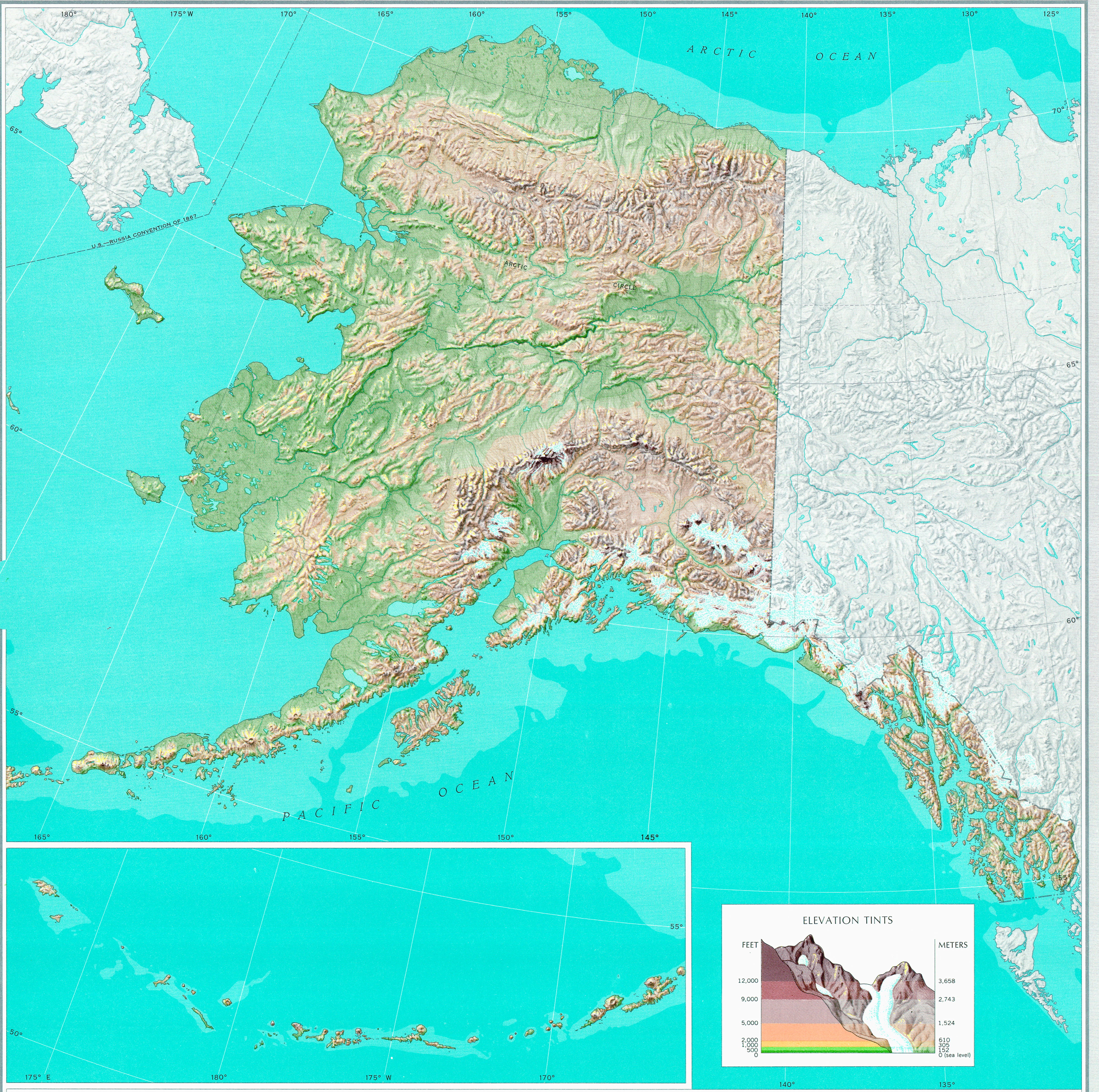

SHADED RELIEF

Richard Edes Harrison, 1969

Albers Equal Area Projection

SCALE 1:7,500,000

The components of man's environment may be classified into three broad categories of closely interrelated phenomena: (1) physical features which are provided by nature, such as landforms, their underlying geologic formations and structures, soils, natural vegetation, climate, hydrologic conditions, and mineral resources, (2) cultural features which man has added through living on the earth, such as houses, roads, dams, and cities, and (3) economic-social-political ways of life that characterize segments of man's cultural complex. In *The national atlas of the United States of America* the components of the physical environment are treated first because they constituted the first environmental conditions to confront man on the earth. The area, location, and condition of land, in association with the basic resources of soil and water to provide food and drink, have from prehistoric times to the present greatly influenced the capacity of an area to support human existence.

However, many earth features of natural origin have gradually been modified by mankind. For example, cultivated soils, much of the earth's vegetation cover, and minor topographic features are not exclusively either natural or cultural, but result from man-environment interactions. The man-environment relationships are becoming increasingly significant as population growth accelerates, as technological developments rapidly increase the per capita use of resources, and as pollutants threaten the health and living standards of the Nation. On the other hand, major topographic features generally change slowly, even through geologic time. Consequently man considers them relatively stable elements of his environment and recognizes that they influence the placement of farms, cities, and transportation networks and are often related to the economic-social-political cultural complex of his way of life.

LANDFORMS

The land surface of the United States of America has a great and generally pleasing variety of mountains, plateaus, hills, plains, and minor physical features, arranged in endless combinations. In order to understand better the distributional patterns and relationships of those landforms, geologists, geomorphologists, physiographers, and physical geographers have devised various schemes for classifying and mapping them. The most direct method of showing relief features within Atlas scale limitations is the shading technique used by Richard Edes Harrison on the following three pages. Each feature is drawn to scale, shaped to create a pictorial representation, and structured to show its degree of flatness or slope, its relative height above sea level, and its spatial relationship to other physical features of the landscape. Although shaded relief maps give the reader an easily interpreted image of the landscape and a reasonably good impression of local relief and general elevation, they do not indicate precise elevations above sea level except for points at which spot elevations may have been added to the map.

Two other commonly used means of portraying relief are shown on page 59. On the upper map, contour lines connect points of equal elevation and layer color tints denote areas with elevations that fall between the contour lines. If data are available for accurate contouring and if the contour interval is small enough, the shapes of many landforms may be revealed, but with less visual impact than on an equally well made shaded relief map. On the other hand, the contour lines provide more specific information about elevation than does a shaded relief drawing. Relief shading may be combined with the contour-layer tint technique, but the result creates a false impression of abrupt changes in slope or elevation at the layer tint boundaries and thus destroys the natural gradients which are shown so well by relief shading alone. This effect can be minimized by using inconspicuously fine contour lines and vignetting the colors at the transition zones.

The lower map on page 59 shows relief features by means of a set of stylistic symbols rather than natural forms. That technique, commonly known as physiographic diagraming, was used by Erwin Raisz to emphasize classes of surface forms, whereas Armin K. Lobeck and Guy-Harold Smith used somewhat different schematic symbols to interpret the origin and structure of landforms. In either case, the perspective of symbolization causes the peak or base to be inaccurately placed planimetrically, but at small scales the displacement may not be as critical as the easy recognition and interpretation of the landforms.

In contrast with maps depicting relief features, either pictorially or through symbolization, other maps delineating physiographic regions, provinces, or divisions were developed. Those classics by the famous scholars, John Wesley Powell (1834–1902), Nevin M. Fenneman (1865–1945), and Armin K. Lobeck (1886–1958), are reproduced on page 60. In spite of differences in the dates of map compilation and in the viewpoints of the authors, the similarities of their work are more conspicuous than the differences, because all three classifications are based fundamentally on genetic factors. On the other hand, the land-surface form maps by Edwin H. Hammond (p. 61–64) were developed from an empirical analysis of a selected group of surface characteristics. They do not conform closely in several respects to the earlier works of Powell, Fenneman, and Lobeck, but Hammond's classification serves a different purpose — the classification of land forms for human use.

Land-surface form, geographically interpreted, constitutes a bridge between other physical phenomena, such as geophysical forces and structures, geology, climate, and vegetation, and man's use of the land for a wide range of economic and socio-cultural purposes. The land-surface form maps (p. 62–64), unlike the earlier works of Powell, Lobeck, and Raisz, were not designed to relate primarily to genetic factors in surface development. They combine, for any given area, five bits of information: (1) percentage of the area which has a gentle slope of less than 8 percent, (2) local relief, (3) generalized profile, (4) distinctive surface materials, and (5) major lineaments such as streams, crests, scarps, and valley sides. Nevertheless, regionalization of the results on a smaller scale map (p. 61) resembles in many ways the physiographic regions depicted on page 60. Internal differentiations, however, can be readily distinguished on the larger scale, land-surface form maps (p. 62–64) and thus are more useful in evaluating land-use potentials.

GEOPHYSICAL FORCES

The geophysical forces of gravity and magnetism, which play such important roles in reshaping the earth's solid crust, or upper mantle, are also basic in measuring the earth's shape and in establishing both horizontal and vertical geodetic controls for mapping. (See p. 316–318.) They also have important roles in determining the earth's internal structure, in helping to locate underground resources, and in providing directional controls for modern inertial navigation and guidance devices. Gravity anomalies (departures from an ideal, theoretical model) are mapped and explained on page 65. Likewise, on page 68 are maps of horizontal and vertical attractions of magnetic forces in the United States as of 1965. These forces of gravity and magnetism, combined with the tectonic stresses and movements discussed on page 69, result in folding, faulting, and intrusive as well as volcanic movements that cause tremors, or earthquakes within the earth's crust.

When stresses between different parts of the earth's solid crust become strong enough, the rocks break and move along fracture surfaces, and energy in the form of elastic vibrations is released. The energy waves are transmitted as displaced particles which vibrate and displace particles next to them. Several different types of waves are transmitted from the center of movement, and they travel at different speeds from each other, as well as at different rates through different substances. Consequently, careful measurements of the earthquake waves yield clues to the nature of the earth's crust and core.

It is the velocity of earthquake waves rather than their amplitude which causes damage to surface structures, the upper parts of which are snapped by the sudden reversal of fast traveling, high frequency, push-pull waves that first emanate from a zone of crustal movement. Secondary waves, which vibrate at right angles to the push-pull waves, travel more slowly and are not transmitted through liquid or gas. These are commonly known as shaker waves. Long, surface waves are the slowest moving and least damaging of the three common wave types.

Earthquakes result from movements of the earth's crust, but in turn result in landslides, tsunamis (huge waves caused by submarine earthquakes; incorrectly called tidal waves), and vibrations in the air that are often audible as cracking sounds near the center of movement, or as a rumble at greater distances. Several scales have been devised to categorize the intensity of earthquakes (McAdie, Richter, and Mercalli scales, for example), but all range from the minimum wave detectable by sensitive instruments to quakes that cause catastrophic damage to buildings and loss of life over wide areas. For the world as a whole, each year man may expect an average of one great earthquake, 1,000 damaging earthquakes, 100,000 noticeable shocks, and close to 1,000,000 detectable tremors.

Since earthquakes are normally associated with mountainous areas, particularly around the Pacific Basin, it is not surprising that most of the quakes recorded in the United States are in the Pacific Coast and Rocky Mountain States, Alaska, and Hawaii, and fewest are recorded in the great interior and coastal plains.

Comparison of the maps of earthquakes (p. 66–67) and of tectonic features (p. 70–72) readily reveals the close relationship between frequency of earthquakes and zones of tectonic activity. The tectonic map of the United States is, in effect, an architectural drawing in cartographic format of the rocks and structures of the upper part of the earth's crust. The structural platform areas, consisting of the Atlantic and Gulf Coastal Plains, and the extensive interior plains and plateaus, are mapped in subdued colors which reflect their relatively inactive condition. The foldbelts, fault zones, and areas of volcanic origin are mapped in brighter colors to emphasize their more dynamic character. For a more detailed analysis of the tectonics of the country, see page 69.

GEOLOGY

Geology, in the broadest meaning of the term, is the study of the whole earth, but the discipline has been traditionally restricted to the crust of the earth—its origin, composition, structure, and life forms. Historical geology provides keys for deciphering the history of the earth as it is recorded in rocks and structures. Those keys are, however, largely derived from the study of processes which are currently at work and which can be observed and analyzed. The fundamental stages in the geologic history of the areas which constitute the United States are described on page 73, and the extent of continental glaciation, with related lake developments, is mapped on page 76. Geologic regions of the United States, mapped in a highly generalized fashion on pages 74–75, are related to the age of bedrocks in those regions, but may also be interpreted in terms of rock types and origins.

Physical geology draws heavily upon the principles of chemistry and physics to identify and classify minerals and rocks; to understand the earth processes of crustal change through volcanism, diastrophism, weathering, erosion, and sedimentation; and to apply the results to practical problems. Geologists are concerned, for example, with the discovery and extraction of useful materials such as metals, petroleum and natural gas, gem stones, construction materials, and water supplies. Engineering and military geologists are more directly concerned with the feasibility and ultimate safety of construction projects, reservoir sites, disposal of wastes, prediction of earthquakes, landslides, and structural failures of earth materials.

For these types of studies, much more detailed, larger scale mapping is essential, but the broad structural features shown on the tectonic maps of this Atlas (p. 70–72) and combined with the geologic regions (p. 74–75) help to identify priority areas for more intensive study. For example, the pre-Cambrian rocks of the Canadian Shield, northeast of Lake Superior and extending into New York and parts of Wisconsin and northern Michigan, are unlikely sources of petroleum because of the scarcity of organic life which is the basis for petroleum formation. On the other hand, such rocks may yield rich deposits of ores associated with igneous intrusions and diastrophic forces. In contrast, the folded sediments of the Appalachians are rich in coal and petroleum, the limestones of Tennessee and Kentucky afford precarious construction sites because of underground drainage that leaches out caves ("Karstlands and caverns", p. 77).

The basic rocks of geologic regions are modified by weathering, which creates soils and often results in the concentration of residual minerals such as aluminum, gold, and some forms of iron ores. Erosion of the weathered materials by running water, glaciers, winds, gravity, and marine forces results in a wide variety of landforms (such as hills, valleys, mountain peaks, and glacial cirques) which differ even within classes according to their position in a cycle of erosion and which are counterbalanced by corresponding depositional features (such as alluvial fans, deltas, dunes, and coastal plains). People are always in the presence of geologic features, and those who understand the origin of the features will derive more satisfaction from their surroundings and learn to use them to better advantage, even in such simple ways as choosing a homesite free from floods, landslides, earthquakes, insecure foundations, and correspondingly high insurance rates.

MARINE FEATURES

The general outline of the seacoast of the United States as computed by the U.S. Coast and Geodetic Survey, Environmental Science Services Administration (ESSA), Department of Commerce, is 12,383 statute miles in length.

Conversion of coastal lengths to percentages reveals that the Pacific and Arctic coastlines of the United States constitute 70.1 percent of the country's general coastline, but due to narrow continental shelves and relatively few indentations except in southeastern Alaska, they account for only 48.3 percent of the more detailed shoreline. In sharp contrast, the Atlantic and gulf coasts constitute only 29.9 percent of the country's general coastline, but due to broad continental shelves and numerous islands, bars, and deep indentations, they make up 51.7 percent of the detailed shoreline.

The map of coastal landforms (p. 78–79) shows cliffed and flat coastal areas, dominant rock types, and shoreline characteristics such as sandy or rocky beaches, mudflats, swamps, coral, and larger scale insets of the more highly developed areas around Chesapeake Bay, New England, Puget Sound, and San Francisco Bay. Most of the Pacific coast, including Hawaii and Alaska south of the Alaska Peninsula, is characterized by high cliffs and narrow continental shelves. New England and parts of western Alaska have lower cliffs, bordered by narrow and generally rocky or pebbly beaches and broader continental shelves. The South Atlantic and gulf coasts, as well as much of northwestern Alaska, have predominantly flat coastal plains and broad offshore shelves with numerous islands, bars, lagoons, and estuaries. In general, the coastline configuration and shoreline characteristics reflect the tectonic forces and rock compositions of the coastal segments, but many of the detailed features are more intimately related to storms, waves, tides, and currents which in turn affect erosion and deposition processes.

Also of great importance to man is the variety of resources, land uses, and problems of the coastal zone. Human uses of that zone range from recreation to port development, from wildlife sanctuaries to sports and commercial fisheries, from sources of petroleum and natural gas to tidal power stations, and from dumping grounds for sewage and waste to increasingly important sources of desalinated water. It is in the coastal zone that natural hazards such as hurricanes, tsunamis, and floods near the mouths of swollen rivers often develop into catastrophes that take huge tolls in property damage and loss of life and create problems of area rehabilitation as well as raise questions of risk concerning the traditional land uses of deltas, flood plains, and coastal plains. A fact of outstanding significance, however, in evaluating the coastal zones of the United States is that coastal counties already contain more than half of the country's total population, and the National Council on Marine Resources and Engineering Development has predicted that the percentage may reach 75 percent by 1980.

SOILS

Aside from air, soil and water are the two most essential resources of the earth. They were the bases for primitive food and drink and have been subjected to constantly increasing demands as the world's population expanded. To enable a meaningful inventory of soils and to use them more effectively, many attempts have been made to analyze and classify soils.

Fundamentally, soils are related to the upper mantle rocks of the earth's crust from which they have evolved through the physical and chemical processes of weathering and the influence of living organisms. The various stages of soil development reflect different combinations of the effects of parent rock, living organisms, and climatic influences, but given enough time, climate becomes the dominant factor in determining the eventual characteristics of soil and can reduce to uniformity the mature soils of a given climatic region, regardless of their origin.

New soils, however, are largely dependent on the nature of the mantle or parent rock for their content and extend downward as far as organic life penetrates. As the soils mature, they develop vertical profiles in which the top, or A horizon, has the most organic life and, in humid climates, is characterized by leaching. The intermediate, or B horizon, is one of deposition from above, and in some soils is made dense and hard by the additions. The C horizon, or subsoil, is decomposed or disintegrated parent rock, modified only slightly by weathering processes and organic material. Within the horizons, soils may be described by their texture or size of particles (gravel, sand, silt, or clay), by their structure or arrangement of particles, pore spaces, and colloids (such as friable, granular, platy, lumpy, or blocky), and by their chemical qualities of acidity or alkalinity, depending upon the proportion of positive charged hydrogen ions in the gelatinous soil colloids on which vegetation growth is dependent.

Because the interaction of climatic elements (moisture, temperature, and wind) and organic life (particularly vegetation and bacteria) with parent rock minerals is fundamental to the evolution of soils, their classification constitutes a highly complex problem. Chinese records show that Engineer Yu classified soils by color and texture about 2,000 B.C., but the founder of a basis for the modern theories of soil origin and classification was a Russian geologist (V. V. Dokuchaiev) whose school of soil science evolved, between 1870 and 1900, a general philosophy that was modified and developed in the 1920's and 1930's by C. F. Marbut, Chief of the Soil Survey Division, U.S. Department of Agriculture, into a comprehensive scheme of soil classification that was adopted by the U.S. Department of Agriculture in 1938. A detailed account of that classification was published in the U.S. Department of Agriculture, *Soils and men,* Yearbook of Agriculture: 1938.

In that scheme, soils are divided into three orders, known as zonal (well drained), intrazonal (poorly drained), and azonal (too new or on slopes too steep to allow the development of clear profile characteristics). Soil orders are subdivided into suborders, then into great groups, families, series, types, and phases. The great groups of soils, such as podzol, prairie, chernozem, red, yellow, and tundra, are most closely related to climatic conditions. Families of soils are groups of related soil series which have similar horizon characteristics, and which are derived from the same type of parent material. A soil type is a subdivision of a series with a clearly identifiable texture of the A horizons. The phase of a soil type refers to such local characteristics as slope, stoniness, or degree of erosion.

In the 1950's emphasis was shifted toward the care and effective use of soils, and a series of land capability classes, described in the U.S. Department of Agriculture, *Soil,* The Yearbook of Agriculture: 1957, categorized soils suitable for regular cropping, those requiring special management practices, and other categories. During those years, American pedologists also became increasingly aware of the desirability of incorporating into the scheme of soil classification definitions of a more quantitative nature than those adopted by the U.S. Soil Survey in 1938. They presented to the Seventh International Congress of Soil Science in 1960 a group of papers on the concept that soil comprises a continuum on the land surface, subdivisions of which should be described in terms of properties that can be universally observed and measured. The scheme of soil classification adopted by the Congress had been carried through a succession of revisions and developments over a period of years. For purposes of identification, the stages were numbered, and the one adopted was called *Soil classification, a comprehensive system, seventh approximation: 1960.* The Seventh Approximation involves a formidable array of newly coined terms, but it became the basis for the National Cooperative Soil Survey Classification of 1967 which was adopted by the United States, and is used for the soils map in this Atlas (p. 86–87).

In this classification the nomenclature is systematic, and the general soil definitions are grouped in three categories: order, suborder, and great groups. Names of the orders, of which there are ten classes, end in "sol" and have three or four syllables. Suborders, of which there are 40 classes, are more directly related to specific land uses and have names consisting of two syllables, one of which is a prefix and the other a syllable from the order name. Great groups, with 120 classes, have one or more syllables prefixing a suborder name. The great groups are further subdivided into 400 subgroups, 1,500 families, and 7,000 series. Due to the broad international acceptance of the basic philosophy and nomenclature of this new classification, about which further information is provided on pages 85–88, the National Cooperative Soil Survey Classification of 1967 is well on its way toward worldwide use for soils analysis and mapping.

VEGETATION

Vegetation, like landforms, hydrographic features, and soils, is a significant element of the landscape, but it reflects to a large extent other factors of the physical environment, such as climatic conditions, soils, relief, and drainage. Natural vegetation develops without appreciable interference or modification by man, but it may be affected indirectly by manmade fires, pollutants in the atmosphere, domesticated animals, and even changes in surface energy budgets related to cities, reservoirs, and other extensive projects. Potential natural vegetation, as mapped on pages 90–92, is that which might be expected to return through a series of stages if man's interference with the natural regimen were suspended.

For many purposes the actual vegetation cover, such as forests (p. 154–155), rangelands (p. 158–160), and crops (p. 170–172), is more significant. For other purposes, a detailed analysis of vegetation formations, percentages of areas burned over, cut for timber, and converted to other uses, is needed. With traditional techniques of data gathering and processing, it has been virtually impossible to obtain current information of uniform quality for areas as large as the United States of America, or even of its major regions, but the use of remote sensor instrumented high altitude aircraft and satellites during the 1970's may enable the computerization and automated mapping of vegetation conditions and timely updating as changes take place.

Because of the latitudinal extent from Hawaii to Alaska and altitudinal ranges from Death Valley to Mt. McKinley, the United States has a tremendous variety of plants which form a natural resource base of great value. The forests, savannas, grasslands, and desert scrub constitute watershed covers, scenic and recreational settings, and renewable sources of food, clothing, shelter, furniture, fuel, and many other commodities. The conservation of the country's vegetative cover from destruction by fire, consumption, and environmental changes becomes increasingly essential as population and per capita consumption grow. For the economic welfare of the Nation, however, the introduction of new species and the upgrading of rangeland grasses, timber supplies, and crops must be sought, within the tolerance limits of environmental complexes.

CLIMATE

Climate is the characteristic condition of the atmosphere, deduced from a number of observations over a period of years. It is more than an average of statistics pertaining to air temperature, pressure, winds, moisture, and storms, because it includes departures from statistical means and implies a prediction of the probability that certain sets of observations will recur in a given area. The observable components of climate are due primarily to transformations of energy between the atmosphere and the land and sea.

For all practical calculations the sun may be considered the source of the earth's heat energy. In spite of thermal cycles (daily, seasonal, and over periods of years) it appears that the receipt of heat energy from the sun and loss of heat energy from the earth are essentially in balance for the planet as a whole. The solar radiation maps (p. 93) reveal the effects of latitude, altitude, and seasonal shifts of angle of the sun's rays on the amount of incoming radiation for various parts of the United States. Since the lower latitudes and higher altitudes receive more heat energy, due respectively to higher sun angles and thinner atmosphere, heat transfer to areas receiving less insolation takes place by means of winds in the atmosphere and currents in the water. The resultant effects on the distribution of temperature, precipitation, and winds is illustrated by a series of climatic maps on pages 94–116. A special aspect of climate, air pollution, is treated on pages 114–115.

A conspicuous omission from the climatic section of this Atlas is a map of climatic regions. Several widely accepted classifications were considered, including those developed by Köppen, Thornthwaite, and Trewartha. It became apparent, however, that such classifications have been applied on a worldwide basis and that enlargement of segments of small-scale world maps might improve their visibility in a classroom but did nothing to add the detail needed for large-scale analysis of climatic complexes in single countries. Furthermore, existing maps of climatic regions are in many ways inaccurate in detail and misleading because they are oversimplified; the systems portrayed tend to emphasize unduly either the influence of temperature or moisture, the effects of evapotranspiration, or the interpretation of climate through vegetation or soils regions. Several attempts were made to induce experts to produce detailed climatic region maps of the United States, but all of them felt that existing maps were faulty and that it would be premature to make new maps based on the short term statistics available from satellite data. Consequently, it was decided to postpone the inclusion of a climatic regions map until a subsequent edition of the *National atlas.* Those who wish, however, to become better acquainted with the principal climatic classification schemes and maps may find the following list of selected references useful.

General Climatology:

Haurwitz, B., and J.M. Austin, *Climatology,* New York, McGraw-Hill Book Co., 1944, 410 p.

Landsberg, H., *Physical climatology,* DuBois, Pa., Gray Print. Co., 1958, 446 p.

Terjung, W.H., "Physiological climates of the conterminous United States; a bioclimatic classification based on man", *Annals of the Assoc. of Am. Geographers,* v. 56, p. 141–179, 1966.

Trewartha, G.T., *An introduction to climate,* New York, McGraw-Hill Book Co., 1968, 408 p.

U.S. Department of Agriculture, *Climate and man,* Yearbook of Agriculture: 1941, Washington, U.S. Govt. Print. Office, 1941. (Many papers on climate topics; United States climate data.)

Visher, S.S., *Climatic atlas of the United States,* Cambridge, Mass., Harvard Univ. Press, 1954, 403 p.

Köppen System:

Köppen, W., and R. Geiger, *Handbuch der Klimatologie,* Berlin, Gebrüder Borntraeger, 5 v., 1930 and later. (See v. 1, pt. C, 1936, for general analysis of Köppen system of climatology.)

—— *Klima der Erde,* Darmstadt, Germany, Justus Perthe, 1954, map. American distributor, A.J. Nystrom and Co., Chicago.

Wilcock, A.A., "Köppen after fifty years", *Annals of the Assoc. of Am. Geographers,* v. 58, p. 12-28, 1968.

Thornthwaite System:

Thornthwaite, C.W., "The climates of North America, according to a new classification", *Geog. rev.,* v. 21, p. 633-655, 1931.

——"An approach toward a rational classification of climate", *Geog. rev.,* v. 38, p. 55-94, 1948.

Chang, Jen-Hu, "An evaluation of the 1948 Thornthwaite classification", *Annals of the Assoc. of Am. Geographers,* v. 49, p. 24-30, 1959.

WATER

The National Water-Resources Data Network, maintained by the U.S. Geological Survey in cooperation with other Federal agencies and the States, is the chief source of basic water data in this country. The stream-gaging network consists of more than 8,400 stream gaging stations, and the ground-water network, of nearly 30,000 observation wells. In addition, about 2,500 water quality stations are maintained to determine the chemical properties, sediment content, thermal conditions, and pollutants of surface waters.

Although the amount of water which falls upon the 50 States as rain and snow (p. 97–100) exceeds current requirements, the distribution of water does not match the concentration of people, and the amount available for use is diminished by both runoff (p. 118–120) and evaporation (p. 96). Much of the remaining water is rendered unfit for essential uses by sediments and chemicals (p. 124–125). Since water plays an important role in the weathering of rocks and formation of soils, the effects of chemical pollution may be reflected indirectly in soil characteristics and food production. On the other hand, temporary surpluses of water cause damaging floods, increase pollution, and in arid lands leach out alkaline and saline chemicals that are subsequently deposited in concentrated forms that ruin soils for most agricultural uses. It is because of the interrelationships of water with climate, soils, geologic processes, and land-surface forms that this resource is treated in the physical rather than the economic or socio-cultural sections of the Atlas. The uses and management problems of water obviously relate to many topics in the economic and socio-cultural sections of the atlas. For a more detailed treatment of the whole scope of water as a resource of primary significance, see page 117.

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