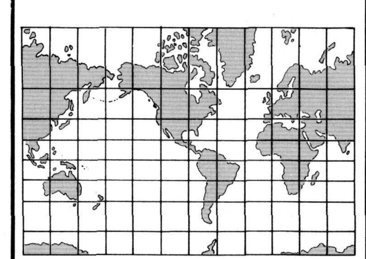
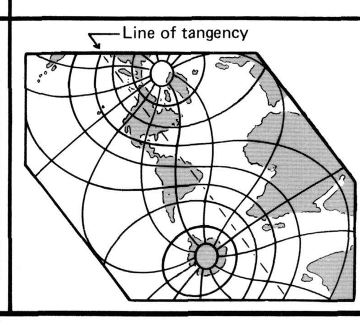
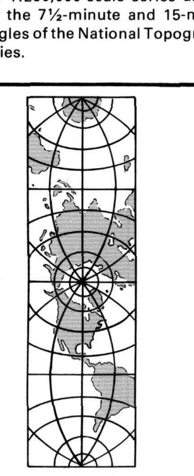
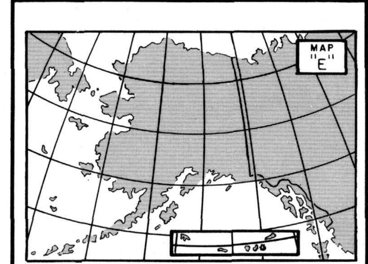
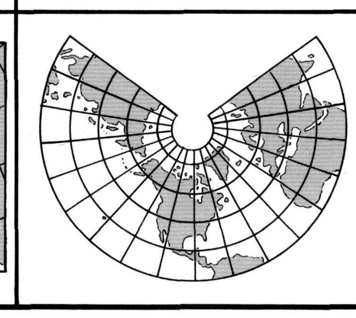
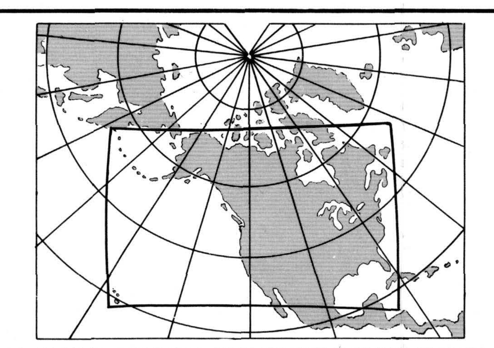
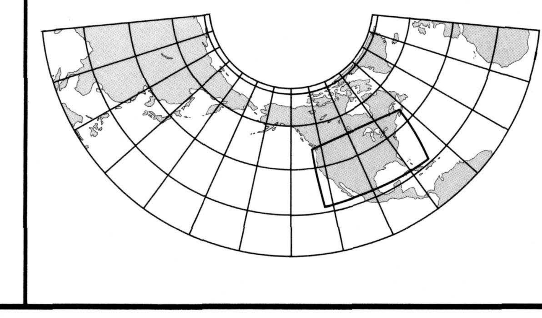
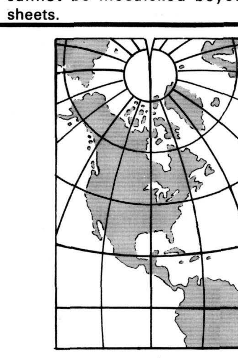
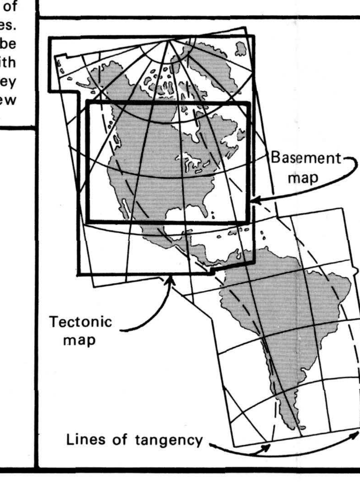
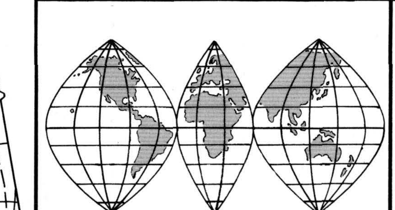
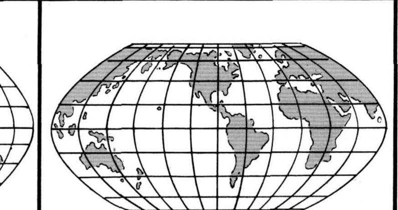
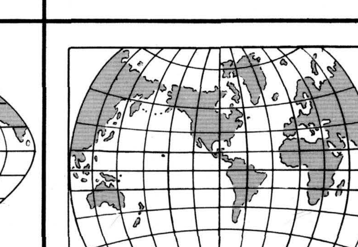
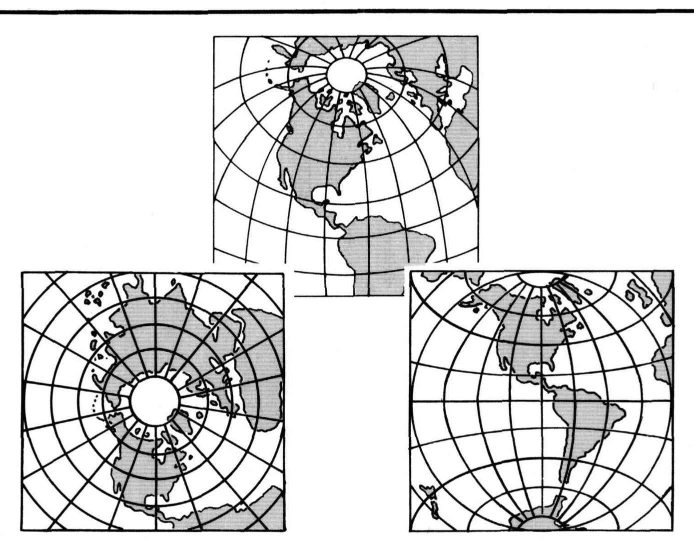
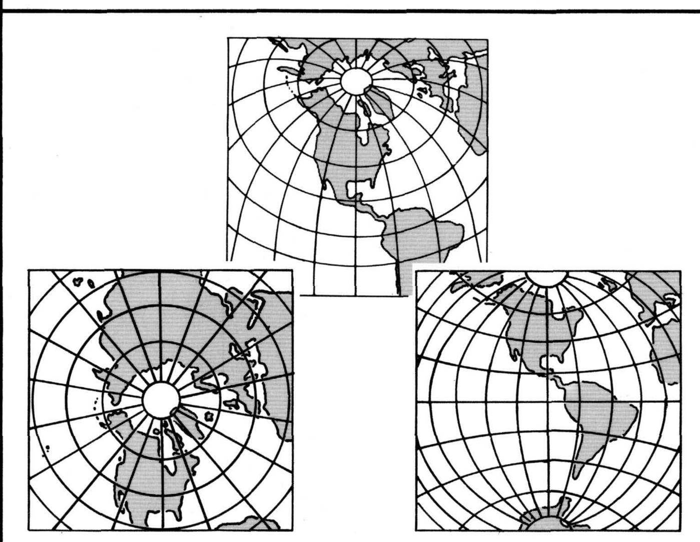
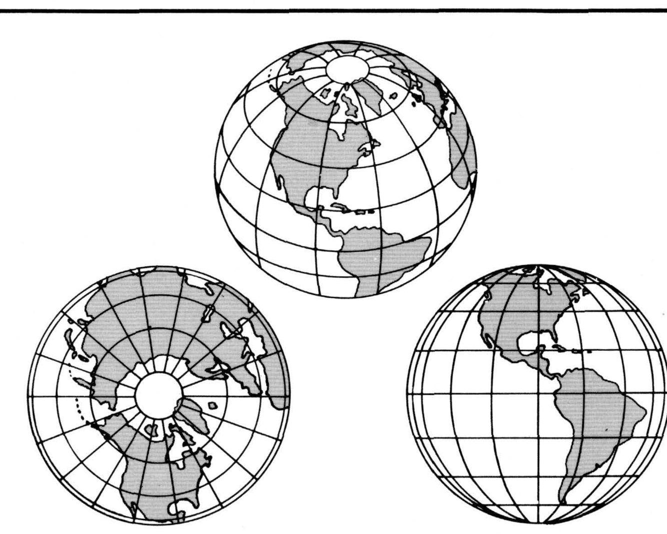
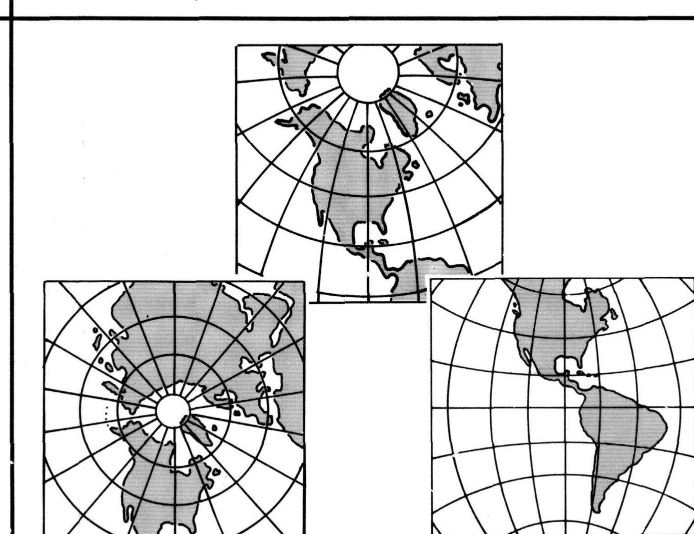
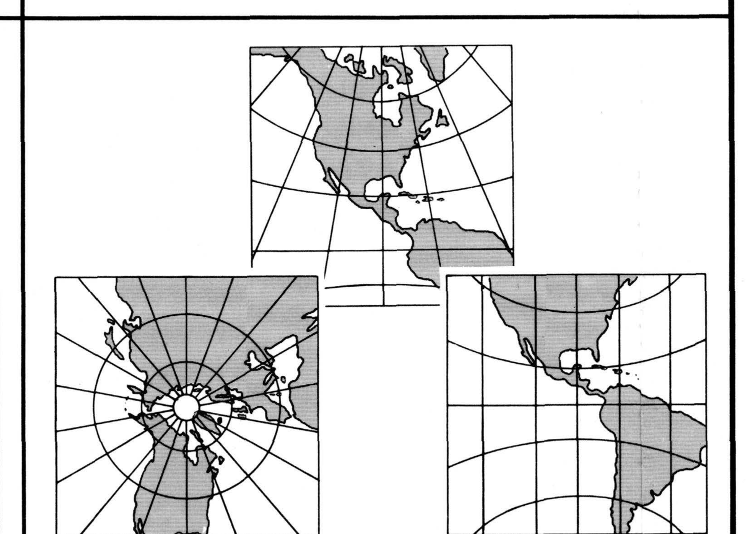
Type of map projection	Cylinders				Cones					Pseudo-Cylinders		Miscellaneous
	Mercator	Oblique Mercator	Transverse Mercator	Modified Transverse Mercator	Equidistant Conic (or Simple Conic)	Lambert Conformal Conic	Albers Conic Equal-Area	American Polyconic	Bipolar Oblique Conic Conformal	Sinusoidal	Eckert No. 6	Van Der Grinten
	Conformal				Equidistant	Conformal	Equal Area		Conformal	Equal Area	Equal Area	Compromise
Lines of longitude (meridians)	Meridians are straight and parallel.	Meridians are complex curves concave toward the line of tangency, except each 180th meridian is straight.	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.	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.	Meridians are straight lines converging on a polar axis but not at the pole.	Meridians are straight lines converging at a pole.	Meridians are straight lines converging on the polar axis, but not at the pole.	Meridians are complex curves concave toward a straight central meridian.	Meridians are complex curves concave toward the center of the projection.	Meridians are sinusoidal curves, curved concave toward a straight central meridian.	Meridians are sinusoidal curves concave toward a straight central meridian.	Meridians are circular arcs concave toward a straight central meridian.
Lines of latitude (parallels)	Latitude lines are straight and parallel.	Parallels are complex curves concave toward the nearest pole.	Parallels are complex curves concave toward the nearest pole; the equator is straight.	Parallels are arcs concave to the pole.	Parallels are arcs of concentric circles concave toward a pole.	Parallels are arcs of concentric circles concave toward a pole and centered at the pole.	Parallels are arcs of concentric circles concave toward a pole.	Parallels are nonconcentric circles except for a straight equator.	Parallels are complex curves concave toward the nearest pole.	All parallels are straight, parallel lines.	All parallels are straight, parallel lines.	Parallels are circular arcs concave toward the poles except for a straight equator.
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.	Graticule spacing increases away from the line of tangency and retains the property of conformality.	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.	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.	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.	Meridian spacing is true on the standard parallels and decreases toward the pole. Parallel spacing increases 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.	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.	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.	Graticule spacing increases away from the lines of true scale and retains the property of conformality.	Meridian spacing is equal and decreases toward the poles. Parallel spacing is equal. The graticule spacing retains the property of equivalence of area.	Meridian and parallel spacing decreases toward the poles. The graticule spacing retains the property of equivalence of area.	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 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.	Linear scale is true along the line of tangency, or along two lines equidistant from and parallel to the line of tangency.	Linear scale is true along the line of tangency, or along two lines equidistant from and parallel to the line of tangency.	Linear scale is more nearly correct along the meridians than along the parallels.	Linear scale is true along all meridians and along the standard parallel or parallels.	Linear scale is true on standard parallels. Maximum scale error is 2½ percent on a map of the United States (48 states) with standard parallels at 33° N. and 45 ° N.	Linear scale is true on the standard parallels. Maximum scale error is 1¼ percent on a map of the United States (48 states) with standard parallels of 29½° N. and 45½° N.	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).	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 as used.	Linear scale is true on the parallels and the central meridian.	Linear scale is true along parallel 49° 16′ north and south of the equator.	Linear scale is true along the equator. Scale increases rapidly toward the poles.
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.	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.	Projection is mathematically based on a cylinder tangent to a meridian. Shape is true only within any small area. Areal enlargment increases away from the tangent meridian. Reasonably accurate projection within a 15° band along the line of tangency. Cannot be edge-joined in an east-west direction if each sheet has its own central meridian.	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.	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.	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.	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 its properties at various scales; individual sheets can be joined along their edges.	Projection is mathematically based on an infinite number of cones tangent to an infinite number of parallels. Distortion increases away from the central meridian. Has both areal and angular deformation.	Projection is mathematically based on two cones whose apexes are 104° apart, and which conceptually are obliquely secant to the sphere along lines following the trend of North and South America.	Projection is mathematically based on a cylinder tangent on the equator. The sinusoidal projection may have several central meridians and 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.	Projection is mathematically based on a cylinder tangent at the equator. Poles are represented by straight lines half the length of the equator. Distortion of shape is extreme at high latitudes.	The projection has both areal and angular deformation. It was conceived as a compromise between the Mercator and the Mollweide, which shows the world in an ellipse. The Van der Grinten shows the world in a circle.
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.	Useful for plotting linear configurations that are situated along a line oblique to the earth's equator. Examples are: 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".	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 7½-minute and 15-minute quadrangles of the National Topographic Map Series.	The U.S. Geological Survey's Alaska Map E at the scale of 1:2,500,000. The figure below represents the 1954 edition. The 1973 edition is similar, but the meridians are straight. The Bathymetric Maps Eastern Continental Margin U.S.A., published by the American Association of Petroleum Geologists, uses these straight meridians on its Modified Transverse Mercator and is more equivalent to the Equidistant Conic map projection.	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 No. 4 map projection is an Equidistant conic map projection, in which standard parallels are chosen to minimize overall error.	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 7½-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. In the figure below, the outline represents the United States (50 states) Base Map.	Used for thematic maps. Used for large countries with an east-west orientation. Maps based on the Albers equal-area conic for Alaska 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 (outlined below) are based on the standard parallels of 29½° N. and 45½° N.	Used for areas with a north-south orientation. Only along central meridian does it portray true shape, area, distance, and direction. Formerly used as the base of the 7½- 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 for convenience. They cannot be mosaicked beyond a few sheets.	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.	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 figure below 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.	Used as an equal-area map projection of the world in atlases such as the Great Soviet World Atlas, 1937. Kavraisky No. 6 map projection closely resembles Eckert No. 6 and is used in the Ocean Atlas, 1953, Vol. 2.	The Van der Grinten projection is used by the National Geographic Society for world maps. Used by the U.S. Geological Survey to show distribution of mineral resources on the sea floor (McKelvey and Wang, 1970).
Examples												

Type of map projection	Planes (Azimuthal)				
	Azimuthal Equidistant	Lambert Azimuthal Equal-Area	Orthographic	Stereographic	Gnomonic
	Equidistant	Equal Area		Conformal	
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.	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.	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.	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.	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 aspect: the parallels are complex curves. Equatorial aspect: the parallels are complex curves concave toward the nearest pole; the equator is straight.	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.	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.	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.	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 point of tangency. Parallel spacing is equidistant. Angular and areal deformation increase away from the point of tangency.	Polar aspect: the meridian spacing is equal and increases, 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.	Polar aspect: meridian spacing is equal and increases, and the parallel spacing decreases from the point of tangency. Oblique and equatorial aspects: the graticule spacing decreases away from the center of the projection.	The graticule spacing increases away from the center of the projection in all aspects, and it retains the property of conformality.	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	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.	Linear scale is better than most azimuthals but not as good as the equidistant. Angular deformation increases toward the periphery of the projection. Scale decreases radially toward the periphery of the map projection. Scale increases perpendicular to the radii toward the periphery.	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.	Scale increases toward the periphery of the projection.	Linear scale and angular and areal deformation are extreme, rapidly increasing away from the center of the projection.
Notes and uses	Projection is mathematically based on a plane tangent to the earth. The entire earth can be represented. Generally the Azimuthal Equidistant map projection portrays less than one hemisphere, though the other hemisphere can be portrayed but is much distorted. Has true direction and true distance scaling from the point of tangency. The Azimuthal Equidistant projection is used for radio and seismic work, as 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.	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 represents only one hemisphere. The polar aspect is used by the U.S. Geological Survey in the National Atlas. The polar, oblique, and equatorial aspects are used by the U.S. Geological Survey for the Circum-Pacific Map.	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. The U.S. Geological Survey uses the Orthographic map projection in the National Atlas.	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 projection are true. Generally only one hemisphere is portrayed. 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.	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 in approximately great circles. The Gnomonic projection is used with the Mercator projection for navigation.
Examples					

INTRODUCTION

Most map users give little thought to the map projection used for a large-scale map of a small area. As the map scale becomes smaller and the area shown increases, however, the properties of the map projection become increasingly important. The brief descriptions of the properties and uses of map projections in this report are intended to help the user compare these projections and choose the one best suited to a particular purpose.

This report is a revision of U.S. Geological Survey Map I–1096, "A survey of the properties and uses of selected map projections" (Alpha and Gerin, 1978). Principal differences between this and the earlier version are that (1) new terms are included, (2) a new example of the Albers equal-area projection is provided, and (3) the Kavraisky No. 4 projection has been deleted (mainly because it is rarely used).

NATURAL PROPERTIES OF THE EARTH'S GRATICULE[1]

1. Parallels are parallel.
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.
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 the 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.

[1]From Robinson (1969, p. 212)

DEFINITION OF TERMS

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 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 then be grouped by a particular developmental 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.
LINEAR SCALE—Linear scale is the relation between a distance on a map projection and the corresponding distance on the earth.
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.

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THE PROPERTIES AND USES OF SELECTED MAP PROJECTIONS

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1982