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THE COMPLETE HISTORY OF THE GREAT ONE!

The Historical Geology of

DENALI NATIONAL PARK

by

Phil Brease

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Alaska, including portions of Denali National Park, was probably part of a northern extension of Gondwanaland (the single supercontinent) during the late Precambrian period (600 mil to 1 billion years ago). This northerly extension may have been portion(s) of the Canadian Shield, the oldest mapped rocks of North America. Paleomagnetic and paleoclimate data indicates that ancestral Alaska was oriented nearly 90 degrees clockwise from its present position and just north of the equator when the North American continent broke away from Gondwanaland (see figure 1).

The erosion of this continent to the north and west deposited quartz-rich sand and mud in shallow, fluctuating seas. Undersea volcanic eruptions contributed lava flows, and marine animals produced limy materials to combine with the sands and muds to become the original sedimentary deposition of the Birch Creek Schist, the oldest known rock (600 million to several billion years) in the Denali vicinity. At least four periods of regional metamorphism (heat and pressure change to existing rock) has altered the sedimentary and volcanic "basement rock " to a series of metamorphic rocks [quartz mica schist, quartzite, phyllite, slate, marble and greenstone]. These rocks can be seen in the deep Nenana River canyon just north of the park entrance, and also as the "outside" range which are the mountains that run along the first 30 miles of the park road on the north.

Continental drift, or world scale plate tectonics, has contributed significantly to the geologic evolution of Alaska. Two major plates, the Pacific Plate and the North American Plate, have been colliding or grinding past each other since at least Early Paleozoic time (300 to 500 million years ago). The boundary between these two plates, now located at the southern coast of Alaska, is a continuation of the plate boundary on the west coast of North America of which a part is known as the San Andreas fault. The Pacific plate (mostly oceanic surface) is moving northward relative to the North American plate (mostly continental - Canada and the U.S.) and is "diving" (subducting) beneath the North American plate at the Aleutian Islands and Alaska Peninsula (see fig 2.)

In Early Paleozoic time (300 to 600 million years ago), the southern continental boundary of Alaska was located possibly as far inland as where the park road is now located. This early shoreline was the site of the ancestral Pacific plate and North American plate collision (a subduction zone), and represents the site of an extraordinary joining of many land masses which make up most of southern Alaska as we know it today. The collision of plates brought in "Islands" of land masses (microplates or terranes) into contact with the Birch Creek Schist (also named the Yukon-Tanana Terrane) creating or accreting new terranes made up of existing rock mixed with marine sediments. Figure 3 shows the Paleozoic beginning of the "conveyer belt" process that has

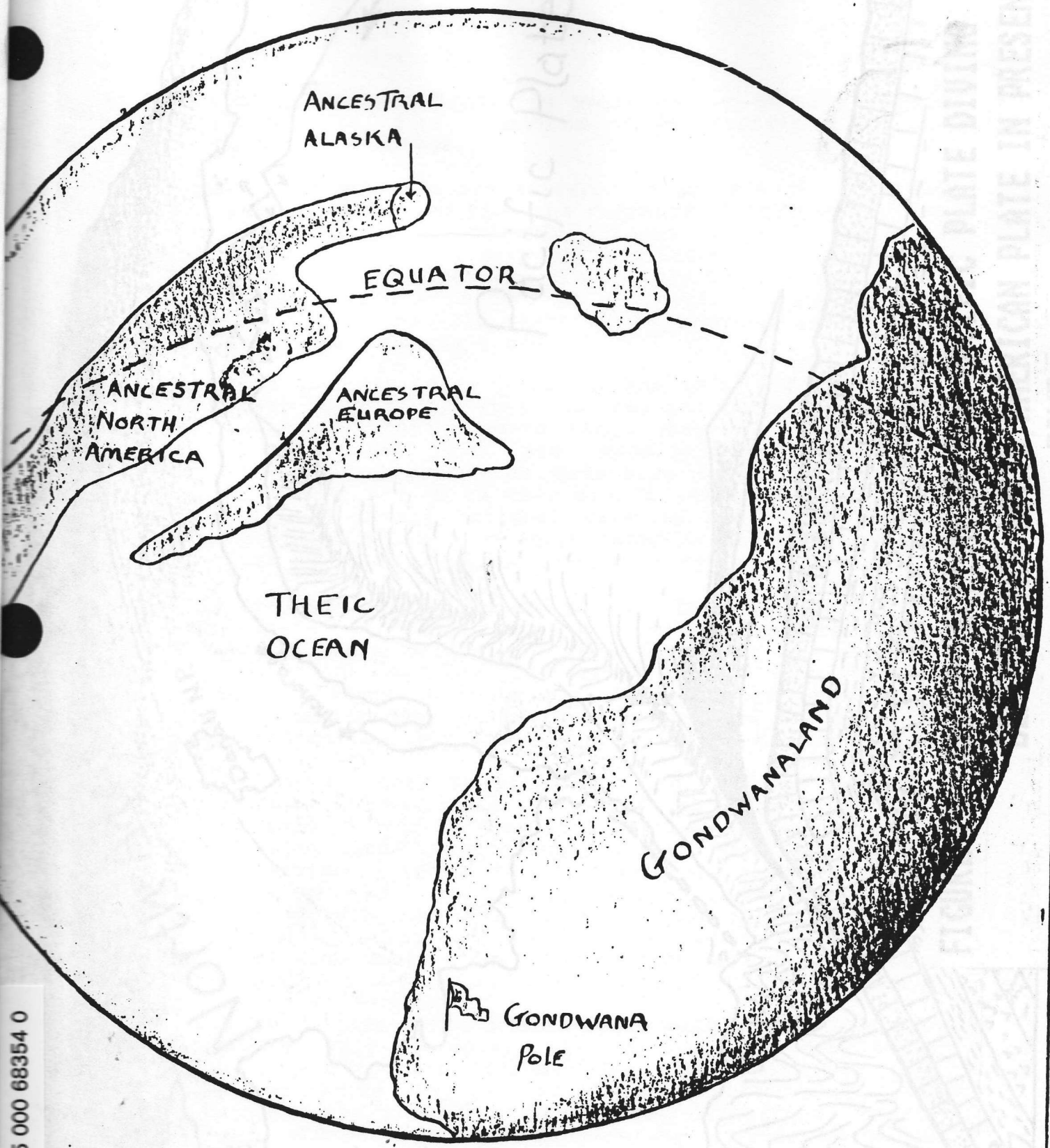

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FIGURE 1. LOCATIONS OF THE ANCESTRAL CONTINENTS IN THE PRECAMBRIAN PERIOD (600 million years ago).

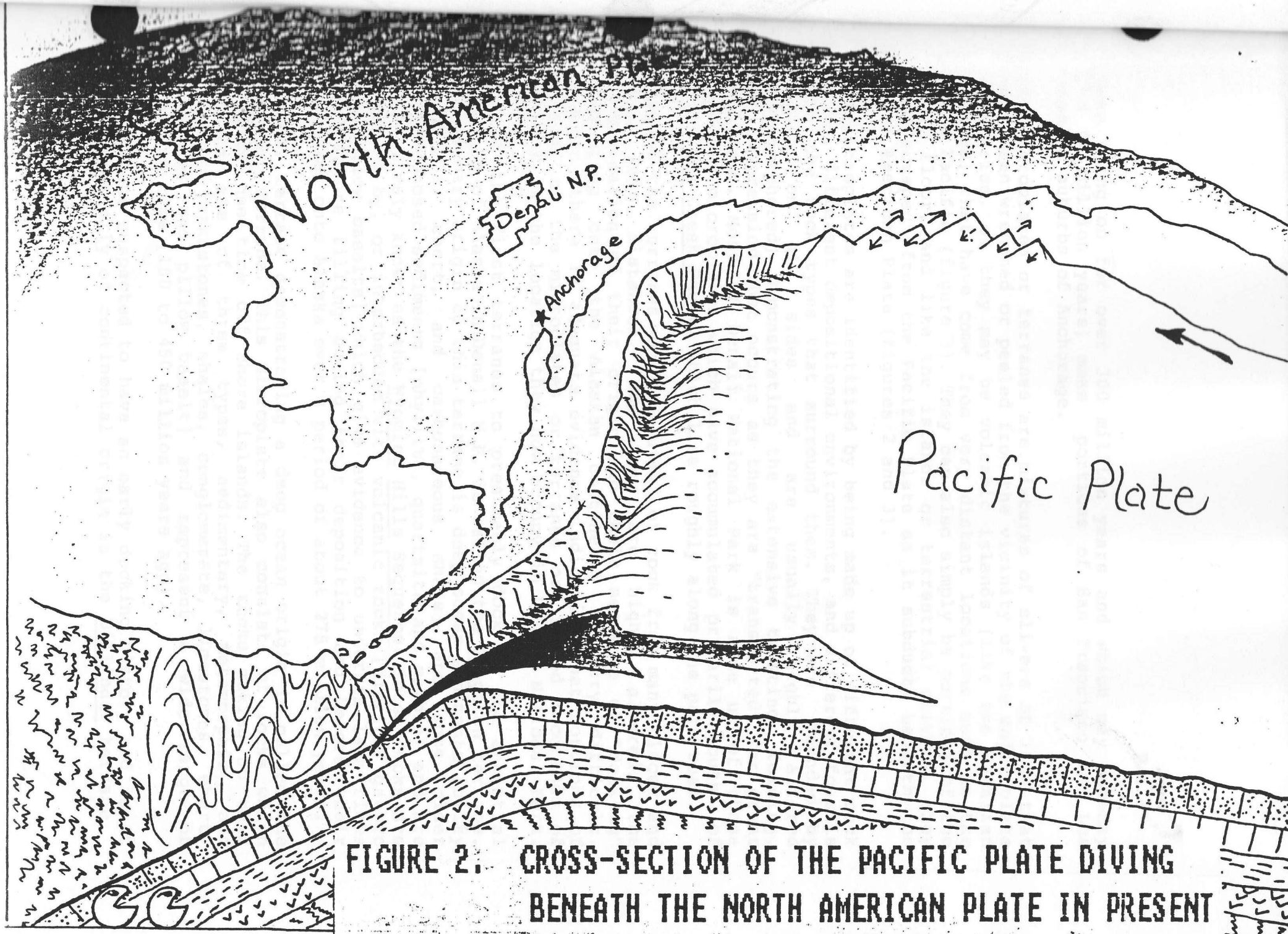

FIGURE 2. CROSS-SECTION OF THE PACIFIC PLATE DIVING BENEATH THE NORTH AMERICAN PLATE IN PRESENT TIME.

been going on for over 300 million years and which may someday (in 50 million years) make portions of San Francisco and Los Angeles suburbs of Anchorage.

The microplates or terranes are mixtures of slivers of land that have been wrenched or peeled from the vicinity of the major plate boundaries, or they may be volcanic islands (like the Hawaiian islands) that have come from very distant locations such as the South Pacific (figure 3). They can also simply be portions of the ocean floor, and like the islands or terrestrial slivers, they are "scraped" from the Pacific Plate as it subducts beneath the North American Plate (figures 2 and 3).

The microplates are identified by being made up of different rock types, different depositional environments, and different fossils than the rock types that surround them. They are bounded by faults on all sides and are usually highly altered (metamorphosed) demonstrating the extensive twisting, folding, and compression that occurs as they are "transported" for great distances. Most of Denali National Park is made up of these imported microplates which have accumulated primarily south of the Hines Creek Fault, which lies roughly along the park road.

Because the terranes are "mixtures" of rock from many places and from long distances, and they are highly altered, the determination of their origin and their sequence of "docking" (accreting onto the Alaskan continent) is very difficult. However, there is adequate evidence indicating that portions of several of the microplates or terranes originated thousands of miles from the location they now occupy in Denali National Park.

One of the first terranes to presumably dock at the ancestral boundary of Alaska in Denali N.P. is called the Pingston terrane. The primary origin of this terrane is deep ocean sediments [silty limestone, chert, and carbonaceous shale] and some older metamorphosed sediments [phyllite, quartzite and marble] and are collectively known as the Wyoming Hills Sequence. These rocks are intruded by, or interbedded with volcanic rocks [diorite, gabbro and pillow basalts] which give evidence to undersea lava flows and fissure filling during their deposition and before their accretion onto Alaska over a period of about 275 million years.

Another terrane demonstrating a deep ocean origin is called the McKinley Terrane. This microplate also consists of rocks which were at one time off shore islands. The rocks making up this terrane are of three types, sedimentary, metamorphic, and volcanic [sandstones, shales, conglomerate, limestones, chert, phyllite, and pillow basalt] and represent a wide range of geologic time (100 to 450 million years ago).

One terrane suspected to have an early docking history and is at least partially of continental origin is the Dillinger terrane.

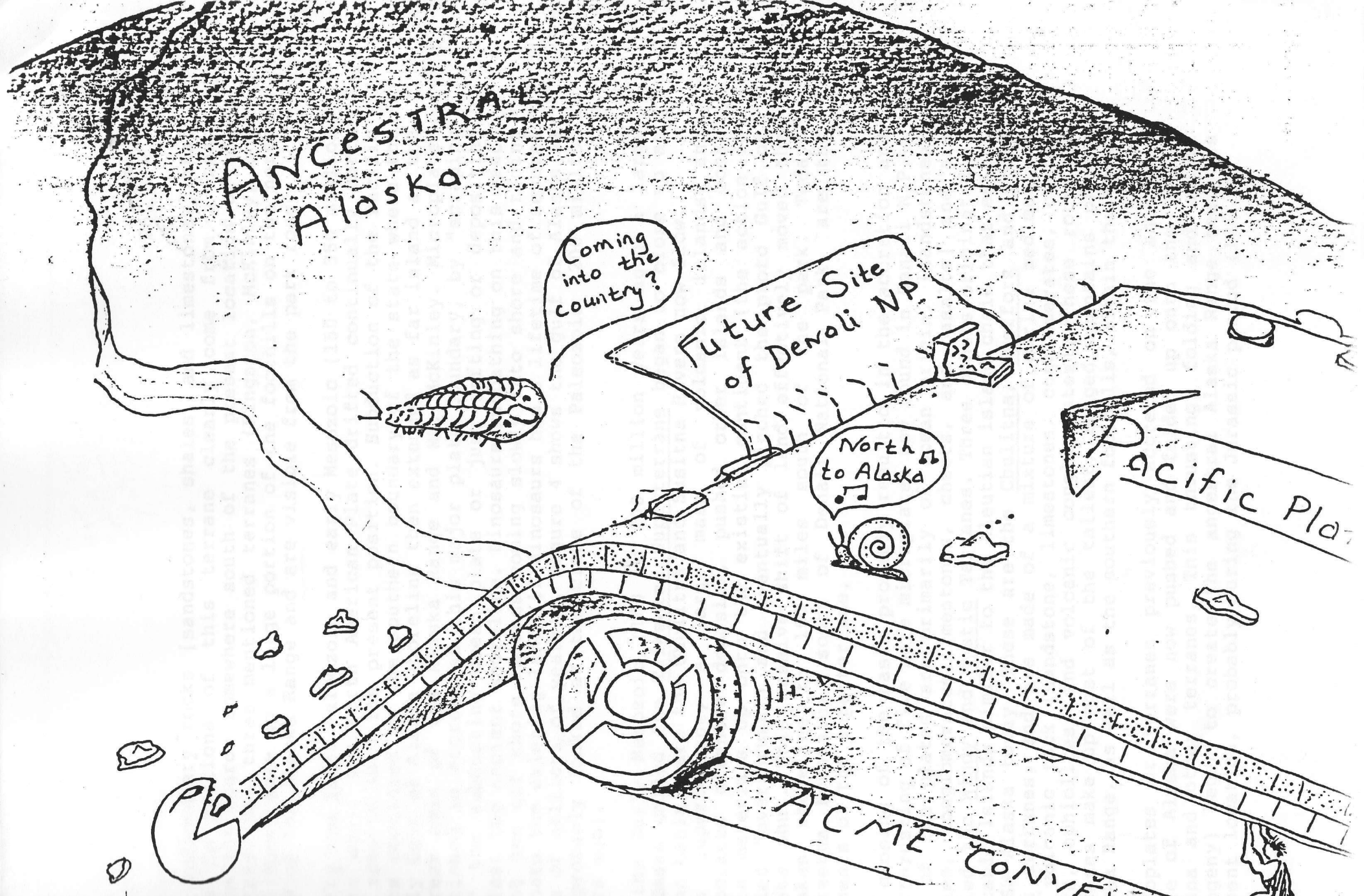

FIGURE 3. PACIFIC PLATE SUBDUCTION WITH ACCRETION OF MICROPLATES IN TH EARLY PALEOZOIC.

The sedimentary rocks [sandstones, shales, and limestones] that make up portions of this terrane clearly come from a near shoreline source somewhere south of the present location of the terrane. The three mentioned terranes (Pingston, McKinley, and Dillinger) make up a large portion of the foothills on the north side of the Alaska Range and are visible from the park road.

During the later Paleozoic and early Mesozoic (150 to 350 million years ago), the North American Plate drifted continually north and rotated into its present position. Subduction of the Pacific plate continued on the southern boundary of the state where the early Gulf of Alaska shoreline then extended as far inland as the current axis of the Alaska Range and Mt. McKinley. Microplates continued to accrete at this major plate boundary, by "scraping off" the subducting ocean plate or just rafting or depositing against the ancient shoreline. Dinosaurs sunbathing on this beach might see off shore islands coming slowly into shore and riding up onto the existing land (if dinosaurs had a lifetime of several 10's of millions of years!). Figure 4 shows the gulf of Alaska as it probably looked at the close of the Paleozoic (200 million years ago).

In the Early Mesozoic (100 to 200 million years ago) a large landmass called the Talkeetna Superterrane began to close up an ocean basin where the Chulitna and Susitna Rivers now flow. This Superterrane, a large mass of volcanic islands and associated offshore deposits, pushed other islands and ocean basin materials up onto the existing continent (the action is called "overthrust") and eventually pinched the proto Gulf of Alaska shut. This massive shift of land effectively moved the Alaskan shoreline to 150 miles south of the park. Todays Talkeetna Mountains, south of Denali National Park, are the remnants of the superterrane.

The closing of the basin probably resulted in the accretion and overthrusting of five more microplates now found in Denali N.P. Two of the plates are primarily of ocean origin, [sandstones, shales, conglomerates,limestones, cherts, and basalts] and are called the Windy and Mystic Terranes. Three others originated as volcanic islands similar to the Aleutian island chain that exists in SW Alaska today. These are the Chulitna, Westfork and Broad Pass Terranes, and are made of a mixture of marine sedimentary and volcanic rock [sandstone, limestones, conglomerates, chert, tuffs, ophiolites, and volcanic conglomerates]. These rocks or terranes make up most of the tallest, rugged mountains of the Alaska Range, as well as the southern foothills, within the park.

Microplates or terranes previously accreted on the ancestral shore of Alaska were now pushed and folded up onto the Yukon-Tanana and other terranes. This thrusting, folding and uplift (orogeny) began to create the ancestral Alaska Range near its present location, probably during the Jurassic period (136 to

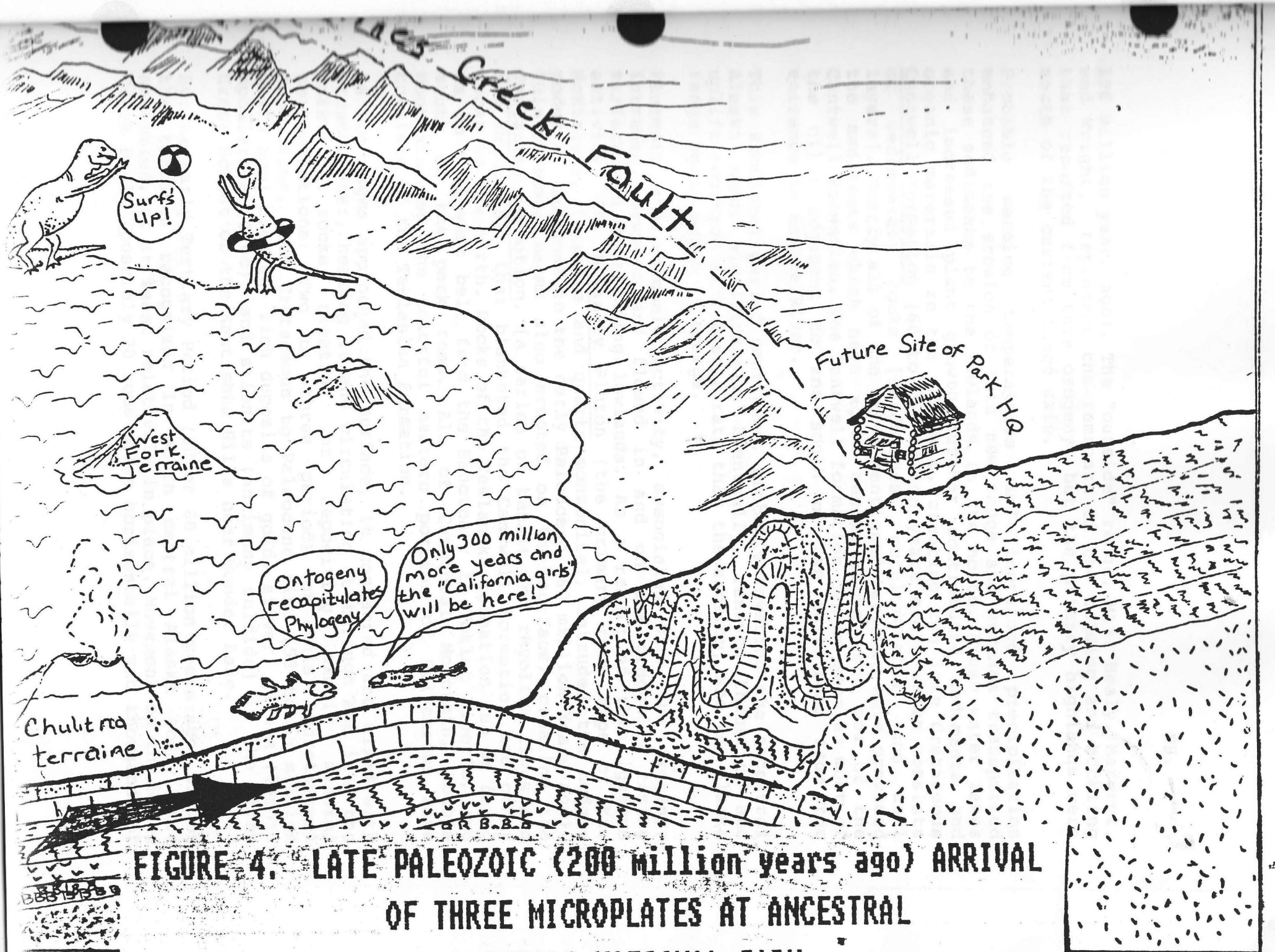

FIGURE 4. LATE PALEOZOIC (200 million years ago) ARRIVAL OF THREE MICROPLATES AT ANCESTRAL DENALI NATIONAL PARK

190 million years ago). The "outside" range, Mts. Healy, Margret, and Wright, represent the remnants of the folding and buckling that resulted from this orogeny, but the primary highlands were south of the current range axis.

Probable warming temperatures and increased precipitation enhanced the erosion of this new range and streams transported these sediments to the lowlands in the north. Fresh water lakes and increased plant growth further contributed sediments and organic materials to the deposit, creating the late Cretaceous Cantwell Formation (60 to 75 million years old), which consists of sedimentary rocks [sandstones, conglomerates, and coal layers]. Nearly all of the above mentioned terranes have provided the sediments which have again become rocks, but now of the Cantwell Formation. The Cantwell formation can be seen as most of the hills adjacent to and south of the park road from the entrance to Savage River.

This erosional period continued, probably lowering the ancestral Alaska range significantly. Eventually, renewed thrusting and uplift occurred at a faster rate than the erosion, and the Alaska range again began to emerge.

Plutonic and volcanic activity, associated with the orogeny, intruded, erupted and flowed in and on the gradually rising surface and surrounding lowlands. As a result of this igneous activity, the McKinley Pluton (the primary rock type of Mt. McKinley), [granite and quartz monzonite], intruded the hodge-podge of terranes in the early Paleocene (60 million Years ago). This igneous magma also erupted on the surface, creating the Teklanika Formation, [a series of basalt and rhyolite flows and ash deposits], that blanketed the Cantwell Formation and other rocks to the north. Rocks of the Teklanika formation can be found as an east-west belt from the Sanctuary to Toklat River's, and south of the park road. All of Cathedral Mountain, Double Mountain and the colorful eastern portion of Polychrome Pass consists of the Teklanika Formation.

As hot magma approched the surface, it contacted and mixed with ground water, heating it and circulating it through and into the existing rocks creating or depositing exotic mineral concentrations. Two or three periods of this hydrothermal deposition, from Cretaceous to Paleocene time (53 to 65 million years ago) created rich deposits of gold, silver, galena (lead), sphalerite (Zinc), and stibnite (antimony sulfide) in the Birch Creek Schist of the Kantishna Hills near Wonder Lake.

By the early Tertiary Period (50 or 60 million years ago) all of the terranes recognized in south central Alaska today were assembled, or at least relatively in place. Movement on the Hines Creek Fault (possibly 20 some miles horizontally and thousands of

feet vertically) slowed and eventually halted in the early Eocene Epoch (40 to 50 million years ago. Plate tectonic pressure continued to apply stress to the newly created Alaskan continental boundary, and major fault movement began at a new location known as the Denali Fault. Over 100 miles of horizontal slip is speculated to have occurred on this fault since it's "birth", and many thousands of feet vertical (uplift or thrust-faulting) has created a massive mountain front, including the highest mountain in North America, Mt. McKinley.

Igneous activity, resulting from the near continuous orogeny produced additional granitic plutons (cooled and solidified molten rock) and some violent eruptions of ash in the northern portions of the Park. The plutons, named the McGonagall and Foraker, intruded the Dillinger and Yukon - Tanana terranes, and have been dated to 38 million years. These rock bodies were probably uplifted slightly before the thrust-faulting occurred at the Denali Fault Zone. These granitic rocks make up the lofty (17,400 foot) Mt. Foraker and the foothills around Mts McGonagall and Gunsight just south of Wonder Lake.

The Mount Galen Volcanics, made up of andesite, basalt, breccia and tuffs, intruded the McKinley terrane and erupted at possibly several vents, blanketing a large area (25 sg km) with andesitic ash falls and flows. One such vent has been mapped within the Park boundary on Thorofare Mt., and material from this location has been dated at 38 million years, the same age as the McGonagall and Foraker Plutons. These volcanic rocks can be found at the far western end of Eielson Bluffs, Mt. Galen, and the mountains south of Thoroughfare Pass. Evidence of the Mt. Galen eruptive products indicate short periods of violent eruptions.

During a portion of the mid Tertiary (20 to 35 million years ago) subsidence (downwarping) occurred just north of the present location of the Alaska range, creating at least two large basins. The climate again warmed, and increased precipitation provided major erosion of the highlands (Birch Creek Schist) north of these basins. Streams flowing south into these basins created fresh water lakes and a depositional environment for the eroded sands and gravels. As the long term precipitation and sedimentation rates fluctuated, the depositional environment fluctuated between lake and swampy environments, and numerous layers of lush plant growth were alternately buried by sand and gravel.

This cycle of activity went on for a period of about 10 or 15 million years (late Oligocene to late Miocene) creating the Coal Bearing Formation [consisting of sandstones, shales, conglomerates and coal]. The Coal Bearing Formation can be viewed as scanty outcrops of sandstone and thin coal primarily on the south side of the road at Sable Pass, although there is a small

amount on the road cut near Ghiglione Creek. This formation is best viewed at and around the town of Healy where the formation is mined for coal.

Uplift on the southern margin of the Alaska range began to spread northward in the early Pliocene (about 10 million years ago), and streams began to flow northerly into the basin area both depositing onto, and eroding the Coal Bearing Formation. The erosion of the range highlands created a wedge of sedimentary material (bajada) that was deposited against the north side of the range, and partially filling the basin area. This material (sands and gravels) became the poorly consolidated sandstones and conglomerates of the Nenana Gravel. It can be found within the park where the park road traverses it from milepost 17 to the Sanctuary Campground and again in Highway Pass.

Cooling trends heralded the Pleistocene Epoch (from 10,000 to 1 million years ago) which resulted in 6 to 8 major glacial advances and many minor advance-retreat sequences. The top or final deposition of the Nenana Gravel was at least partly glacially derived, and probably occurred from 150,000 to 500,000 years ago. Ice covered most of the southern half of the state from the mid Pleistocene to about 10,000 years ago, and ice lobes extended north of the existing range, fluctuating in response to local faulting and uplift, topographic erosion, and micro-climatic conditions.

During the Brown Advance (150,000 years ago), the ice sheet covered most of the area now occupied by the Alaska Range, with only Mt. McKinley and Mts. Deborah and Hayes protruding through the ice at elevations of about 17,000 feet and 10,000 feet respectively. Ice extended down the Nenana River valley 25 miles past the town of Healy and terminating at a railroad stop called Brown. This ice advance left many glacial erratics (large boulders transported by ice) in lofty locations when the ice retreated. Most of the present drainages through the "outside" range were occupied by ice and were eroded or maintained during this glacial period (~~see figure 5~~).

Subsequent glacial episodes, including the Lignite/Iron creek Advance (125,000 years ago), the Healy/Mcleod Creek Advance (70,000 years ago) and the Riley Creek/Wonder Lake Advance (27,000 years ago) refilled and/or sculptured most of the valleys existing today, and various ice lobes reached the Park road at Wonder lake, Eielson Visitors Center, and the Toklat, Sanctuary, Teklanika and Savage Rivers. The final retreat of the Healy Advance created a 9 mile long 1/2 mile wide temporary lake (Lake Healy) which occupied the Nenana River canyon from Hines Creek to the Healy Road House about 50,000 years ago. This lake drained the existing canyon to the East, bypassing its former, present filled channel where the Road House is located. Similar glacial and meltwater filling occurred during the Riley Creek

and Wonder lake advances, creating a temporary lake at Carlo Creek (between Windy Creek and McKinley Village) and the existing Wonder Lake, which was formed by a stranded mass of ice left by a retreating Muldrow Glacier.

Glaciation and erosion, sedimentation and deposition, faulting and folding, plate tectonics and microplate accretion have all contributed to the geography and geology of Denali National Park and are all continuing to shape the park and Alaska today. Fifty million years from now our decedents may drive 400 miles north from Disneyland (by then located in the Anchorage area) to view a flat, featureless plain which was the location of the former highest point in North America, Mt. McKinley. Or perhaps mountain climbers the world over will travel to the Alaska Range to climb the new highest mountain in the world!