, 92p. OF91-533 -B, 3.5-in. HD Macintosh diskette.

To select a map projection follow the arrows to Developable surfaces or click on the map projection name on this card.

This guide is organized in the following manner:

To stack outline

DEFINITION OF TERMS:

ASPECT–Individual azimuthal map projections are divided into three aspects: (1) the polar aspect, which centers the map at one of the poles of the globe; (2) the equatorial aspect, which centers the map at the equator; and (3) the oblique aspect, which centers the map anywhere else. (The word "aspect" has replaced the word "case" in the modern cartographic literature).

CONFORMALITY-A map projection is conformal when (1) meridians and parallels intersect at right angles, and (2) at any point the scale is the same in every direction. The shapes of very small areas and angles with very short sides are preserved.

DEVELOPABLE SURFACE–A developable surface is a simple geometric form capable of being flattened without stretching. Many map projections can be grouped by a particular developable surface: cylinder, cone, or plane.

EQUAL AREA-A map projection is equal area when every part, as well as the whole, has the same area as the corresponding part on the earth, at the same reduced scale.

GRATICULE–The graticule is the spherical coordinate system based on lines of latitude and longitude.

"INTERRUPTED"--Interruption of a projection is where the continous surfrace of the map is broken. All maps are interrupted, usually a map is called "interrupted" if more than one meridian is involved.

LINEAR SCALE–Linear scale is the relation between a distance on a map projection and the corresponding distance on the earth.

LINE OF TANGENCY–The line where the developable surface intersects or touches the globe.

MAP PROJECTION–A map projection is a systematic representation of a round body such as the earth on a flat (plane) surface. Each map projection has specific properties that make it useful for specific objectives.

POINT OF TANGENCY–The point where the developable surface (a plane) touches the globe.

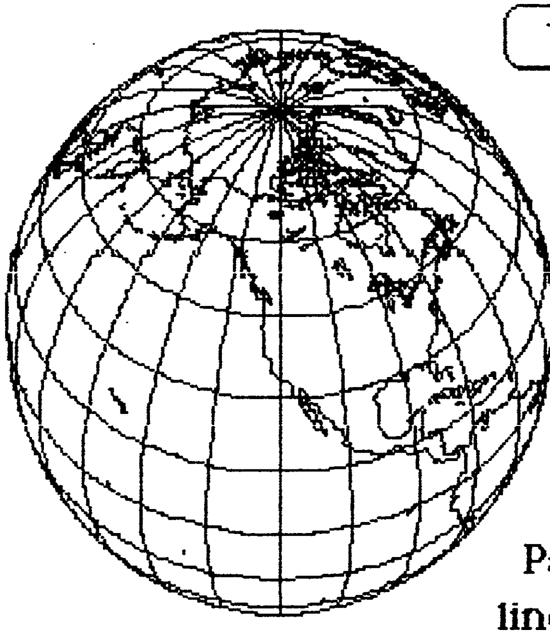
PRIME MERIDIAN–The zero meridian (longitude 0°) which passes through Greenwich England.

SCALE FACTOR–The relation between the scale of the map projection and the actual scale of the globe.

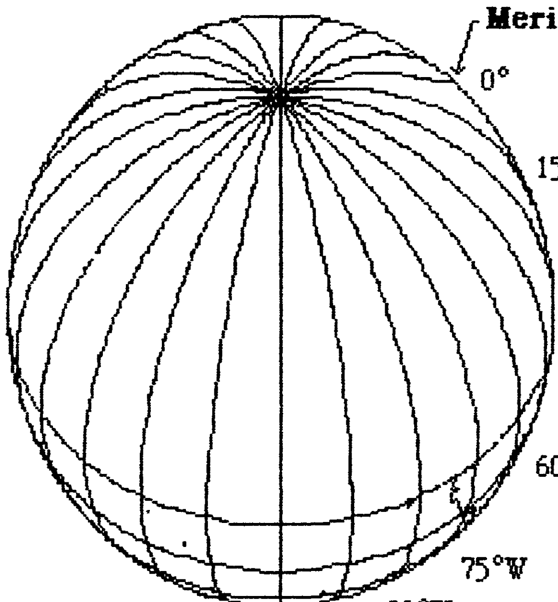
To stack outline

Graticule

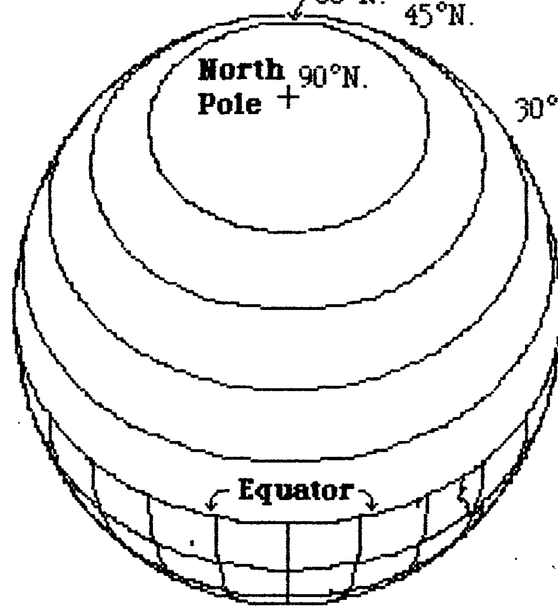
The earth's spherical graticule.



Meridians or lines of longitude



Parallels or lines of latitude



To select an individual property of the Earth's spherical graticule, click on that property name on this card.

Natural properties of the earth's spherical Graticule

card one of two

1. Parallels are an equal distance apart.
2. Parallels are spaced equally on meridians.
3. Meridians and other great-circle arcs are straight lines. (if looked at perpendicularly to the earth's surface).
4. Meridians converge toward the poles and diverge toward the equator.
5. Meridians are equally spaced on the parallels, but their distance apart decreases from the equator to the pole.

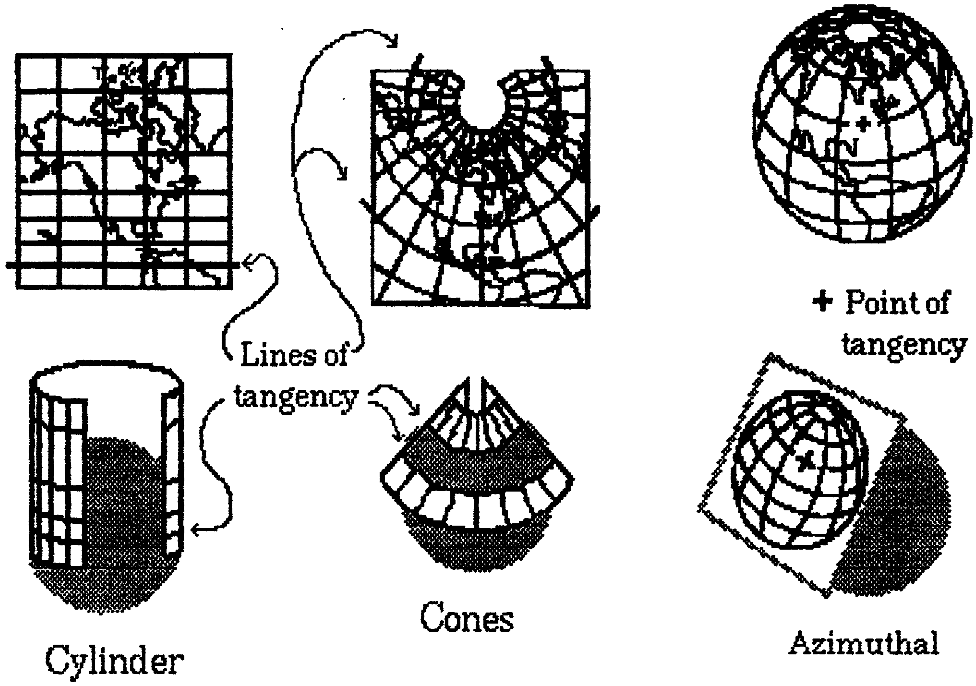
To select an individual property of the Earth's spherical graticule, click on that property name on this card.

Natural properties of the earth's spherical Graticule

card two of two

6. Meridians at the equator are spaced the same as parallels.
7. Meridians at 60° are half as far apart as parallels.
8. Parallels and meridians cross one another at right angles.
9. The area of surface bounded by any two parallels and two meridians (a given distance apart) is the same anywhere between the same two parallels.
10. The scale factor at each point is the same in any direction.

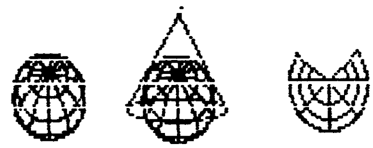
The earth's spherical **Graticule**
"projected"
on to a developable surface

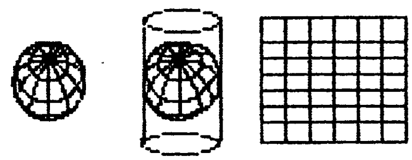


Developable surfaces

To stack outline

Azimuthal 

Cones 

Cylinders 

Miscellaneous 

On this card click on the developable surface name to select it.

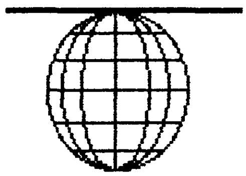
In this guide map projections are grouped according to developable surfaces.

To developable surfaces | To stack outline

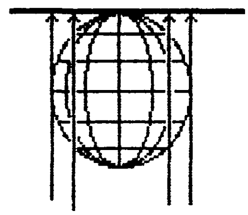
Azimuthal

On this card click on the map projection name to select it.

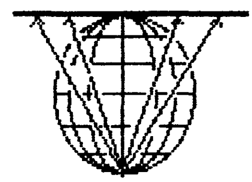
1 Azimuthal Equidistant
or
2 Lambert Azimuthal Equal-Area
(are mathematically derived and canot be shown graphically)



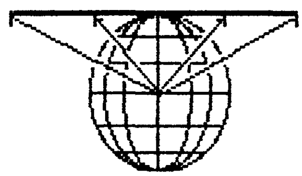
3 Orthographic



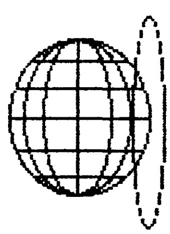
4 Stereographic



5 Gnomonic

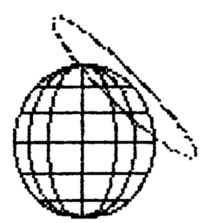


Aspect of azimuthal map projections.



Equatorial Aspect

Polar Aspect



Oblique Aspect

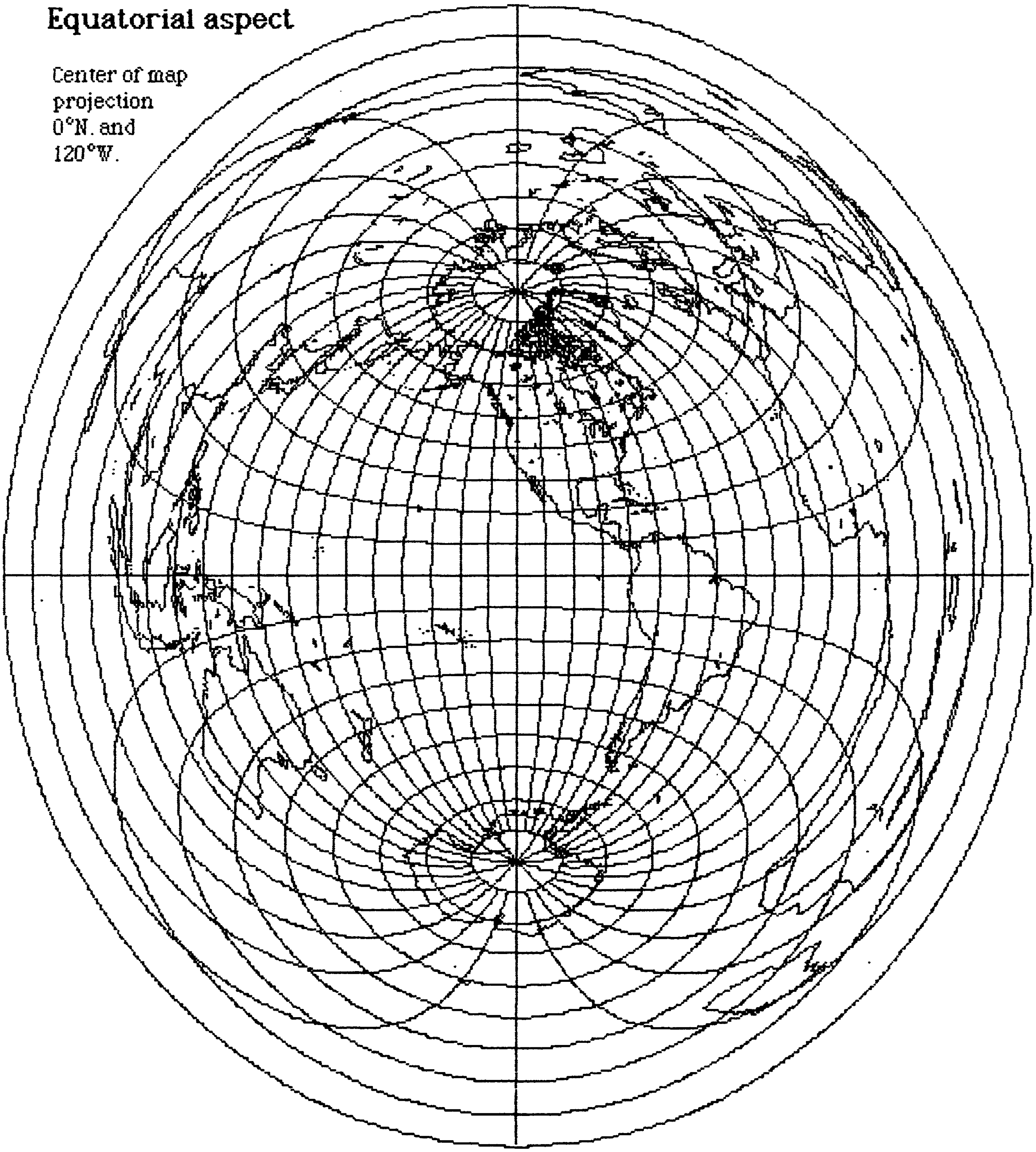
Individual azimuthal map projections are divided into three aspects: the polar aspect, which is tangent at the pole; the equatorial aspect, which is tangent at the equator; and the oblique aspect, which is tangent anywhere else. The oblique aspect is generally the most useful.

To Azimuthal | To stack outline

Azimuthal Equidistant

Equatorial aspect

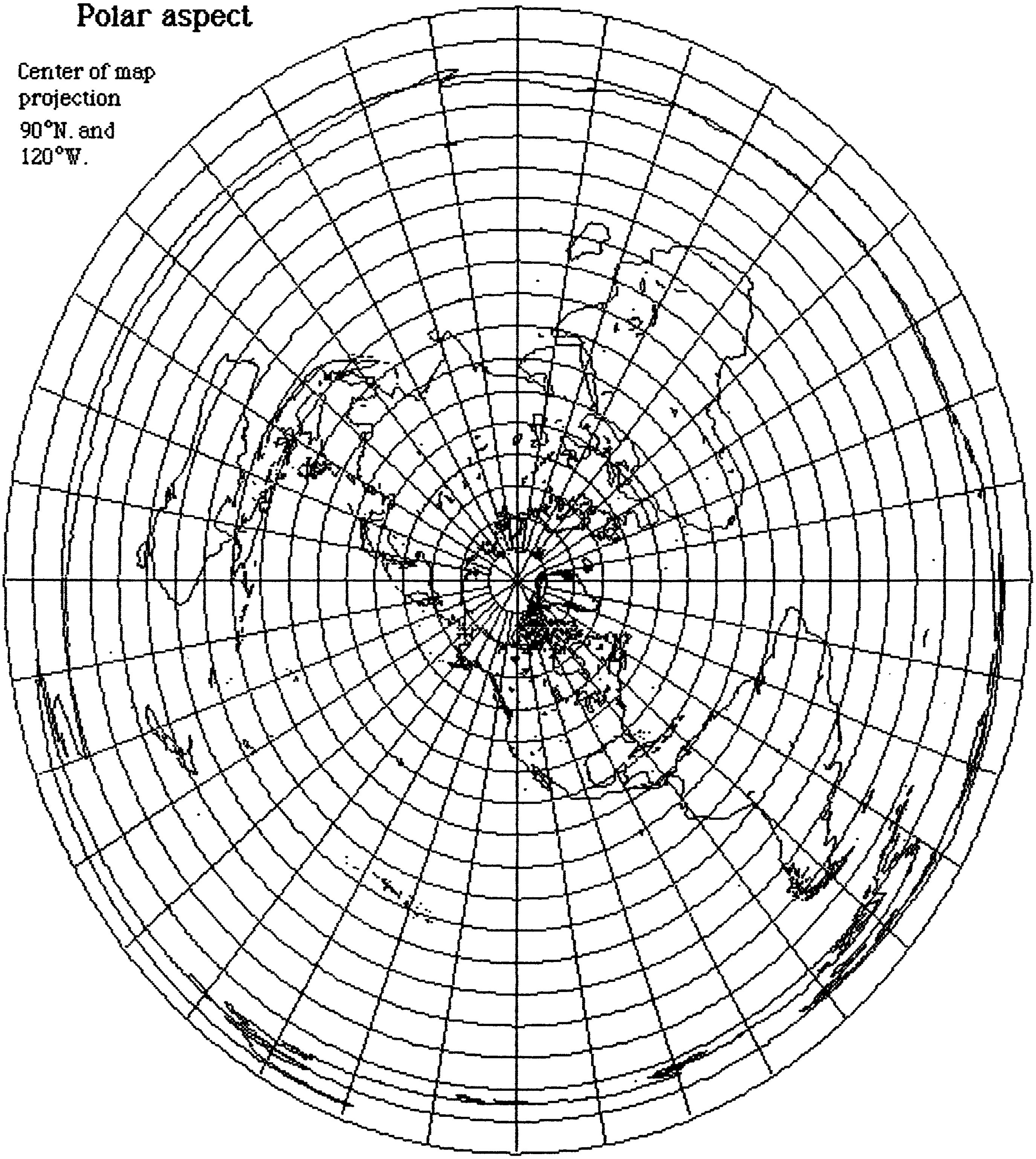
Center of map projection 0°N. and 120°W.



Azimuthal Equidistant

Polar aspect

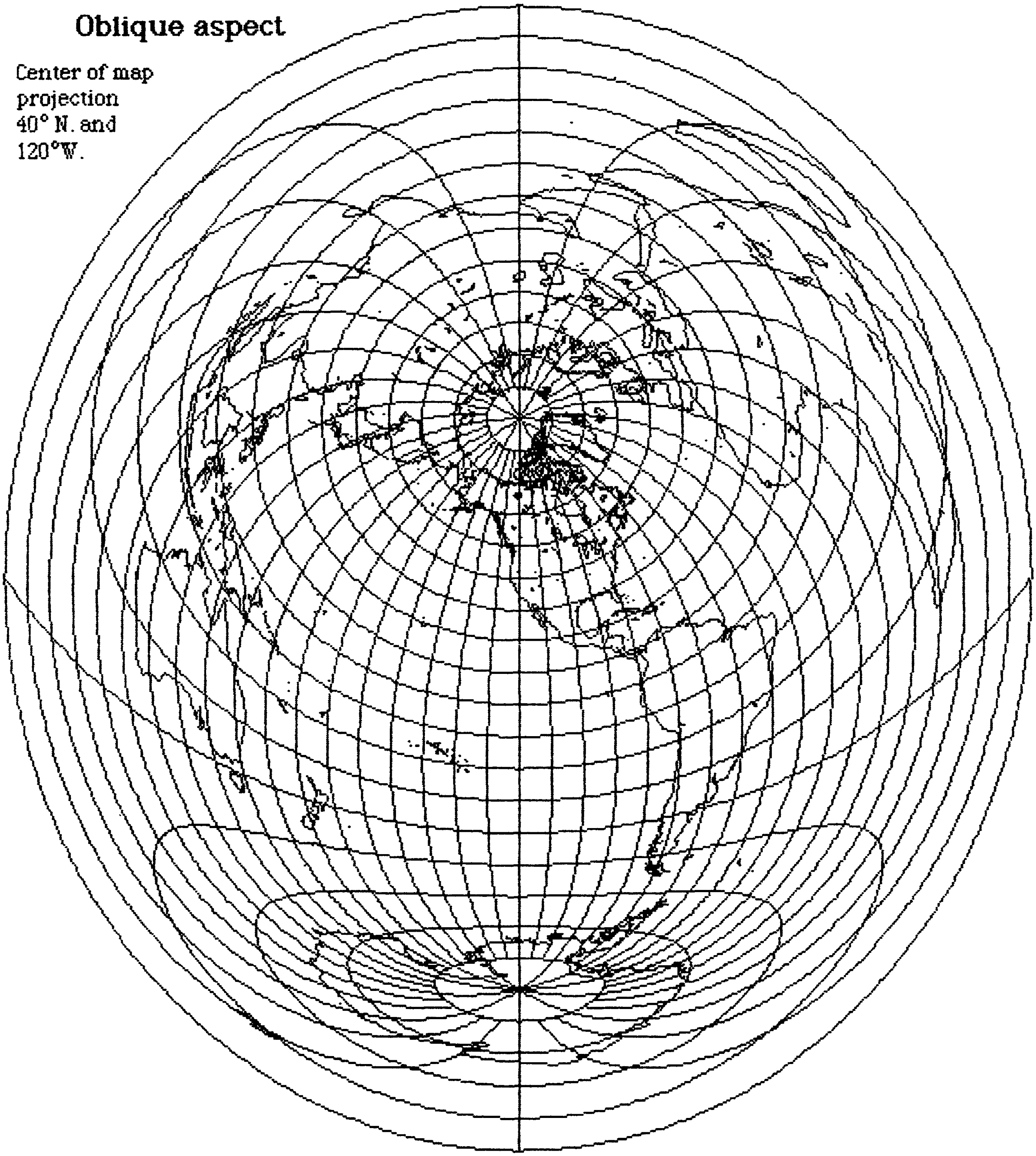
Center of map projection 90°N. and 120°W.



Azimuthal Equidistant

Oblique aspect

Center of map projection 40° N. and 120°W.



Azimuthal Equidistant

Lines of longitude (meridians):

Polar aspect; the meridians are straight lines radiating from the point of tangency. Oblique aspect; the meridians are complex curves concave toward the point of tangency. Equatorial aspect; the meridians are complex curves concave toward a straight central meridian, except the outer meridian of a hemisphere, which is a circle.

Lines of latitude (parallels):

Polar aspect; the parallels are concentric circles. Oblique aspect: the parallels are complex curves. Equatorial aspect: the parallels are complex curves concave toward the nearest pole; the equator is straight.

Graticule spacing:

Polar aspect: the meridian spacing is equal and increases away from the point of tangency.

Linear scale:

Polar aspect: linear scale is true from the point of tangency along the meridians only. Oblique and equatorial aspects: linear scale is true from the point of tangency. In all aspects the Azimuthal Equidistant, shows distances true to scale when measured between the point of tangency and any other point on the map.

Notes:

Projection is mathematically based on a plane tangent to the earth. The entire earth can be represented. Generally the Azimuthal Equidistant map projection is used to portray less than one hemisphere; the other hemisphere can be portrayed but areas and angles are distorted. Has true direction and true distance scaling only from the point of tangency.

Uses:

The Azimuthal Equidistant projection is used for radio and seismic work, because every place in the world will be shown at its true distance and direction from the point of tangency. The U.S. Geological Survey uses the oblique aspect of the Azimuthal Equidistant in the National Atlas and for large-scale mapping of Micronesia. The polar aspect is used as the emblem of the United Nations.

Azimuthal Equidistant

as used by the U. S. Geological Survey

Used in the oblique aspect in National Atlas of the United States.

Azimuthal Equidistant used as part of the symbol of the United Nations.

Lambert
Azimuthal
Equal-Area

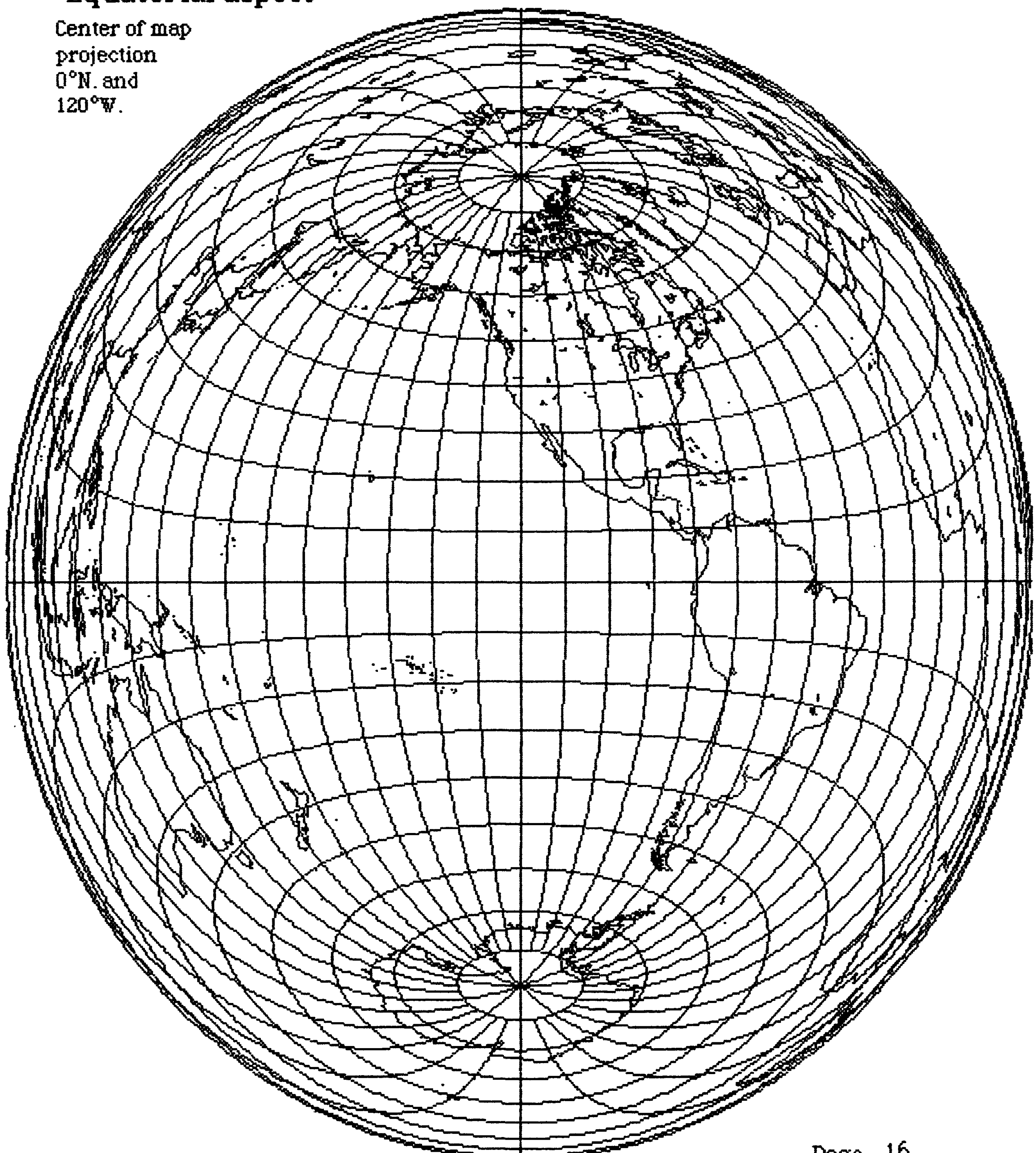
To Azimuthal

To stack outline

To "as used by U.S.G.S."

Equatorial aspect

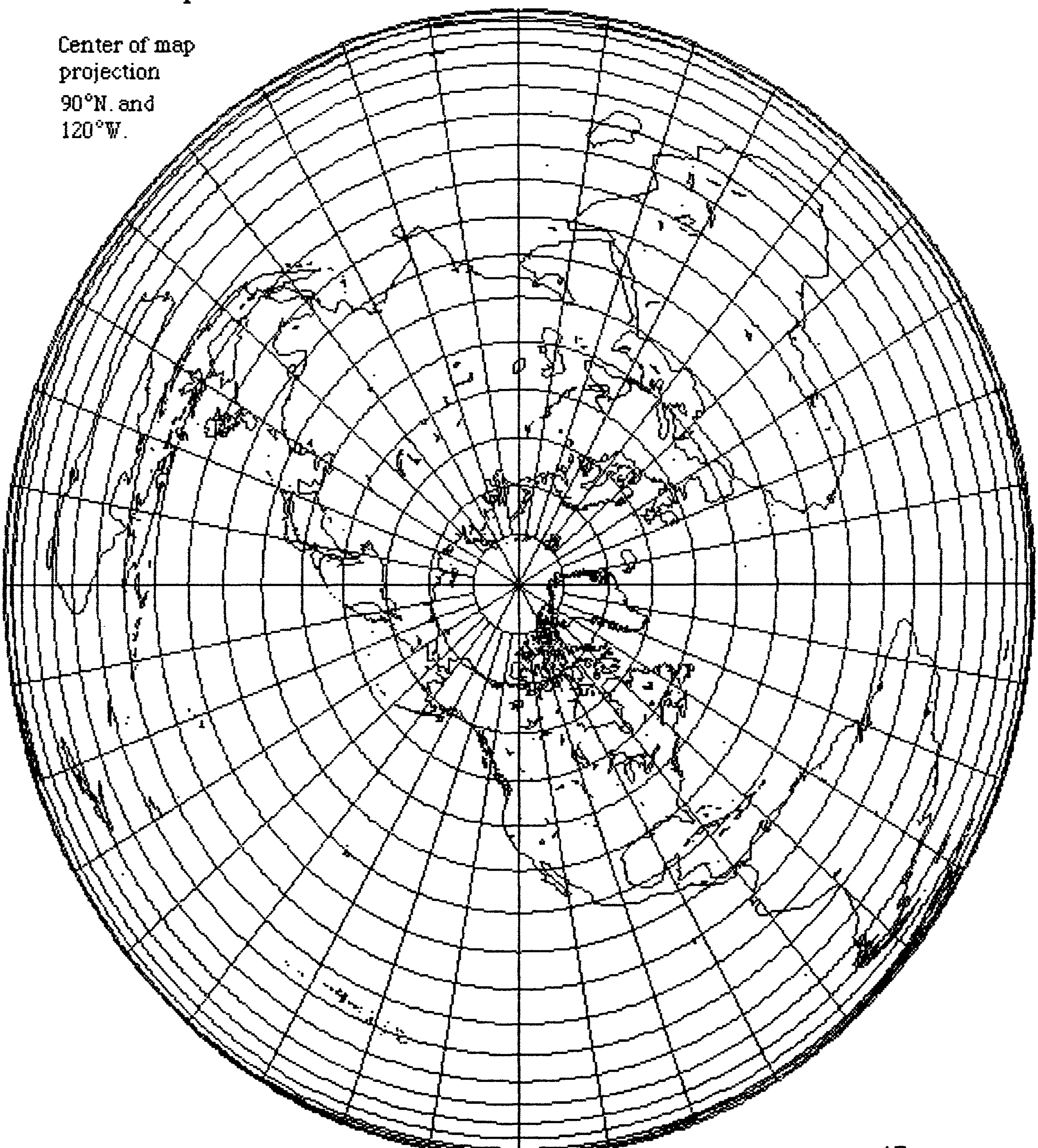
Center of map projection 0°N. and 120°W.



Lambert Azimuthal Equal-Area

Polar aspect

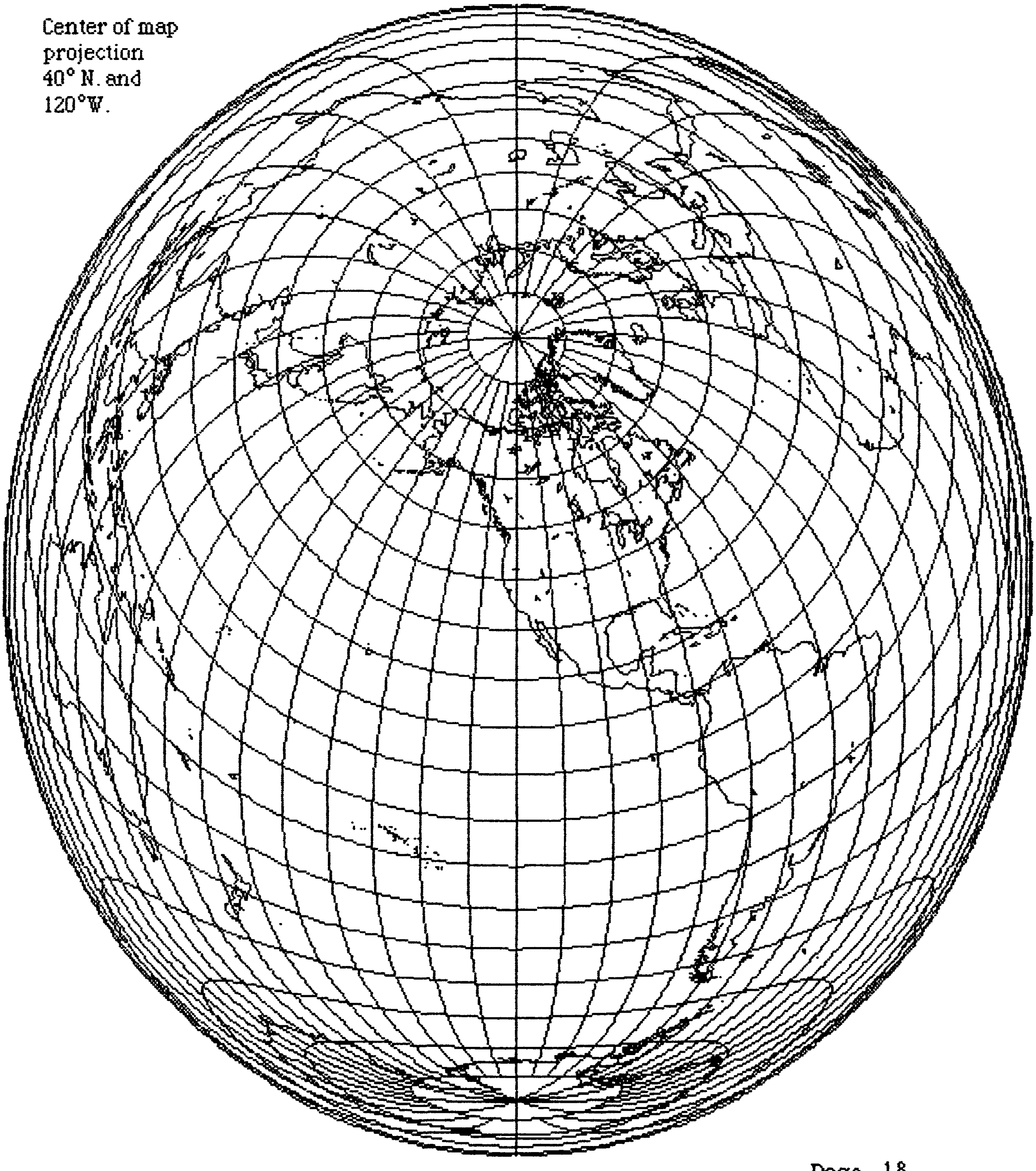
Center of map projection
90°N. and 120°W.



Lambert Azimuthal Equal-Area

Oblique aspect

Center of map projection 40° N. and 120°W.



Lambert Azimuthal Equal-Area

Lines of longitude (meridians):

Polar aspect: the meridians are straight lines radiating from the point of tangency. Oblique and equatorial aspects: meridians are complex curves concave toward a straight central meridian, except the outer meridian of a hemisphere, which is a circle.

Lines of latitude (parallels):

Polar aspect: parallels are concentric circles. Oblique and equatorial aspects: the parallels are complex curves. The equator on the equatorial aspect is a straight line.

Graticule spacing:

Polar aspect: the meridian spacing is equal, on all parallels, and the parallel spacing is unequal and decreases toward the periphery of the projection. The graticule spacing in all aspects retains the property of equivalence of area.

Linear scale:

Linear scale is better than most azimuthals, but not as good as in the azimuthal equidistant. Angular deformation increases toward the periphery of the projection. Scale increases perpendicular to the radii, that is, toward the periphery.

Notes:

The Lambert Azimuthal Equal-Area projection is mathematically based on a plane tangent to the earth. It is the only projection that can accurately represent both areas and true direction from the center of the projection. This projection generally is used to represent only one hemisphere.

Uses:

Used in numerous atlases as a equal-area map projection representing large continent-size areas to display thematic data. The polar aspect is used by the U.S. Geological Survey in the National Atlas, and for some of the Antarctica 1:250,000 Reconnaissance Series maps . The polar, oblique, and equatorial aspects are used by the Circum-Pacific Council for Energy and Mineral Resources and the U.S. Geological Survey for the Circum-Pacific Map Project.

To "as used by U.S.G.S."

Lambert Azimuthal Equal-Area

To see the areas covered by the Circum-Pacific Council Map Project, follow the arrows or click on the references listed below.

As used by the U. S. Geological Survey and Circum-Pacific Council for Energy and Mineral Resources for the **Circum-Pacific Map Project.**

American Association of Petroleum Geologists, 1977, Geographic Map of the Circum-Pacific Region, Northwest Quadrant: Tulsa, Okla., American Association of Petroleum Geologists, scale 1:10,000,000.

----, 1978, Geographic Map of the Circum-Pacific Region, Antarctica Sheet: Tulsa, Okla., American Association of Petroleum Geologists, scale 1:10,000,000.

----, 1978, Geographic Map of the Circum-Pacific Region, Northeast Quadrant: Tulsa, Oklahoma, American Association of Petroleum Geologists, Tulsa, Okla., scale 1:10,000,000.

----, 1978, Geographic Map of the Circum-Pacific Region, Southeast Quadrant: Tulsa, Okla., American Association of Petroleum Geologists, scale 1:10,000,000.

----, 1978, Geographic Map of the Circum-Pacific Region, Southwest Quadrant: Tulsa, Okla., American Association of Petroleum Geologists, scale 1:10,000,000.

----, 1978, Geographic Map of the Circum-Pacific Region, Pacific Basin Sheet: Tulsa, Okla., American Association of Petroleum Geologists, scale 1:17,000,000.

----, 1990, Geographic Map of the Circum-Pacific Region, Arctic Sheet: Tulsa, Okla., American Association of Petroleum Geologists, scale 1:10,000,000.

Other map projections that can be used —

for North America.

To Albers Conic Equal-Area

To Lambert Conic Conformal

for the World,

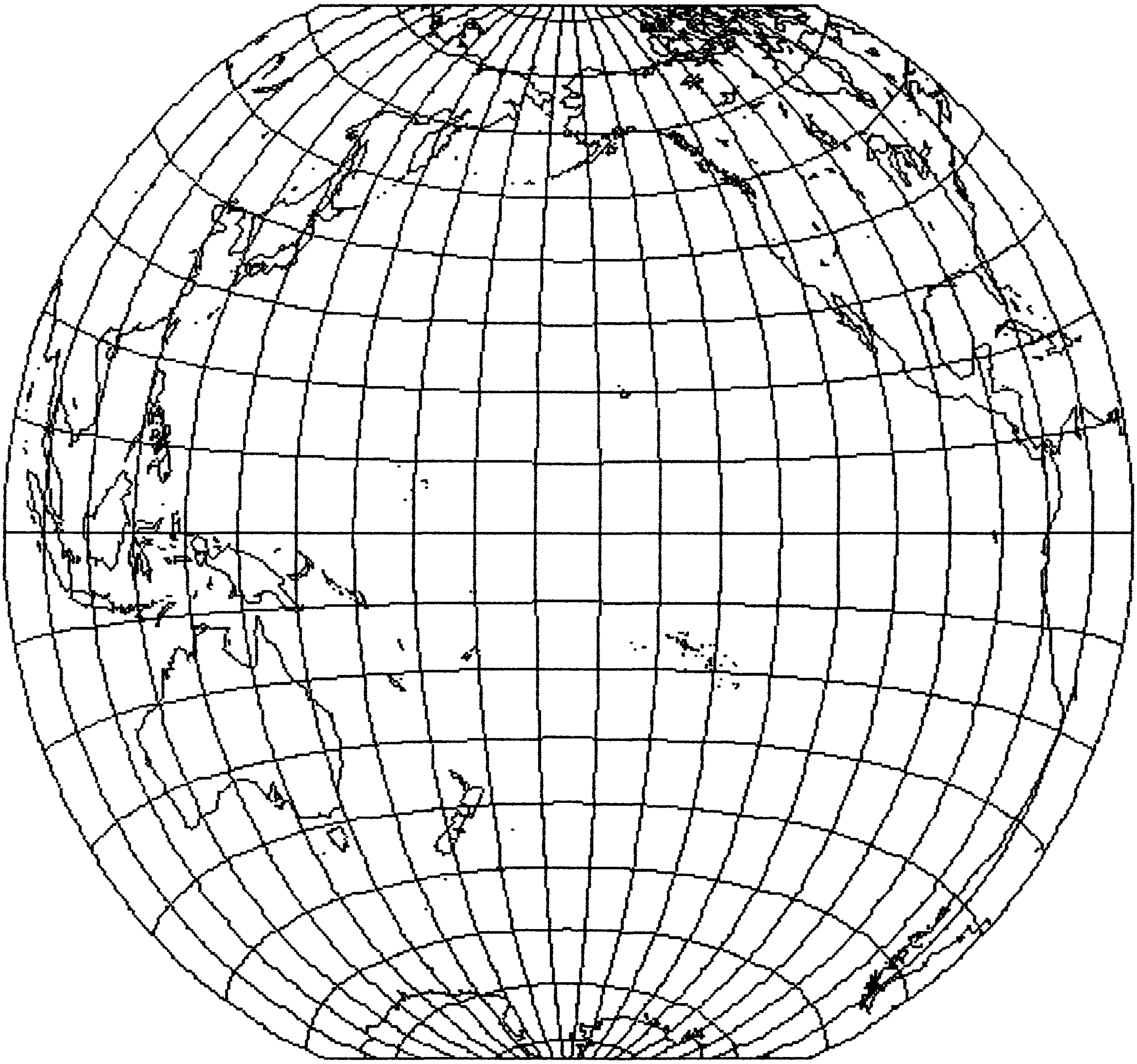
To Sinusoidal

To Goode Homolosine

To Robinson

Lambert Azimuthal Equal-Area

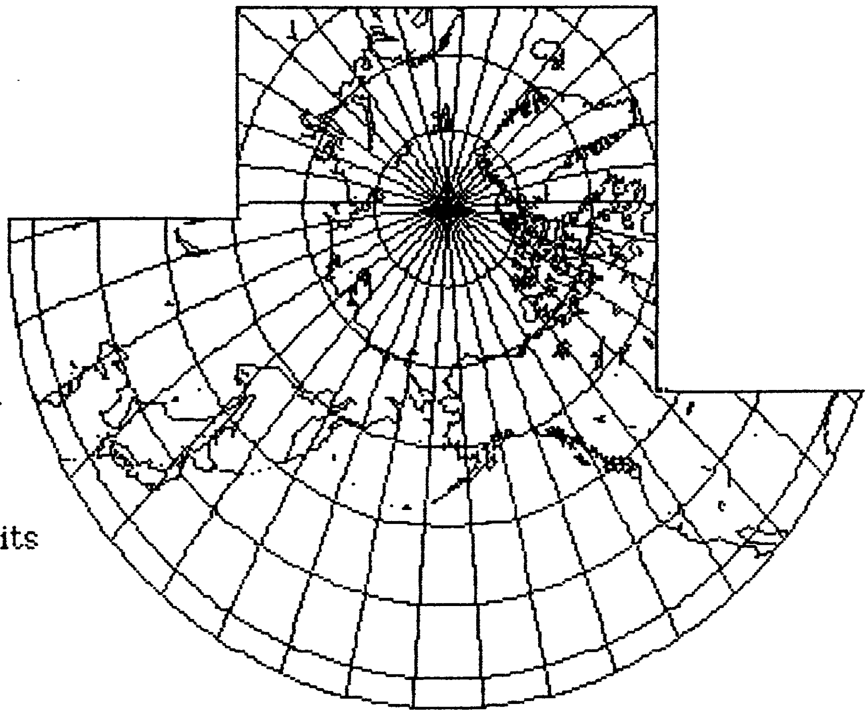
Circum-Pacific Maps



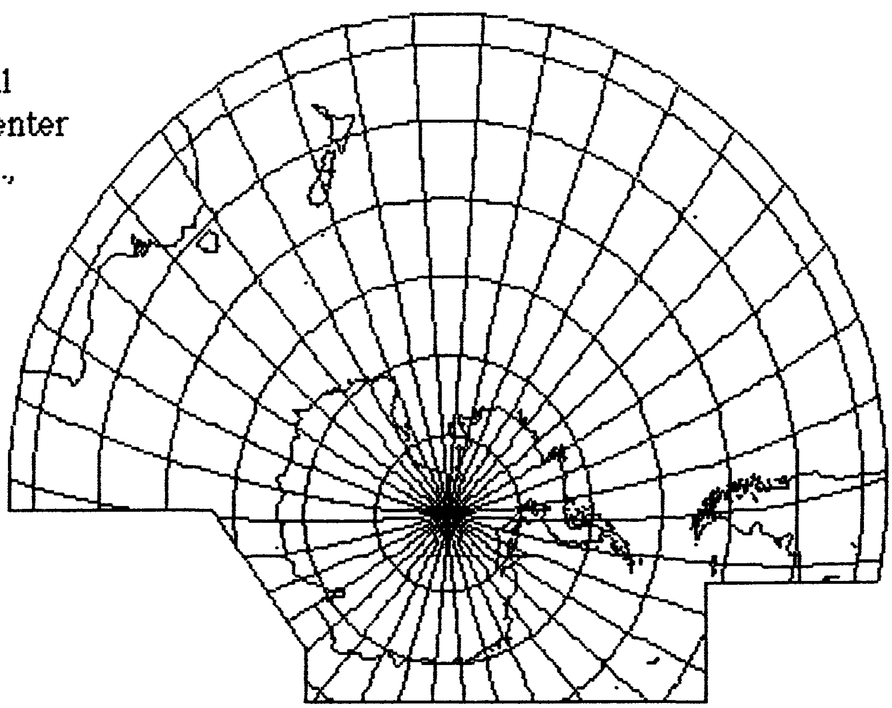
Lambert Azimuthal Equal-Area with center point 0°., 160°W., as used by the Circum-Pacific Map Project for its Pacific Basin Sheet.

Lambert Azimuthal Equal-Area

Circum-Pacific Maps



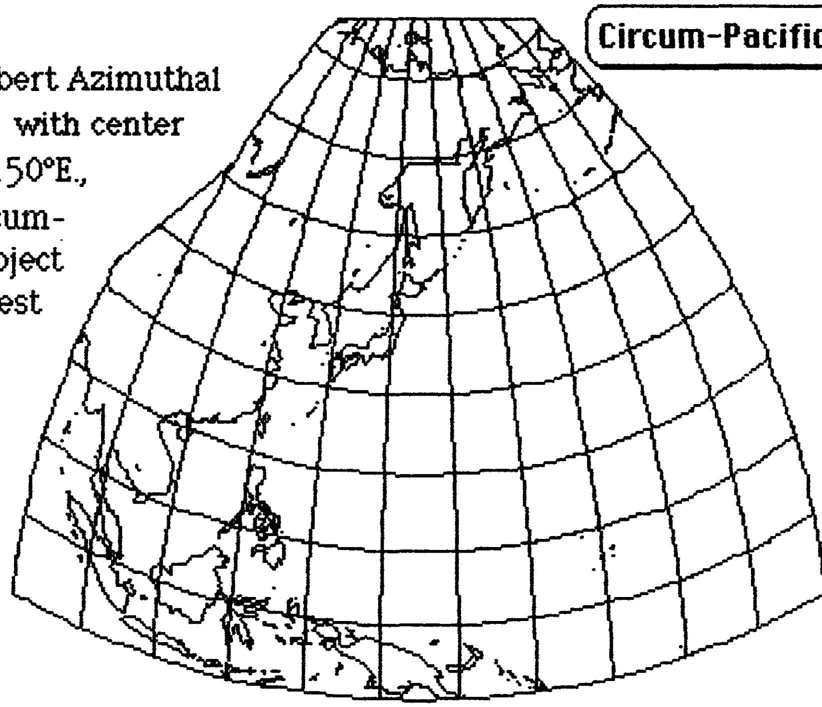
Lambert Azimuthal Equal-Area with center point 70°N., 165°W., as use by the Circum-Pacific Map Project for its Arctic Sheet.

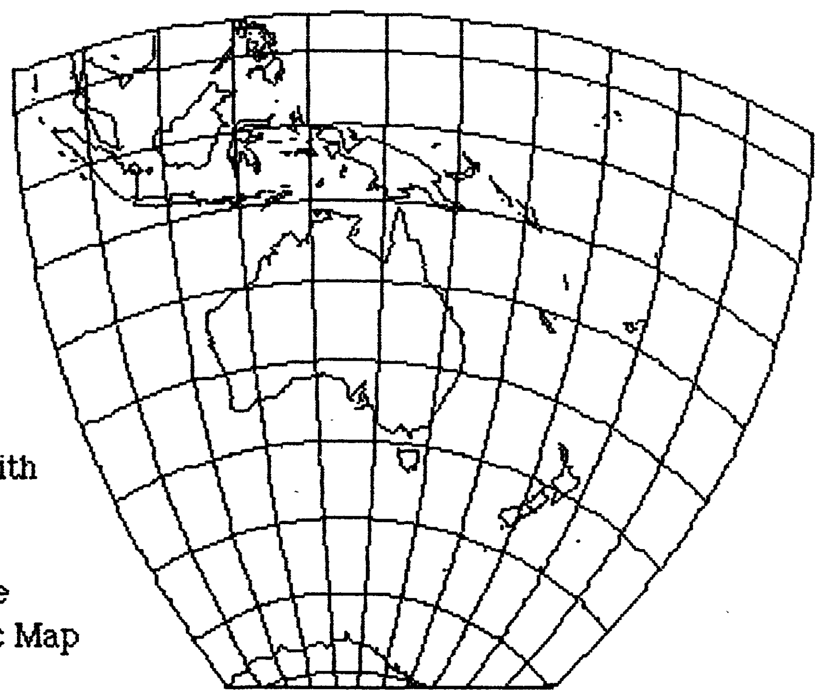


Lambert Azimuthal Equal-Area with center point 70°S., 165°W., as used by the Circum-Pacific Map Project for its Antarctica Sheet.

Lambert Azimuthal Equal-Area

Lambert Azimuthal Equal-Area with center point 35°N., 150°E., as used by Circum-Pacific Map Project for its Northwest Quadrant.



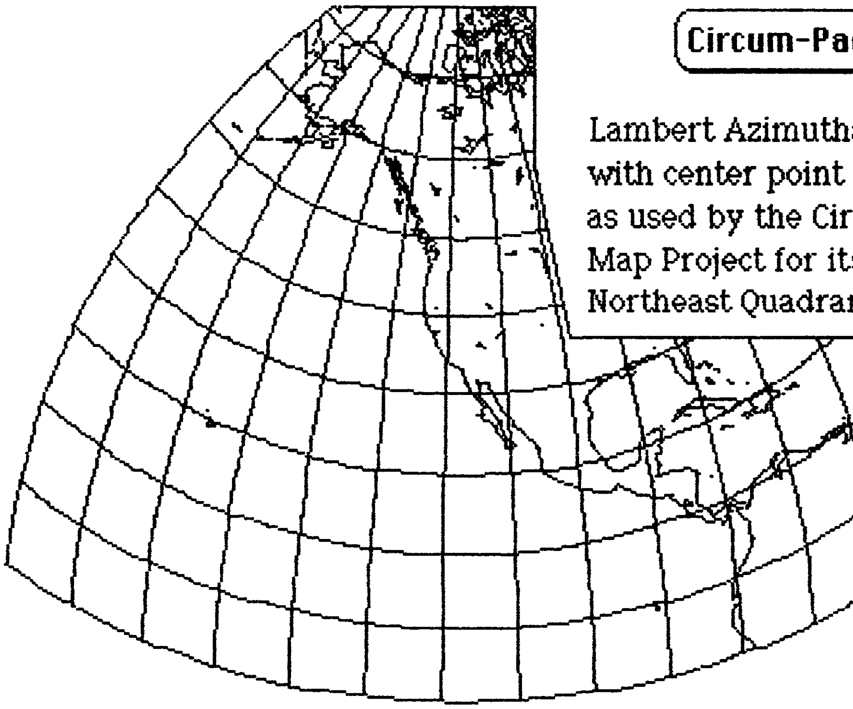


Lambert Azimuthal Equal-Area with center point 35°S., 135°E., as used by the Circum-Pacific Map Project for its Southwest Quadrant

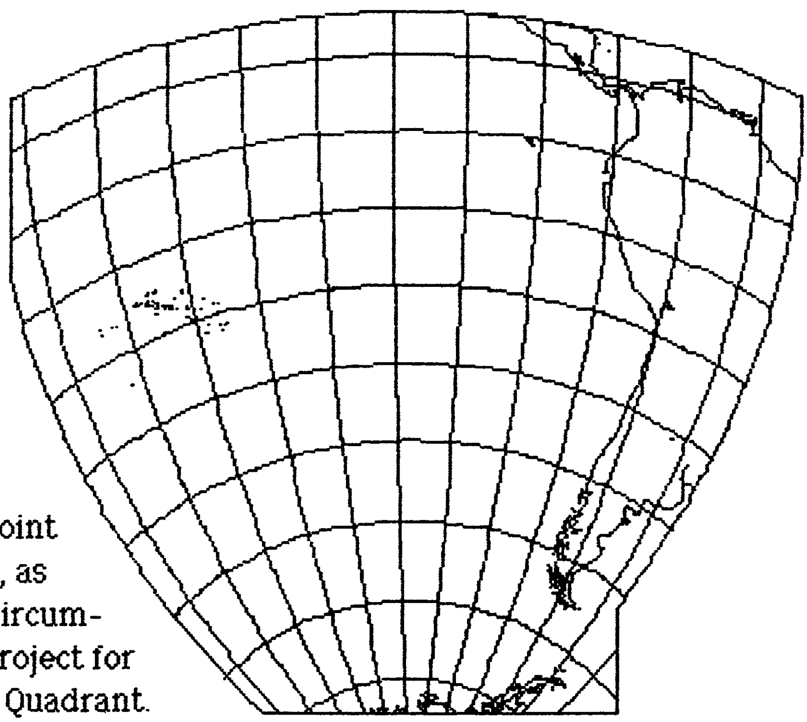
Lambert Azimuthal Equal-Area

Azimuthal

Circum-Pacific Maps



Lambert Azimuthal Equal-Area with center point 35°N., 135°W., as used by the Circum-Pacific Map Project for its Northeast Quadrant.



Lambert Azimuthal Equal-Area with center point 40°S., 100°W., as used by the Circum-Pacific Map Project for its Southeast Quadrant.

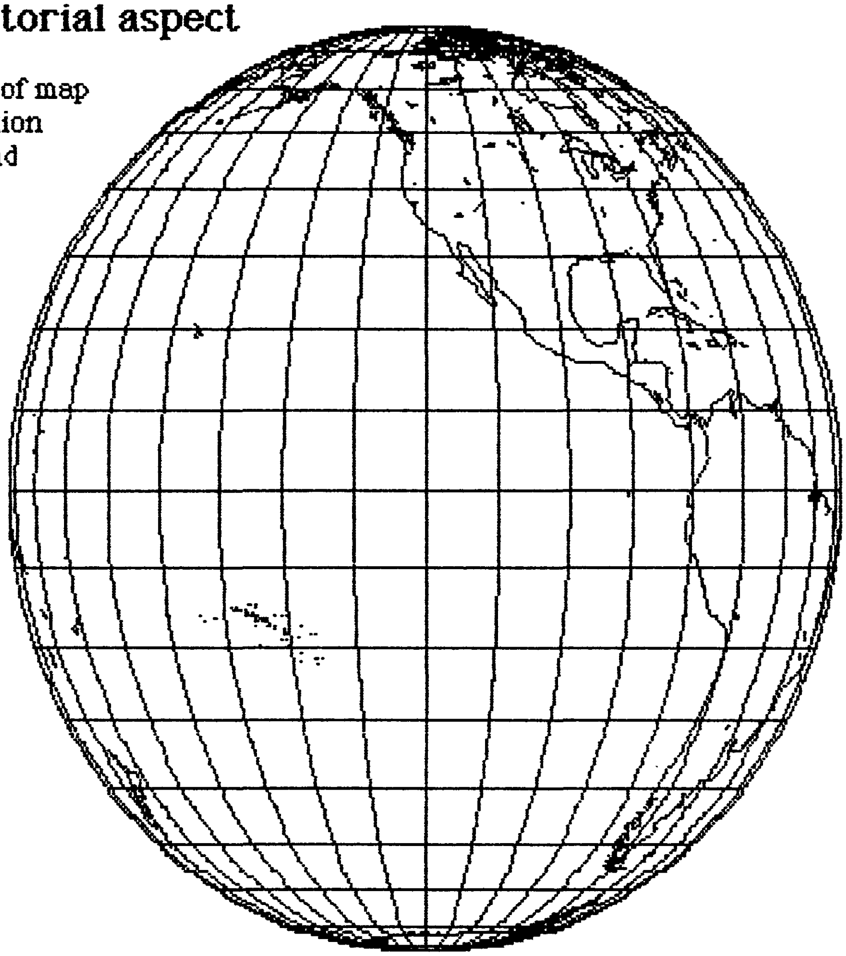
To Azimuthal

To stack outline

Orthographic

Equatorial aspect

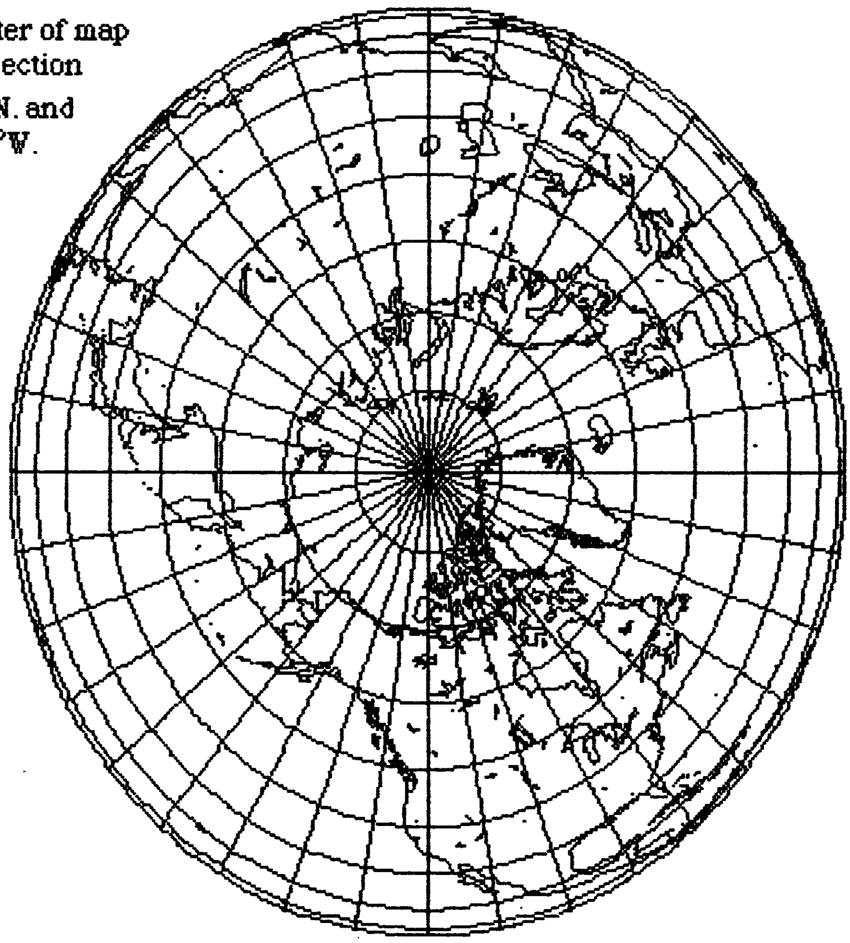
Center of map projection 0°N. and 120°W.



Orthographic

Polar aspect

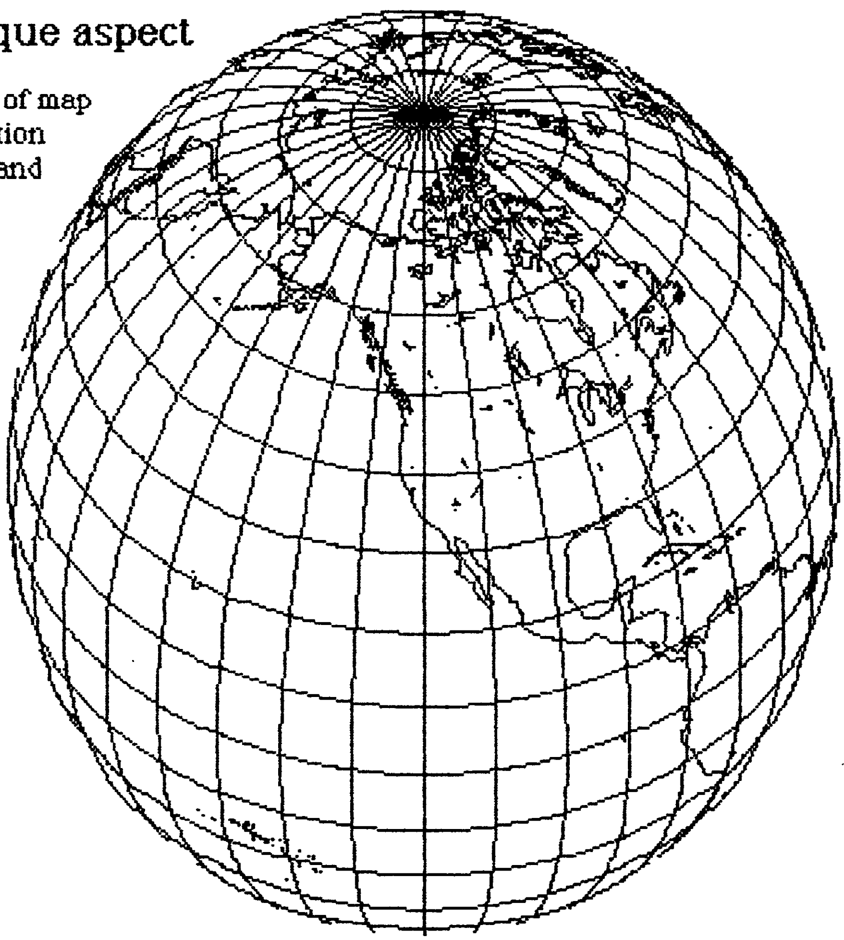
Center of map projection
90°N. and 120°W.



Orthographic

Oblique aspect

Center of map projection 40° N. and 120°W.



Orthographic

Lines of longitude (meridians):
Polar aspect: the meridians are straight lines radiating from the point of tangency. Oblique aspect: the meridians are ellipses, concave toward the center of the projection. Equatorial aspect: the meridians are ellipses concave toward the straight central meridian.

Lines of latitude (parallels):
Polar aspect: the parallels are concentric circles. Oblique aspect: the parallels are ellipses concave toward the poles. Equatorial aspect: the parallels are straight and parallel.

Graticule spacing:
Polar aspect: meridian spacing is equal on any parallel and increases toward the equator, and parallel spacing decreases from the point of tangency. Oblique and equatorial aspects: the graticule spacing decreases away from the center of the projection.

Linear scale:
Scale is true on the parallels in the polar aspect and on all circles centered at the pole of the projection in all aspects. Scale decreases along lines radiating from the center of the projection.

Notes:
The Orthographic projection is geometrically based on a plane tangent to the earth, and the point of projection is at infinity. The earth appears as it would from outer space. This projection is a truly graphic representation of the earth and is a projection in which distortion becomes a visual aid. It is the most familiar of the azimuthal map projections. Directions from the center of the Orthographic map projection are true.

Uses:
The U. S. Geological Survey uses the Orthographic map projection in the National Atlas and for a World Seismicity map.

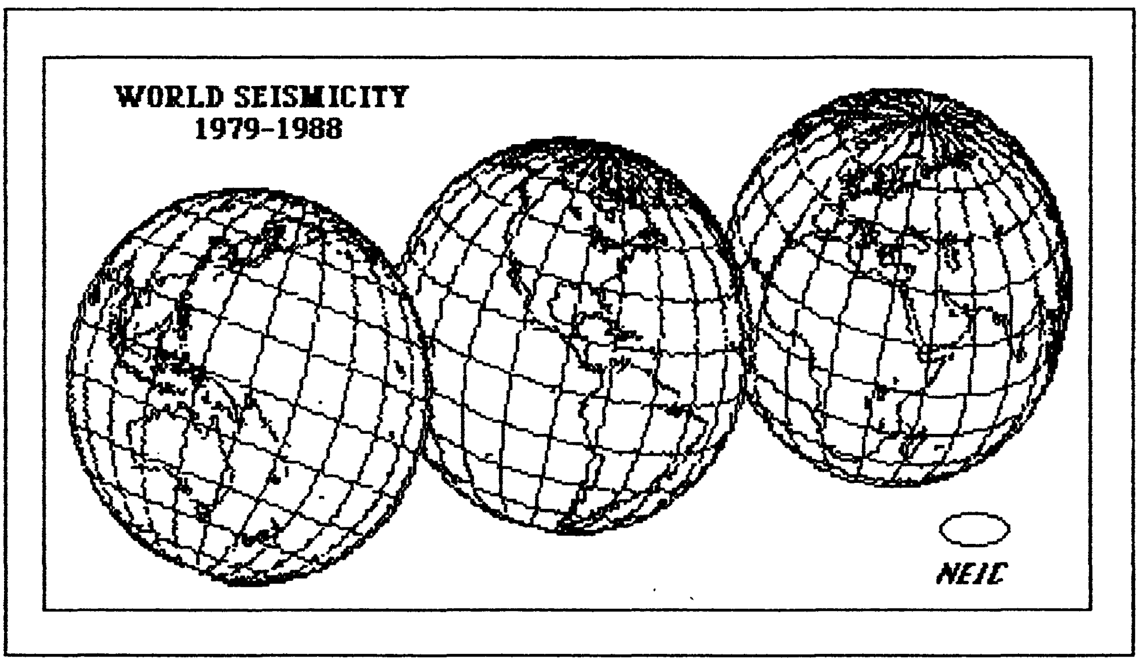
To Azimuthal
To stack outline

Orthographic

As used by the U. S. Geological Survey.

Used in the National Atlas of the United States.

Goter, Susan K., compiler, 1989, World Seismicity, 1979-1988; U. S. Geological Survey, National Earthquake Information Center Poster 1, 1 sheet (see illustration below)



Used as a logo.

Orthographic map projection used in Pan American Airways Logo 1944.

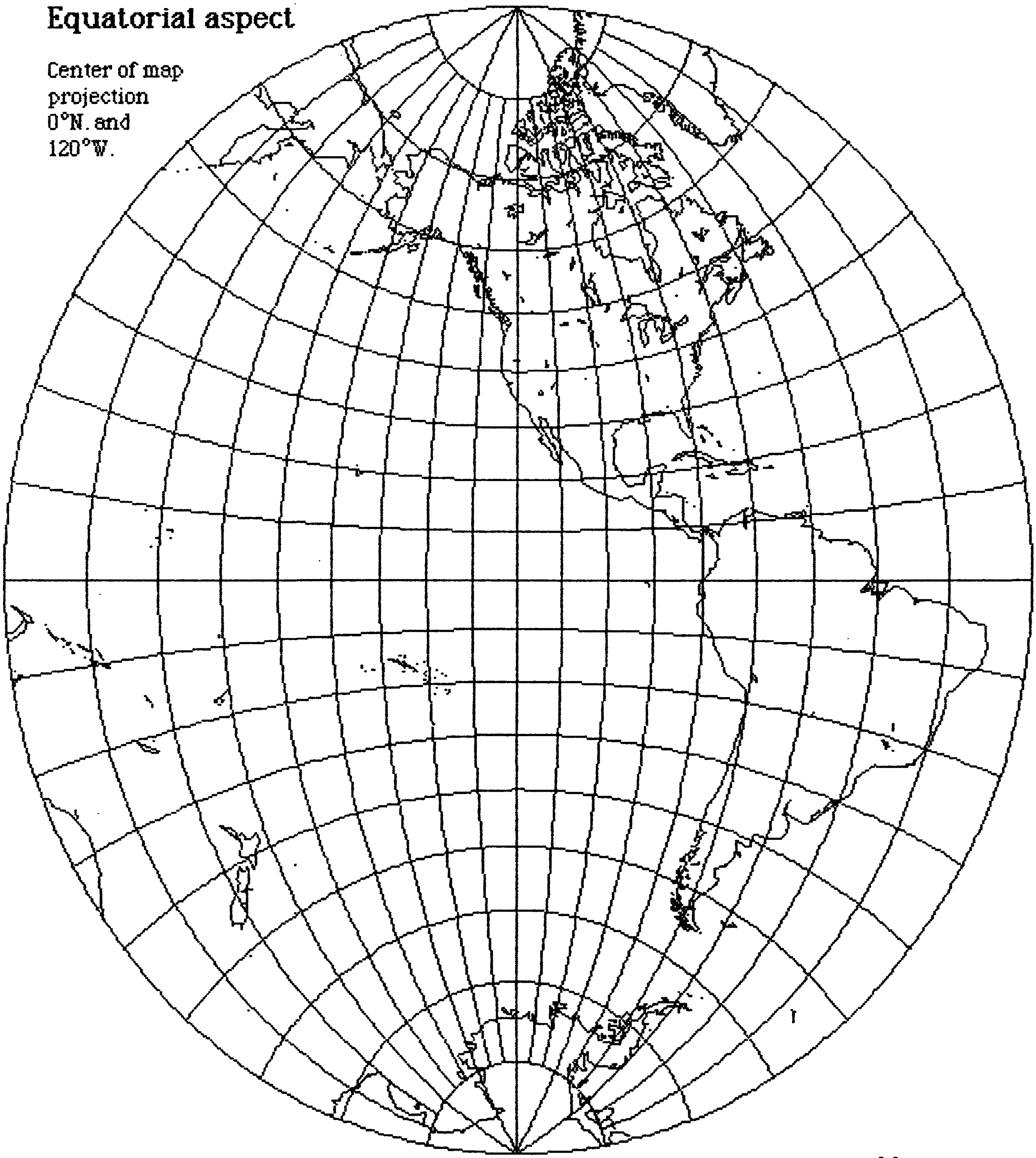
To Azimuthal

To stack outline

Stereographic

Equatorial aspect

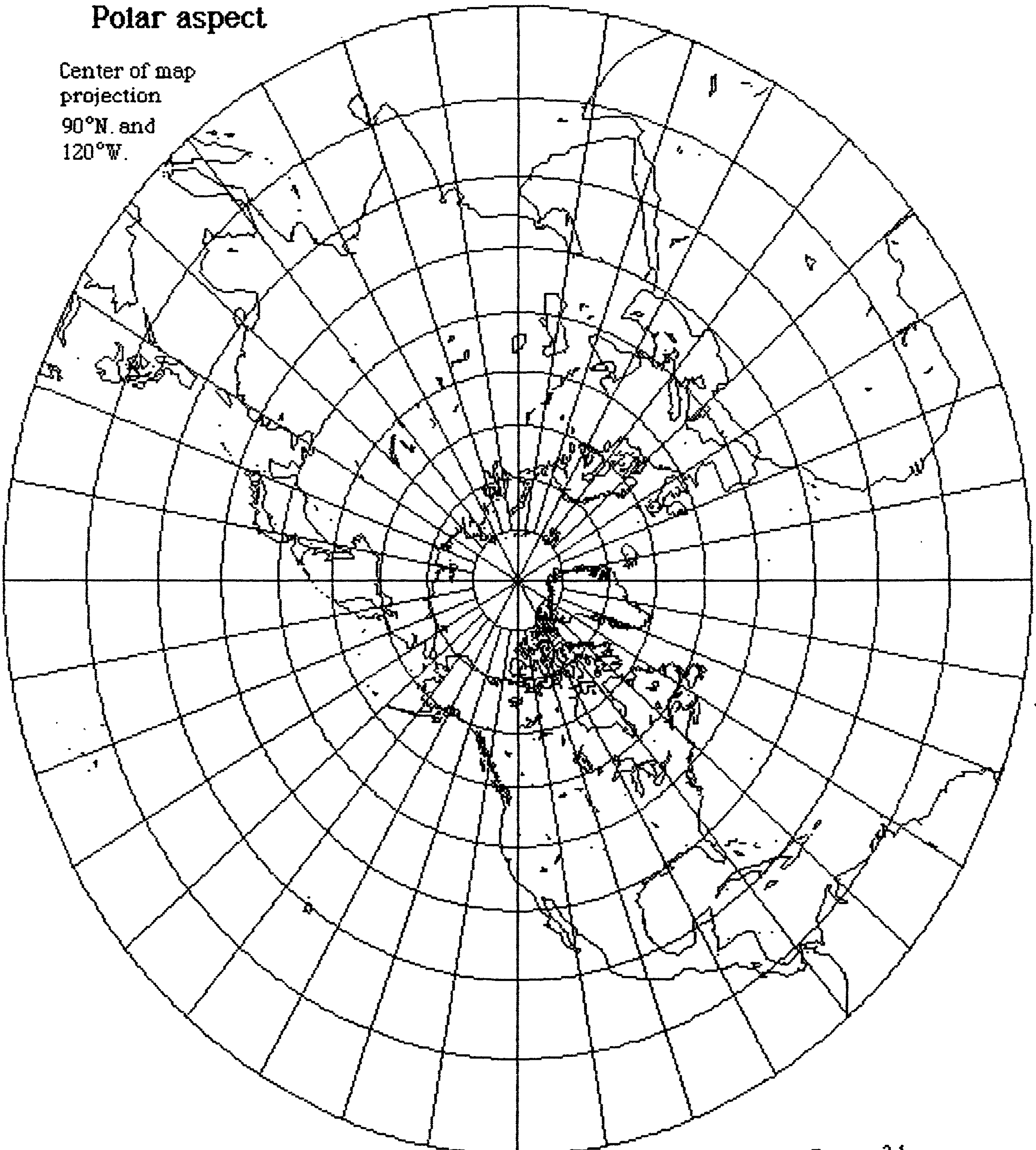
Center of map projection 0°N. and 120°W.



Stereographic

Polar aspect

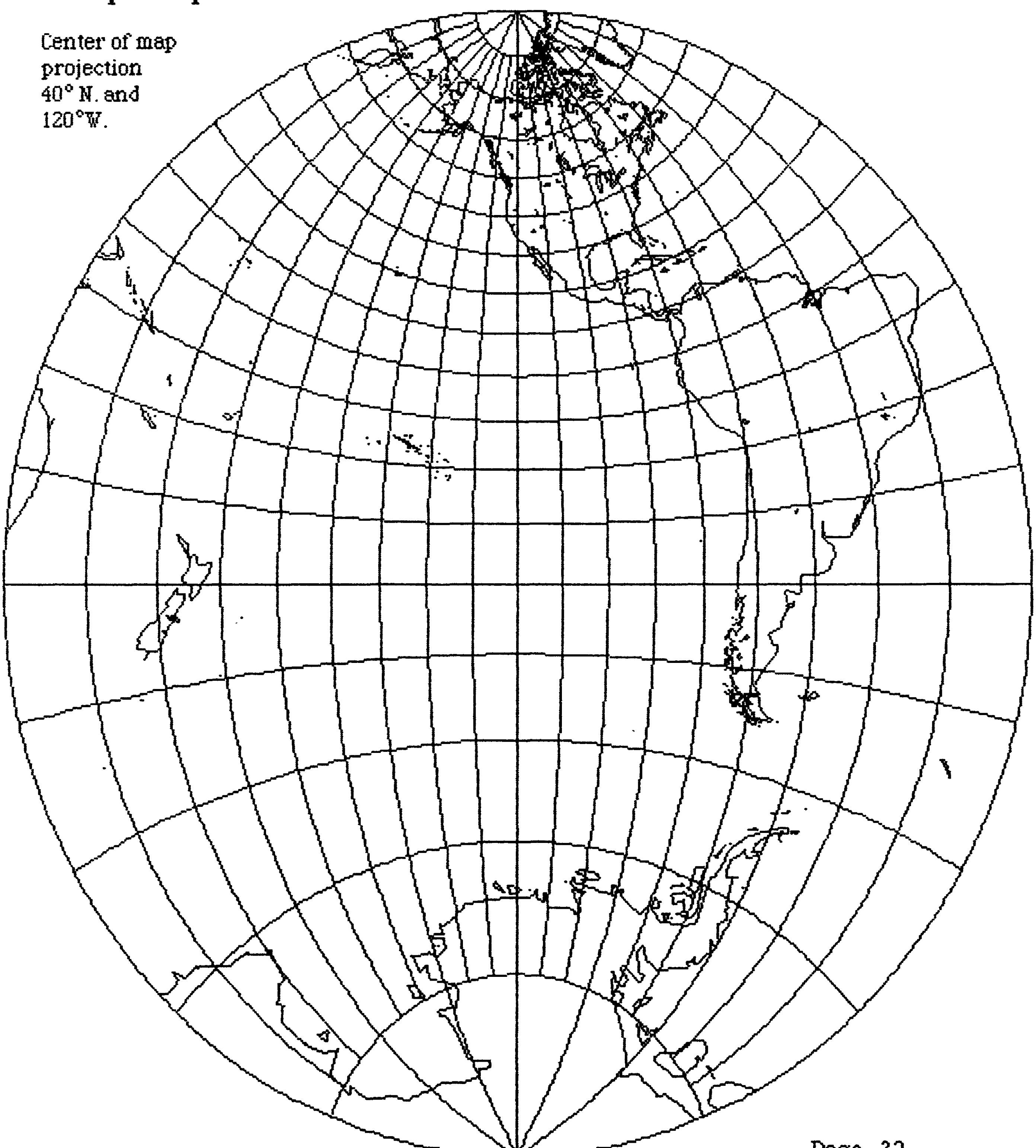
Center of map projection
90°N. and 120°W.



Stereographic

Oblique aspect

Center of map
projection
40° N. and
120°W.



Stereographic

Lines of longitude (meridians):

Polar aspect: the meridians are straight lines radiating from the point of tangency. Oblique and equatorial aspects: the meridians are arcs of circles concave toward a straight central meridian. In the equatorial aspect, the outer meridian of the hemisphere is a circle centered at the projection center.

Lines of latitude (parallels):

Polar aspect: the parallels are concentric circles. Oblique aspect: the parallels are nonconcentric arcs of circles concave toward one of the poles with one parallel being a straight line. Equatorial aspect: parallels are nonconcentric arcs of circles concave toward the poles; the equator is straight.

Graticule spacing:

The graticule spacing increases away from the center of the projection in all aspects, and it retains the property of conformality.

Linear scale:

Scale increases toward the periphery of the projection. Areas are also enlarged outward from the center.

Notes:

The Stereographic projection is geometrically projected onto a plane, and the point of the projection is on the surface of the sphere opposite the point of tangency. Circles on the earth appear as straight lines, parts of circles, or circles on the projection. Directions from the center of the stereographic map projecton are true and lines intersect at their proper angle. Generally only one hemisphere is portrayed.

Uses:

The Stereographic projection is the most widely used azimuthal projection, mainly used for portraying large, continent-size areas of similar extent in all directions. It is used in geophysics for solving problems in spherical geometry. The polar aspect is used for topographic maps and navigational charts. The American Geographical Society uses the stereographic map projection as the basis for its "Map of the Arctic." The U.S. Geological Survey uses the stereographic map projection as the basis for maps of Antarctica.

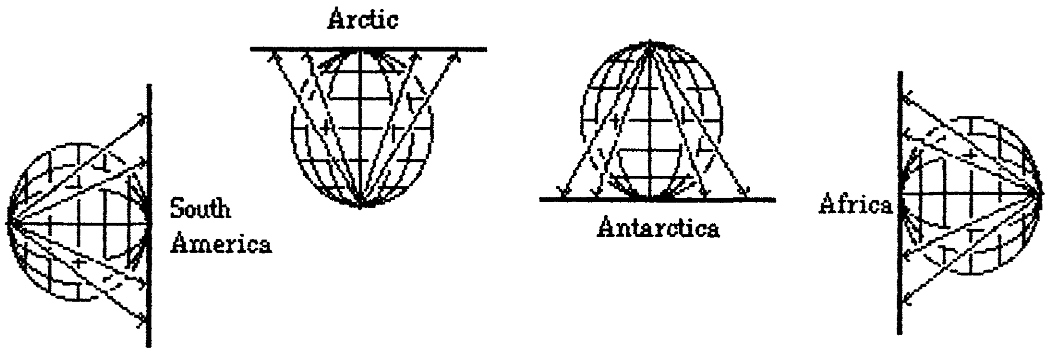
To Azimuthal

Stereographic

To stack outline

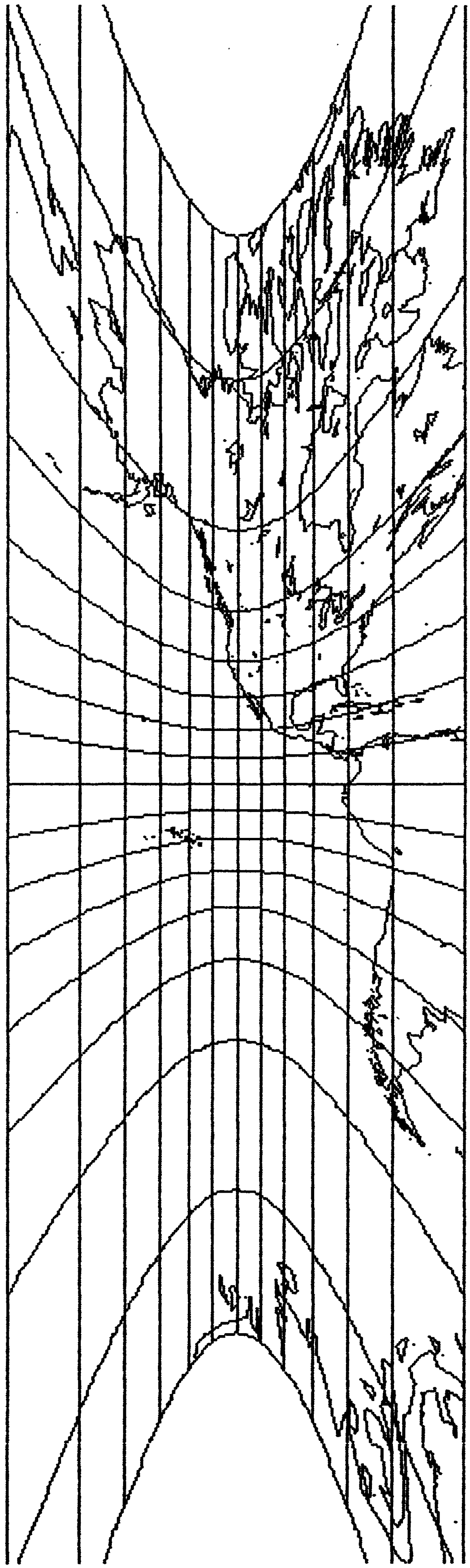
As used by the U. S. Geological Survey.

Used for some of the Antarctica 1:250,000 Reconnaissance series Maps.



Gnomonic

Equatorial aspect

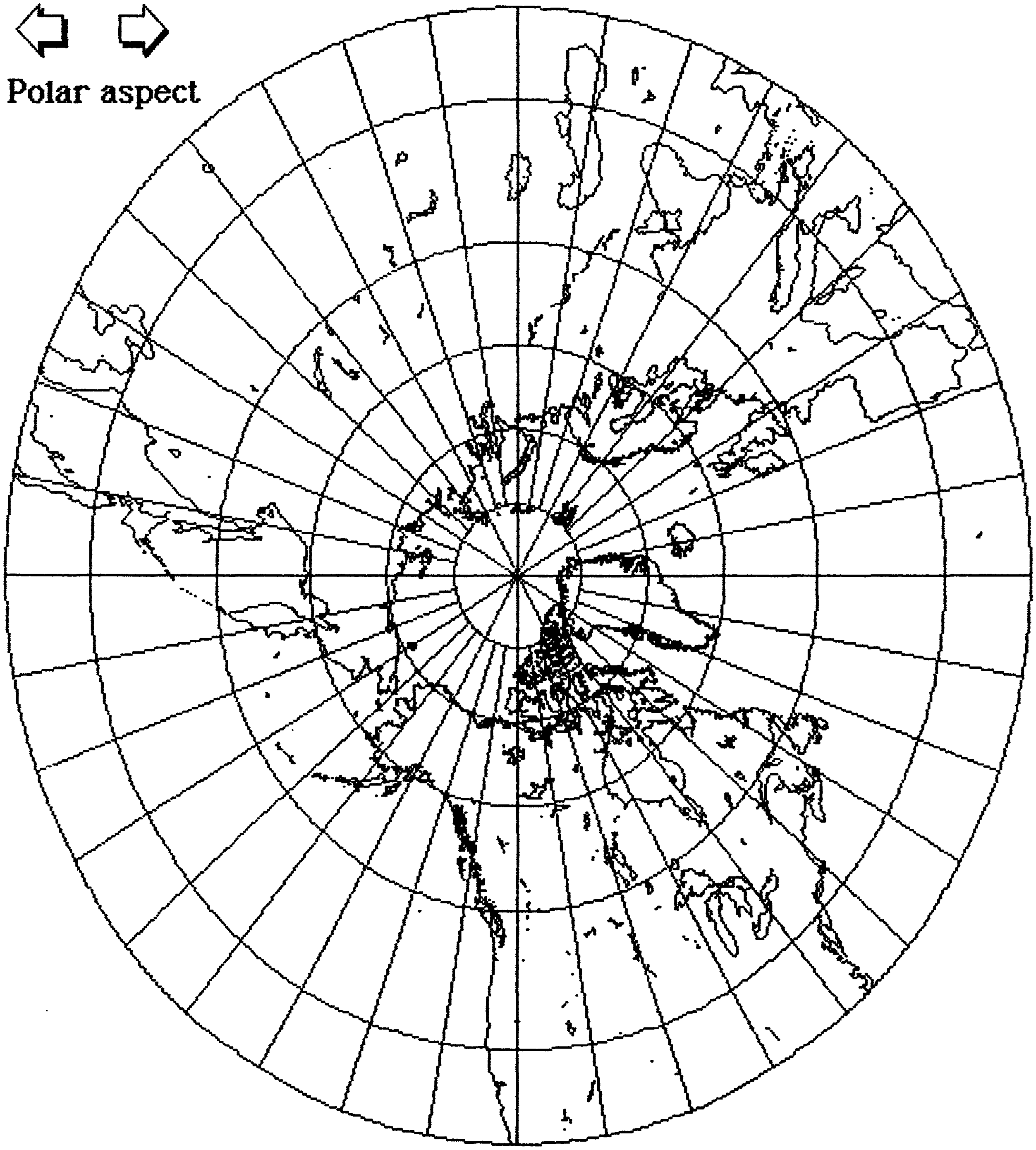


To Azimuthal

To stack outline

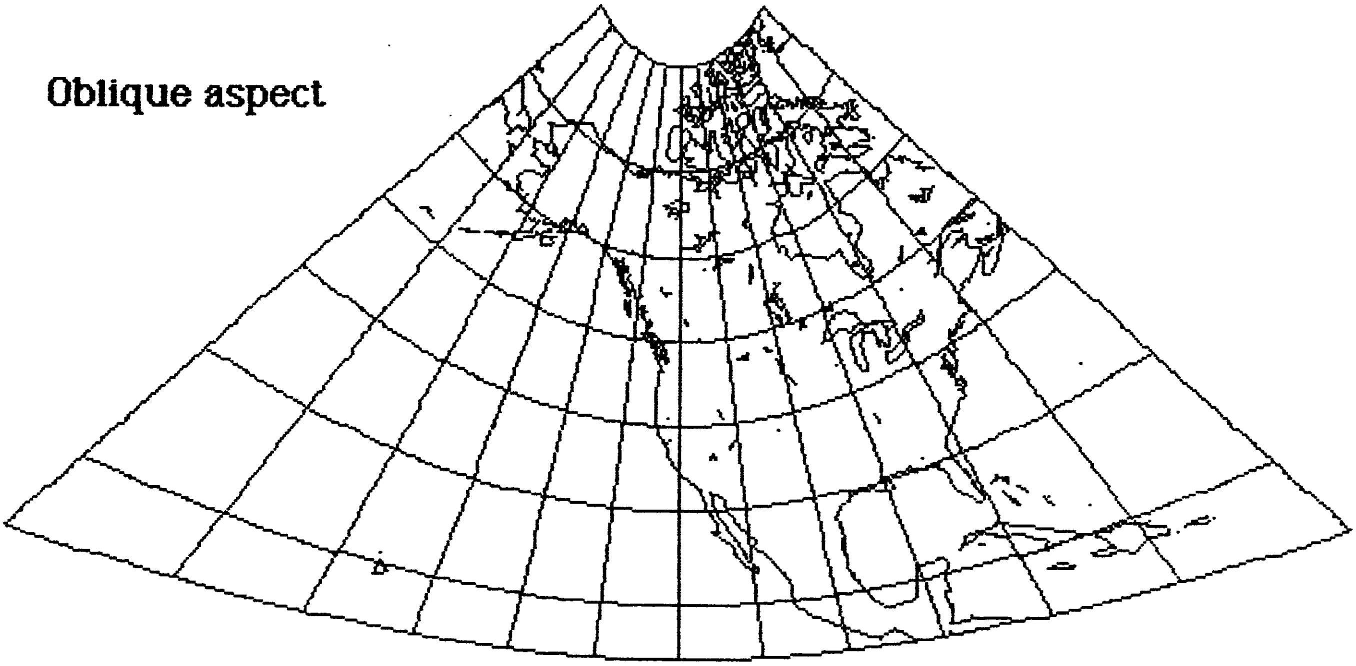
Gnomonic

Polar aspect



Gnomonic

Oblique aspect



To Azimuthal | To stack outline

Gnomonic

Lines of longitude (meridians):

Polar aspect: the meridians are straight lines radiating from the point of tangency. Oblique and equatorial aspects: the meridians are straight lines.

Lines of latitude (parallels):

Polar aspect: the parallels are concentric circles. Oblique and equatorial aspects: parallels are ellipses, parabolas, or hyperbolas concave toward the poles (except for the equator, which is straight).

Graticule spacing:

Polar aspect: the meridian spacing is equal and increases away from the pole. The parallel spacing increases very rapidly from the pole. Oblique and equatorial aspects: the graticule spacing increases very rapidly away from the center of the projection.

Linear scale:

Linear scale and angular and areal deformation are extreme, rapidly increasing away from the center of the projection.

Notes and uses:

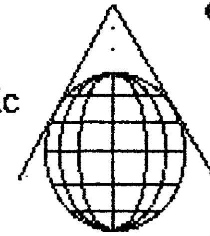
The Gnomonic projection is geometrically projected onto a plane, and the point of projection is at the center of the earth. It is impossible to show a full hemisphere with one Gnomonic map. It is the only projection in which any straight line is a great circle, and it is the only projection that shows the shortest distance between any two points as a straight line. Consequently, it is used in seismic work because seismic waves travel approximately in great circles. The Gnomonic projection is used together with the Mercator projection for navigation.

To developable surfaces | To stack outline

Cones

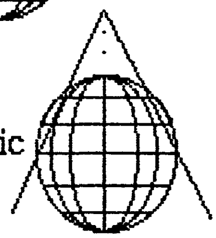
On this card click on the map projection name to select it.

1 Equidistant Conic

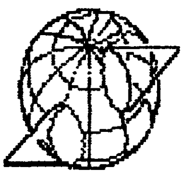


2 Albers Conic Equal-Area

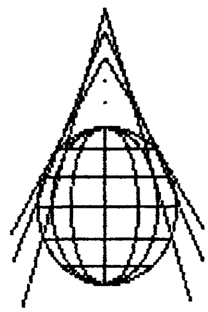
3 Lambert Conformal Conic



There are five conic map projections in this guide.



4 American Polyconic

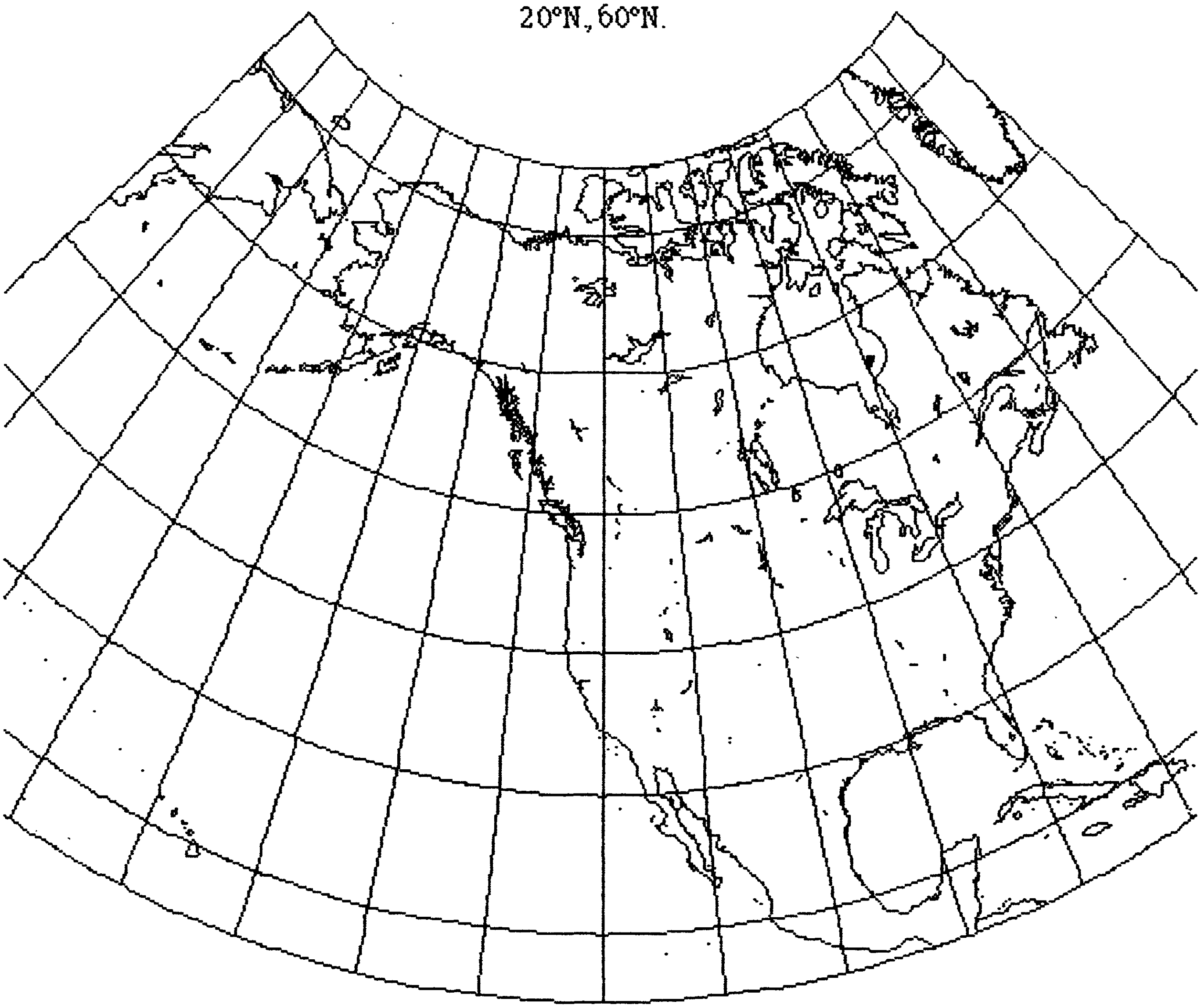


5 Bipolar Oblique Conic Conformal

Equidistant Conic (or Simple Conic)

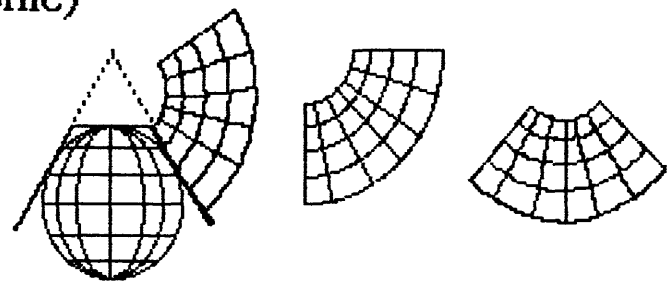
To Cones

To stack outline



To Cones | To stack outline

Equidistant Conic (or Simple Conic)



Lines of longitude (meridians):

Meridians are straight lines converging on a polar axis. When one of the standard parallels is at the pole (90° N. or S.) then the meridians converage at the pole.

Lines of latitude (parallels):

Parallels are arcs of concentric circles, concave toward a pole.

Graticule spacing:

Meridian spacing is true on the standard parallels and decreases toward the pole. Parallels are spaced at true scale along the meridians. Meridians and parallels intersect each other at right angles. The graticule is symmetrical.

Linear scale:

Linear scale is true along all meridians and along the standard parallel or parallels.

Notes:

Projection is mathematically based on a cone that is tangent at one parallel or conceptually secant at two parallels. North or South Pole is represented by an arc.

Uses:

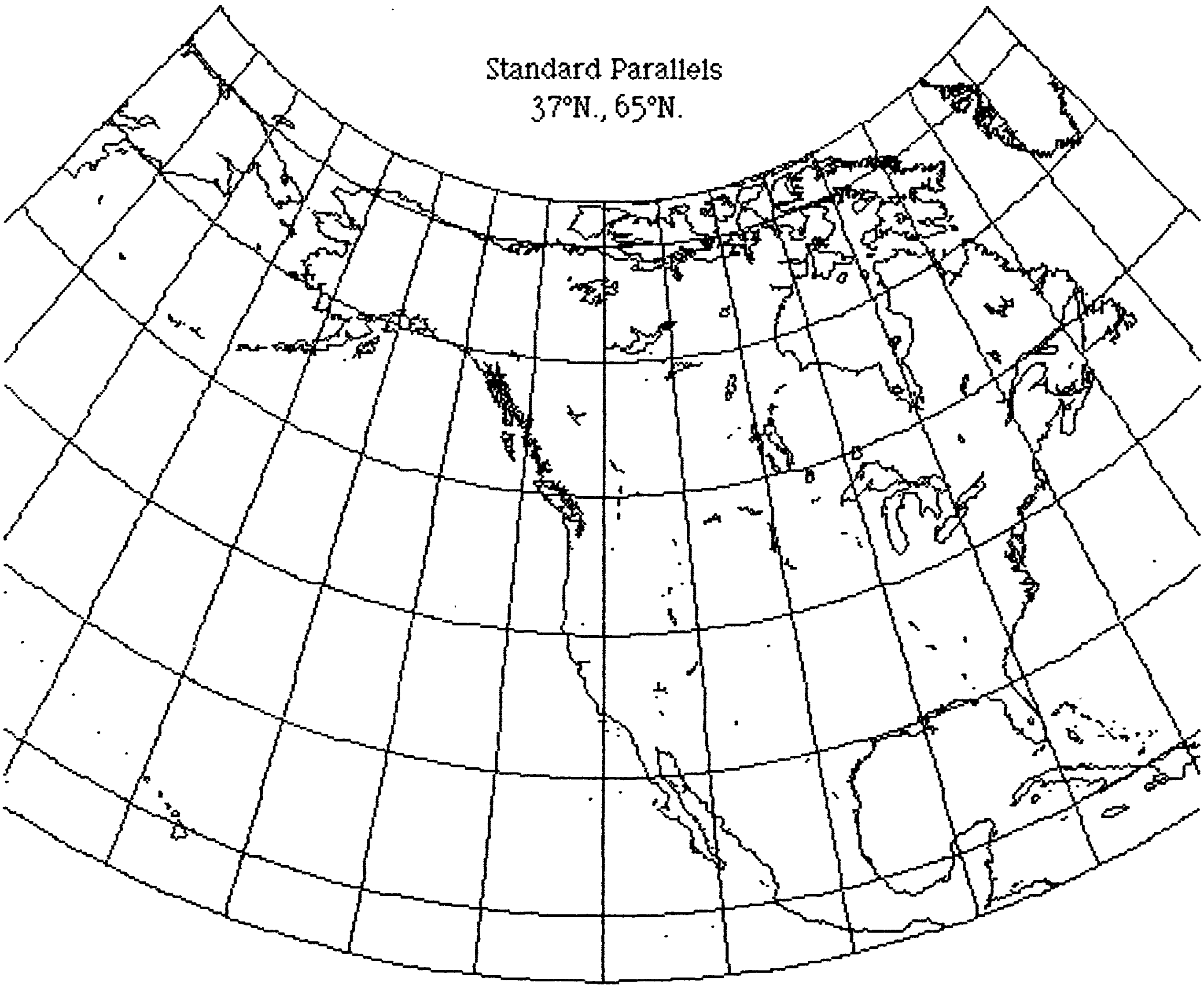
The Equidistant Conic projection is used in atlases for portraying mid-latitude areas. It is good for representing regions with a few degrees of latitude lying on one side of the Equator. The Kavraisky's fourth map projection is an Equidistant conic map projection in which standard parallels are chosen to minimize overall error.

Albers Conic Equal-Area

To Cones

To stack outline

To "as used by U.S.G.S."



Compair with Lambert Conformal Conic using the same standard parallels.

Albers Conic Equal-Area

⇦ ⇨

Lines of longitude (meridians):
Meridians are straight lines converging on the polar axis, but not at the pole.

Lines of latitude (parallels):
Parallels are arcs of concentric circles concave toward a pole.

Graticule spacing:
Meridian spacing is equal on the standard parallels and decreases toward the poles. Parallel spacing decreases away from the standard parallels and increases between them. Meridians and parallels intersect each other at right angles. The graticule spacing preserves the property of equivalence of area. The graticule is symmetrical.

Linear scale:
Linear scale is true on the standard parallels. Maximum scale error is 1.25 percent on a map of the contignous United States (48 states) with standard parallels of 29.5° N. and 45.5° N.

Notes:
Projection is mathematically based on a cone that is conceptually secant on two parallels. No areal deformation. North or South Pole is represented by an arc. Retains properties at various scales; indivdual sheets can be joined along their edges. Dr. Albers derived this projection and published about it in 1805.

Uses:
Used for thematic maps requiring correct areas. Used for large countries with an east-west orientation. Maps for Alaska based on the Albers Equal-Area Conic use standard parallels 55° N. and 65° N.; for Hawaii, the standard parallels are 8° N. and 18° N . The National Atlas of the United States, United States Base Map (48 states), and the Geologic map of the United States all are based on standard parallels of 29.5° N. and 45.5° N.

To Cones | To stack outline

Albers Conic Equal-Area

As used by the U.S. Geological Survey.

1932	Geologic map of the United States	1:2,500,000
1933	Base map, United States	1:5,000,000
1962	Tectonic map of the United States	1:2,500,000
1965	Base map, United States	1:3,168,000
1970	National Atlas of United States	1:2,000,000 and 1:7,500,000
1961	Base map of United States	1:2,500,000
1967	Base map of United States	1:2,500,000
1972	Base map of United States	1:2,500,000
1974	Geologic map of the United States	1:2,500,000
1980	Geologic map of Alaska	1:2,500,000
1983	Generalized structural, lithologic, and physiographic provinces on the fold and thrust belts of the United States	1: 2,500,000

Other map projections that can be used for North America

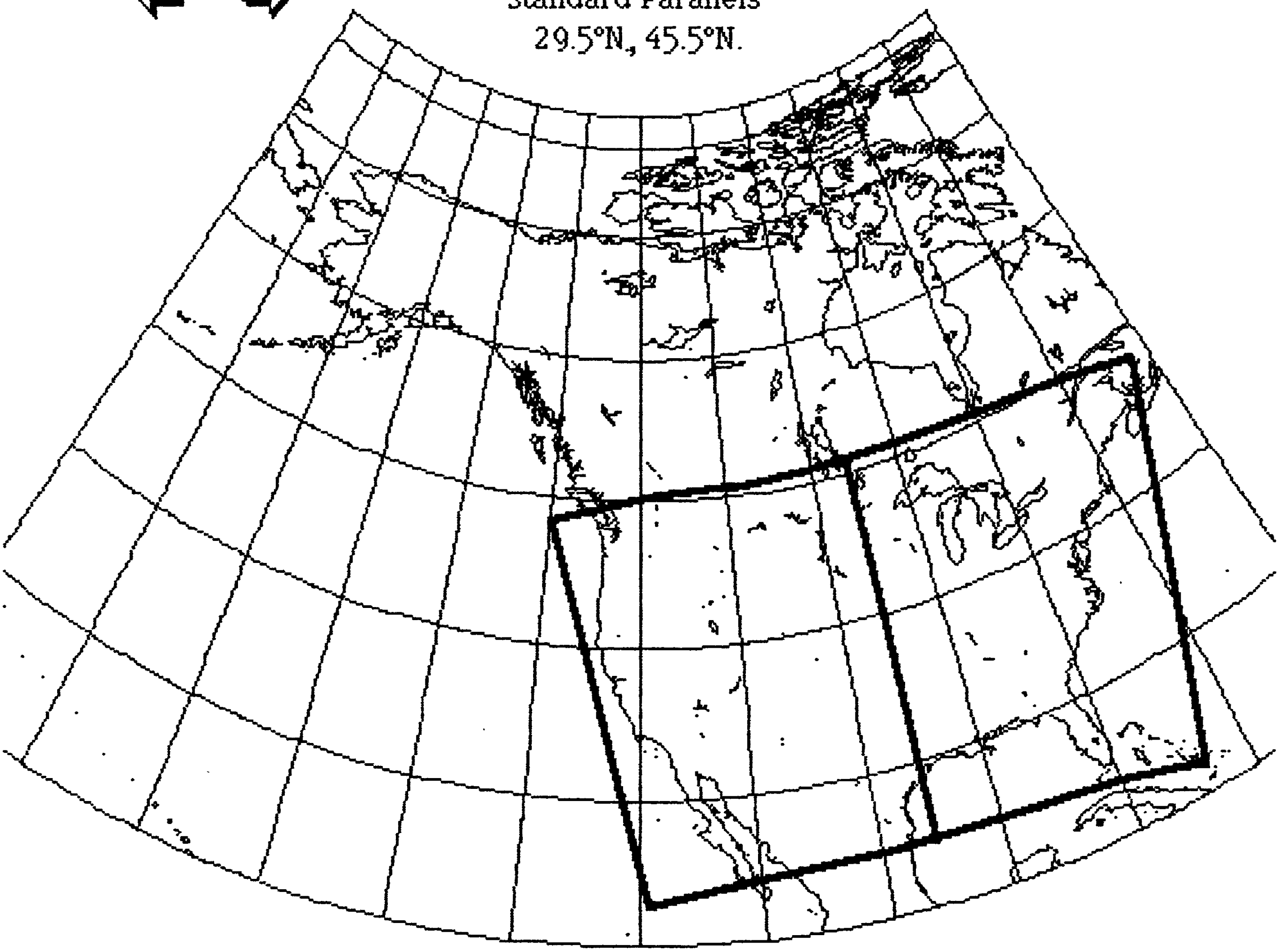
To Lambert Conic Conformal | To Orthographic

To Lambert Azimuthal Equal-Area | To Sinusoidal

Albers Conic Equal-Area

50-State map of the United States

Standard Parallels
29.5°N., 45.5°N.



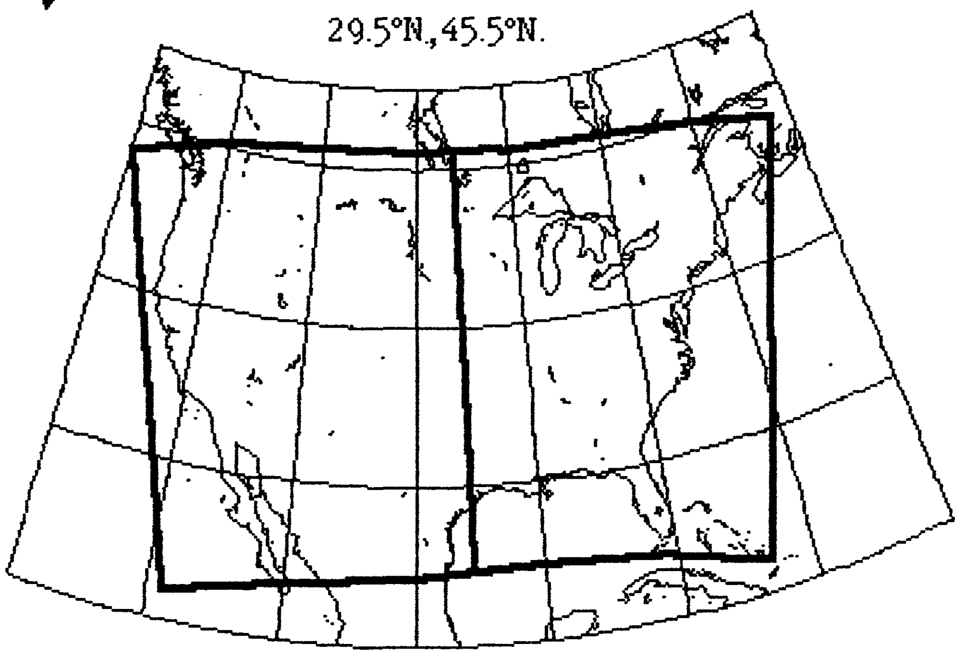
Outline represents area covered by the U. S. Geological Survey's Geologic and Tectonic Maps based on the base map entitled "United States" at the scale of 1:2,500,000, two sheets, using standard parallels 29.5°N. and 45.5°N.

Albers Conic Equal-Area

48 - State map of the United States

Standard Parallels

29.5°N.,45.5°N.

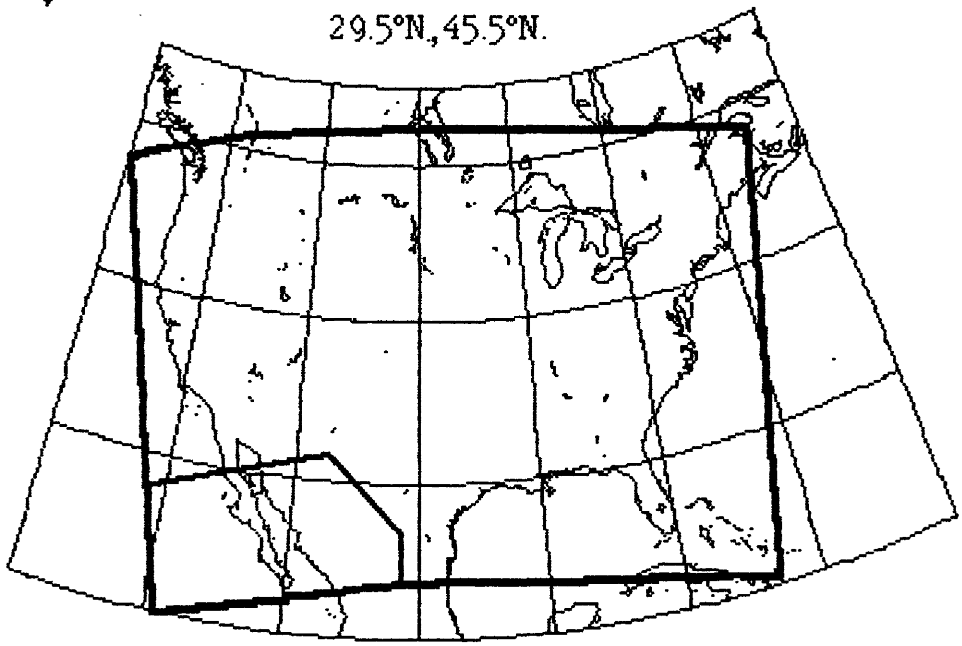


Outline represents area covered by the U. S. Geological Survey's Geologic and Tectonic Maps based on the base map entitled "United States" at the scale of 1:2,500,000, two sheets, using standard parallels 29.5°N. and 45.5°N.

Albers Conic Equal-Area

48-State map of the United States

Standard Parallels
29.5°N., 45.5°N.



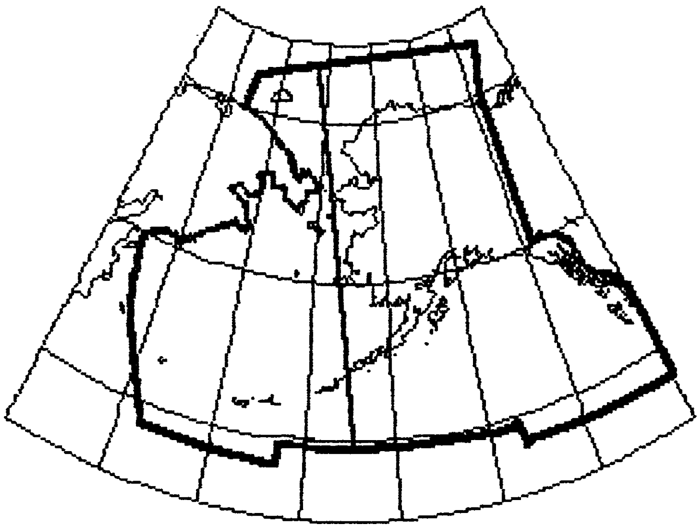
Outline represents area covered by thematic maps in The National Atlas of the United States of America at the scale of 1:7,500,000 using standard parallels 29.5°N and 45.5°N.

To stack outline

Albers Conic Equal-Area

Alaska

Standard Parallels
55°N., 65°N.



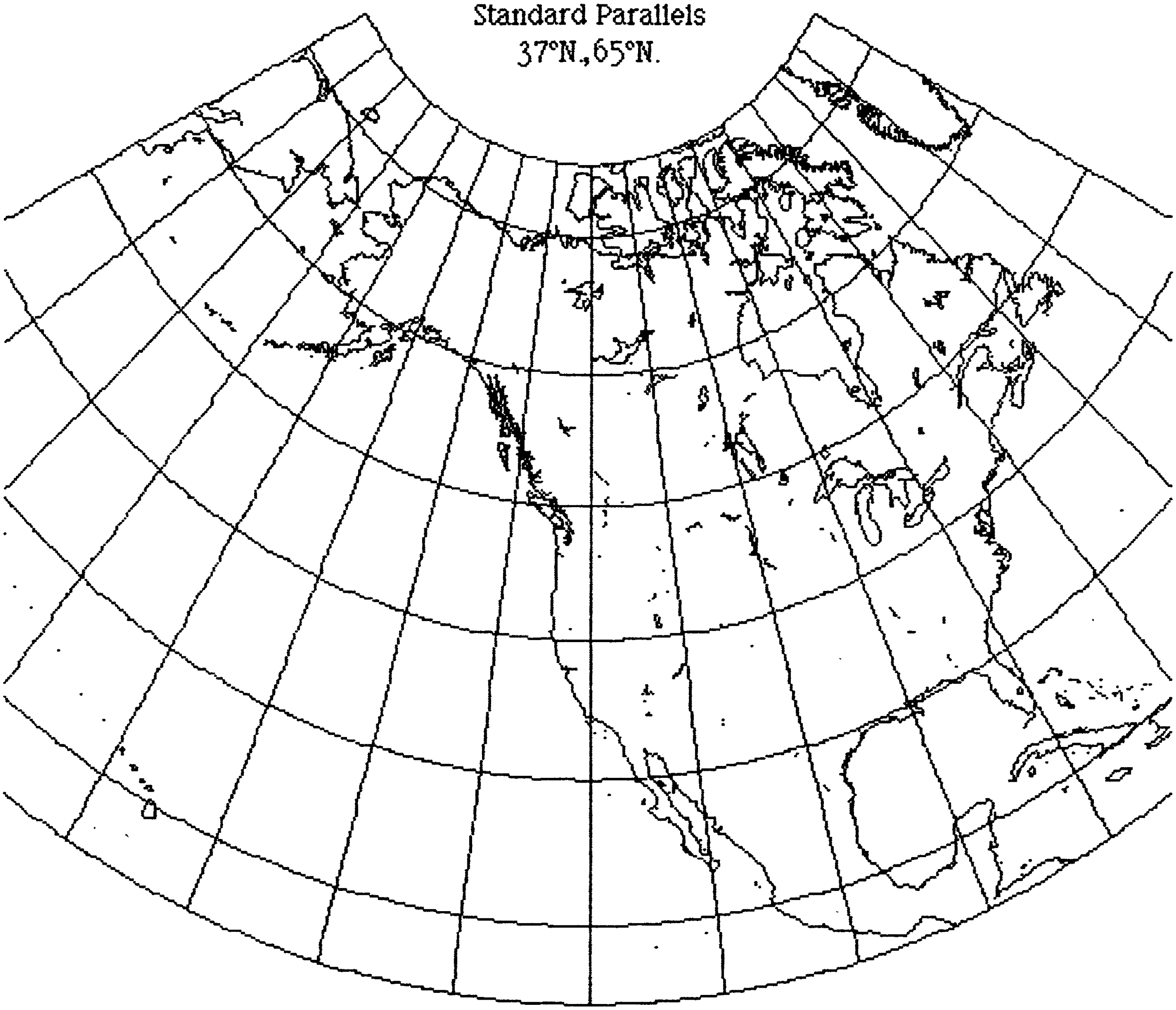
Outline represents area covered by
the 1980 Geologic Map of Alaska
U. S. Geological Survey Scale 1: 2, 5000, 000
using Standard Parallels 55°N. and 65°N.
(two sheets)

Lambert Conformal Conic

To Cones

To stack outline

To "as used by U.S.G.S."



Compair with Albers Equal-Area
using the same standard parallels.

⇦ ⇨ # Lambert Conformal Conic

Lines of longitude (meridians):
Meridians are straight lines converging at a pole.

Lines of latitude (parallels):
Parallels are arcs of concentric circles concave toward a pole and centered at the pole.

Graticule spacing:
Meridian spacing is true on the standard parallels and decreases toward the pole. Parallel spacing inceases away from the standard parallels and decreases between them. Meridians and parallels intersect each other at right angles. The graticule spacing retains the property of conformality. The graticule is symmetrical.

Linear scale:
Linear scale is true on standard parallels. Maximum scale error is 2.5 percent on a map of the contignous United States (48 states) with standard parallels at 33° N. and 45° N.

Notes:
Projection is mathematically based on a cone that is tangent at one parallel or (more often) that is conceptually secant on two parallels. Areal distortion is minimal but increases away from the standard parallels. North or South Pole is represented by a point: the other pole cannot be shown. Great circle lines are approximately straight. Retains its properties at various scales: sheets can be joined along their edges. The projection was described 1772 by Johann Heinirich Lambert

Uses:
Used for large countries in the mid-latitudes having an east-west orientation. The United States (50 states) Base Map uses standard parallels at 37° N. and 65° N. Some of the National Topographic Map Series 7.5-minute and 15-minute quadrangles and the State Base Map Series are constructed on the Lambert Conformal Conic map projection. The latter series uses standard parallels of 33° N. and 45° N. Aeronautical charts for Alaska use standard parallels at 55° N. and 65° N. The National Atlas of Canada uses standard parallels at 49° N. and 77° N. On the previous card, the outline represents the United States (50 states) Base Map.

To Cones | To stack outline

Lambert Conformal Conic

As used by the U.S. Geological Survey.

Used for some of the State Base Map Series and for some of the 7.5-minute and 15-minute quadrangles of the National Topographic Map Series.

1965	East Coast bathymetric maps	1:1,000,000
1975	Base map, The United States	1:6,000,000 and 1:10,000,000

Other map projections that are used for the 7.5-minute and 15-minute quadrangles of the National Topographic Map Series.

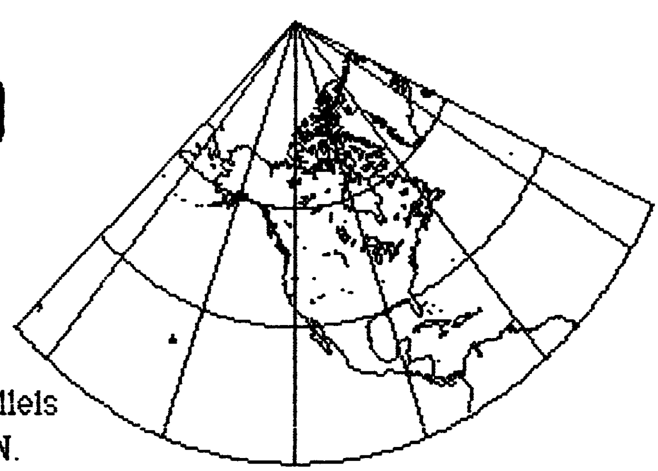
To American Polyconic | To Transverse Mercator

Other map projections that can be used for North America.

To Albers Conic Equal-Area

To Lambert Azimuthal Equal-Area

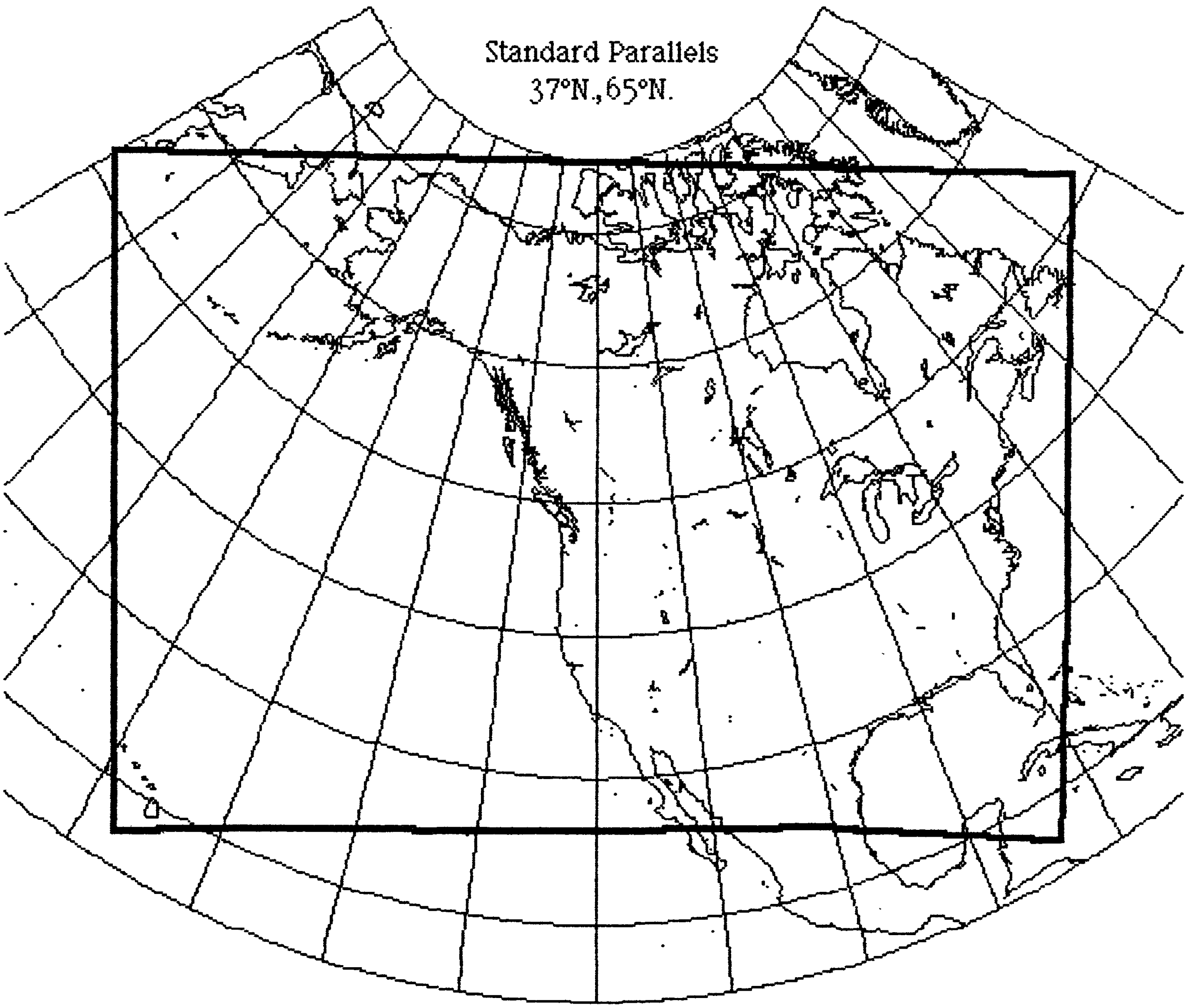
To Sinusoidal



Lambert Conformal Conic
Standard Parallels 33°N. and 45°N.

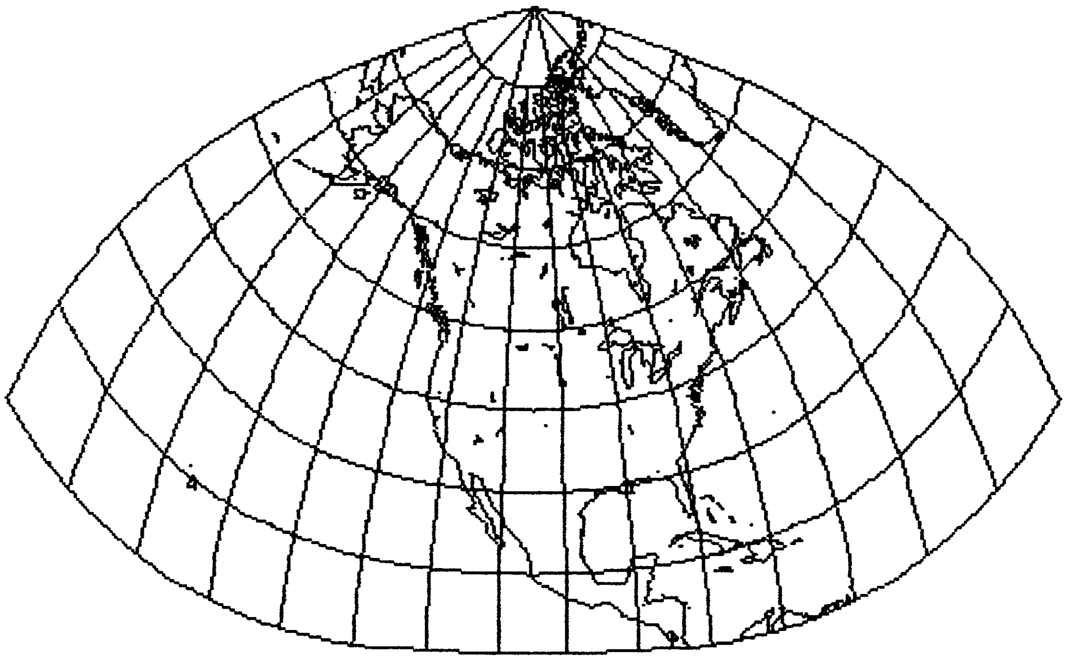
Lambert Conformal Conic

Outline represents area covered by U. S. Geological Survey's base map entitled "The United States" at the scales of 1:6,000,000 and 1:10,000,000, using Standard Parallels 37°N. and 65°N.



To Cones | To stack outline

American Polyconic



American Polyconic

Lines of longitude (meridians):
Meridians are complex curves, concave toward a straight central meridian.

Lines of latitude (parallels):
Parallels are nonconcentric circles except for a straight equator.

Graticule spacing:
Meridian spacing is equal and decreases toward the poles. Parallels are spaced true to scale on the central meridian, and the spacing increases toward the east and west borders. The graticule spacing results in a compromise of all properties.

Linear scale:
Linear scale is true along each parallel and along the central meridian. Maximum scale error is 7 percent on a map of the United States (48 states).

Notes:
Projection is mathematically based on a infinite number of cones tangent to an infinite number of parallels. Distortion increases away from the central meridian. Has both areal and angular deformation, but these are small for a small area. This projection was specifically devised for early maps of the United States.

Uses:
Used for areas with a north-south orientation. Only portrays true shape, area, distance, and direction along the central meridian. Formerly used as the base of the 7.5- and 15-minute quadrangles of the National Topographic Map Series. Individual sheets of this series can be edge-joined since they are drawn with straight meridians. They cannot be mosaicked beyond a few sheets.

To Cones | To stack outline

American Polyconic

as used by the U.S. Geological Survey

Used for some of the 7.5-minute and 15-minute quadrangles of the National Topographic Map Series.

Other map projections that are used for the 7.5-minute and 15-minute quadrangles of the National Topographic Map Series.

To Lambert Conic Conformal

To Transverse Mercator

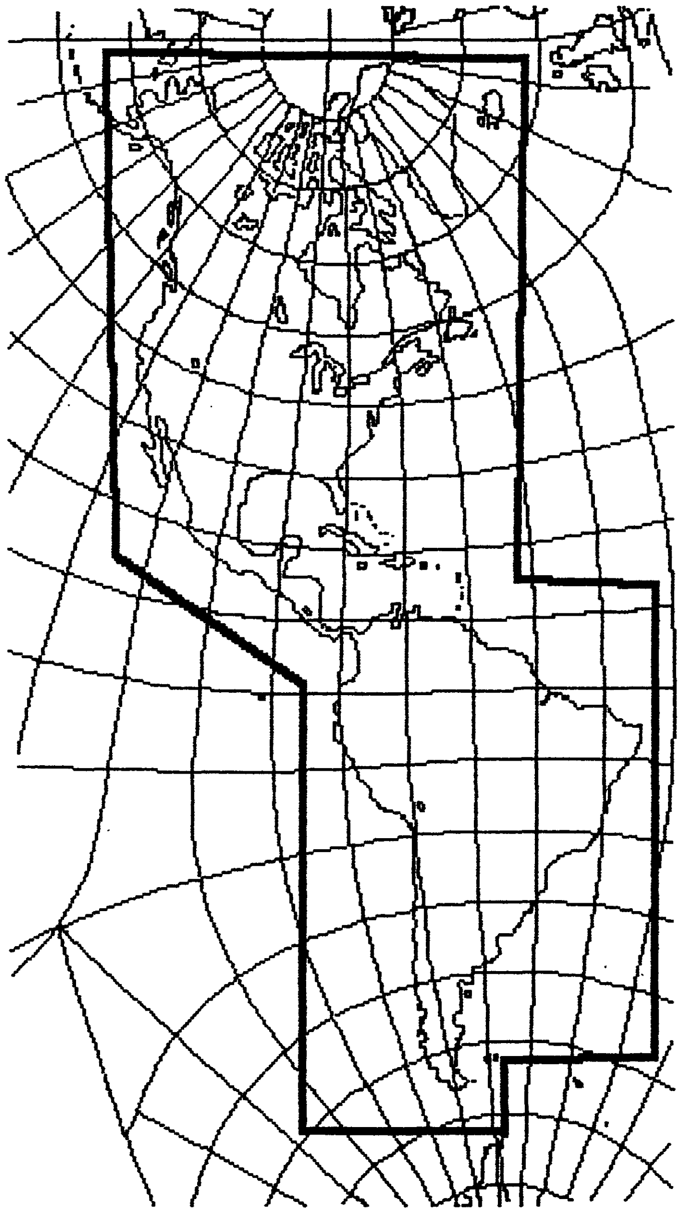
To Cones

To stack outline

To "as used by U.S.G.S."

Bipolar Oblique Conic Conformal

Outline represents area covered by the Bipolar Oblique Conic Conformal developed by Osborn M. Miller and William A. Briesemeister of the American Geographical Society in 1941.



from: An Album of Map Projections, U. S. G. S. P.P. 1453, p. 99

Bipolar Oblique Conic Conformal

Lines of longitude (meridians):
Meridians are complex curves, concave toward the center of the projection.

Lines of latitude (parallels):
Parallels are complex curves concave toward the nearst pole.

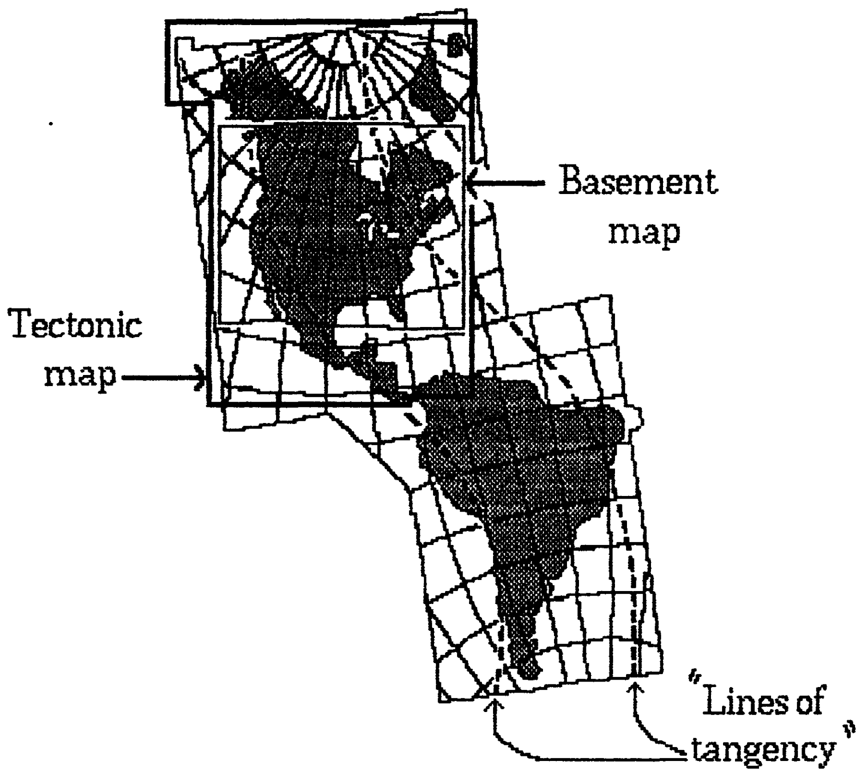
Graticule spacing:
Graticule spacing increases away from the lines of true scale and retains the property of conformality.

Linear scale:
Linear scale is true along two lines that do not lie along any meridian or parallel. Scale is compressed between these lines and expanded beyond them. Linear scale is generally good, but there is as much as a 10 percent error at the edge of the projection. Areas are also compressed or expanded.

Notes:
Projection is mathematically based on two cones whose apexes are 104° apart, and which conceptually are obliquely secant to the sphere along lines (lines of tangency) following the trend of North and South America. See next card for illustration of "lines of tangency".

Uses:
Used to represent one or both of the American continents. Examples are the Basement map of North America and the Tectonic map of North America. See outlines of these maps, on next cards.

Bipolar Oblique Conic Conformal



To Cones | To stack outline

Bipolar Oblique Conic Conformal

as used by the U.S. Geological Survey

1965	Geologic map of the United States	1:5,000,000
1967	Basement map of North America	1:5,000,000
1968	Basement rock map of the United States	1: 2,500,000
1969	Tectonic map of North America	1:5,000,000
1976	Sub-surface Temperature map of North America	1:5,000,000
1981	Metallogenic map of North America	1:5,000,000

Other map projections that can be used for North America.

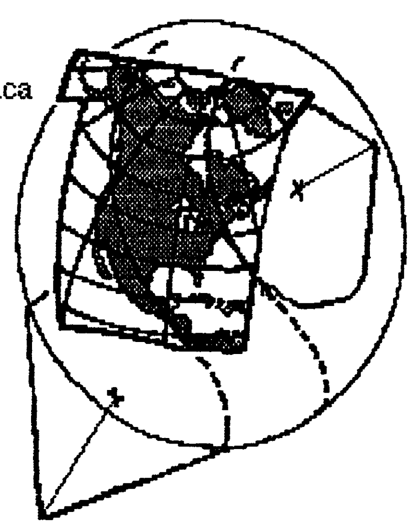
To Albers Conic Equal-Area

To Lambert Conic Conformal

To Lambert Azimuthal Equal-Area

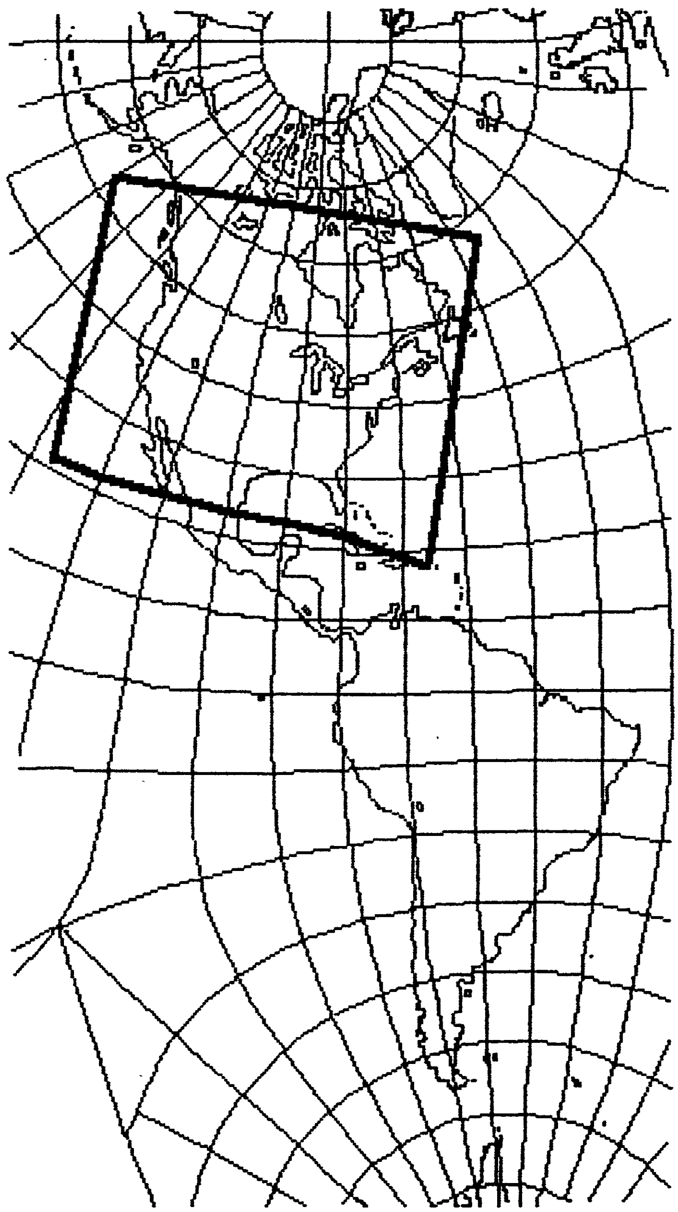
To Sinusoidal

Outline represents,
Tectonic Map of North America



Bipolar Oblique Conic Conformal

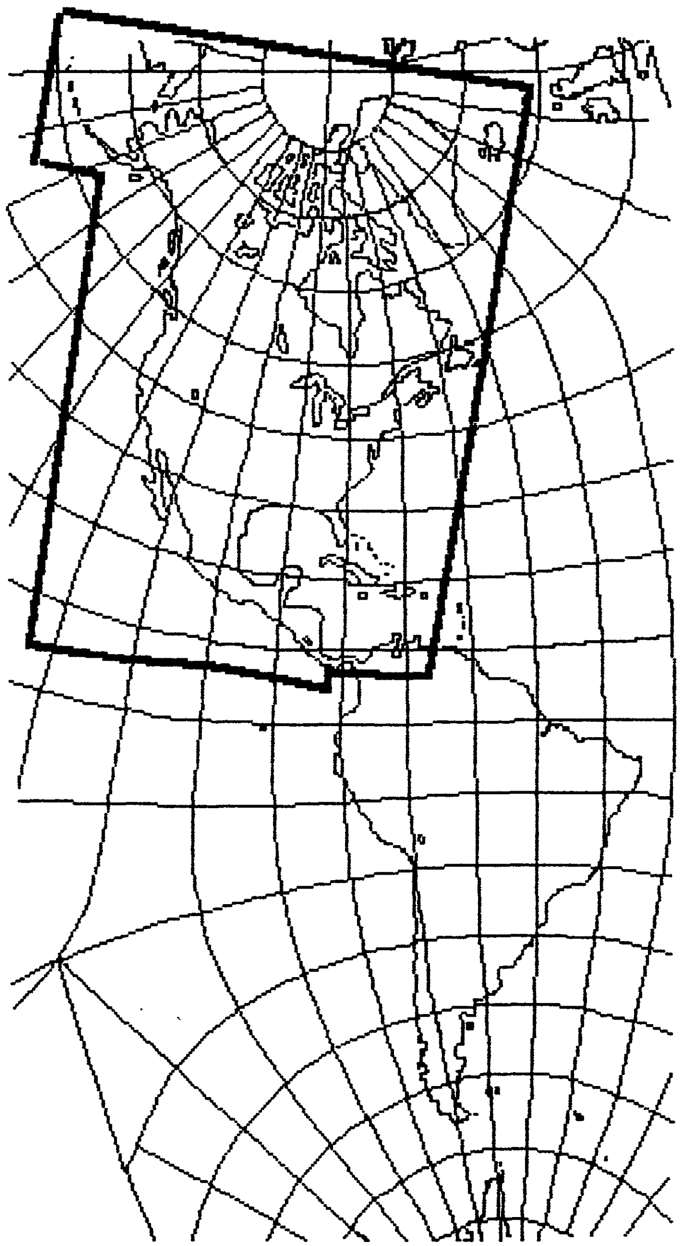
Outline represents area covered by Basement Map of North America 1:5,000,000.



To stack outline

Bipolar Oblique Conic Conformal

Outline represents area covered by Tectonic Map of North America (1969) and Metallogenic Map of North America (1981), both at the scale of 1:5,000,000.

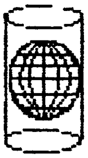


To developable surfaces | To stack outline

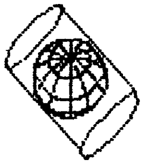
Cylindrical

On this card click on the map projection name to select it.

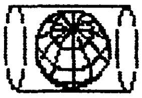
1 Mercator



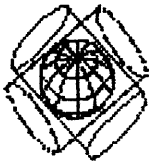
2 Oblique Mercator



3 Transverse Mercator



4 Modified Transverse Mercator

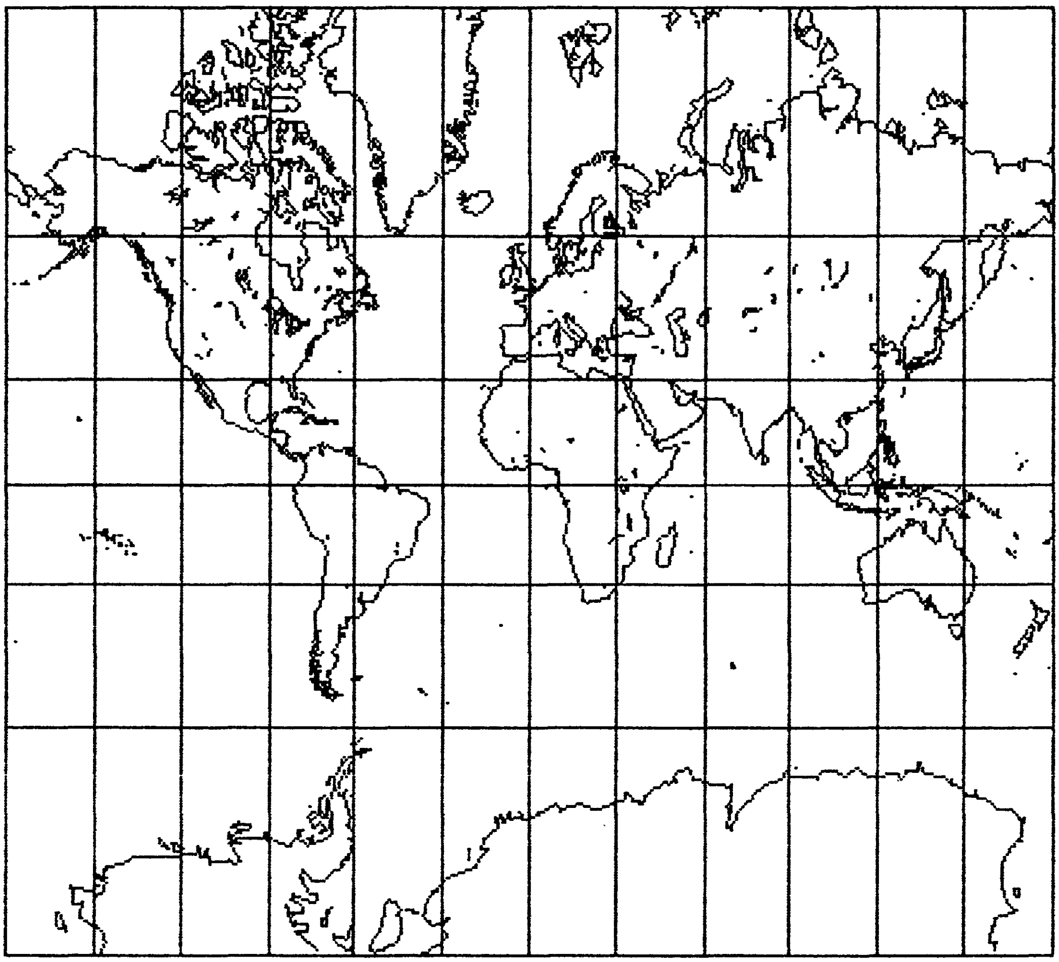


There are four cylindrical map projections in this guide.

To Cylindrical

To stack outline

Mercator



To Cylindrical | To stack outline

Mercator

⇦

Map projections that should be used for the world.

To Sinusoidal

To Goode Homolosine

To Robinson

Lines of longitude (meridians):
Meridians are straight and parallel.

Lines of latitude (parallels):
Latitude lines are straight and parallel.

Graticule spacing:
Meridian spacing is equal, and the parallel spacing increases away from the equator. The graticule spacing retains the property of conformality. The graticule is symmetrical. Meridians and parallels intersect at right angles.

Linear scale:
Linear scale is true along the equator only (line of tangency), or along two parallels equidistant from the equator (the secant form). Scale can be determined by measuring one degree of latitude, which equals 60 nautical miles, 69 statute miles, or 111 kilometers.

Notes:
Projection can be thought of as being mathematically based on a cylinder tangent at the equator. Any straight line is a constant- azimuth (rhumb) line. Areal enlargement is extreme away from the equator; poles cannot be represented. Shape is true only within any small area. Reasonably accurate projection within a 15° band along the line of tangency.

Uses:
An excellent projection for equatorial regions. Otherwise the Mercator is a special-purpose map best suited for navigation. Secant constructions are used for large-scale coastal charts. The use of the Mercator map projection as the base for nautical charts is universal. Examples are the charts published by the National Ocean Survey, U. S. Dept. of Commerce. It should not be used for world maps or for maps of North America.

Map projections that should be used for the world.

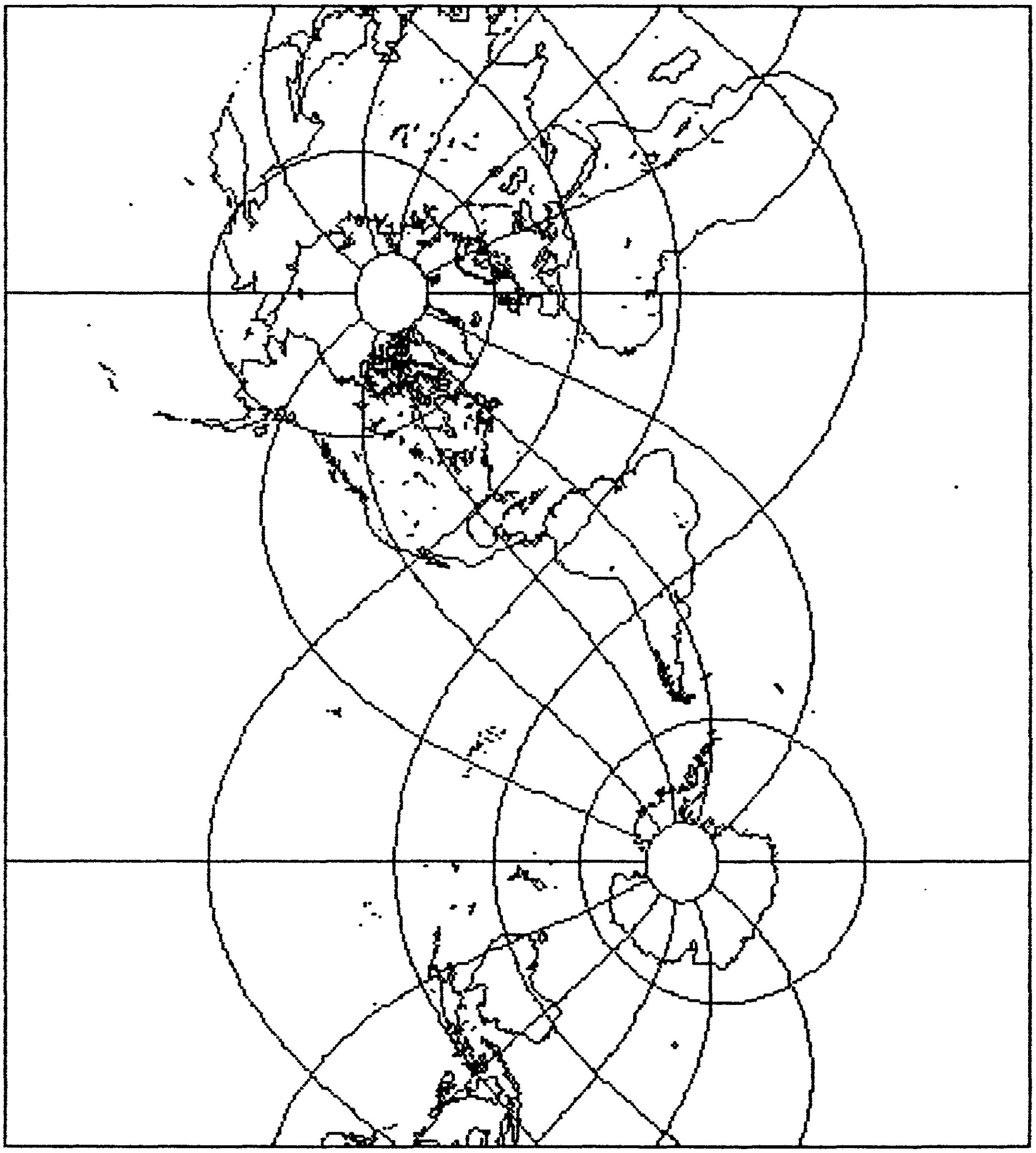
To Albers Conic Equal-Area

To Lambert Azimuthal Equal-Area

To Sinusoidal

To Cylindrical | To stack outline

Oblique Mercator



Oblique Mercator

Lines of longitude (meridians):
Meridians are complex curves concave toward the line of tangency, except each 180th meridian is straight.

Lines of latitude (parallels):
Parallels are complex curves concave toward the nearest pole.

Graticule spacing:
Graticule spacing increases away from the line of tangency and retains the property of conformality.

Linear scale:
Linear scale is true along the line of tangency, or along two lines equidistant from and parallel to the line of tangency.

Notes:
Projection is mathematically based on a cylinder tangent along any great circle other than the equator or a meridian. Shape is true only within any small area. Areal enlargement increases away from the line of tangency. Reasonably accurate projection within a 15° band along the line of tangency.

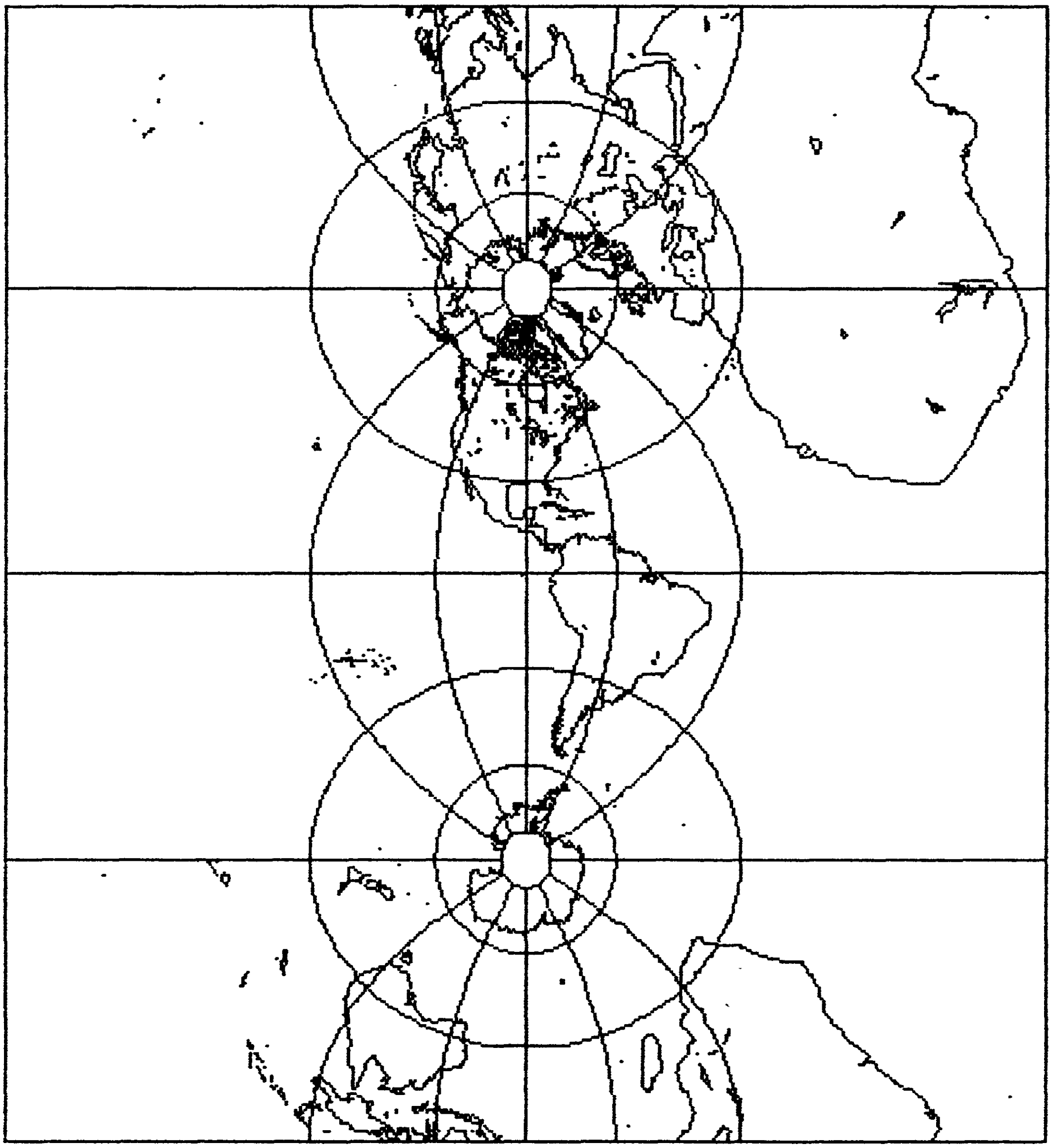
Uses:
Useful for plotting linear configurations that are situated along a line oblique to the earth's equator. Examples are: NOAA plane coordinates in the Aleutoin Islands ,NASA Surveyor Satellite tracking charts, ERTS flight indexes, strip charts for navigation, and the National Geographic Society's maps "West Indies,""Countries of the Caribbean,""Hawaii,"and "New Zealand."

Transverse Mercator

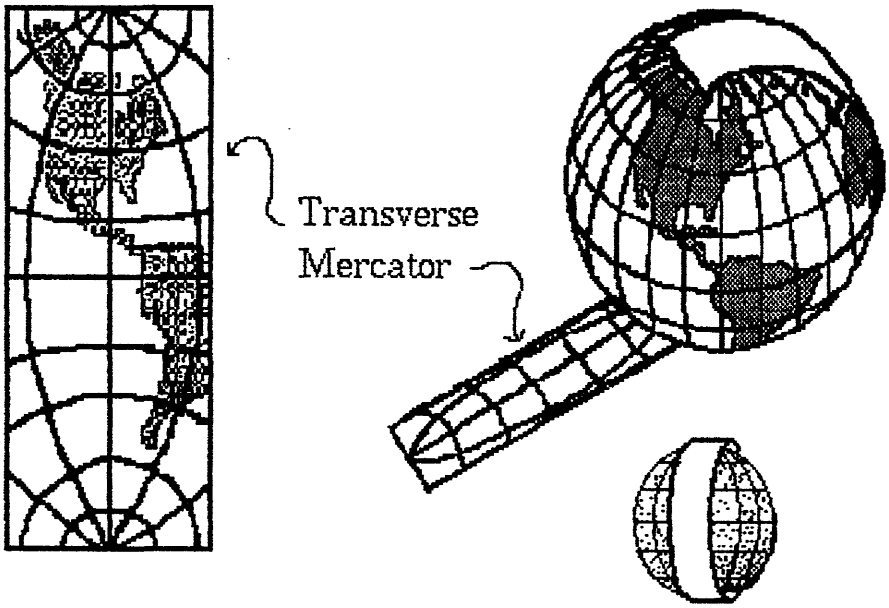
To Cylindrical

To stack outline

To "as used by U.S.G.S."



Transverse Mercator



Transverse Mercator

Lines of longitude (meridians):

Meridians are complex curves concave toward a straight central meridian that is tangent to the globe. The straight central meridian intersects the equator and one meridian at a 90° angle.

Lines of latitude (parallels):

Parallels are complex curves concave toward the nearest pole; the equator is straight.

Graticule spacing:

Parallels are spaced at their true distances on the straight central meridian. Graticule spacing increases away from the tangent meridian. The graticule retains the property of conformality.

Linear scale:

Linear scale is true along the line of tangency, or along two lines equidistant from and parallel to the line of tangency.

Notes:

Projection is mathematically based on a cylinder tangent to a meridian. Shape is true only within any small area. Areal enlargement increases away from the tangent meridian. Reasonably accurate projection within a 15° band along line of tangency. Cannot be edge-joined in an east-west direction as each sheet has its own central meridian. First described by J. H. Lambert in 1772.

Uses:

Used where the north-south dimension is greater than the east-west dimension. Used as the base for the U.S.Geological Survey's 1:250,000-scale series and for some of the 7.5-minute and 15-minute quadrangles of the National Topographic Map Series.

To Cylindrical | To stack outline

Transverse Mercator

Transverse Mercator

as used by the U.S. Geological Survey

Used for all of the 1:250,000-scale and for some of the 7.5-minute and 15-minute quadrangles of the National Topographic Map Series.

1982	Base Map, North America	1:5,000,000 and 1:10,000,000
1988,	Coal Map of North America	1: 5,000,000

Other map projections that are used for the 7.5-minute and 15-minute quadrangles of the National Topographic Map Series.

To Lambert Conic Conformal

To American Polyconic

Other map projections that can be used for North America.

To Albers Conic Equal-Area

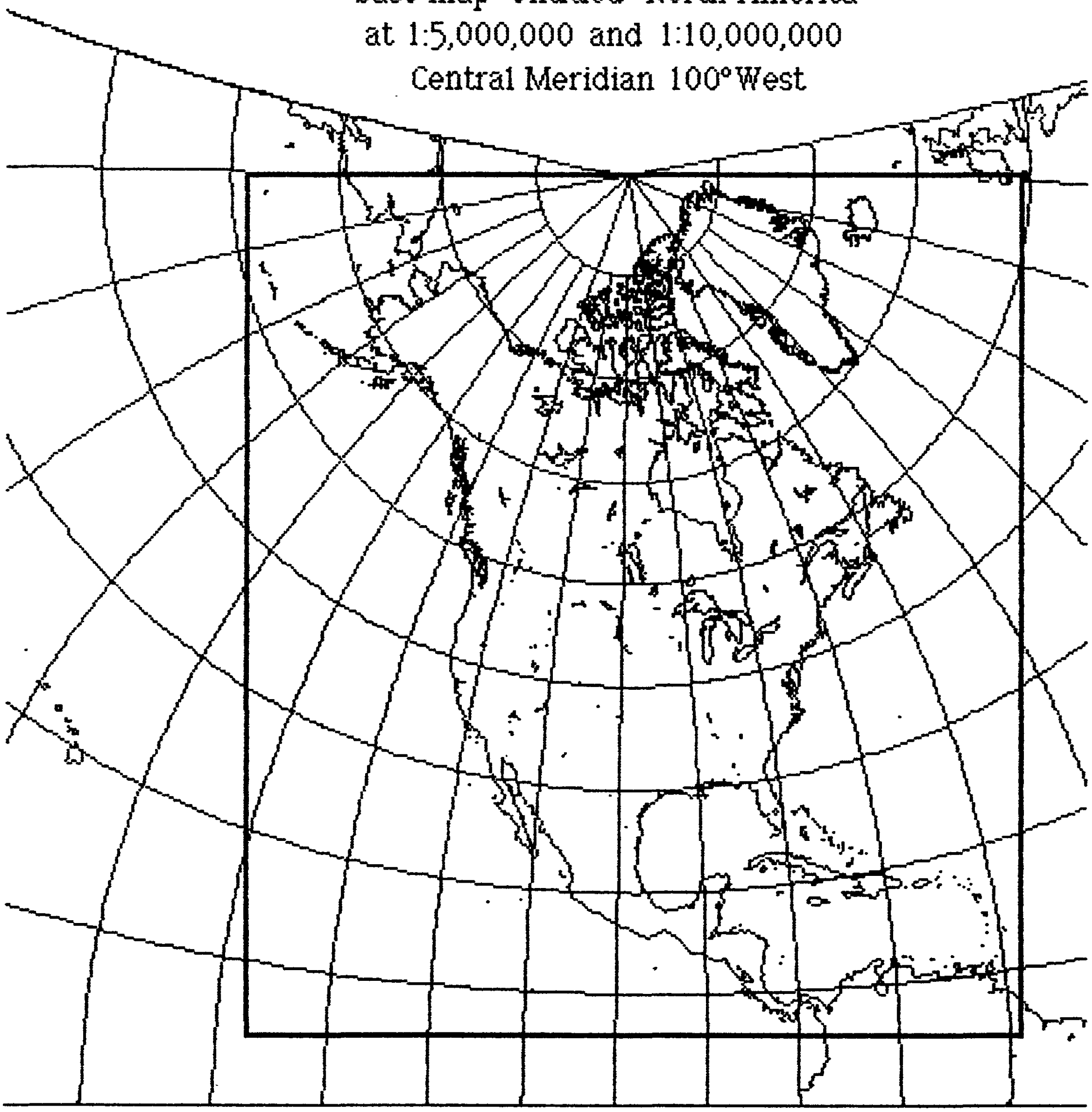
To Sinusoidal

To Lambert Azimuthal Equal-Area

To Lambert Conic Conformal

Transverse Mercator

Outline represents area covered by U. S. Geological Survey's
base map entitled "North America"
at 1:5,000,000 and 1:10,000,000
Central Meridian 100° West

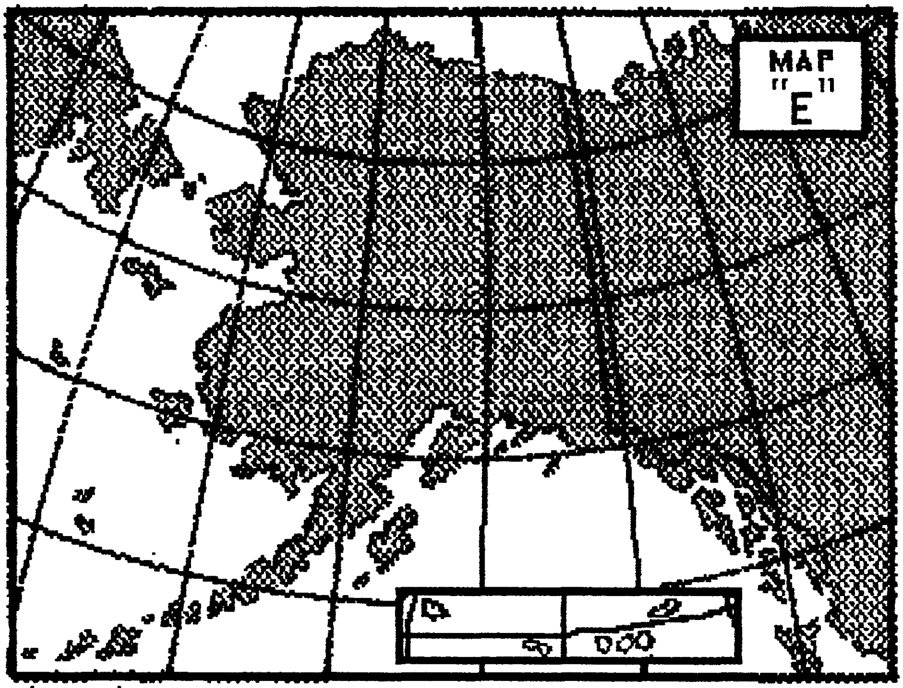


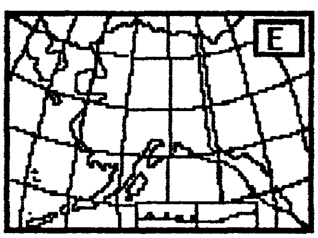
To Cylindrical

To stack outline

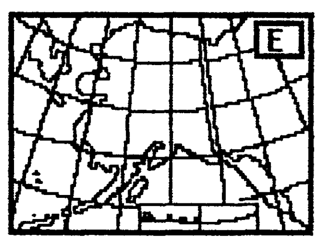
To "as used by U.S.G.S."

Modified Transverse Mercator





Pre-1973 Editions
Curved Meridians



Post-1973 Editions
Straight Meridians

Modified Transverse Mercator

Lines of longitude (meridians):
On pre-1973 editions of the Alaska Map E, meridians are curved concave toward the center of the projection. On post-1973 editions the meridians are straight.

Lines of latitude (parallels):
Parallels are arcs concave to the pole.

Graticule spacing:
Meridian spacing is approximately equal and decreases toward the pole. Parallels are approximately equally spaced. The graticule is symmetrical on post-1973 editions of the Alaska Map E.

Linear scale:
Linear scale is more nearly correct along the meridians than along the parallels.

Notes:
The Alaska Map E was adapted from a set of Transverse Mercator projections 8° wide and approximately 18° long, repeated east and west of an arbitrary point of origin until a projection 72° wide was obtained. The post-1973 editions of the Alaska Map E more nearly approximate an equidistant conic map projection.

Uses:
The U.S.Geological Survey's Alaska Map E at the scale of 1:2,500,000. The previous card represents the 1954 edition. The 1973 edition is similar, but the meridians are straight. The Bathymetric Map, Eastern Continental Margin U.S.A., published by the American Association of Petroleum Geologists, uses straight meridians on its Modified Transverse Mercator. The Modified Transverse Mercator projection is almost equivalent to the Equidistant Conic map projection.

To Cylindrical | To stack outline

Modified Transverse Mercator

as used by the U.S. Geological Survey

1954	Alaska map "E"	1:2,500,000
1973	Alaska map "E"	1:2,500,000

Other map projections that can be used for Alaska.

To Albers Conic Equal-Area Use Standard Parallels of 55° N. and 65° N.

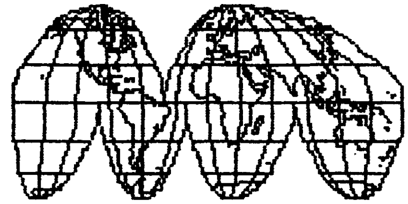
To Lambert Azimuthal Equal-Area

To Stereographic

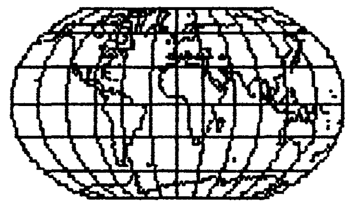
Miscellaneous

On this card click on the map projection name to select it.

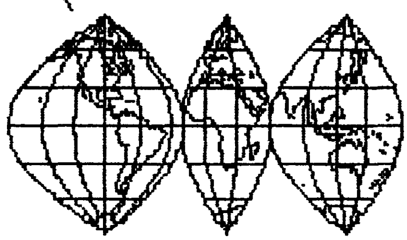
1 Goode Homolosine



2 Robinson



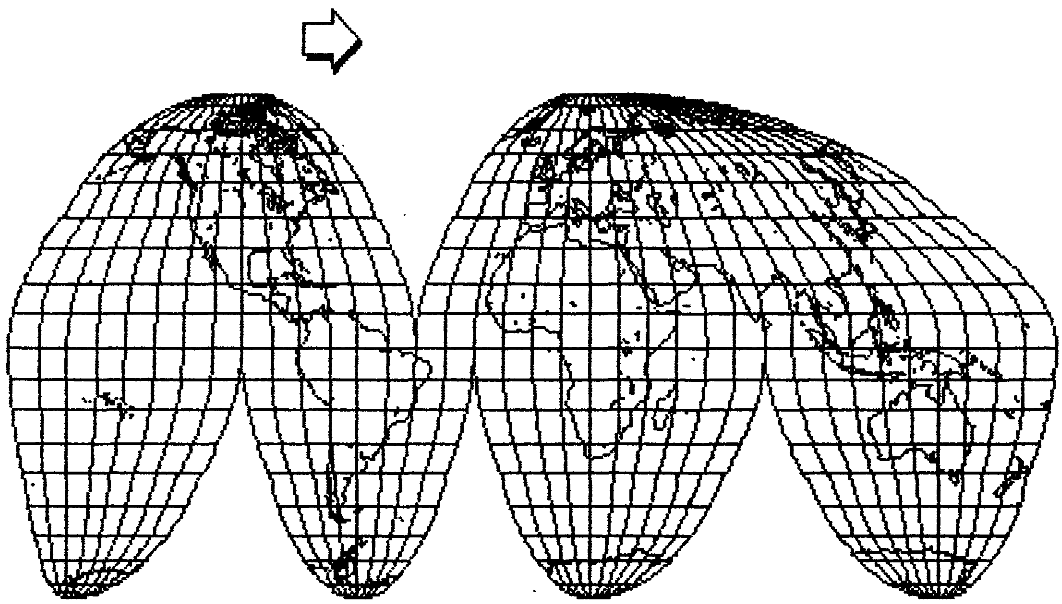
3 Sinusoidal



4 Van der Grinten

To Miscellaneous | To stack outline

Goode Homolosine



Goode Homolosine

Lines of Longitude (meridians):

Meridians from near the 40th parallels, to the Equator are sinusoidal curves, curved concave toward a straight central meridian. From the poles to near the 40th parallels, meridians are semi-ellipse curved concave toward a straight central meridian.

Lines of latitude (parallels):

All parallels are straight, parallel lines, equally spaced, perpendicular to the central meridians.

Graticule spacing:

Meridian spacing is equal. Parallel spacing is equal to the 40th parallels, then the spacing decreases toward the poles. The graticule spacing retains the property of equivalence of area.

Linear scale:

Linear scale is true on the parallels and central meridians between the 40th parallels. Scale decreases toward the poles.

Notes:

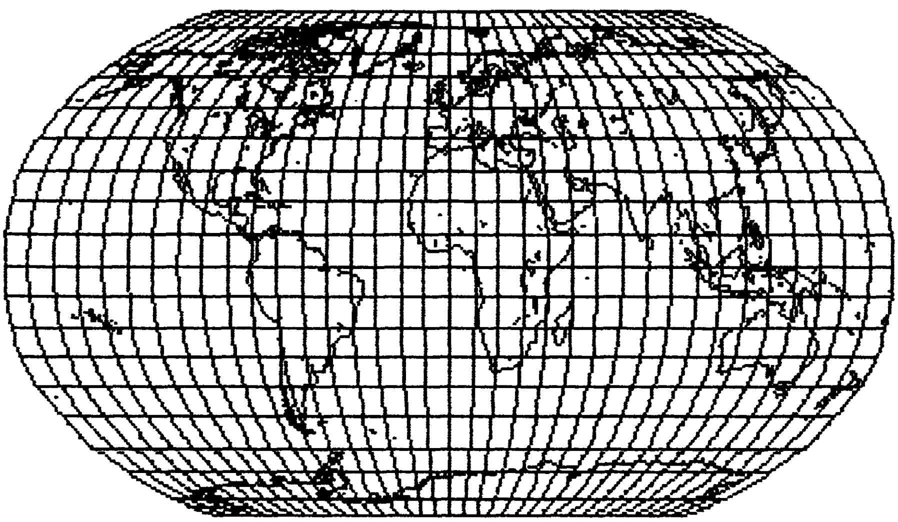
Goode's Homolosine map projection was developed by J. Paul Goode in 1923 at the University of Chicago. It is an "interrupted" projection and combines the Sinusoidal map projection and the Mollweide map projection. The Sinusoidal is used between 44° 44' North and South and the Mollweide is used from 44° 44' to the poles.

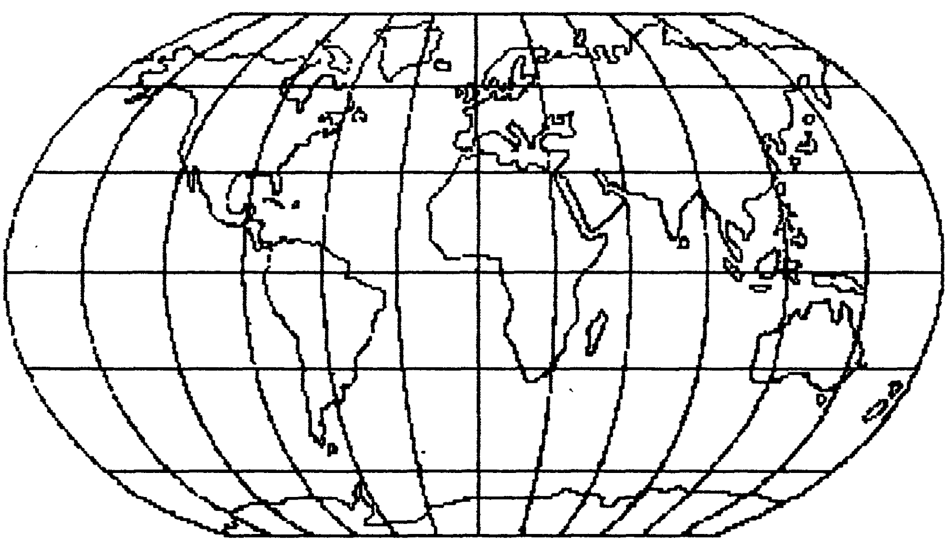
Uses:

Used as an equal-area map projection of the world to display thematic data in numerous atlases. The previous card represents the Goode Holomosine as found in Goode's World Atlas published by Rand McNally and Co. The Goode's Homolosine projection was copyright protected by the University of Chicago.

To Miscellaneous | To stack outline

Robinson





To Miscellaneous | To stack outline

Robinson

Lines of Longitude (meridians):
Meridians are arcs, curved concave toward a straight central meridian.

Lines of Latitude (parallels):
All parallels are straight, parallel lines.

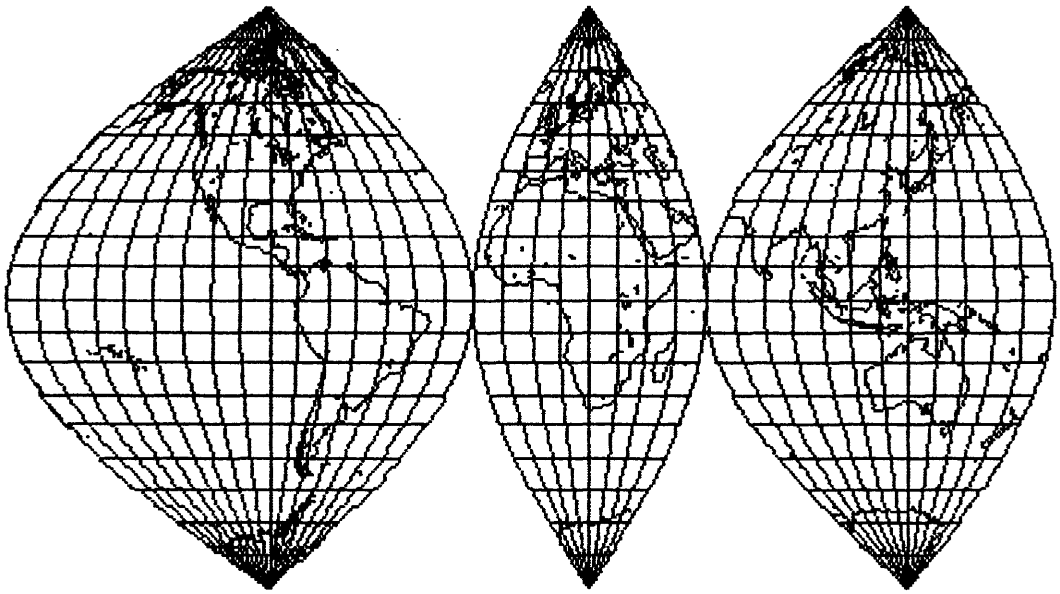
Graticule spacing:
Meridian spacing is equal and decreases toward the poles. Parallel spacing is equal between the 30th parallels, then the spacing decreases toward the poles. The graticule spacing results in a compromise of all properties.

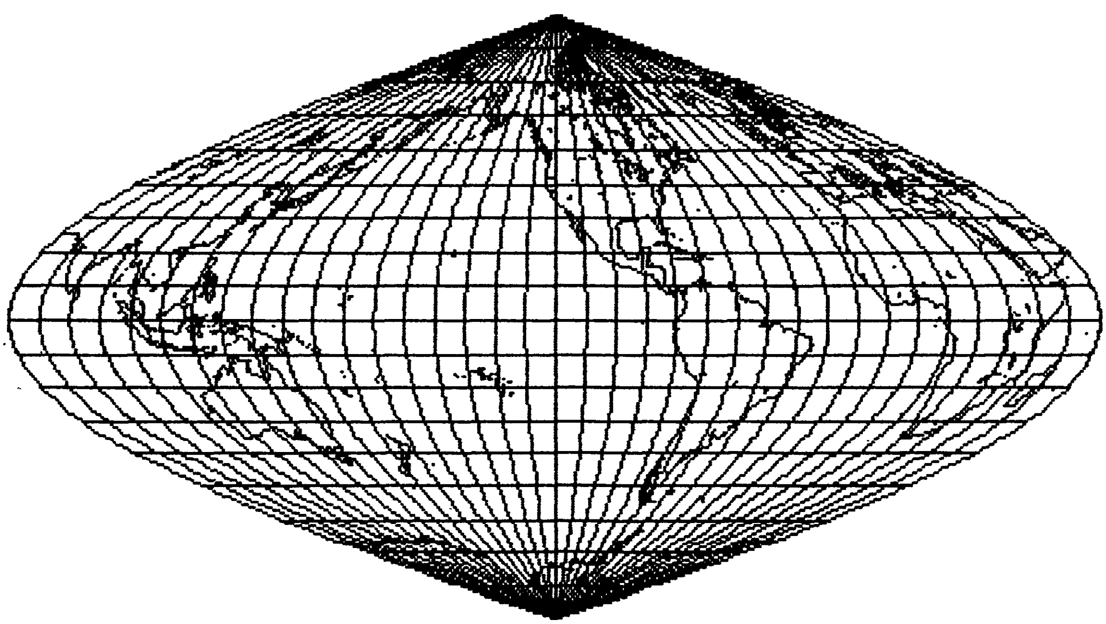
Linear scale:
Linear scale is true along latitudes 38° North and South.

Notes:
Robinson map projection was developed by A. H. Robinson in 1963 at the University of Wisconsin. The map projection is not based on mathematical formulas but on tabular coordinates.

Uses:
For world maps the National Geographic Society in 1988 replaced the Van der Grinten map projection with the Robinson map projection. The Robinson map projection is copyright protected by Rand McNally and Company.

Sinusoidal





Sinusoidal

Lines of longitude (meridians):
Meridians are sinusoidal curves, curved concave toward a straight central meridian.

Lines of latitude (parallels):
All parallels are straight, parallel lines.

Graticule spacing:
Meridian spacing is equal and decreases toward the poles. Parallel spacing is equal. The graticule spacing retains the property of equivalence of area.

Linear scale:
Linear scale is true on the parallels and the central meridian.

Notes:
Projection is mathematically based on a sequence of cylinders with the first cylinder tangent to the equator. The sinusoidal projection may have several central meridians depending on where the map projection is interrupted. The projection may be interrupted on any meridian to help reduce distortion at high latitudes. There is no angular deformation along the central meridian and the equator.

Uses:
Used as an equal-area projection to portray areas that have a maximum extent in a north-south direction. Used as a world equal-area projection in atlases to show distribution patterns. The previous card represents an interrupted version of the sinusoidal projection with three central meridians. Used by the U.S. Geological Survey as the base for maps showing prospective hydrocarbon provinces of the world and sedimentary basins of the world.

To Miscellaneous | To stack outline

Sinusoidal

Sinusoidal

as used by the U.S. Geological Survey

Coury, A. B., Hendricks, T. A., Tyler, T. F., 1978, Map of Prospective Hydrocarbon Provinces of the World, Miscellaneous Field Studies Map MF-1044 - A,- B, and - C. Scale 1:20,000,000.

Other map projections that can be used for world maps.

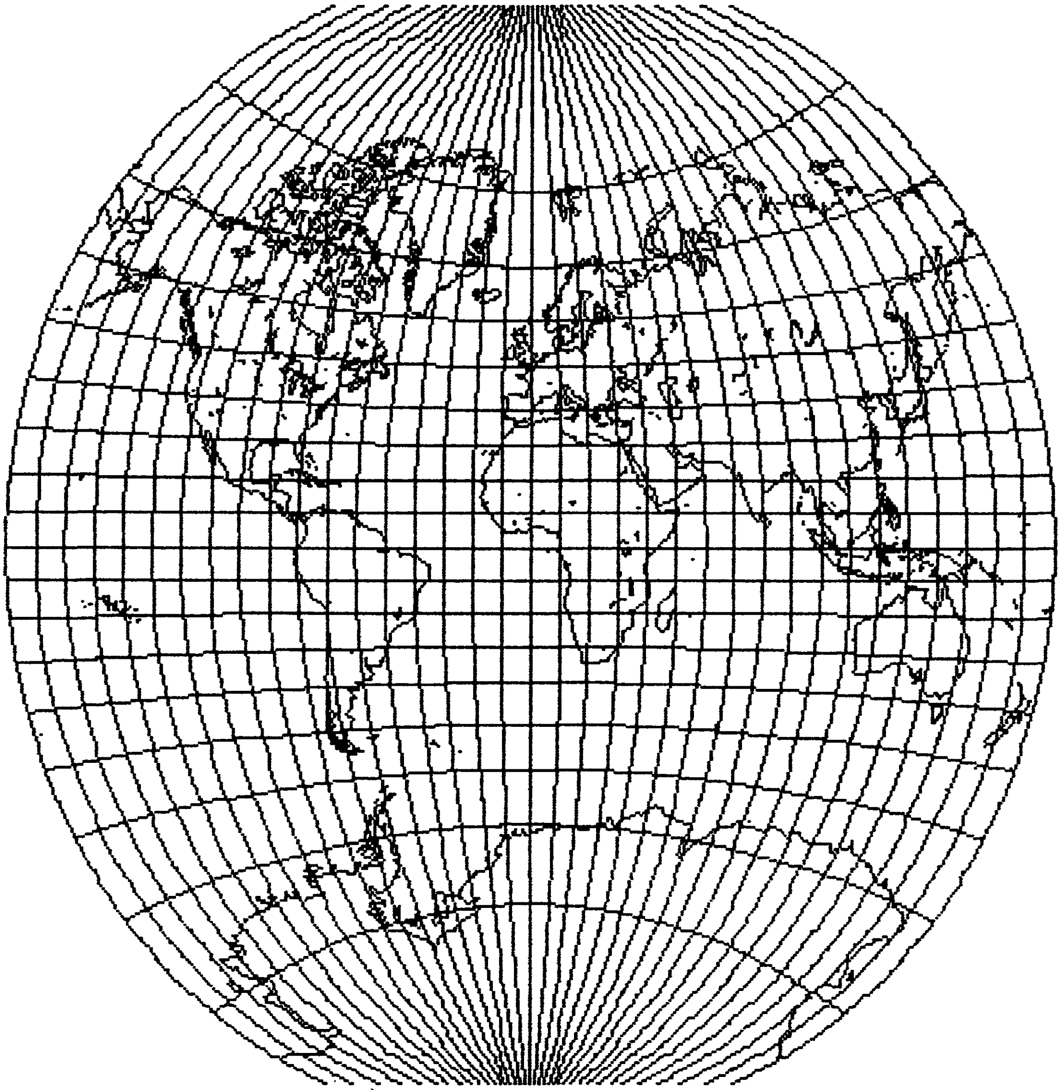
To Goode Homolosine | To Robinson

Other map projections that can be used for North America.

To Albers Conic Equal-area | To Lambert Conic Conformal

To Miscellaneous | To stack outline

Van der Grinten



Van der Grinten

Lines of longitude (meridians):
Meridians are circular arcs concave toward a straight central meridian.

Lines of latitude (parallels):
Parallels are circular arcs, concave toward the poles except for a straight equator.

Graticule spacing:
Meridian spacing is equal at the equator. The parallels are spaced farther apart toward the poles. Central meridian and equator are straight lines. The poles commonly are not represented. The graticule spacing results in a compromise of all properties.

Linear scale:
Linear scale is true along the equator. Scale increases rapidly toward the poles.

Notes:
The projection has both areal and angular deformation. The Van der Grinten shows the world in a circle.

Uses:
The Van der Grinten projection has been used by the National Geographic Society for world maps for many years. It has now been replaced by Robinson's map projection. Used by the U. S. Geological Survey to show distribution of mineral resources on the sea floor (McKelvey and Wang, 1970).

To Miscellaneous To stack outline

Van der Grinten

Van der Grinten

as used by the U. S. Geological Survey

Mc Kelvey, V. E., and Wang, F. H., 1970, World Subsea Mineral Resources, Miscellaneous Geologic Investigations Map I-632, scale 1:39,283,200 and 1:60,000,000.

Other map projections that can be used for world maps.

To Sinusoidal To Goode Homolosine To Robinson

To stack outline

Selected map projections and regional thematic maps published by the U.S. Geological Survey.

Date	Base map or thematic map	Map projection	Scale
1932,	Geologic map of United States	Albers Conic Equal-Area	1:2,500,000

To Albers Conic Equal-Area

To Bipolar Oblique Conic

To Lambert Azimuthal Equal-Area

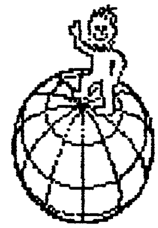
To Lambert Conformal Conic

To Modified Transverse Mercator

To Transverse Mercator

To stack outline

References



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Alpha, T. R., and Snyder, J. P., 1982, The properties and uses of selected map projections: U.S. Geological Survey Miscellaneous Investigation Series, Map 1-1402.

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Earth
Society

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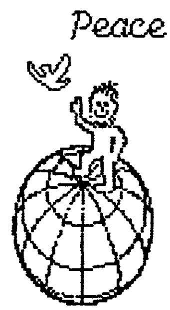

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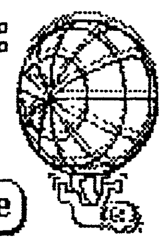
References continued: last card



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---- 1962, Tectonic map of the United States, scale 1:2,500,000.

---- 1967, Basement map of North America, scale 1:5,000,000.

---- 1970, The national atlas of the United States of America: Washington, D.C., 417 p.

---- 1972, United States, scale 1:2,500,000 (base map, 2 sheets).

---- 1973, Alaska Map E, scale 1:2,500,000 (base map).

---- 1975, The United States, scale 1:6,000,000 (base map).

---- 1982, North America, scale 1:5,000,000 and 1:10,000,000 (base map).

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The authors thank Mr. Jim Pinkerton of the U. S. Geological Survey and and Dr. Waldo R. Tobler of the University of California at Santa Barbara for inspiring conversations and helpful reviews.

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