Geology of Southeast Alaska: With Special Emphasis on the Last 30,000 Years

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The unique habitats of Southeastern Alaska are the end result of its geologic history. Southeast Alaska is a geologically complex region. Known as the Alexander Archipelago and named after Tsar Alexander of Russia, this land now covered by a temperate rainforest has had a long and dynamic geologic history.

Some of this region's bedrock formed within 15° latitude of the equator and later moved via sea-floor spreading and ocean plate movement to its present location beginning about 200 million years ago. The journey included joining with other geologic terranes or unique packages of rocks and their ultimate collision with the North American continent. Southeast Alaska began to take shape as the ocean crust conveyor belt moved fragments of volcanic island arcs, old coral atolls, deep sea sedimentary rocks and even pieces of continents across the northeastern Pacific and caused their accretion onto ancient North America.

Within the past 30,000 years, the Alexander Archipelago was scoured and polished by late Pleistocene ice and subsequently flooded as a warming climate caused glaciers and ice caps to melt, resulting in a worldwide sea level rise. This unique geologic history has given Southeast Alaska the steep-sided mountains and deep fjords that make the region so distinctive today.

Southeast Alaska and its Terranes

Three very different terrenes now lay side-by-side in Southeast Alaska. In Middle Triassic time about 220 million years ago, the Wrangellia, Alexander and Stikine terranes were somewhere offshore.

The Stikine terrain is made up of andesite, basalt and rhyolitic volcanic flow rocks and sedimentary rocks of late Paleozoic age that are interbedded with marine sandstone and limestone. This group of rocks probably began as a volcanic island chain much like Indonesia today. The Stikine terrain docked with North America by the early Jurassic about 200 million years ago, attaching itself onto what is now interior British Columbia. The Alexander terrane includes lower and middle Paleozoic deep ocean trench deposits,

volcanic rocks, shallow water limestone and late Paleozoic limestone, chert and volcanic rocks. The limestones and marbles found today in the Heceta-Tuxekan Islands west of Prince of Wales Island and in Glacier Bay were formed as part of the early Alexander Terrane.

To the west, rocks of Wrangellia record a volcanic island arc capped by shallow-water marine shale. Limestones interbedded with the shale are Permian (240-280 million years) in age and contain distinctive marine fossils. Following the reef environment, a thick unit of volcanic basalt records a rifting of the ocean floor that began beneath sea level but was so thick that it surfaced eventually producing 100,00 to 200,00 cubic kilometers of basalt (Jones et al. 1982). The volcanism ended by about 200 million years ago and was followed by carbonate deposition similar to that presently occurring in the Persian Gulf. The copper deposits of the Wrangell Mountains ultimately came to reside in these shallow water carbonates.

The Wrangellia and Alexander terranes joined together off the North American coast by Middle Jurassic time and before they accreted onto North America, rocks of the Gravina Belt were deposited upon this superterrane. Rocks in Auke Bay, Douglas Island, eastern Admiralty, Kupreanof Island and Gravina Island opposite Ketchikan are all part of the Gravina belt.

Early Cretaceous folding and faulting in Wrangellia/Alexander terrane rocks record the initial collision of that superterrane with North America. Deformation of the rocks caused regional metamorphism and generated large volumes of granite rock intruding this newly forming coastal mountain region. Metamorphic and intrusive igneous rocks crop out in the Juneau area and extend eastward under the Juneau Icefield (Ford and Brew 1977).

The beginning of the Tertiary Period records the arrival of the Chugach terrane outboard of Wrangellia around 65 million years ago. About 25 million years ago the Yakutat block was sliced off the continental margin southeast of Chatham Strait and moved 330 miles northwest along the Queen Charlotte-Fairweather transform fault system. This coastal crash, much like India against Asia, is uplifting the St. Elias Mountains in the Yakutat area.

North of the St. Elias Mountains, right lateral movement along the Denali Fault beginning as early as Cretaceous time, has deformed Miocene and Oligocene cobbles in conglomerate rocks and offset sandstones 180 miles. Branches of the Denali Fault extend into the Chilkat Valley and have deformed Tertiary rocks there.

Alaska's Glacial History; Evidence From the Gulf of Alaska

The Gulf of Alaska region has been glaciated since late Miocene time (Molnia 1986). Evidence from the Yakataga Formation northwest of Icy Bay had shown that sediments about six million years old were deposited by glaciers into a marine environment. Drill hole information for Middleton Island (Plafker 1971) reveals that 1000 km off the coast there are at least 1,150 m of the Yakataga Formation glacial deposits.

Pleistocene Glaciation in the Alexander Archipelago

Between Icy Bay and the Queen Charlotte Islands, the extent and timing of ice advances over the past two million years or Pleistocene epoch is not well known. The ubiquitous U-shaped valleys and numerous rounded passes provide evidence for a long history of intensive glaciation that spared only the mountains of central Baranof Island and a few scattered summits above 1,000 m on Chichagof, Admiralty and Prince of Wales Islands. Local island ice caps and valley glaciers were later invaded by ice from the Coastal Mountains and interior British Columbia that spilled over the archipelago. An ice sheet 1,000 m thick sculpted this landscape.

In the Juneau area, radiocarbon dated peats yielded ages greater than 39,000 years ago (Miller 1973a). These peats are covered by glacial marine deposits and record a pause in the latest Pleistocene phase of glaciation. Fossil pollen recovered from this interstitial peat records a flora dominated by shrubs and ferns with rare trees. The peat beds suggest that glaciers had receded out of the inner fjord zone of Southeast Alaska sometime prior to 39,000 years ago (Mann 1986).

Capps (1931) was the first to propose that large outlet glaciers of the past 25,000 years ended along the outer continental shelf of Southeast Alaska in deep submarine valleys beyond the large fjord entrances. Acoustical studies of sediments on the continental shelf between Cross Sound and Prince William Sound have helped to map some of these sea valleys and delineate glacial deposits. Unfortunately, these techniques do not provide age control. It is, therefore, not possible to say whether the entire continental shelf was glaciated during the last Pleistocene glacial advance beginning about 25,000 years ago. Mann (1986) believes that during the last Pleistocene, glacial maximum outlet glaciers 20-50 km wide flowed out of the Alexander Archipelago at Dixon Entrance, Sumner Strait, Chatham Strait and Icy Strait with surfaces as high as 600 m above present sea level. Deglaciation was probably rapid with much catastrophic calving.

Raised Marine Deposits Record Deglaciation

As glaciers melted and sea level began to rise, the landscape was still depressed by the weight of the newly departed ice. The glacier-carved valleys, once flooded with seawater, form steep-sided fjords with poor foraging for eagles. However, the head of these valleys have wonderful outwash plains with superlative eagle foraging space.

In Juneau, beach gravels were deposited at an elevation as high as 230 m above sea level just before 13,000 years ago (Miller 1973a). Along the south coast of the Chilkat Peninsula, raised beaches and bedrock terraces record three episodes of crustal depression associated with ice loading in nearby Glacier Bay beginning about 13,350 years ago (Ackerman et al. 1979). Twelve thousand year old marine shells occur at 70 m on Northeast Chichagof (Mann 1986). Glacial marine material exists at 213 m on Admiralty Island (Miller 1973b) and at 150 m on the mainland east of Prince of Wales Island (McConnell 1913). Near Petersburg, marine shells dated to about 12,400 years occur at an elevation of about 62 m (Ives et al. 1967). Marine terraces were found by Berg (1973) at 60 m near Ketchikan and Sainsbury (1961) found shells and glacial-marine deposits up to 61 m on Prince of Wales Island. These altitudes of marine limits result in part from ice

loading and they provide a rough indication of ice thickness.

Bald Eagles and the Pleistocene

Somewhere in southeast Asia before about 25 million years ago, the group of birds known as kites provided the ancestors for the sea eagle (Stalmaster 1987). From this Asian ancestor, the Bald Eagle emerged, but no fossil evidence of this evolution is found until about 1 million years ago when eagle bones appear in the Rancholabrean faunas of California's tar deposits (Howard 1932).

Meanwhile the steelhead trout (*Oncorhynchus mykiss*), formerly (*Salmo gairdneri*) had moved northward into the North Pacific from North America. These fish provided the ancestral pool for five species of Pacific salmon which are thought to have evolved during the Pleistocene (McPhail and Lindsey 1970, Neave 1958). Isolated groups of salmon survived in fresh water streams on the Bering land bridge during maximum glacial advances and in the Columbia River basin in Washington.

Bald Eagles may have invaded Alaska prior to 1,000,000 years ago, following Asian shorelines around the Pacific rim to feed on the newly evolving taste sensation, salmon and then continued down the coast to become entombed in the La Brea tar pits of southern California.

Bald Eagles feeding on spawned-out chum salmon. Photo by Bob Armstrong.

Ice retreated from Southeast Alaska beginning about 16,000 years ago in the Queen Charlotte Islands (Clague et al. 1982) and by 12,000 years ago in the inner fjord areas to the north, setting the scene for the arrival of the "People of the Tides" (Tlingit) by way of the Nass and Skeena River canyons from the interior. The numerous members of the Tlingit Eagle Clan can attest to the presence of the Bald Eagle in Southeast Alaska upon the arrival of their ancestors, the first Southeast Alaskans.

Editor's note: To this day northern Southeast Alaska is rising either as a result of rebound of the land now that the glaciers have retreated (isostatic rebound) or due to mountain building and uplift. The Glacier Bay area is rising at about 3cm per year.

Literature Cited

Ackerman, R. E., T. D. Hamilton and R. Stuckenruth. 1979. Early culture complexes on the northern northwest coast. Canadian Journal of Archeology 3:195-209.

Berg, H. C. 1973. Geology of Gravina Island, Alaska. U.S. Geological Survey Bulletin 1373. 41 pp.

Capps, S. R. 1931. Glaciation in Alaska. U.S. Geological Survey Professional Paper 1700A, pp. 1-8.

Clague, J. J., J. R. Harper, R. J. Hebda and D. E. Howes. 1982. Late Quaternary sea levels and crustal movements, coastal British Columbia. Canadian Journal of Earth Sciences 19:597-618.

Ford, A. B. and D. A. Brew. 1977. Preliminary geologic and metamorphic-isograd map of northern parts of the Juneau a1 and a-2 quadrangles, Alaska. U.S. Geological Survey Miscellaneous Field Studies, Map MF-847.

Howard, H. 1932. Eagles and eagle-like vultures of the Pleistocene of Rancho LaBrea: Carnegie Institution of Washington D.C. Publ. 429. 82 pp.

Ives, P. C., G. Levin, C. L. Oman and R. Meyer. 1967. U.S. Geological Survey radiocarbon dates IX. Radiocarbon 9:505-529.

Jones, D. L., A. Cox, P. Coney and M. Beck. 1982. The growth of western North America. Scientific America 247(5):70-84.

Mann, D. H. 1986. Wisconsin and Holocene glaciation of Southeast, Alaska. Glaciation in Alaska, Hamilton et al., eds. Alaska Geological Society. pp. 237-265.

McConnell, R. G. 1913. Portions of Portland Canal and Skeena mining divisions, Skeena District, British Columbia. Canadian Geological Survey Memoir 32. 101 pp.

McPhail, J. D. and C. C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Fisheries Research Board of Canada Bulletin 173. 381 pp.

Miller, R. D. 1973a. Gastineau Channel formation, a composite glaciomarine deposit near Juneau, Alaska. U.S. Geological Survey Bulletin 1394. pp. C1-C20.

Miller, R. D. 1973b. Two diamictons in a landslide scarp on Admiralty Island, Alaska and the tectonic insignificance of an intervening peat bed. U.S. Geological Survey Journal of Research. 1:309-314.

Molnia, B. F. 1986. Glacial history of the northeastern Gulf of Alaska-A synthesis. Glaciation in Alaska, Hamilton et al., eds. The Geological Society of Alaska. pp. 219-236.

Neave, F. 1958. The origin and speciation of "*Oncorhynchus*" (SALMON). Transactions of the Royal Society of Canada Vol., LII, Series III, Section 5. pp. 25-39.

Plafker, G. 1971. Pacific margin Tertiary basin. In: Cram, I.H., ed. Future petroleum provinces of North America. American Association of Petroleum Geologists Mermoir. 15:120-135.

Sainsbury, C. L. 1961. Geology off part of the Craig C-2 quadrangle and adjoining areas, Prince of Wales Island, southeastern Alaska. U.S. Geological Survey Bulletin 10058-H. pp. 299-362.

Stalmaster, M. V. 1987. The Bald Eagle. Universe Books, New York. 227 pp.