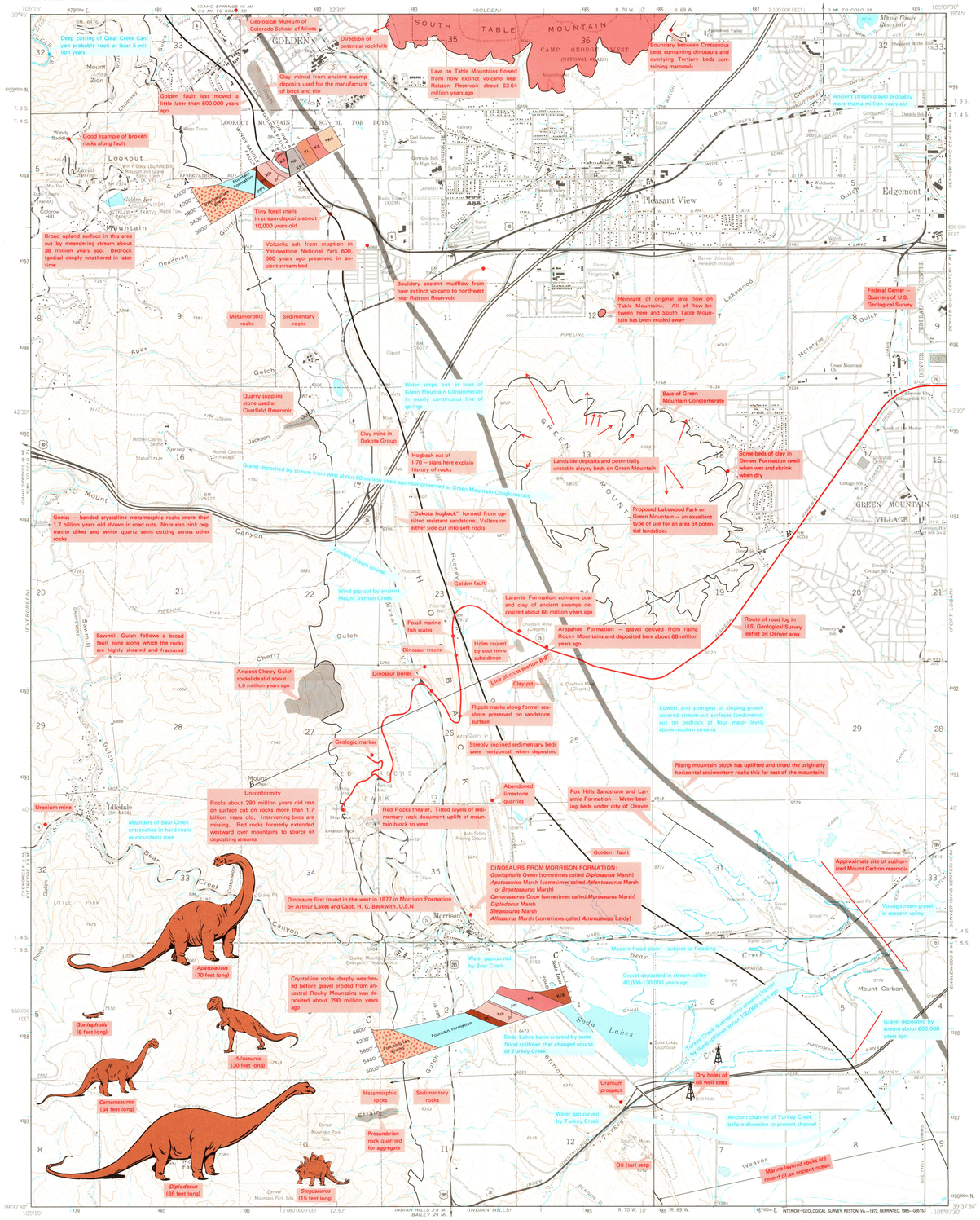
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

FOLIO OF THE
MORRISON QUADRANGLE, COLORADO
MAP I-790-E



MAP SHOWING SOME POINTS OF GEOLOGIC INTEREST IN THE MORRISON QUADRANGLE, JEFFERSON COUNTY, COLORADO

By
Glenn R. Scott

1972

HOW THE ROCKS WERE FORMED[1]

Although the earth is estimated to be about 4.5 billion years old, the "recorded" history of the Denver area began less than 2 billion years ago when intense heat and pressure, generated by the forces of mountain building, contorted and recrystallized the rocks of the earth's crust. Great masses of molten granite intruded the upper part of the crust and contributed to the deformation.

While uplift was in progress and afterward, the mountains were being eroded. Ultimately they were reduced to a flat featureless plain, which was submerged at the beginning of the Paleozoic Era, some 570 million years ago, when a broad seaway engulfed the Denver area. Sediments that became limestone, sandstone, and shale accumulated on the floor of this sea, only to be uplifted and eroded. After most of these marine Paleozoic rocks had been removed during this second wearing-down process (perhaps about 290 million years ago) sand and gravel, eroded mainly from the Precambrian core rocks of the planed-off ancient mountains, were deposited by streams. These sediments, now hardened, are called the Fountain Formation.

Two major advances and withdrawals of the sea marked the next 215 million years. As the sea readvanced across the region, during the Permian Period, onshore dunes and stream sands were deposited. These now make up the Lyons Sandstone. As the waters deepened, muds and limy sediments accumulated on the sea floor, and these became the shale and limestone of the lower part of the Lykins Formation.

In the later part of the Paleozoic Era the sea withdrew to the east, leaving a lake-dotted coastal plain drained by sluggish streams. In Triassic time the area probably was a dry land on which silt and sand of the upper part of the Lykins Formation were deposited by wind and intermittent streams. No deposits of Early Jurassic age are preserved, but in Late Jurassic time the area became a swampy lowland where sediments were deposited that became the Ralston Creek and Morrison Formations. Dinosaurs fluorished in Morrison time, and their fossilized bones are found in the Morrison Formation throughout the Rocky Mountain region.

During the Cretaceous Period, beginning about 136 million years ago, the sea again moved westward across the area, and the ripplemarked sands of the Dakota Sandstone accumulated near the advancing shore. Dinosaurs which trod these intertidal beaches were driven westward by the advancing waters. With the shoreline far to the west, water covered the Denver area, and thousands of feet of muds and limy muds accumulated on the ocean floor. These are the Graneros Shale, Greenhorn Limestone, Carlile Shale, Niobrara Formation, and Pierre Shale. They contain abundant remains of marine life such as the shells of mollusks and the skeletons and teeth of great fish and marine reptiles.

Late in the Cretaceous Period the entire region began to rise slowly, forcing the sea to withdraw for the last time. As the shoreline retreated eastward across the area, beach sands of the Fox Hills Sandstone were deposited. Streams then deposited muds and sands on the newly emerged coastal plain, which supported a lush growth of vegetation that was buried and became coal. These are the rocks of the Laramie Formation. As the mountains rose nearby, vigorous streams stripped away the soft sedimentary rocks and, for the first time since the Fountain Formation was deposited, cut into the hard Precambrian rocks. The eroded material was carried eastward beyond the mountain front, where some of it is preserved in the younger formations of the plains, such as the Arapahoe Formation.

During Late Cretaceous time, about 66 million years ago, the sedimentary layers adjacent to the mountains were bent sharply upward. Molten lava found its way to the surface in early Tertiary time about 64 million years ago through great fractures along the flanks of the mountains. Volcanoes, probably somewhere to the west, contributed to the stream-laid volcanic debris as well as to layers of mud of the Denver Formation. Fossilized leaves and twigs of trees that grew in the fertile volcanic soil are preserved in the rocks of the Denver Formation. A new volcano was created and its core is seen at Ralston dike 4 miles north of Golden. Lavas that poured across what was then the land surface now form the caprock on the Table Mountains.

The shape of the Front Range as we see it today is the result of processes of erosion acting over 60 million years; the greatest erosion, however, took place during the last 5 million years. In most places the mountains are dissected into peaks, ridges, and canyons. Remnants of a gently rolling upland surface, however, are preserved locally in the Front Range as on Lookout Mountain. This upland surface is a remnant of a former widespread erosional plain. Erosion in late Tertiary time cut the deep canyons of Bear and Clear Creeks.

During the Pleistocene Epoch – popularly called the Great Ice Age – which continued throughout most of the past million years or more, great masses of snow and ice accumulated along the crestline of the mountains and moved down the valleys as glaciers. Water issuing from the fronts of these glaciers became streams like Clear Creek and Bear Creek, which carried glacial sand and gravel eastward onto the plains where it was deposited. During times of glacial retreat, the small plains streams cut broad surfaces called "pediments" at several levels, and subsequently covered them with gravel. During times of glacial advance in later Pleistocene time, valleys were incised in these surfaces that were partly filled with stream-borne glacial sand and gravel.

After final retreat of the valley glaciers, some 6,500 years ago, the streams continued their work of downcutting in the mountains and foothills, and transporting and depositing sand and gravel throughout the plains. Thus, over the past billion and a half years, the combined forces of mountain building, volcanism, and erosion and deposition by streams and oceans, winds, frost, and glaciers have sculptured our present-day landscape.

[1] Adapted from Mountains and Plains – Denver's Geologic Setting, a U.S. Geological Survey leaflet.

SELECTED REFERENCES

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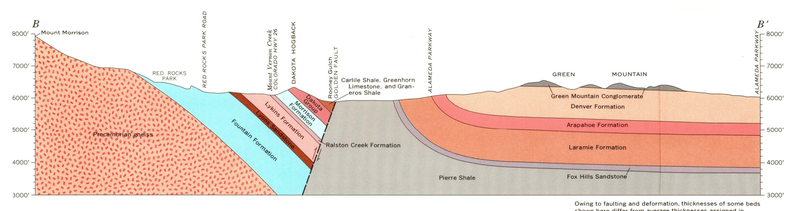
GEOLOGIC AGE		AGE IN MILLIONS OF YEARS	NAME OF FORMATION
CENOZOIC ERA	Quaternary: Holocene	(10,000 yrs.)	Alluvium of the valley floors Terrace deposits
	Quaternary: Pleistocene	2–3	Pediment deposits
	Tertiary: Pliocene	7	Green Mountain Conglomerate
	Tertiary: Miocene	29	Table Mountain Shoshonite
	Tertiary: Oligocene	37–38	Denver Formation (Tkd)
	Tertiary: Eocene	53–54	Arapahoe Formation (Ka)
	Tertiary: Paleocene	65	Laramie Formation (Kl)
MESOZOIC ERA	Cretaceous	136	Fox Hills Sandstone (Kf) Pierre Shale (Kp) Niobrara Formation (Kn) Carlile Shale Greenhorn Limestone (Kcg) Graneros Shale Dakota Group (Kd)
	Jurassic	190–195	Morrison Formation (Jm) Ralston Creek Formation (Jr)
	Triassic	225	Lykins Formation (TRl)
PALEOZOIC ERA	Permian	280	Lyons Sandstone (Pl) Fountain Formation (PPf)
	Pennsylvanian	300	
	Mississippian	345	
	Devonian	395	
	Silurian	430–440	
	Ordovician	500	
	Cambrian	570	
	Precambrian		

NOT PRESENT

GEOLOGIC TIME CHART AND DENVER'S ROCKS
Letter symbols for formations are used on cross sections inset in map
(Adapted from Mountains and Plains–Denver's Geologic Setting, a U.S. Geological Survey leaflet)



Owing to faulting and deformation, thicknesses of some beds shown here differ from average thicknesses assigned in explanation for Map I–790–A.

CROSS SECTION SHOWING GOLDEN FAULT AND BEDROCK UNITS BETWEEN MOUNT MORRISON AND GREEN MOUNTAIN

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