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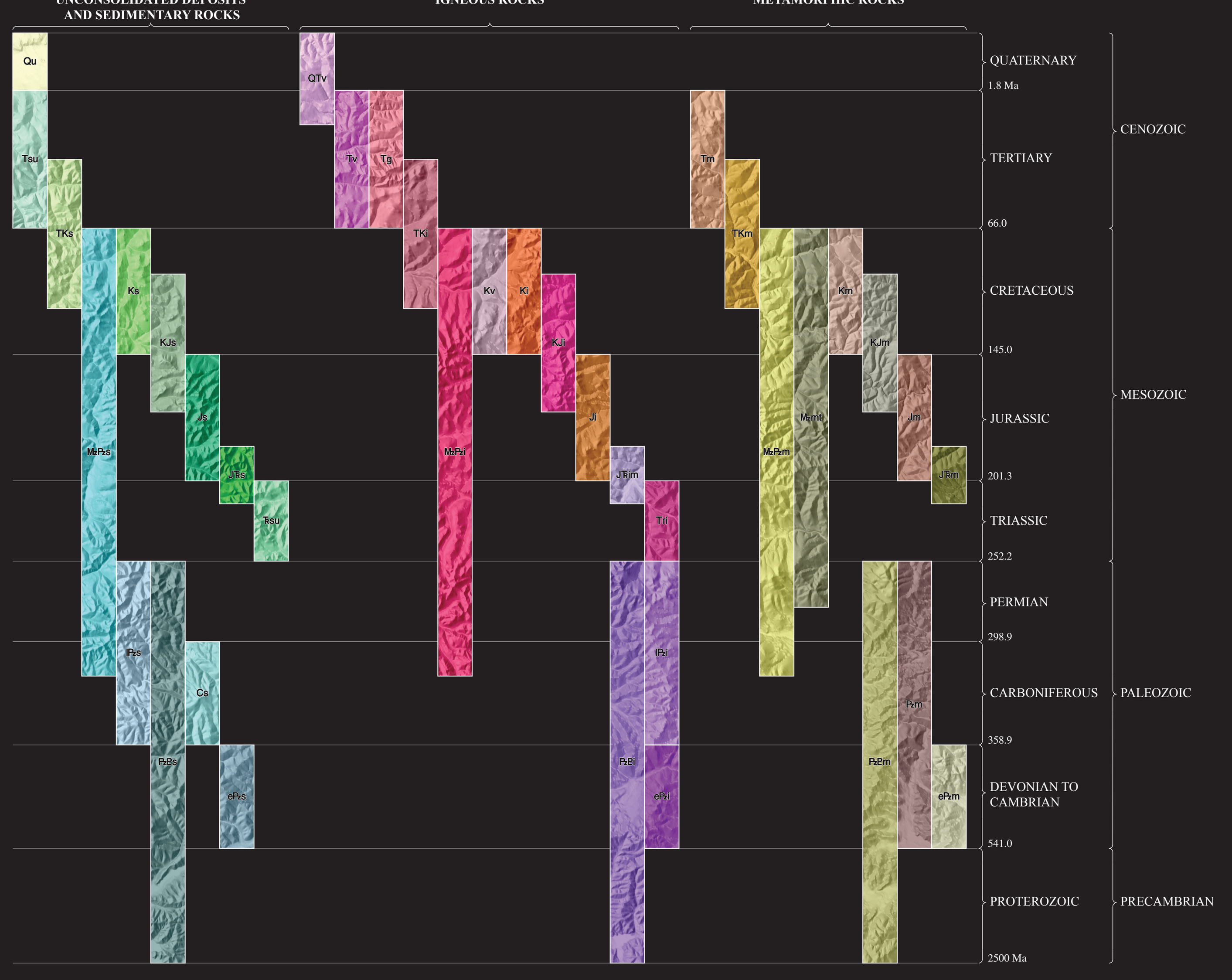


LIST OF MAP UNITS

Bedrock of unknown type or age (Quaternary to Paleozoic)

UNCONSOLIDATED DEPOSITS AND SEDIMENTARY ROCKS

- Surficial deposits (Quaternary)
- Sedimentary rocks (Tertiary)
- Sedimentary rocks (Tertiary or Cretaceous)
- Sedimentary rocks (Mesozoic and Paleozoic)
- Sedimentary rocks (Cretaceous)
- Sedimentary rocks (Cretaceous or Jurassic)
- Sedimentary rocks (Jurassic)
- Sedimentary rocks (Jurassic or Triassic)
- Sedimentary rocks (Triassic)
- Sedimentary rocks (Late Paleozoic)
- Sedimentary rocks (Paleozoic and Proterozoic)
- Carbonate rocks (Carboniferous)
- Sedimentary rocks (Early Paleozoic)

IGNEOUS ROCKS

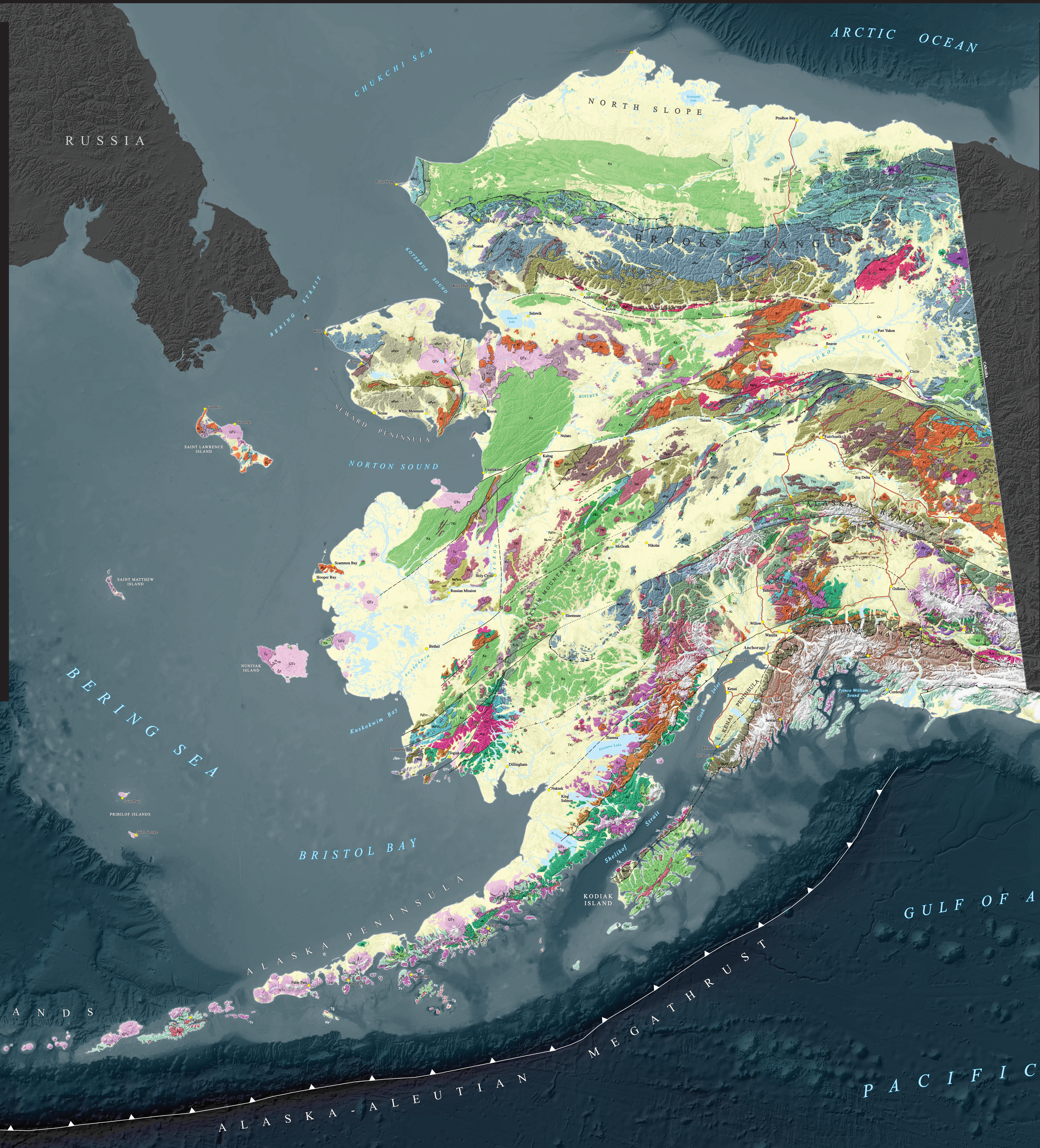
- Volcanic rocks (Quaternary and Tertiary)
- Volcanic rocks (Tertiary)
- Intrusive rocks (Tertiary)
- Igneous rocks (Tertiary or Cretaceous)
- Igneous rocks (Mesozoic or late Paleozoic)
- Volcanic rocks (Cretaceous)
- Intrusive rocks (Cretaceous)
- Igneous rocks (Cretaceous or Jurassic)
- Igneous rocks (Jurassic)
- Igneous rocks and ophiolite (Jurassic or Triassic)
- Igneous rocks (Triassic)
- Igneous rocks (Paleozoic and Proterozoic)
- Igneous rocks (Late Paleozoic)
- Igneous rocks (Early Paleozoic)

METAMORPHIC ROCKS

- Metamorphic rocks (Tertiary)
- Metamorphic rocks (Tertiary or Cretaceous)
- Metamorphic rocks (Mesozoic and late Paleozoic)
- Melange and tectonites (Mesozoic)
- Metamorphic rocks (Cretaceous)
- Metamorphic rocks (Cretaceous or Jurassic)
- Metamorphic rocks (Jurassic)
- Metamorphic rocks (Jurassic or Triassic)
- Metamorphic rocks (Paleozoic and Proterozoic)
- Metamorphic rocks (Paleozoic)
- Metamorphic rocks (Early Paleozoic)

EXPLANATION OF MAP SYMBOLS

- **Contact**—Solid where location is approximate; shown only between bedrock units
- **Fault**—Solid where location is certain; long-dashed where location is approximate; short-dashed where location is inferred; dotted where location is concealed
- **Thrust fault**—Solid where location is certain; long-dashed where location is approximate; dotted where location is concealed; sawteeth on upper plate
- **High-angle thrust fault**—Solid where location is certain; long-dashed where location is approximate; short-dashed where location is inferred; dotted where location is concealed; sawteeth on upper plate
- Road
- International border
- City or town



INTRODUCTION

This map shows the generalized geology of Alaska, which helps us to understand where potential mineral deposits and energy resources might be found, define ecosystems, and ultimately, teach us about the earth history of the State. Rock units are grouped in very broad categories on the basis of age and general rock type. A much more detailed and fully referenced presentation of the geology of Alaska is available in the Geologic Map of Alaska[1] (http://dx.doi.org/10.3133/sim3340).

This product represents the simplification of thousands of individual rock units into just 39 broad groups. Even with this generalization, the sheer complexity of Alaskan geology remains evident. The following is a brief overview that highlights some important geologic aspects of Alaska with a few, well-known examples noted. See the cited references for more specific information about these examples.

ALASKAN GEOLOGY: AN OVERVIEW

Geologically, Alaska is highly complex; however, the advent of the terrane concept in the 1970s revolutionized the study of geology in the State. By definition, terranes are discrete, fault-bounded blocks of rock having distinct geologic histories. Fundamentally, Alaska is a collage of terranes[2] pieced together about 65 to 100 million years ago, but the process of their formation and assembly continues today. As these terranes were tectonically assembled, their rocks were deformed and metamorphosed. Initially, many of these terranes were considered exotic, meaning that they were formed elsewhere, were unrelated to each other, and were transported by the movement of the tectonic plates. However, more recent studies have shown there to be geologic links and partly shared geologic histories amongst many of the terranes. Solving the puzzle of how and when the Alaska terranes were assembled is the topic of much active research.

Alaska has a long geologic history involving rocks of many different ages and character. The state includes sedimentary and igneous rocks that are billions of years old, as well as volcanic rocks that have erupted in our lifetimes. The oldest are metamorphic rocks that are at least 2 billion years old and could be as much as 2.5 billion years old. The best documented of these rocks is called the Kanektok metamorphic complex, or Kilbuck terrane[3,4], in southwestern Alaska. The chemistry of this terrane suggests that it was originally an igneous belt along the margin of a continent[5]. The existence of other very old rocks in east-central Alaska, the southern Brooks Range, and on the Seward Peninsula is suggested by the inclusion of minerals (zircons) in the rocks that are as much as 2.3 billion years old[6]; however, the original source for the zircons is unknown.

Rocks about 250 to 550 million years old are widely distributed in Alaska. The oldest of these had origins in places quite distant from their position today; they include carbonate (for example, limestone) and clastic sedimentary (for example, sandstone) rocks and minor igneous rocks that are now in northern and western Alaska, and metamorphic rocks in southeastern Alaska. About 345 to 380 million years ago, magmatic arcs produced a number of large granitic intrusions, all of which have since been metamorphosed to gneiss that is now exposed in central, western, and northern Alaska. At the same time, some of these igneous rocks erupted at the surface, yielding volcanic rocks found in the Brooks Range and western and central Alaska[7]. The old rocks of northern Alaska were later compressed, deformed, and eroded, resulting in thick deposits of nonmarine (terrestrial) sedimentary rocks. Subsequently, relative sea level rose and the terrestrial rocks were overlain by marine deposits—widespread, deep marine chert, limestone, and shale that today is found in the Brooks Range, the Yukon, and even the Russian Far East. These rocks include the black shale that hosts the large zinc and lead deposits of northern Alaska, including the prominent Red Dog deposit, which is the target of one of the world's largest zinc mines. In some places, the deep marine rocks were overlain by younger, shallow-water limestones, and even younger terrestrial sandstone and shale about 245 million years ago. These younger rock units include the main source and reservoir rocks for the Prudhoe Bay oil field.

At about the same time that the reservoir rocks of Prudhoe Bay were being deposited in what became northern Alaska, a quite different environment existed on an oceanic platform located near the equator. There, thick basalt flows were erupted, limestone was deposited in fringing reefs, and evaporitic rocks developed on tidal flats above mean high tide. This oceanic platform is thought to have supported a sabkha environment (an arid coastal environment) similar to today's Persian Gulf and clearly exotic to Alaska[8]. Today, these sedimentary rocks and basalt are found in southern and southeastern Alaska, and the basalt was the source of the large Kennecott copper deposit, which was mined from 1911 until 1938.

In western and northern Alaska, south of the Brooks Range, there is evidence an oceanic basin existed about 200 to 350 million years ago surrounding the Yukon-Koyukuk and the Yukon Flats basins.

About 200 to 250 million years ago, as a result of the movement of tectonic plates, the terranes that form modern Alaska began to assemble; concurrently, widespread igneous activity and metamorphism took place, and the Yukon-Koyukuk and the Yukon Flats ocean basins closed. In a number of areas of southern and southeastern Alaska, large granitic bodies 145 to 200 million years old formed the roots of igneous island arcs that were joined to Alaska; the best known of these arcs extends from the Talkeetna Mountains to the Alaska Peninsula[9]. In east-central Alaska, granitic bodies of a variety of ages between 90 and 200 million years old were emplaced, some of which explosively vented to the surface and created large volcanic craters. During this time, the last major phase of metamorphism occurred in many parts of Alaska, ending around 110 million years ago. Following this metamorphism, 90- to 100-million-year-old granite bodies were emplaced in central and southeastern Alaska and on the Seward Peninsula; some of these bodies have associated gold deposits.

Approximately 60 to 120 million years ago, thick deposits of fine- to medium-grained sedimentary rocks were deposited in ocean basins that closed as the many terranes that compose Alaska joined. Today some of these sedimentary rocks are found in west-central and southwestern Alaska. At the same time, on the North Slope of Alaska, terrestrial and shallow-marine rocks, including large areas of coal in the west, were deposited. In many of these sedimentary rocks, layers of volcanic ash are present, indicating active volcanism; however, no igneous bodies of this age are known from the North Slope, leaving the source of the ash unknown. During the latter part of this interval, an extensive sedimentary deposit filled an oceanic trench that surrounded the Gulf of Alaska; the rocks range to as young as 50 million years old.

Beginning about 70 million years ago, and spanning a period of 20 to 25 million years, hundreds of small granite bodies were emplaced in southern and central Alaska, as well as in a linear belt spanning the length of southeastern Alaska. Along the coast of the Alaska Peninsula and south-central Alaska, a series of granitic intrusions were emplaced in the trench-fill deposits mentioned above; the mechanism for how these igneous rocks were intruded so soon after deposition of these sediments is controversial.

Roughly 45 to 50 million years ago, the ancestral Aleutian volcanic arc began to form. The arc remains active today, as evidenced by the volcanoes of Alaska, as the Pacific Plate dives under mainland Alaska and the Aleutian Islands—a small part of the circum-Pacific "Ring of Fire." Elsewhere, small basins formed around the state where terrestrial sedimentary rocks and coal were developed, such as near Healy.

The most recent terrane addition to Alaska is occurring near Yakutat, where a large block carried along with the Pacific Plate began to collide with mainland Alaska starting about 26 million years ago; the collision has resulted in localized deformation that can be measured in modern GPS studies[10]. The assembly of Alaska continues, and the resulting compression has forced the uplift of the Alaska Range in the past 5 million years.

Just a few million years ago, glaciers began to develop, particularly in southern Alaska, leading to extensive glaciation during the past 2.5 million years in southern and northern Alaska, but leaving central Alaska mostly ice-free. During this time, the Bering land bridge to the Russian Far East was intermittently exposed, fostering the migration of the first humans from Eurasia to North America; this is generally accepted to have occurred about 15,000 years ago.

Many major and minor faults crisscross Alaska; some are ancient and have had no movement in the last hundreds of thousands or millions of years. Others have long histories and are still active, a few of which have more than 400 km (250 miles) of offset. Some faults form the boundaries of terranes, others cut through ancient terranes. The active faults of Alaska[11] are responsible for frequent and sometimes large earthquakes.

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[1] Wilson, F.H., Hults, C.P., Mull, C.G, and Karl, S.M, comps., 2015, Geologic map of Alaska: U.S. Geological Survey Scientific Investigations Map 3340, pamphlet 196 p., 2 sheets, scale 1:1,584,000, http://dx.doi.org/10.3133/sim3340.

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[3] Hoare, J.M., and Coonrad, W.L., 1979, The Kanektok metamorphic complex, a rootless belt of Precambrian rocks in southwestern Alaska, *in* Johnson, K.M. and Williams, J.R., eds., The United States Geological Survey in Alaska—Accomplishments during 1978: U.S. Geological Survey Circular 804–B, p.72–74.

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[7] Plafker and Berg, 1994

[8] Jones, D.L., Silberling, N.J., and Hillhouse, John, 1977, Wrangellia—A displaced terrane in northwestern North America: Canadian Journal of Earth Sciences, v. 14, no. 11, p. 2565-2577.

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SCALE 1:2 500 000

50 0 50 100 150 200 250 MILES

50 0 50 100 150 200 250 300 350 KILOMETERS

Alaska Albers Equal Area Projection; North American Datum 1983 (NAD-83)

Alaska shaded relief generated from U.S. Geological Survey National Elevation Dataset (NED) 60-meter Digital Elevation Model (DEM).

Additional topographic and bathymetric shaded relief from Shuttle Radar Topography Mission (SRTM) 15-plus DEM.

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Alaska Geology Revealed

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U.S. Geological Survey

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