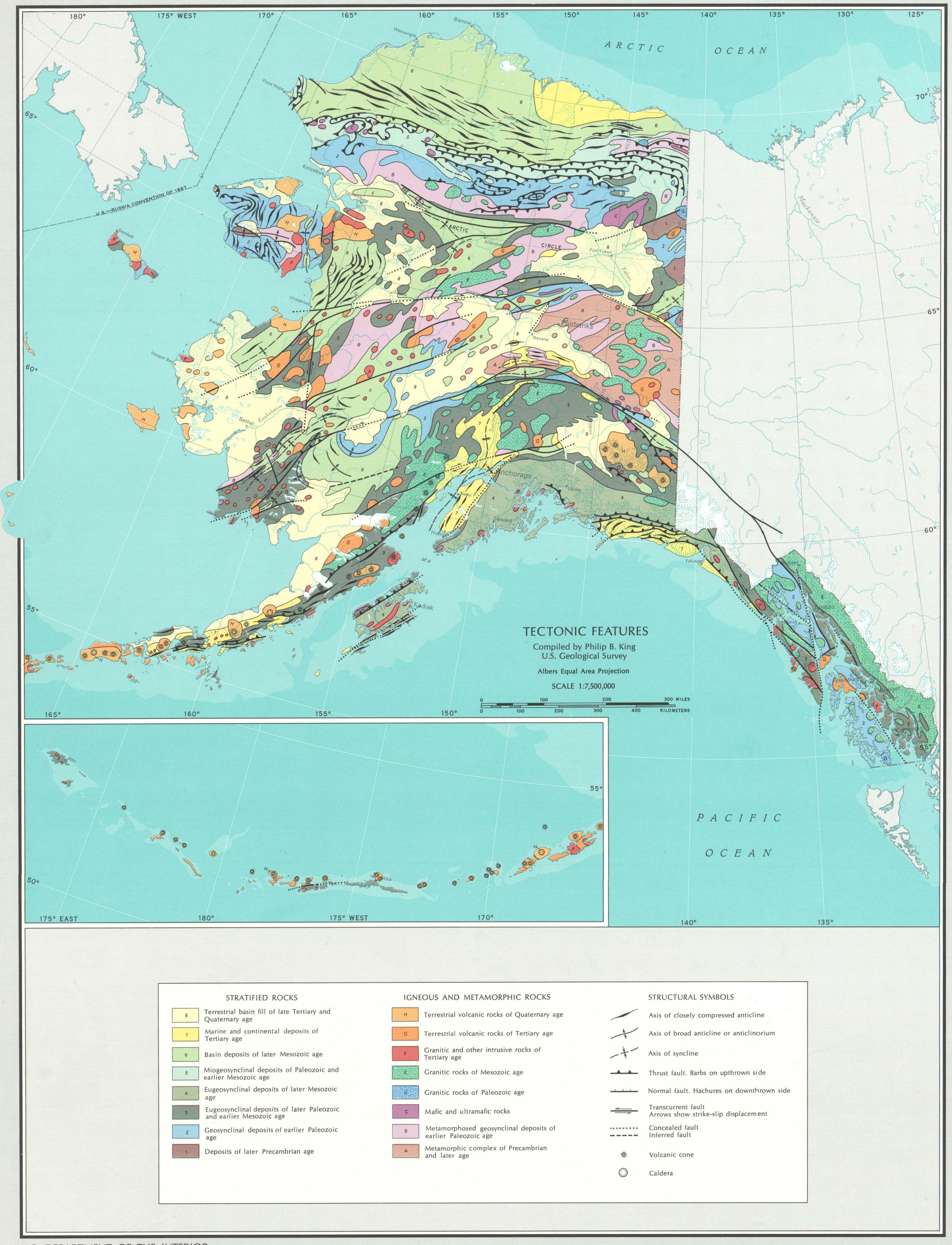

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TECTONIC FEATURES

TECTONIC MAPS OF THE UNITED STATES

The maps on pages 70–71 and 72 summarize tectonic data compiled from many sources by the staff of the U.S. Geological Survey during preparation of a "Tectonic Map of the United States, exclusive of Alaska and Hawaii," scale 1:2,500,000 (Cohee, 1962); a "Tectonic Map of North America," scale 1:5,000,000 (King, in press); and an unpublished compilation of the tectonics of Alaska, made under the direction of George Gryc in 1958. In addition, tectonic data for Hawaii have been supplied by James G. Moore, based on original observations. For the two maps in the National Atlas, these tectonic data were generalized by Philip B. King, and the results were made into tectonic maps by Gertrude Edmonston.

TECTONIC MAPS DEFINED

To comprehend the tectonic maps, the user should compare them with the geologic map of the United States which appears on pages 74–75. The user will observe both resemblances and differences. By means of contrasting colors, both represent various classes of rocks which form the surface, and on both maps the fundamental classification of the rocks is according to their geologic ages. On the geologic map, however, the subdivision according to age is more detailed than that on the tectonic maps and only incidental attention is given to the nature of the rocks themselves. On the tectonic maps the rocks are subdivided according to their place in the evolution of the region of which they form a part. On the tectonic maps, moreover, structural symbols are used to represent the manner in which the rocks have been warped into domes and basins, folded into anticlines and synclines, and broken by faults. The combination of different colors and various structural symbols which appear on the maps thus portray the tectonics, or architecture of the rocks of the upper part of the earth's crust.

On the tectonic map of the 48 conterminous States, the arrangement of colors and symbols brings out two contrasting kinds of regions which are explained in more detail below—the platform areas and the foldbelts. The tectonic map of Alaska, covers only an area within a single foldbelt.

PLATFORM AREAS

Platform areas are generally constituted of plains and plateaus. They are underlain by flat lying, or gently dipping strata, largely of sedimentary origin, which are mostly a few hundred or a few thousand feet thick, but which in places attain thicknesses of 10,000 to 25,000 feet, or 3,000 to 8,000 meters. The sedimentary strata of the platform areas lie on a basement of much more deformed rocks which were at one time parts of foldbelts like those described below. After the foldbelts were created, their surfaces were eroded to lowlands which were subsequently buried by the strata of the platforms; since then, only very slight deformation has affected either these ancient foldbelts or their platform covers.

The map of the 48 conterminous States shows two platform areas: (A) the Interior Plains and Plateaus consisting of deposits of Paleozoic, Mesozoic, and Cenozoic ages that overlie the eroded surface of foldbelts of various Precambrian ages; (B) the Atlantic and Gulf Coastal Plains, consisting of deposits of Mesozoic and Cenozoic ages that overlie the eroded surface of foldbelts of Paleozoic age.

On the map, the two platform areas, A and B, are shown in subdued tints of flesh and gray, respectively. The configuration of the surfaces of the basement rocks beneath the platform deposits is shown by contour lines—red for Precambrian basement, purple for Paleozoic basement—drawn on an interval of 1,000 meters (3,280 feet). These contours express all the deformation to which the rocks of the platform areas have been subjected after the time when their ancient foldbelts were covered by deposits.

FOLDBELTS

Foldbelts commonly form a mountainous terrain. They are formed by orogenies which are, in effect, storms within the crust of the earth; but whereas atmospheric storms come and go within a few hours or days, the crustal storms endure for many millions of years because of the much greater rigidity of the materials involved. To be more exact, each foldbelt was created during stormy periods of geologic time—a succession of orogenic storms following on and reinforcing each other, the whole constituting an orogenic cycle. Like atmospheric storms, the orogenic tempests had small beginnings, built up to a climax, and then slowly wasted away. Like atmospheric storms, also, the orogenic storms occurred from time to time and from place to place in the earth. One foldbelt might be in the grip of an orogenic tempest, while others were becalmed. Thus, each of the orogenic cycles during which the foldbelts were created has its own age and duration.

The causes of these orogenic storms are poorly understood. Nevertheless their manifestations are plain—the folding and faulting of the near-surface strata; the flowage, recrystallization, and metamorphism of the parts beneath, and the emplacement of bodies of granite and other plutonic rocks into the deepest layers.

On the two tectonic maps, the various foldbelts are distinguished by brighter colors than those used for the platform areas, by the juxtaposition of areas of contrasting color, and by the close crowding of structural symbols.

FOLDBELTS OF PRECAMBRIAN AGE

The oldest foldbelts known on earth are of Precambrian age. In the 48 conterminous States these emerge at the surface only in small areas, the areas in the north being extensions of much larger areas in Canada; elsewhere, they compose the cores of uplifts in the younger foldbelts.

The small surface extent of the Precambrian foldbelts makes it impossible to indicate them in detail. The only subdivision of Precambrian rocks that is made is into differently colored units that represent three general ages of folding.

Ages of folding in the Precambrian rocks have been determined by isotopic dates which range from more than 3,000 million years to 600 million years ago, or to the time of the beginning of the Cambrian. The tectonic map of the 48 conterminous States shows that the ages of the Precambrian metamorphic and plutonic rocks tend to cluster about distinct spans of time; therefore, these rocks are divided into earlier Precambrian (rocks yielding dominant isotopic dates of about 2,500 million years; C1), middle Precambrian (rocks yielding dominant isotopic dates of about 1,700 million years; C2), and later Precambrian (rocks yielding dominant isotopic dates of about 1,000 million years; C3). These clusters of dates, believed to represent climaxes of orogeny, have been termed the Kenoran, Hudsonian, and Grenville orogenies in Canada (Stockwell, 1965). During these times, the rocks of each successive foldbelt were deformed and metamorphosed and were invaded by plutonic rocks.

Besides the Precambrian metamorphic and plutonic rocks, there are sedimentary and volcanic strata of middle and later Precambrian age (C4) which were little deformed during Precambrian time. These strata were laid down on the eroded surfaces of foldbelts formed earlier and were outside regions affected by orogeny later in Precambrian time.

FOLDBELTS OF PALEOZOIC AND LATER AGES

The tectonic maps show that the surface extent of foldbelts of Paleozoic and later ages is much greater than that of the foldbelts of Precambrian age. The Appalachian foldbelt extends across most of the Eastern States, from Maine to Alabama, and the related Ouachita foldbelt emerges in smaller areas farther west. The Cordilleran foldbelt covers all the western conterminous States and almost all of Alaska. Because of the wide surface extent of these younger foldbelts, it is possible, by means of different colors, to show separately the various kinds of rocks that compose them.

During the initial phases of an orogenic cycle, the areas that later evolved into foldbelts were geosynclines, or broad troughs in which great thicknesses of strata accumulated, mostly in a marine environment. Parts of the geosynclines were differently affected by crustal forces, and contrasting rocks and structures were produced; the rocks of these different parts are shown separately.

The miogeosynclines, or parts nearer the continental interior, were only mildly affected by crustal activity until late in their history and received mainly carbonate and quartzose sediments (limestone, dolomite, shale, sandstone, and quartzite; D3, F8, 5). The eugeosynclines, or parts farther from the continental interior and nearer the ocean basins, were much more affected by crustal activity throughout their history and were the first to feel the effects of orogeny. The eugeosynclines received large volumes of volcanics and volcanic-derived sediments, as well as poorly sorted clastic sediments (argillites and graywackes); carbonate rocks are minor, but beds of siliceous sediment (chert) are common (D2, F6, 3).

Before and during the climaxes of orogenies, the rocks of the eugeosynclinal areas were deeply depressed in the earth where they were subjected to heat and pressure, so that they are commonly much metamorphosed. Also during these same times, plutonic rocks were emplaced in these areas—partly by injection from below and partly by transformation of the eugeosynclinal rocks themselves. The most extensive of the plutonic rocks are silicic or granitic (D1, F2, E). Plutonic rocks of mafic or ultramafic composition are of smaller extent. In the Appalachian foldbelt such rocks form bodies too small to represent on the present map, but in the Cordilleran foldbelt they are differentiated in both the western conterminous States and in Alaska (F1, C). In the Cordilleran foldbelt in both the Western States and Alaska, smaller bodies of plutonic rocks continued to be emplaced in Cenozoic time, after the climax of the orogenies (F3, F).

The present gross features of the Cordilleran foldbelt are mainly the product of orogenic and postorogenic events during Mesozoic and Cenozoic time, but this region did not lie undisturbed throughout earlier geologic time; there are indications of earlier orogenies, both in early Mesozoic time and during various parts of Paleozoic time. The extent and nature of these earlier orogenies are as yet incompletely known, because their effects have been obscured by the later orogenies.

The rocks affected by these earlier orogenies cannot be indicated on the present map in the Western States, but some differentiation can be made in Alaska. Here, older Paleozoic geosynclinal deposits (2) are in many places much more deformed than the younger strata, and they have, in part, been much metamorphosed (B); there are also some bodies of granitic rocks of Paleozoic age (D), which are probably related to these early orogenies. Central Alaska includes extensive areas of a metamorphic complex (A), whose rocks may have originated during some part of the Precambrian; but in the complexes, metamorphic and plutonic processes are known to have continued much later, in places even into Mesozoic time.

After the climax of the orogenic cycles, various postorogenic deposits were laid down which form small mappable units in the Appalachian foldbelt and extensive mappable units in the Cordilleran foldbelt of both the conterminous States and Alaska.

The climax of the orogenic cycle in the northern part of the Appalachian foldbelt was during mid-Paleozoic time. Here, younger Paleozoic deposits (D4) are preserved in small areas; they lie on eroded surfaces of much more deformed and metamorphosed earlier Paleozoic rocks, but they are themselves deformed by orogenies late in Paleozoic time. Throughout the length of the Appalachian foldbelt there are also remnants of land-laid Triassic deposits (D5); these have been merely tilted and broken into fault blocks. Aside from these, the only post-orogenic products in the Appalachian foldbelt are the late Mesozoic and younger platform deposits which cover the southeastern extension of the foldbelt beneath the Atlantic and Gulf Coastal Plains.

By contrast, the later orogenic history of the Cordilleran foldbelt was much more eventful; crustal instability continued long after the main orogenies, and areas near the Pacific coast are still unstable. The Cordilleran foldbelt thus contains tectonically significant post-orogenic units that formed between later Mesozoic time and the present.

In the eugeosynclinal part of the Cordilleran foldbelt in both the Western States and Alaska, climax of the orogenic cycle occurred during the mid-Mesozoic, at which time the rocks that had formed in the eugeosynclinal area were deformed, partly metamorphosed, and invaded by plutonic rocks. In this region, in later Mesozoic time, basins were formed, which received large volumes of sedimentary and volcanic deposits. These basins and their deposits occupy extensive areas in central and southern Alaska (6). In the interior of the Western States, such basins are less extensive and are shown in only a few places on the map; but toward the Pacific coast, especially in California, comparable deposits were laid down nearly continuously along the western margin of the earlier foldbelt (F9).

In addition, in both the Western States and Alaska, along the edge of the Pacific Ocean basin, a younger eugeosyncline developed which received large volumes of later Mesozoic deposits (F7, 4).

During Cenozoic time, marine and land-laid deposits accumulated in smaller basins in the Cordilleran foldbelt and were variously deformed by the later orogenies of the cycle. These are differentiated near the Pacific coast (F10). Such deposits are shown throughout Alaska (7), where they underlie small areas in the interior and more extensive areas along the Pacific coast.

Separately shown in the Cordilleran foldbelt on both maps are the thick youngest deposits, largely land-laid and of late Tertiary and Quaternary age (F11, 8). The thick youngest deposits are the products of the last movements of the orogenic cycle in the Cordilleran foldbelt—such as broad downwarps (as in Alaska), and the subsidence of fault troughs (as in the Basin and Range province of the Western States).

Igneous as well as sedimentary processes continued in the Cordilleran foldbelt after the climax of the orogenic cycle. Lavas and volcanic products were spread throughout Cenozoic time over extensive areas. The volcanics effectively conceal the earlier rocks over large parts of the Northwestern States and occur in smaller areas elsewhere. On the maps, they are divided into the earlier volcanics of Tertiary age (F4, G), and the younger volcanics, mainly of Quaternary age (F5, H). The younger volcanics occupy more restricted areas than the older and their distribution reflects the volcanic-tectonic patterns of latest geologic time. Especially significant, both in Alaska and the Northwestern States, are the belts of latest volcanics that lie near and parallel to the Pacific coast. These belts, marked by lines of volcanoes whose cones are represented on the maps, are small segments of the "circle of fire" that rings much of the Pacific Ocean basin.

TECTONICS OF HAWAII

The tectonic features of the State of Hawaii are shown on an inset on page 70. The islands which constitute this State lie in the central part of the Pacific Ocean; they are all volcanic. Landforms, the history of the volcanic activity, and isotopic dating all indicate that the islands have grown progressively southeastward with time, those to the northwest being the oldest, the "Big Island" of Hawaii to the southeast being the youngest. The process of volcanic island building began to the northwest in late Tertiary time, and continued through Quaternary time to the southeast. Based on isotopic dating, the volcanic rocks on Oahu and the islands northwest of it are mapped as Tertiary (F4), and those southeast of Oahu as Quaternary (F5).

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