

McGRAW-HILL SERIES IN GEOGRAPHY

V. C. FINCH, *Consulting Editor*



PHYSICAL ELEMENTS
OF GEOGRAPHY

**McGRAW-HILL SERIES
IN GEOGRAPHY**

and

Bennett—SOIL CONSERVATION

Finch and Trewartha—ELEMENTS OF
GEOGRAPHY: Physical and Cultural

Finch and Trewartha—PHYSICAL
ELEMENTS OF GEOGRAPHY
(A republication of Part I of the above)

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WEATHER AND CLIMATE

Whitbeck and Finch—ECONOMIC
GEOGRAPHY

Whitbeck and Williams—ECONOMIC
GEOGRAPHY OF SOUTH
AMERICA

ELEMENTS OF GEOGRAPHY

Physical and Cultural

By

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and

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Professor of Geography, University of Wisconsin

SECOND



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FOURTH IMPRESSION

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ELEMENTS OF GEOGRAPHY
PHYSICAL AND CULTURAL

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VERNOR C. FINCH AND GLENN T. TREWARTHA

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P R E F A C E

The second edition of this book, like the first, is designed to supply textual material covering the elements of geography in a form particularly suited to classroom discussion in beginning courses in college geography. The special merit of the treatment of the subject employed in this text is believed to lie in the choice of the material that has been included in it, in the structure of its organization, and in the manner of its presentation.

The selection of material for inclusion has been made with a single objective: to describe and depict the major elements of geography and to enable the student to acquire a background for interpreting the significance of their areal association. The material included is confined to the development of what may be considered a check list of the elements of natural earth and the elements of material culture. In this an attempt has been made to lay a solid foundation for studies in cultural geography by description and analysis of the habitat potentialities of the natural features of the earth and its conspicuous forms of human culture. The material is presented in a manner that the authors believe furnishes a basis not only for understanding on the part of the student but also for a full and rich classroom discussion of the subjects included.

The structure of the book's organization is considered by the authors an essential part of the presentation and includes (a) two opening chapters which provide a degree of orientation in the field of geography, together with certain basic facts and geographical tools, and (b) two principal parts. The latter treat, respectively, of (i) the elements of natural earth and (ii) the elements of material culture.

Part I of the book receives the most extended treatment, and it has been divided into five sections of several chapters each. This

organization has the merit of enabling the student to distinguish clearly between the *elements* of weather and climate and the *types* of climate into which they are combined, and of distinguishing earth *processes* from the classes of earth *features* produced by them. The emphasis has been placed deliberately upon the nature or form of the elements of geography and upon their world distribution rather than upon the processes of their origin. Not that the rational interpretation of features through the manner of their origin is neglected. It is employed constantly, but in part the discussion of process is segregated, and always it is made secondary in importance to the essential physical characteristics of the features produced. In this respect the treatment of landforms, for example, is to be distinguished sharply from that which is customary in physiography or physical geology.

Part II of the book alone deals with the features of material culture essential to geography. Omitting that part, the book functions as a basic text for a course in natural science. Just as Part I is an analytical treatment of natural features, so Part II is a similar, but briefer, analysis of the *types of features* resulting from human beings occupying regions. This manner of treatment of the subject of material culture is new to American textbooks of geography. Part III of the earlier edition, which concerned the associations of physical features characteristic of each of the great geographical realms of the earth, has been omitted as such, but certain of its features have been incorporated with Parts I and II.

The revision of the Elements of Geography from its original form has been suggested from three directions; the rapid advancement of knowledge in some of the fields upon which it touches, the practical test of five years of classroom use, and the kindly criticism of professional colleagues. Section *A* of Part I, which treats of the elements of weather and climate, has required the most thorough revision. This has been made necessary by recent and extensive changes in physical climatology, particularly in those aspects of the subject dealing with the nature and behavior of air masses; the types and significance of storms, etc. In the revision of both Sections *A* and *B*, the latter dealing with climatic types and their distribution, every effort has been made to abbreviate and simplify the numerous details in order that the essentials shall be emphasized and that the whole presentation may more readily be grasped by the beginning student.

Sections *C* and *D* of Part I, which deal, respectively, with the origin of landforms and with the characteristics and classification of

landforms themselves, have seemed to require less revision. The changes that were made have, it is believed, resulted in the clarification of obscure points, the avoidance of some controversial matters, and the omission of certain details on which there is recognized difference of scientific opinion beyond the concern of an introductory course. Similar changes have been made in Section *E*, which deals with earth resources, particularly in the chapters which are concerned with the nature and classification of soils and the distribution of the principal soil groups of the world.

Those who are familiar with the structure of the earlier edition of the book will find the most extensive changes of all in Part II, which surveys the cultural elements of geography. As before, this discussion is concerned with the nature and classification of the significant elements of human culture manifest in the geographical scene. However, the treatment of them has been much expanded, their inherent qualities are analyzed, the bases of their classification are indicated, and the significant features of their world patterns are introduced. Many details of cultural form and feature have been added. The purpose of these, however, is not to present a brief human geography of the world but to give added significance to the bases of classification upon which the facts of world geography may be brought into rational order in other courses which may follow this introduction to the field. The present discussion is an attempt at a scheme of analysis and classification of cultural elements comparable with and parallel to that applied to the physical elements in Part I of the book. Admittedly, the development of theory and the body of knowledge adaptable to this procedure are less complete than for the physical elements, which are the special fields of several branches of science. It is not remarkable therefore that Part II of the book is not equal in extent with Part I.

It may be asked why the authors have so restricted their discussion of the cultural elements of geography and why they have not dealt at some length with the social implications of the various elements of physical earth. In some geography books the description of each of the physical features is followed by a summary of the human activities supposedly related to that feature. For example, the study of the physical characteristics of mountains will be supplemented by a description of the activities "dependent on or centered about" mountains. Such a treatment bespeaks a belief that geographical science is primarily concerned with showing how and to what degree physical earth influences human affairs. To such a philosophy of their subject the present authors cannot subscribe.

It may be asked also why the authors have not enlarged upon numerous themes suggested by the discussions of the cultural elements. Why, for example, have they not considered the world patterns of wheat production or forest exploitation or of any other of the many topics which are a part of the body of systematic economic geography? It may only be stated that this was not their objective. Neither was it their purpose to explore the complex of areal associations that comprise the field of regional study in its full geographical sense. Rather, their purpose has been, as was noted above, to show that *the elements of geography, physical and cultural, are capable of analysis and classification* and to show something of the pattern of distribution of each of these elements over the surface of the earth. Only after these functions have been performed does the student begin to distinguish the elements as such and to appreciate the significance of their areal associations. The details of these complex associations, whether treated from the systematic or the regional viewpoint, are, however, left to other authors and other courses of study.

Several grades of distinction in type have been employed in the part, section, chapter, and center headings of the book for the purpose of keeping before the student the nature of the structural outline within which he works. Also, the component *articles* of the chapters have been numbered serially through the book. It is believed that this feature will be of use in encouraging forward and backward reference by the student and in making easy the definition of class assignments by the instructor. It will be noted also that many of the numbered articles are further distinguished by being printed in slightly smaller type and shorter lines. Those articles are selected as having a secondary or elaborative place in the discussion, and they are, by their type and length of line, indicated for omission by students in briefer courses where there is not time to consider all the topics presented in the book.

The authors have striven for readability as well as explicitness in the style of the text. They have undertaken also, sometimes at the expense of brevity, to place special emphasis upon certain phases of the discussion. The interrelated nature of the subjects treated and the structure of the presentation both facilitate emphasis. The same association of facts may be, and often is, approached from two or more directions in as many different connections. This has made emphasis possible by a judicious use of repetition or by restatement to suit the new occasion.

The style of presentation seeks to avoid being merely a compendium of facts. The elements of geography are ordered, and the student is

led to distinguish, by comparison and contrast, similar but not identical elements. Since this text attempts to lay a good foundation for the understanding of the geographical forms, patterns, and associations of world regions, many statements of fact and association concerning the features of specific world regions or localities have been included. To study these statements most effectively the student should make frequent reference to an atlas. Instructors are urged to see to it that students have facilities for that kind of study.

The text illustrations have been drawn or selected with the special purpose of centering attention upon significant features under discussion and of making possible a reduction in the amount of descriptive text. To that end they are placed in as close proximity to the related text as possible, although, in order to save space, some illustrations are made to serve in more than one connection. The plates that accompany the book have been prepared in blank. They are intended for student drawing and coloring as a manual aid to the appreciation of significant facts and associations in the distributions of geographical phenomena. Duplicate sets of these plates may be obtained from the publisher. Relatively few rainfall and temperature data have been presented in graphic form in the text, since it is believed that the student profits much more by the construction of these graphs for himself. A plate containing a number of coordinate paper blocks provides facilities for doing this. In addition to the classified climatic data provided for the several types of climate within the text proper, data for other stations are available in Appendix *A*.

Through teaching experience it has been found that in most introductory courses there is scant time for the development of the subject matter relating to forms of map projection, however much the instructor would like to present it. That has therefore been omitted from the body of the text and transferred to Appendix *B*, where it still is available for reference or for those teachers having time or inclination to use it. The balance of the former Chapter III, dealing with the general features of maps, has been incorporated with Chapter II. Appendix *D* has been added to deal with the American systems of land survey.

Reference lists are appended to those chapters, sections, or parts of the book that treat of distinct fields without conspicuous overlap in source material. These have been revised to include significant publications of recent date. The lists are not intended to be merely the references consulted by the authors, although many of those are included, and their aid is acknowledged with gratitude. The purpose of these lists is to suggest some of the more recent and authoritative

general works in each field. In these the instructor or the gifted student may find supplementary reading with which to broaden his understanding of the subjects considered.

The indebtedness of the authors for valuable suggestions, illustrations, and other kinds of aid extends in many directions and to numerous individuals. This cordial cooperation is much appreciated.

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UNIVERSITY OF WISCONSIN,
May, 1942.

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ELEMENTS OF GEOGRAPHY.
Physical and Cultural



APPENDICES



Appendix A

Supplementary Climatic Data for Selected Stations

(T., temperature in degrees Fahrenheit; Rf., rainfall in inches)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year	Range
1. T.	79	79	80	81	81	80	81	82	83	83	82	81	81	4.0
Rf.	7.9	4.6	7.2	6.0	11.1	11.7	9.9	6.5	3.1	2.9	6.7	11.1	88.7	
2. T.	80	80	82	83	83	82	81	81	81	81	80	80	81	3.2
Rf.	3.3	1.9	4.3	9.7	10.9	7.3	4.4	3.2	4.3	13.4	11.3	5.1	80.1	
3. T.	80	79	80	80	80	80	80	79	80	70	70	80	80	1.1
Rf.	3.9	1.7	1.7	4.2	12.0	13.5	13.2	14.9	12.5	14.8	21.5	11.9	129.4	
4. T.	79	81	84	86	84	82	82	82	82	81	80	79	82	7.0
Rf.	0.0	0.1	0.3	1.7	8.3	12.6	11.1	11.0	13.3	11.1	3.7	3.1	77.2	
5. T.	84	83	84	84	82	79	77	80	83	86	86	85	83	8.5
Rf.	15.3	13.0	9.7	4.5	0.7	0.2	0.1	0.1	0.5	2.1	5.2	10.3	61.7	
6. T.	70	75	83	90	89	87	87	86	85	83	76	71	82	20
Rf.	0.1	0.1	0.2	1.1	5.8	5.5	3.3	4.6	5.7	4.7	1.6	0.4	35.1	
7. T.	60	62	65	64	66	64	62	61	61	62	59	59	62	7
Rf.	0.6	1.9	2.3	3.4	3.0	5.7	11.0	12.1	7.6	0.8	0.5	0.2	49.6	
8. T.	49	54	61	71	81	90	95	94	88	80	63	53	73	46
Rf.	1.2	1.3	1.3	0.9	0.2	0.0	0.0	0.0	0.0	0.1	0.8	1.2	7.0	
9. T.	60	60	59	58	57	55	55	54	55	58	59	60	58	6
Rf.	0.0	0.1	0.2	0.2	0.4	0.3	0.2	0.4	0.3	0.0	0.2	0.1	2.3	
10. T.	58	62	63	73	79	82	82	83	78	71	64	57	71	25.2
Rf.	0.5	0.5	0.7	1.1	1.2	2.3	2.1	2.0	4.4	2.4	1.3	1.0	19.5	
11. T.	19	23	33	48	64	73	76	74	63	50	36	27	49	56.9
Rf.	0.5	0.4	0.4	0.7	0.7	0.8	0.5	0.5	0.5	0.5	0.5	0.6	6.6	
12. T.	74	74	70	64	58	54	52	54	57	62	67	71	63	22.4
Rf.	0.7	0.6	1.0	1.7	2.3	3.1	2.6	2.5	2.0	1.7	1.2	1.0	20.9	
13. T.	70	70	68	63	59	56	55	56	58	61	64	68	62	15.6
Rf.	0.7	0.6	0.9	1.9	3.8	4.5	3.6	3.4	2.3	1.6	1.1	0.8	25.2	
14. T.	49	50	53	56	61	68	73	75	70	64	57	52	61	25.4
Rf.	4.0	2.6	3.3	2.0	1.7	0.7	0.1	0.1	1.1	3.4	4.1	3.9	27.0	
15. T.	74	73	69	61	55	50	49	51	55	60	66	71	61	24.7
Rf.	3.1	2.7	4.4	3.5	2.9	2.5	2.2	2.5	3.0	3.5	3.1	3.9	37.3	
16. T.	53	55	63	69	75	81	83	83	79	70	61	54	69	30.6
Rf.	1.4	1.6	1.8	2.7	3.2	2.7	2.5	2.6	3.5	2.0	2.2	1.8	28.0	
17. T.	77	77	76	72	68	65	65	66	68	70	73	75	71	12
Rf.	4.6	4.5	4.6	3.0	2.0	0.7	0.8	2.0	3.7	4.9	4.4	4.5	39.7	
18. T.	34	34	35	42	49	55	58	53	53	45	39	35	45	24.3
Rf.	8.5	6.4	5.9	4.1	4.5	3.3	5.8	7.5	8.7	8.9	8.3	8.5	81.0	
19. T.	62	60	58	53	50	46	46	46	48	52	55	59	53	16.4
Rf.	2.4	3.0	5.5	9.4	15.2	17.0	16.1	13.2	8.7	5.2	5.0	4.1	104.8	
20. T.	39	40	43	48	53	57	60	60	56	50	45	42	49	21.1
Rf.	4.5	3.5	2.5	1.7	1.3	0.9	0.4	0.6	2.0	2.5	6.5	5.9	32.5	

Supplementary Climatic Data for Selected Stations.— (Continued)

(T., temperature in degrees Fahrenheit; Rf., rainfall in inches)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year	Range
21. T.	22	25	37	51	63	72	77	75	66	55	39	27	51	55
Rf.	0.7	0.9	1.3	2.8	4.1	4.7	4.0	3.2	3.0	2.3	1.1	0.9	29.0	
22. T.	32	38	46	55	63	70	75	73	66	56	44	36	55	42
Rf.	2.4	2.3	2.7	3.4	4.1	3.3	2.8	3.2	3.5	4.7	4.3	3.0	39.8	
23. T.	8	14	30	47	60	71	77	75	61	43	29	14	44	68.4
Rf.	0.2	0.3	0.7	1.1	2.2	3.4	5.8	5.3	3.3	1.5	0.0	0.2	24.9	
24. T.	-4	0	15	38	52	62	66	64	54	41	21	6	35	70
Rf.	0.9	0.7	1.2	1.4	2.0	3.1	3.1	2.2	2.2	1.4	1.1	0.9	20.2	
25. T.	24	23	27	33	49	57	62	59	50	41	32	25	41	39
Rf.	1.3	1.1	1.2	1.2	1.7	2.0	2.7	2.8	2.0	2.1	1.7	1.6	21.4	
26. T.	-3	2	13	30	47	59	64	59	43	32	13	2	31	66.9
Rf.	1.1	0.8	0.8	0.7	1.5	2.7	3.0	2.3	1.4	2.4	1.4	1.9	20.0	
27. T.	24	24	32	40	49	58	65	65	59	43	40	29	44	44.7
Rf.	6.0	4.7	5.1	4.6	3.3	3.8	3.7	4.6	4.1	5.5	5.9	5.5	57.3	
28. T.	8	9	18	30	41	53	60	56	43	34	22	12	33	52
Rf.	0.9	0.7	0.8	0.7	1.2	1.8	2.4	2.4	2.2	1.6	1.2	0.9	16.8	
29. T.	-23	-11	4	29	46	57	59	54	42	25	1	-13	23	82.4
Rf.	0.8	0.8	0.5	0.7	0.9	1.3	1.6	1.0	1.7	1.3	1.3	1.1	13.6	
30. T.	4	-2	-2	8	23	35	42	40	32	22	11	6	18	44
Rf.	1.4	1.3	1.1	0.9	0.5	0.4	0.6	0.9	1.0	1.2	1.0	1.5	11.8	

Stations for which data are given above:

- | | |
|---|--|
| <ol style="list-style-type: none"> 1. Georgetown, British Guiana 2. Colombo, Ceylon 3. Colón, Canal Zone 4. Saigon, French Indochina 5. Darwin, Australia 6. Mandalay, Burma 7. Addis Ababa, Ethiopia 8. Baghdad, Iraq 9. Port Nolloth, Union of South Africa 10. Monterrey, Mex. 11. Astrakhan, U.S.S.R. 12. Adelaide, Australia 13. Capetown, Union of South Africa 14. Algiers (Algiers), Algeria 15. Buenos Aires, Argentina | <ol style="list-style-type: none"> 16. San Antonio, Tex. 17. Durban, South Africa 18. Bergen, Norway 19. Valdivia, Chile 20. Victoria, Can. 21. Omaha, Neb. 22. Milano (Milan), Italy 23. Mukden, Manchuria 24. Winnipeg, Can. 25. Uppsala, Sweden 26. Tomsk, U.S.S.R. (Siberia) 27. Halifax, Can. 28. Arkhangelsk (Archangel), U.S.S.R. 29. Dawson, Can. 30. Spitsbergen |
|---|--|



Appendix B

Map Projections

THE NATURE OF MAP PROJECTIONS. The term map projection commonly is used in a rather broad sense, since many projections, so called, are more truly mathematical devices, and only a few are true perspective projections. The nature of the latter may be understood readily if one imagines a hemispherical basket of wire so constructed that the wires represent the parallels and meridians of the earth. The shadow of such a grid cast upon a plane touching it at a single point (tangent plane) is called a perspective projection because the observer appears to be looking through the grid. The spacing of the shadow lines obviously may be changed, and the resulting projection given different properties, by shifting the position of the light that casts the shadow to different distances from the point at which the plane is tangent to the wire grid. In certain projections the shadow is supposed to be cast not upon a plane but upon a tangent cone or a tangent cylinder, either of which is then developed into a plane. Many other "projections," and often more useful than those of the perspective class, have been devised by different scholars through mathematical computations, mainly within the last two centuries.

Some map projections are constructed so that they represent the *shapes* of earth features properly as compared to their shapes on a globe. Others represent *areas* so truly that all parts of the map are in proper areal relation to the globe. *It is impossible for any projection that includes a considerable area to accomplish both these objectives; some accomplish neither.* A projection on which the *shape* of any small area of the earth is truly rendered is called a *conformal projection*. One on which the ratio of *areas* is constant¹ between the globe and any part of the map is called an *equal-area, or equivalent, projection*. There are certain equal-area projections which, in achieving equality of area, produce gross distortions of the shapes of parts of the areas they show. All do so to some degree. Conversely, conformal projections in securing proper shapes do violence to the comparability of areas within the map. The name

¹ Areas are in constant ratio when the area of any quadrilateral included between two parallels and two meridians on a map has the same size relationship to the area on the earth that it represents that any other quadrilateral on the map has to the earth area that it represents.

of the projection employed usually will be found below each map in any scientific atlas, and often also a statement telling whether it is of the conformal or the equal-area type.

Some projections have an added quality: that of showing compass directions properly all ways from the center of the map. Such a projection is called *azimuthal* or sometimes, for no very good reason, "zenithal." One of these descriptive words may be coupled with one of those indicated above and with the name of its originator, to make the complete name of the projection, as, for example, the "Lambert azimuthal equal-area projection."

In order that the qualities of a few of the more commonly used projections may be understood they are here explained briefly and illustrated, together with some that are less used but are in striking contrast with them.

MAPS OF THE WHOLE EARTH

MERCATOR'S PROJECTION, which is commonly used for maps of the world, may be understood better by first examining two other contrasting projections

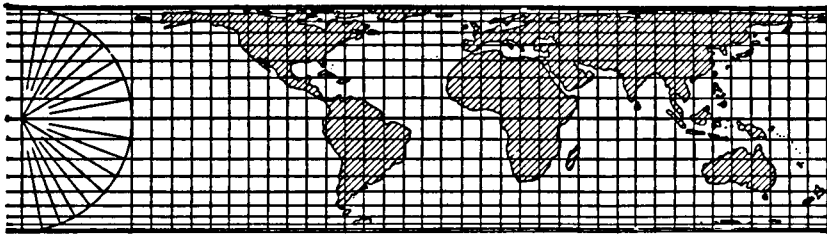


FIG. A.—A cylindrical equal-area projection.

between which it effects a compromise. Figures *A* and *B* show forms of projection in which the shadow of the imaginary basket grid of the earth is cast by lights located at different points. These shadow patterns give the spacing for the parallels upon tangent cylinders. In Fig. *A* the position assumed by the light is at an infinite distance so that its rays are parallel. The result is an equal-area projection but one in which the shapes of areas in high latitudes are so stretched out east and west and so shortened north and south that they look very odd—so odd, in fact, that the projection is little used. At the opposite extreme is Fig. *B*. In this one the shadow-casting light is assumed to be at the center of the basket grid. In this projection also there is a great east-west expansion in high latitude but a still greater north-south expansion. It is neither equal-area nor conformal.

The contrast between these two makes clear the nature and purpose of Mercator's projection (Fig. *C*), first published in 1569. In it the converging meridians of the globe are represented as parallel lines spaced as they are at the equator. This obviously involves a rapid east-west expansion with increase of latitude. To balance that distortion the positions for the parallels of latitude are mathematically computed to produce north-south expansion which shall increase *at the same rate* as the east-west expansion. The result is a conformal projection; *i.e.*, any small area, like a bay or a peninsula, is shown with practically its true shape. Large areas, however, are distorted

both in size and shape by the constant change of scale from place to place. Indeed, the scale of miles sometimes printed with this very common form of map is of little use outside the equatorial region, where the distortion of area is small. The expansion of the grid of this projection is a serious defect in a map for educational use, since it causes land areas in high latitudes to appear vastly larger than they really are in comparison with those near the equator.

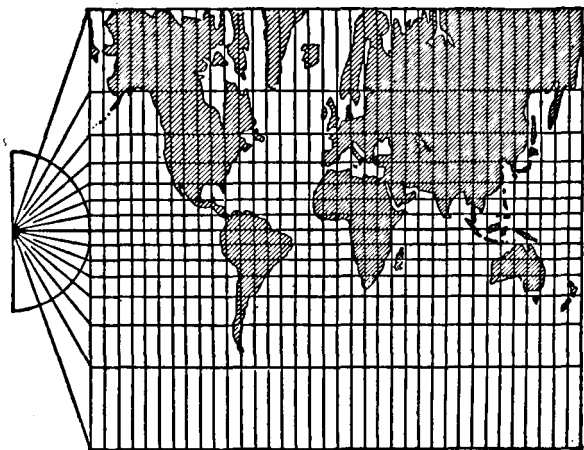


FIG. B.—A central-perspective cylindrical projection.

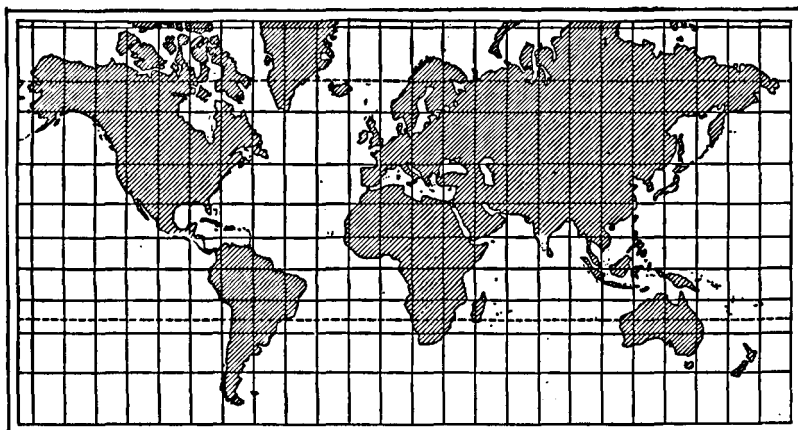


FIG. C.—Mercator's projection.

In addition to its conformality Mercator's projection has another quality that recommends it, especially to navigators. Straight lines drawn upon it show constant compass directions. For example, a straight line drawn at an angle of 45° to the right of a meridian on this projection trends northeast throughout its length. This is most useful for plotting ship's courses. The shortest distance between any two commercial ports follows the arc of the *great circle* of the earth passing through those ports, but that is a hard course to steer because the compass direction at any given point on the course is different from that at every other point, and the ship's course must be gradually

but continuously changed. In practice, such a course is approximated by plotting on Mercator's projection a series of short straight lines (rhumb lines) which follow the general direction of the great circle but along each of which the compass direction remains constant.

THE OVAL PROJECTIONS AND THEIR COMBINATION. The projections described above portray the entire earth on one or another form of rectangular grid. There is another group of projections which mainly are oval in form, having their poles shown as points instead of lines as long as the equator. Figures *D*, *E*, and *F* show the plans of three of these. All three are equal-area projections, but they differ slightly in other respects. All are developed

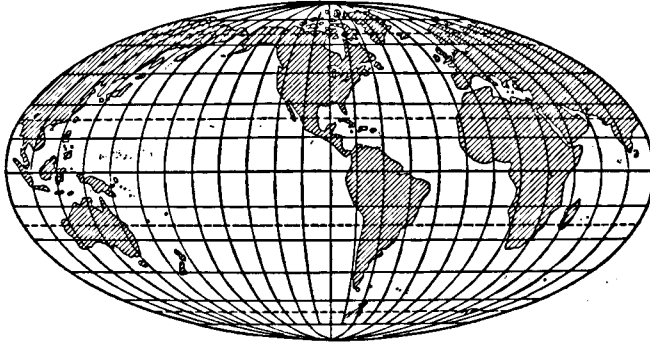


FIG. *D*.—Mollweide's homolographic projection.

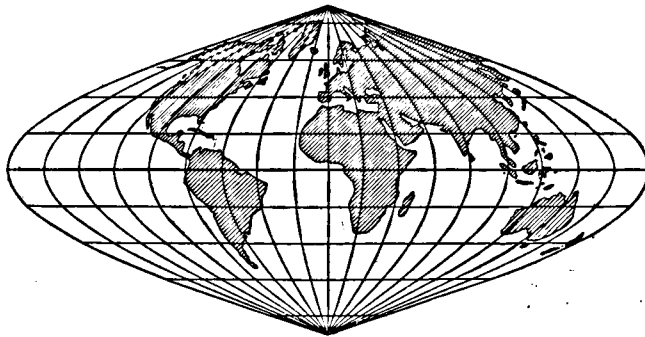


FIG. *E*.—The Sanson-Flamsteed sinusoidal projection

on polar axes that are one-half the length of the equatorial axis, which is the proper ratio of the length of the equator to the distance from pole to pole. In Mollweide's homolographic projection (Fig. *D*) and the sinusoidal projection (Fig. *E*) the meridians are equally spaced, as they are on a globe, and the parallels are truly parallel, as they also are on a globe. The difference between the two is in the shapes of their meridians and in the spacing of their parallels. Both of them distort shapes, especially near the margins of the maps and in high latitudes, but to slightly different degrees in different places. Aitoff's projection (Fig. *F*), while keeping equality of area, secures slightly better shapes by decreasing the spacing of the meridians from the center of the map outward and by using curved parallels. There are other projections of this general type.

In recent years also certain modified forms of projections in this group have appeared. They are characterized by interruptions of continuity for

the purpose of having more than one central or principal meridian, near which there is the least distortion of shape. Goode's homolosine projection (Fig. *G*) is one of these. It is made by combining the sinusoidal projection (from the equator to latitude 40°) with Mollweide's projection (from 40° to the pole). Since it is composed of equal-area projections, it also has that quality. In addition, a proper selection of the meridians to be repeated as principal meridians causes each continent to appear as if it were in the center of the original projection where shapes are very good. The form of Aitoff's projection used in the plates accompanying this volume employs the principle of interruption also. Offsetting these two desirable properties (equality of area

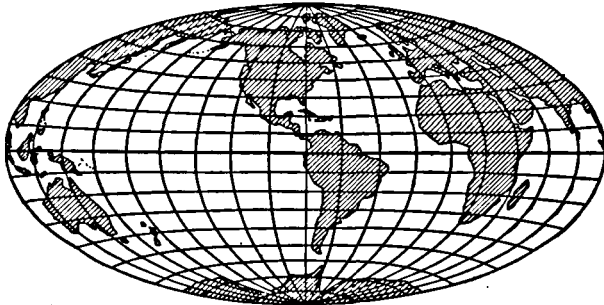


FIG. *F*.—Aitoff's projection.

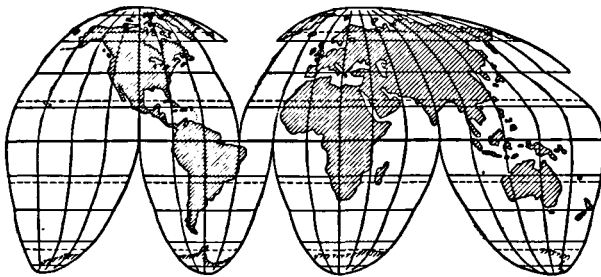


FIG. *G*.—Goode's homolosine projection.

and a fairly good shape) is the necessity for the eye of the observer to bridge the gaps in the grid caused by the interruptions. Equal-area projections of the entire earth's surface are of great value for the purpose of showing the world distribution of economic data or other phenomena of any kind that require areas to be shown in their true proportion to one another.

In the first of the above groups of projections the earth poles (if they can be shown) are represented by lines as long as the equator. In the second group they are represented by points, the meeting places of all the meridians. In certain other projections neither of these conditions is fulfilled, the poles being represented by lines, not points, but by lines less long than the equator. In some of the projections of this latter group the positions of the parallels are computed so that the resulting grids are equal-area or equivalent. One of several such projections is employed for the maps of the world shown in Figs. 24, 25, and others of this book.

MAPS OF HEMISPHERES AND SIMILAR AREAS

PERSPECTIVE PROJECTIONS. The front of nearly every atlas contains maps of the hemispheres, or of the polar areas, which are circular in outline. These are constructed according to any one of several schemes of projection,

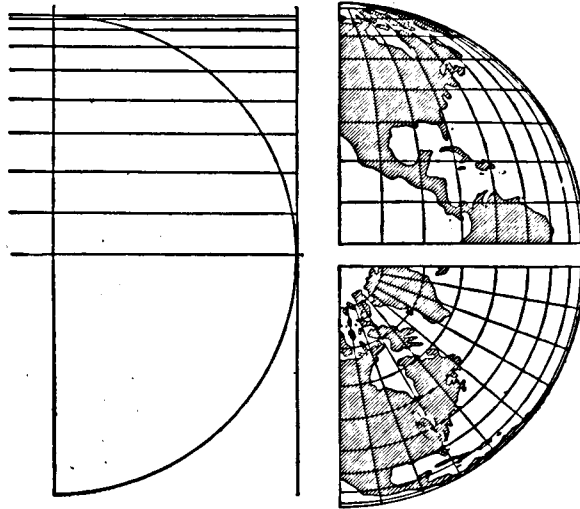


FIG. *H*.—The orthographic projection; the manner of obtaining the spacings of its parallels and meridians, and segments of its meridional and polar forms.

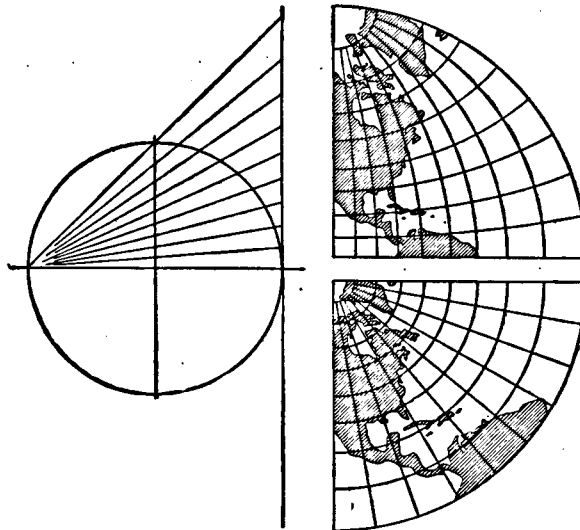


FIG. *I*.—The stereographic projection; the manner of obtaining the spacings of its parallels and meridians, and segments of its meridional and polar forms.

more or less used. Some of them have properties of peculiar value. Among them are perspective projections which are derived as if by projecting the shadows of the wire-basket grid upon tangent planes, just as in Figs. *A* and *B* they were cast upon tangent cylinders. Map grids constructed by these methods may take either the polar or the meridional form, and the illustrations show quadrants

in each, together with the mode of obtaining the spacings of the meridians and parallels.

The *orthographic projection* (Fig. H) shows great compression about its margin but expansion of areas in its center and gives the appearance of looking into a bowl. It is much used for star charts of the heavens but not much for maps of the earth. The *stereographic projection* (Fig. I) shows a spacing of lines just the reverse of the preceding. It is a conformal projection and renders the shapes of limited areas accurately but

greatly distorts the relative areas of different parts of the surface shown. Still more extreme in its marginal expansion is the *gnomonic projection* (Fig. J). In fact, the expansion of the latter is so great that no large part of a hemisphere can be shown by it, and on it both shapes and areas are so distorted that it has no value for showing either the shapes or the sizes of regions. It has, however, one unique quality that gives it a place among the valuable projections. On it every arc of a great circle of the earth is rendered as a straight line, and, conversely, every straight line drawn on the projection is an arc of a great circle. This is a most useful device for plotting great-circle (shortest possible) air or ocean routes. Because most lines that would be drawn upon this projection for the purpose of locating sailing

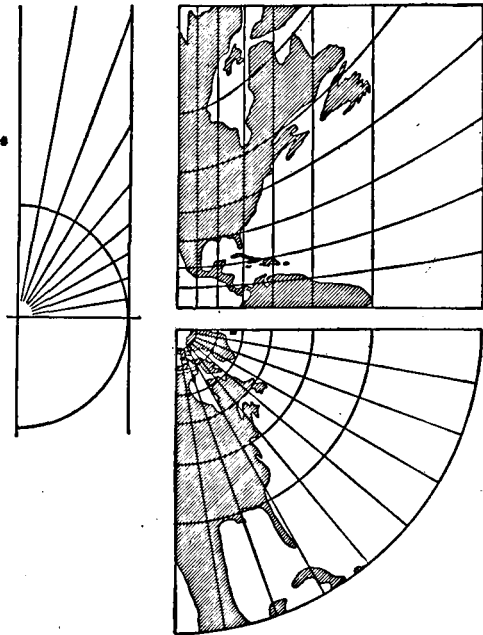


FIG. J.—The gnomonic projection; the manner of obtaining the basic spacings of its grid, and segments of its meridional and polar forms.

courses would cut parallels and meridians at various angles, compass steering by it is not easy. For that reason the significant points of latitude and longitude on the course usually are transferred from the gnomonic to a Mercator's projection and are connected by a series of short straight lines, as previously indicated. This approximates the great-circle route and makes steering much simpler. *Lambert's azimuthal equal-area projection* (Fig. K) illustrates the manner of constructing another of the hemispherical projections, which, however, is not of the perspective type. The spacing of the parallels or meridians from the center of the map is proportional to the chord distance of the arc of the number of degrees of earth circumference represented by the position of the line. This spacing gives the projection qualities the reverse of those of the stereographic. It is equal-area, azimuthal (*i.e.*, all points have their true compass directions from the center of the map), and the distortion of shapes, while considerable about the margins, is not great near the center of the projection. This valuable device commonly is used to show the hemispheres

in school atlases. The principle employed in it, when expanded to include the whole earth, underlies the construction of Aitoff's projection (Fig. *F*).

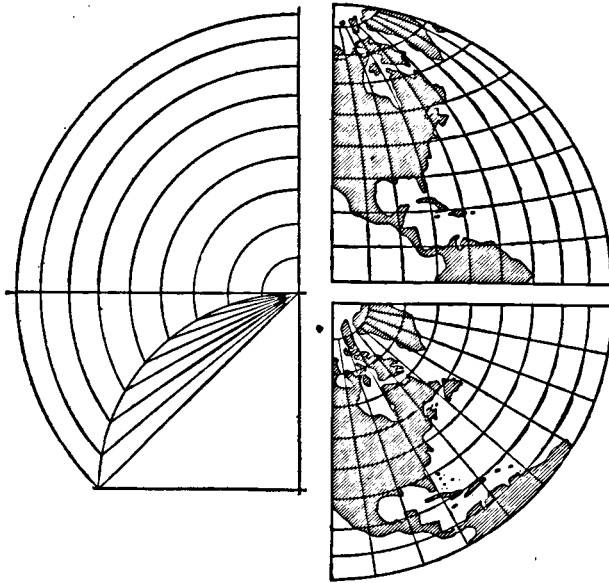


FIG. K.—Lambert's azimuthal equal-area projection; the manner of obtaining the spacing of its parallels and meridians, and segments of its meridional and polar forms.

THE CONICAL PROJECTIONS

FORMS OF CONICAL PROJECTION. It has been noted previously that grids of various forms may be projected upon tangent cones as well as upon tangent cylinders and planes. Some forms of conical projection are truly perspective in type, some of even greater value are mathematically derived, whereas still others are obtained only by modification of one or more of the basic characteristics of the conical group.

To understand the simple form of the conical projection, imagine a large paper cone set down upon a globe with its apex directly above the pole of the globe. The cone is tangent to the globe along the entire circumference of some selected parallel, which is called the *standard parallel*. Because this parallel is everywhere equally distant from the apex of the cone, it becomes an arc of a circle when the cone is opened out into a plane surface, and all other parallels become arcs of concentric circles (Fig. *L*). Lines drawn on the surface of the cone from the apex through selected points on the standard parallel become the meridians of the map and always are straight lines radiating from the common center. Meridians that are radial straight lines and parallels that are arcs of concentric circles always indicate one of the several forms of the true conical projection.

In the simple form of the conical projection the scale of the map is true only along the standard parallel. North or south of that parallel the longitudinal distance expands rapidly, and the scale does not apply. Much greater area may be brought within the range of reasonable distortion if the map be

constructed on *two standard parallels* instead of one. This is done by making the cone *secant* to the globe rather than tangent to it (Fig. *M*). By careful choice of position for the standard parallels an arrangement of lines may be had which, over a wide band of latitude, produces surprisingly little distortion. By mathematical adjustments of the exact positions of the parallels the distortions may be restricted either to the shapes or to the areas of the features shown. Thus both equal-area and conformal types of this projection exist.

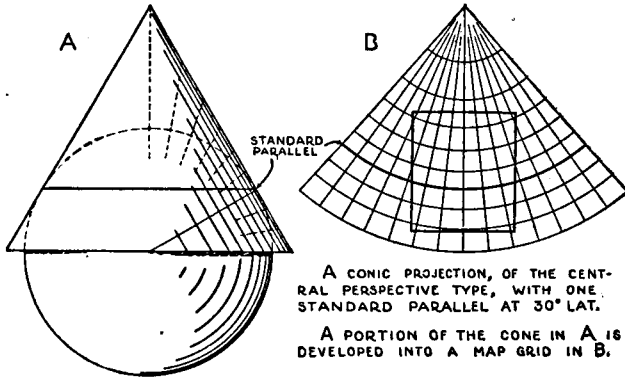


FIG. L.

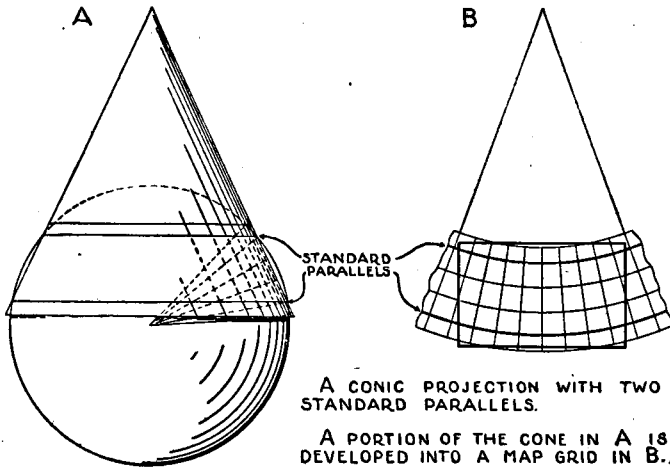


FIG. M.

Such are the Lambert conformal conic projection and the Albers equal-area projection, each with two standard parallels. The latter is particularly good for showing an area, like the United States, which has a greater east-west than north-south dimension. By proper selection of the standard parallels a map of the United States may be made in which the maximum scale error, which is on the northern and southern margins, is only a little more than 1 per cent. The map is, therefore, by construction equal-area and, for so large a region as the United States, very nearly conformal. The map of the geology of the United States, prepared by the United States Geological Survey in 1932, utilizes this excellent projection.

MODIFIED FORMS OF CONICAL PROJECTION. Several forms of projection adopt the basic principles of conical projection but, by modification of them in one way or another, produce grids having somewhat different qualities.

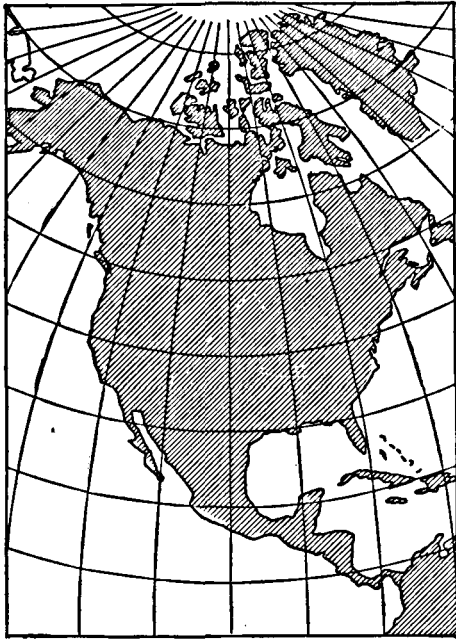


FIG. N.—Bonne's projection.

One of these is Bonne's projection, much used in atlases for maps of some of the continents (Fig. N). In this projection all parallels are arcs of concentric circles, as they are in the truly conical projections, and they are spaced in their proper positions relative to those on the globe. The meridians, however, are not straight lines but curves which converge at the pole and pass through points on the parallels that are spaced in true proportion to their spacing on the globe. Thus every quadrilateral of the grid has its true proportional length and breadth as compared with that quadrilateral on a globe, and the projection is equal-area. It gives good shapes near the principal meridian of a map, but distortion of shape increases rapidly with distance east or west. The projection is most properly

used, therefore, for a land area, such as the continent of North America, having its greater dimension north and south rather than east and west.

Another modified form of conical projection often is used as a basis of detailed surveys, such as the United States topographic maps or the International Map of the World on a scale of 1:1,000,000. This projection is called polyconic (meaning many cones) (Fig. O). It is drawn as if many cones of different taper were fitted upon a globe, each tangent on a different parallel. The parallels of this projection are arcs of circles, as in all conical projections, but not, as in the others, arcs of concentric circles. The meridians, except a central one, also are curved.

COMPROMISE PROJECTIONS. Among the scores of map projections that have been devised some are fanciful in the extreme or have only single or very limited uses. Others make no claim to scientific value but are easily understood and generally useful, since they compromise between the distortions of shape, common in equal-area projections, and the distortions of area, usual in conformal projections. One such is the Van der Grinten projection of the earth, which has qualities intermediate between those of the Mercator and Mollweide projections. Another is the familiar globular projection of the hemispheres.



FIG. O.—A polyconic projection.

Appendix C

American Systems of Land Survey¹

TOWNSHIP AND RANGE SYSTEM. Over a large part of the United States the basic subdivision of the land follows a system of survey adopted by the United States government in 1785. It was applied especially to the region of the Great Lakes, the Mississippi Valley, and the western states. By this system public land and rural property are described and their ownership deter-

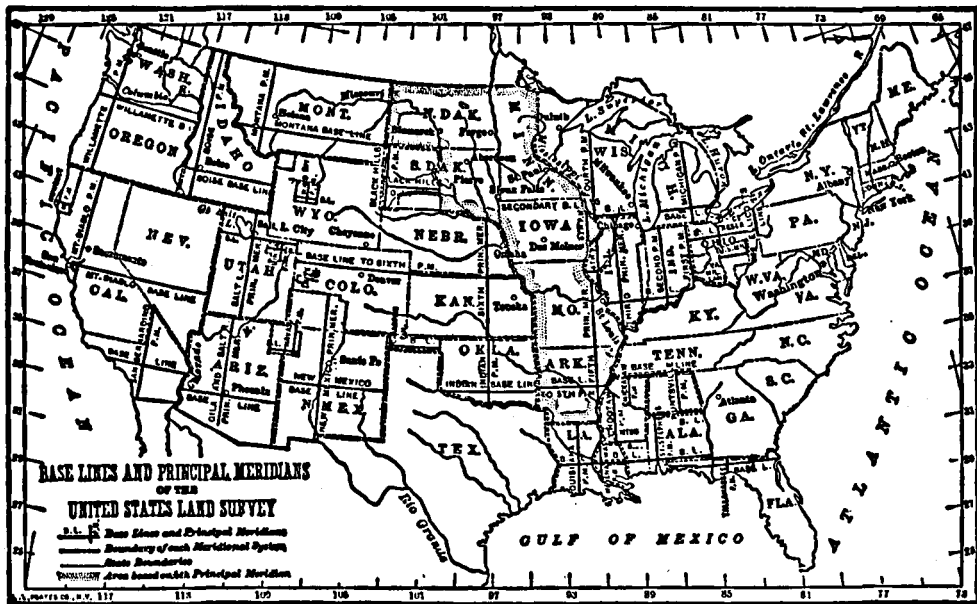


FIG. A.

mined in relation to a network of north-south and east-west lines. These include selected meridians, which are called principal meridians, and base lines and correction lines (Fig. A). Their use has the effect of dividing the land into essentially rectangular blocks. The location of these blocks is indicated by numbered *townships* and *ranges*. The ranges are north-south strips of land 6 miles wide, and they are numbered east and west from the nearest or most convenient principal meridian. In Wisconsin, for example, the controlling

¹ Adapted from Appendix F., Bull. 36 of the Wisconsin Geological and Natural History Survey. Illustrations by courtesy of E. F. Bean, Director.

line is the 4th principal meridian, the 1st being in eastern Indiana, and there are 30 ranges east and 20 west of it (Fig. B). The ranges are divided into townships by east-west lines at intervals of 6 miles, beginning at a selected southern boundary. In Wisconsin, this is the Illinois-Wisconsin state line. Thus a range consists of a north-south tier of townships each of which is supposed to be

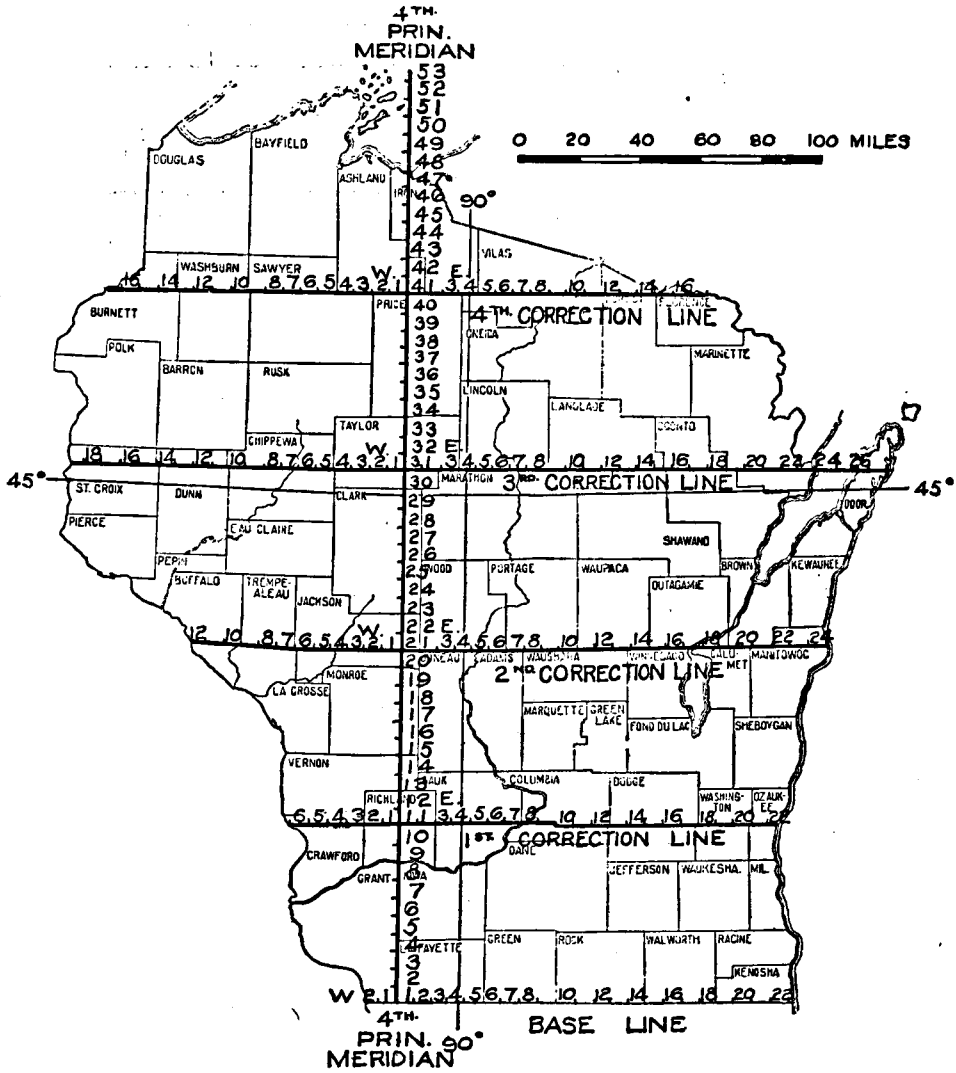


Fig. B.

6 miles square. There are 53 townships in the longest range in Wisconsin. By this system any township can be located by reference to its township and range numbers, e.g., township 7 north, range 9 east. This is usually written T. 7 N., R. 9 E. Owing to the fact that the meridians converge toward the north certain corrections and allowances must be made. Other factors require allowance also, such as a base line which is not true east-west, errors in surveying, and the presence of lakes or streams at critical points. The four correction lines for Wisconsin are shown in Fig. B.

The civil, organized, or municipal towns into which counties are divided are units of political administration, and they may or may not coincide with government townships, which are for purposes of location. In thinly settled districts the civil towns often are much larger and may include two or more government townships or parts of townships. In other areas one government township may be divided into two or more small civil towns. Using Dane County, Wisconsin, as an illustration we note that most of its civil towns are also government townships, but this is not true of the two northwesternmost towns of Black Earth and Mazomanie (Fig. C). There the corner of the county

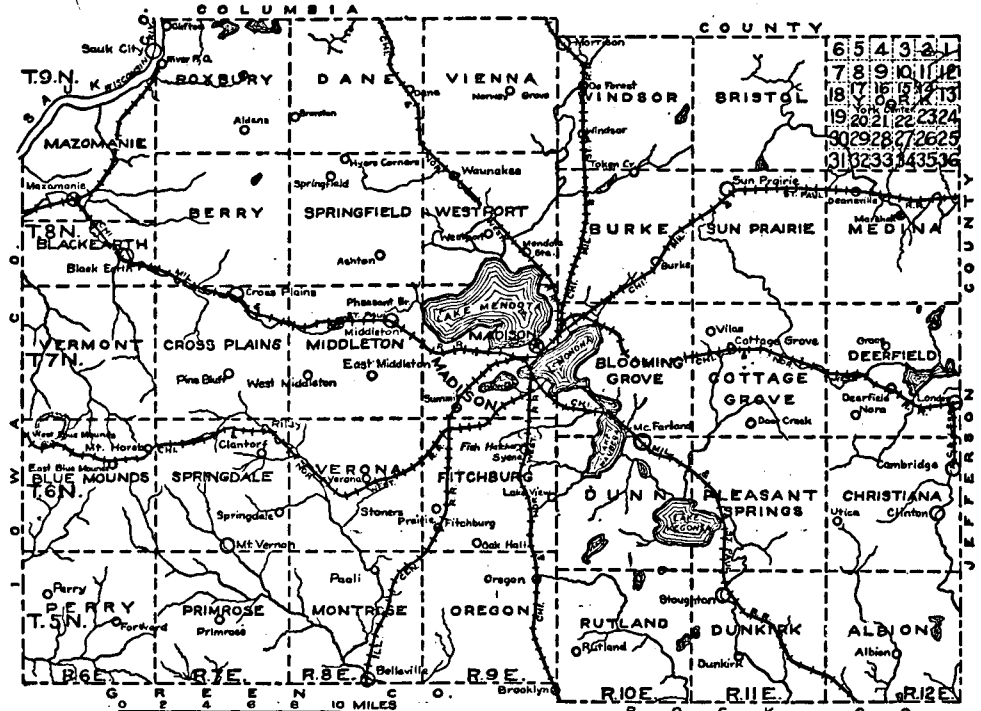


FIG. C.

is not rectangular, owing to the presence of the Wisconsin River. The boundaries of civil towns also are subject to change by appropriate legislation, but the government townships remain.

Every government township is divided into 36 sections, each 1 mile square. The sections are numbered, beginning at the northeastern corner and ending at the southeastern, as is shown in the northeastern township in Fig. C. The locations of the township and section corners are supposedly marked by a stake, stone, mound, tree, or other device, but too often these are impermanent features and are now difficult to locate. Since each section is 1 mile square, its area is 640 acres. For purposes of more detailed location and description the section is divided into quarters, each containing 160 acres, and the quarter sections are further divided into quarters of 40 acres each (Fig. D). These are commonly called "forties." The quarter sections are indicated by the points of the compass, and so also are the forties. To describe and locate a given forty,

therefore, one might say that it is the NE $\frac{1}{4}$ of SW $\frac{1}{4}$ of Sec. 31, T. 18 N., R. 9 E. Such a location is almost as precise as if it were given in latitude and longitude, and it tells also the area of the parcel of land in question.

METES AND BOUNDS. In the Atlantic Coast states and certain others the original land grants and surveys were made prior to the adoption of the township and range system of survey. In those states parcels of land are described by a system known as "metes and bounds." In that system an arbitrary point is taken, such for example as a projecting rock, a tree, or some significant point on the bank of a river or lake. The property is then bounded by lines

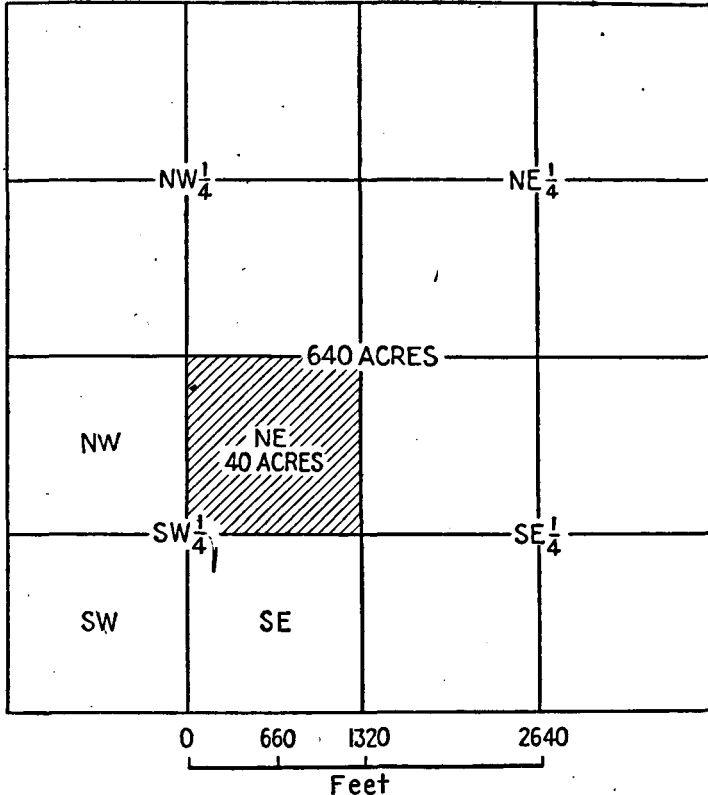


FIG. D.

run in a given compass direction for a certain distance, then in another direction for a specified distance, and so on around to the point of beginning. This system has often led to conflict over property lines because after a time the tree, stone or other arbitrary beginning point has been lost or its location has changed. Moreover, the stated distances were sometimes measured inexactly, as in parts of Texas, for example, where some of the early Spanish land grants are said to have been measured in terms of the length of a lariat rope or of how far a horse could walk in a given time. Such lines often did not surround rectangular parcels of land, and seldom did the plots of land have any consistent pattern of shape with respect to the cardinal compass directions.

This lack of coordination is plainly apparent in the road patterns to be seen in detailed maps of New England, Texas, and other states. In some North

American localities the present small parcels of land are subdivisions of grants made by the kings of England, France, or Spain to noblemen or to the sponsors of settlement projects. In French Canada, for example, the present farms often are rectangular but are very long and narrow, their narrow frontage being upon a river and their length extending at right angles from the river, regardless of compass direction. Some of the counties of the Province of Quebec may be seen to have the same shape. They were established at a time when river frontage was a most prized possession but the land of the interior had little value. Various systems more or less like that of metes and bounds are prevalent in most of Europe and, in fact, in the larger part of the world.

Appendix D

A SELECTED LIST OF UNITED STATES TOPOGRAPHIC QUADRANGLES

The topographic quadrangles indicated below have been selected from those published by the United States Geological Survey because they illustrate in map form certain of the landforms discussed in the text. Some of the subjects discussed, ice-scoured plains, for example, do not find clear illustration in any of the United States Topographic Quadrangles now published and are therefore omitted from the list.

Certain of the maps named below may be used to illustrate more than one class of features, and their names are repeated. Such maps are indicated by the asterisk. In some instances two or three adjacent quadrangles are required to show adequately the extent of the feature in question. Such are indicated as a series by being listed in series.

These topographic quadrangles may be obtained from the United States Geological Survey, Washington, D. C. In the following list, sheets of sizes other than standard are marked “(special).”

PLAINS OF STREAM DEGRADATION

Newly emerged plains:

Bladen and Everett City, Ga.

Cambon, Fla.

Chicora, S. C.

Moniac, Ga.-Fla.

Higher and better drained coastal plain:

Bamberg, S. C.

Forest, Miss.

Springhope and Rocky Mount, N. C.

Plains with cuestaform ridges and escarpments:

Blanchardville and Blue Mounds, Wis.

Epes, Ala.

Fond Du Lac and Neenah, Wis.

Kendall and Mauston, Wis.*

Llano, Tex.*

Nashville, Tenn.*

New Boston and Linden, Tex.

Niagara, N. Y.

Pelahatchie and Morton, Miss.

Knobs and outliers on cuestaform plains:

Big Clifty, Ky.*

Franklin, Tenn.

Kendall and Mauston, Wis.*

Llano, Tex.*

Nashville, Tenn.*

Young plains (mainly in glacial drift):

Gillespie, Ill.*

La Salle, Ill.*

Macon, Mo.

Paulding, Ohio*

Ray, N. D.*

Rough, maturely dissected plains:

La Farge, Wis.

Newcomerstown, Ohio

Nortonville, Ky.

<i>Dissected river bluffs</i> (river breaks):	Gastonia, N. C.
Ray, N. D.*	Kings Mountain, N. C.
Porcupine Valley and Spring Creek, Mont.	<i>Karst plains:</i>
<i>Old-age plain:</i>	Big Clifty, Ky.*
Mount Carmel, Ill.-Ind.	Interlachen, Fla.
Owensboro, Ind.-Ky.	Mammoth Cave, Ky.
<i>Peneplains with monadnocks:</i>	Princeton, Ky.
Atlanta and Marietta, Ga.	Williston, Fla.

PLAINS OF STREAM AGGRADATION

<i>Delta margin:</i>	Gays Mills, Wis.
East Delta, La.	Ogallala, Neb.*
Timbalier, La.	Prairie du Chien, Wis.*
<i>Narrow levees:</i>	<i>Alluvial terraces:</i>
Bayou de Large, La.	East Cincinnati, Ohio
Pt. a la Hache, La.	Malaga, Wash.
Quarantine, La.	Prairie du Chien, Wis.*
Shell Beach, La.	Tarboro, N. C.
<i>Wide levees:</i>	<i>Alluvial fans and piedmont alluvial plains:</i>
Baton Rouge, La.	Cucamonga and San Bernardino, Calif.
Donaldsonville, La.	Levis, Calif.
New Orleans, La.	Pacoima and Sunland, Calif.
<i>Wide alluvial floodplains:</i>	Whittier, Calif.
Bayou Sara, La.	<i>Plains of older alluvium:</i>
Clarksdale, Miss.	Assiniboine, Mont.
Marks, Miss.	Colorado Springs, Colo.
Memphis, Tenn.-Ark.	Eaton, Colo.
Vicksburg, Miss.	Sanborn, Colo.
<i>Narrow floodplains:</i>	Vilas, Colo.
Chester, Ill.	

GLACIAL DRIFT PLAINS

<i>Till plains</i> (younger drift):	St. Francis, Minn.
Poorly drained	<i>Till plains</i> (older drift):
Chokio, Minn.	Albia and Pella, Iowa
Lansing, Mich.	Gillespie, Ill.*
Neshkoro, Wis.	<i>Till plains</i> (relief controlled by bedrock features):
Well-drained	Baraboo, Wis.
La Salle, Ill.*	Stonington and Moosup, Conn.
Slater, Iowa	Youngstown, Ohio
Upper Sandusky, Ohio	<i>Marginal moraines:</i>
With drumlins	Kettle-moraine regions (large area)
Boston, Mass.*	Pelican Rapids and Vergas, Minn.
Clyde and Weedsport, N. Y.	Kettle-moraine belts (with associated pitted outwash plains)
Palmyra, N. Y.	Rives Junction* and Stockbridge, Mich.
Sun Prairie and Stoughton, Wis.	Schoolcraft, Mich.
With eskers	
Fowlerville, Mich.	
Rives Junction, Mich.*	

St. Croix Dalles, Wis.
 Whitewater, Wis.
Lake plains (glacial):
 Detroit, Mich.

Fargo, N. D.-Minn.
 Paulding, Ohio*
 Ridgeway, N. Y.

PLAINS IN DRY CLIMATES

Eolian sand plains:

Brown, Neb.
 Lakin, Kans.
 North Platte, Neb.
 Ogallala, Neb.*

Loess plains (stream eroded):

Omaha and Vicinity, Neb. and Iowa
 (*special*)
 Red Cloud, Neb.
 York, Neb.

SHORE FEATURES OF PLAINS

Ria shorelines:

Bath and Boothbay, Maine
 Boston, Mass.*
 Choptank, Md.
 Kilmarnock, Va.

Deposited shore features:

Offshore bars:
 Atlantic City, Sea Island, and
 Barnegat,* N. J.
 Lopena Island and Saltillo Ranch,
 Tex. .

Spits and hooks:

Cape Henlopen, Del.*
 Erie, Pa.
 Provincetown, Mass.
 Sandy Hook, N. Y.

Shore dunes:

Barnegat, N. J.*
 Cape Henlopen* and Rehoboth, Del.
 Fenville, Mich.
 Three Oaks, Mich.

DRY-PLATEAU FEATURES

Plateau valleys and escarpments:

Abajo, Utah*
 Bisuka, Idaho
 Bright Angel, Ariz.
 Diamond Creek, Ariz.
 Escalante, Utah
 Hanford and Scooteny Lake, Wash
 Henry Mountains, Utah*
 Kanab, Utah

Mesas and buttes:

Mesa de Maya, Colo.
 Mount Trumbull, Ariz.
 Raton, N. M.
 Tascotal Mesa, Tex.

Plateau bolsons:

Carson Sink, Nev.*
 Cienega Springs, N. M.
 Disaster, Nev.*
 Silver Peak, Nev.*

HILL LANDS

Stream-eroded hills in horizontal strata:

Arnoldsburg, W. Va.
 Bald Knob, W. Va.
 Confluence, Pa.
 Fayetteville, W. Va. (plateau features)
 Parkersburg, W. Va.-Ohio

Badlands:

Rock Springs, Wyo.

Hills in folded sedimentary strata:

Hyndman, Pa.
 Millersburg, Lykens, and Pine Grove,
 Pa.

Mount Union, Pa.

Winding Stair, Okla.

Hills in complex rocks:

Asheville, N. C.-Tenn.
 Knoxville, Tenn.-N. C.

Hills in areas of linear faulting:

McKittrick, Calif.
 Priest Valley, Calif.
 San Mateo, Calif.

Glaciated hill lands:

In crystalline rock
 Allagash, Maine

Bolton, N. Y.
Greenlaw, Maine

In horizontal strata
Bath and Hammondsport, N. Y.

MOUNTAINS

Volcanic peaks:

Crater Lake National Park, Ore.
Lassen Volcanic National Park, Calif.
Maiden Peak, Ore.
Mount Hood, Ore.
Mount Rainier National Park, Wash.*

Laccolithic mountains:

Abajo, Utah*
Fort Benton, Mont.
Henry Mountains, Utah*

Fault-block mountains:

Ballarat and Furnace Creek, Calif.
Carson Sink, Nev.*
Disaster, Nev.*
Sequoia and General Grant National
Parks, Calif. (*special*)*
Silver Peak, Nev.*

*Mountain foothills of the hogback-ridge
type:*

Boulder, Colo.

Loveland, Colo.

Rapid, S. D.

Glaciated mountains:

Glacier National Park (*special*)
Hamilton, Mont.
Hayden Peak, Utah.
Mount Rainier National Park, Wash.*
Sequoia and General Grant National
Parks, Calif. (*special*)*

Emerged highland shore features:

La Jolla, Calif.
San Diego, Calif.
San Luis, Calif.
Santa Ana, Calif.
Solstice Canyon and Las Flores, Calif.

Fiords:

Reconnaissance Map—Alaska Railroad,
Seward to Matanuska Coal Field
(*special*)
Takoma and Snohomish, Wash.

Appendix E

PRINCIPAL SUBDIVISIONS OF EARTH HISTORY AND SOME OF ITS EVENTS AS THEY ARE RECORDED IN THE ROCKS OF NORTH AMERICA					
ERA	PERIOD	TOPOGRAPHIC DEVELOPMENTS	BIOLOGIC DEVELOPMENTS		
↑ MORE RECENT TIME					
THE SPACES ALLOTTED BELOW TO THE ERAS AND PERIODS ARE NOT IN PROPORTION TO THEIR ESTIMATED DURATION					
CENOZOIC ERA OF MODERN LIFE DUR. EST. AT ± 4% OF ALL GEOL. TIME	QUATERNARY	RECENT ESTIMATED AT ± 25,000 YRS.	PRESENT TECTONIC AND GRADATIONAL LAND FORMS	THE DEVELOPMENT AND DOMINANCE OF INTELLIGENT MAN	
		PLEISTOCENE	CALIF. COAST MTS. APPEAR THE GREAT ICE AGE	NEW SPECIES OF PLANTS AND ANIMALS APPEARANCE OF PRIMITIVE MAN	
	TERTIARY	PLIOCENE	ELEVATION OF ROCKY, SIERRA NEVADA & CASCADE MTS., THE COLORADO & COLUMBIA PLATEAUS, AND THE GREAT BASIN		DEVELOPMENT OF MAMMALS (PRIMITIVE TYPES OF ELEPHANTS, HORSES, DEER, CATS, DOGS, WHALES & MANY OTHERS, INCLUDING FIRST APES) BIRDS & TREES SIMILAR TO MODERN TYPES
		MIOCENE			
		OLIGOCENE			
	Eocene				
GENERAL EROSION INTERVAL					
MESOZOIC ERA OF MIDDLE LIFE DURATION EST. AT ABOUT 8% OF ALL GEOL. TIME		CRETACEOUS ROCKY MT. COAL DEPOSITS	LAST GREAT SUBMERGENCE, GULF OF MEXICO TO ALASKA, FOLLOWED BY UPHEAVAL & BEGINNING OF ROCKY MTS.	RISE OF MAMMALS & BIRDS - DECLINE & EXTINCTION OF DINOSAURS. DEVELOPMENT OF MODERN FLOWERING PLANTS & DECIDUOUS TREES	
		JURASSIC	APPALACHIAN MTS. BASE-LEVELLED - PACIFIC COAST VULCANISM - SUBMERGENCE FROM COLO. TO ALASKA.	GIANT REPTILES (DINOSAURS) - FIRST BIRDS - PRIMITIVE MAMMALS - MANY INSECTS SIMILAR TO PRESENT FORMS	
		TRIASSIC	LARGE LAND AREA - ARIDITY CONTINUED - SOME ROCKS OF LAND-DEPOSITED ORIGIN - VULCANISM	REPTILES (CRAWLING, WALKING & FLYING, SWIMMING) DIVERSE & ABUNDANT. MANY COMPLEX MARINE ANIMALS - FORESTS MAINLY CONIFEROUS	
GENERAL EROSION INTERVAL					
PALEOZOIC ERA ERA OF ANCIENT LIFE DURATION VARIOUSLY ESTIMATED AT ABOUT 20 PER CENT OF ALL GEOLOGIC TIME	CARBONIFEROUS "THE COAL AGE"	PERMIAN	GENERAL EMERGENCE - FOLDING OF APPALACHIAN MTS. - WIDESPREAD ARIDITY	DECLINE OF FERN TREES & RISE OF CONIFERS - GREAT VARIETY IN REPTILES & INSECTS - MANY MARINE INVERTEBRATES DISAPPEAR	
		PENNSYLVANIAN	FLUCTUATING SEAS IN THE INTERIOR - FORMATION OF EXTENSIVE SWAMPS	VAST FORESTS OF FAST-GROWING TREES AND OTHER PLANTS. COMPLEX MARINE LIFE - RISE OF REPTILES AND INSECTS	
		MISSISSIPPIAN	WIDESPREAD SUBMERGENCE AND DEPOSITION OF SEDIMENTS	DEVELOPMENT OF SHARKS AND OTHER FISH - NUMEROUS AMPHIBIANS - ABUNDANT FORESTS OF FERNS & PRIMITIVE CONIFERS.	
		DEVONIAN	WIDESPREAD SUBMERGENCE - MOUNTAIN UPLIFT AND VULCANISM IN NEW ENG.	ABUNDANT FISHES WITH VERTEBRA AND PAIRED FINS, FIRST AMPHIBIANS, FIRST FORESTS (TREE FERNS)	
		SILURIAN	WIDESPREAD DEVELOPMENT OF PLAINS BY EROSION AND BY EMERGENCE	DEVELOPMENT OF FISHES - FIRST LAND ANIMALS (SPIDER-LIKE) - FIRST LAND PLANTS - ABUNDANT CORALS	
		ORDOVICIAN	SEDIMENTS DEPOSITED - MOUNTAIN BUILDING IN NEW ENGLAND AND CANADA	ABUNDANT MOLLUSKS AND TRILOBITES - EARLY FORMS OF FISH - NO EVIDENCE OF LAND ANIMALS OR PLANTS	
		CAMBRIAN	WIDESPREAD SUBMERGENCE AND DEPOSITION OF SEDIMENTARY ROCKS	FIRST ABUNDANT FOSSILS MAINLY OF SHELLED MARINE INVERTEBRATES (MOLLUSKS AND TRILOBITES)	
LONG INTERVAL OF UPLIFT AND EROSION					
PROTEROZOIC		MUCH MOUNTAIN BUILDING, METAMORPHISM OF ROCKS, AND VULCANISM	PRIMITIVE MARINE LIFE, MAINLY WITHOUT SHELLS, LEAVING ONLY MEAGRE FOSSIL REMAINS		
LONG INTERVAL OF UPLIFT AND EROSION					
ARCHEOZOIC		MOUNTAIN BUILDING AND VULCANISM MANY EVENTS OBLITERATED BY VAST LAPS OF TIME	PRIMITIVE FORMS OF MARINE LIFE, PERHAPS ALGAE-LIKE NO DIRECT FOSSIL EVIDENCE		
EARLIER TIME			EARTH HISTORY EXTENDS BACK AND MERGES WITH EARTH ORIGIN		
PREVAILING CLASSES OF ROCKS IN THE GEOLOGIC REGIONS OF NORTH AMERICA					
			YOUNGER SEDIMENTARY ROCKS	ALLUVIUMS - OLD & NEW - GLACIAL DRIFT, LOESS	
			LOCAL INTRUSIVE AND EXTRUSIVE IGNEOUS ROCKS	LOCAL IGNEOUS ROCKS	
			OLDER AND MORE RESISTANT SEDIMENTARY ROCKS		
			LOCAL INTRUSIVE AND EXTRUSIVE IGNEOUS ROCKS		

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