THE CLIMATIC HISTORY OF ALASKA FROM A NEW VIEWPOINT

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In the earlier days of geologic study, inferences regarding the climates of bygone periods were drawn chiefly from fossils. Palm leaves in Greenland and musk-ox bones in Kentucky gave their obvious testimony. Even in those days, however, the climatic significance of certain kinds of sediments was well recognized. But at first, it was only the peculiar and extreme sedimentary types, such as glacial till and beds of rock salt or gypsum, that were interpreted in this manner. Ordinary sandstones, shales and conglomerates were hardly suspected of containing a hidden record of ancient climates to which the key had not yet been found.

Within the last few years, however, we have come to understand that the formation of sedimentary rocks is controlled by several factors and that one of the most important—in many cases the dominant—factor is climate. As the influence of the climatic factor comes to be understood, we find ourselves able, with increasing confidence, to read from the sediments the climatic conditions under which they originated. In this respect we owe much to Professor Joseph Barrell of Yale.

At present the climatic significance of the continental sediments is much better understood than that of the marine deposits. There is however, good reason to hope that we may soon understand the latter as well as the others. The value of the sedimentary deposits to the student of ancient climates depends upon the fact that the climatic conditions either directly or indirectly control most of the physiographic processes, and particularly the highly important process of weathering. Thus, in very dry regions chemical decay cannot have much effect—because moisture is the medium upon which it depends. Such sediments as are produced, are, therefore, the products of abrasion and isolation rather than of chemical dissolution. On the other hand, in a hot moist climate under the dense vegetation which inevitably prevails, chemical decay becomes dominant and it normally results in ferruginous clays which have but little resemblance to the rocks from which they were derived. It is, of course, evident that climatic conditions also influence the immediate deposition of sediments, as well as their derivation through the process of weathering. Thus a sedimentary layer which is deposited under water and in contact with much decaying organic matter, will necessarily be kept in a reduced or unoxygenated condition, whereas if it comes to rest on an exposed dry surface where aerated waters circulate down through it, the materials are likely to become thoroughly oxidized.

These are merely illustrations of a series of such influences of climate on sediments. Of course, there is still a large amount of work to be done by way of putting this branch of the science of geology on a firm basis. We are still far short of the point where we shall be able to interpret the climatic conditions from every kind of sedimentary deposit.

Let us now apply this principle to the detrital formations of Alaska. Neglecting the obvious local variations, the sedimentary deposits of Alaska possess important characteristics in common, but as a group they are contrasted with the sediments of, say, Southern California or Brazil. In some of the present mountain valleys the glaciers are forming till. In others the products of frost action and of glacial or fluviatil abrasion are being swept down by the streams and deposited as gravel, sand, and silt. In all of these deposits the mineral particles are almost entirely undecayed, and hence still contain the original ferromagnesian silicates, feldspars, calcite, micas, etc. The iron is still largely in the ferrous state, and the alkalis and alkaline earths are still present in large quantities.

Furthermore, most of the surface of Alaska is covered either with forest or that thick mossy carpet, the "tundra." Swamps are abundant, and in many parts of Alaska the entire surface, even on considerable slopes, seems to be merely one vast saturated sponge of moss and lichens grading down into black muck. If buried without disturbance, this material, which decays but slowly, would doubtless produce coaly layers, but a large part of the muck is washed out by the streams and redistributed among the sands and silts, thus forming black or gray carbonaceous sediments full of shreds of wood and fiber. The saturated and, in large part frozen, condition of most Alaskan deposits effectually prevents that aeration which is requisite for the complete oxidation of the iron-bearing constituents. The red and brown colors, which such deposits often take on in other countries, are, therefore, seldom seen in Alaska.

In brief, the modern terrestrial sediments of the territory, are typically gray or black in color, are rich in unaltered complex silicate minerals and carbonaceous matter, and are associated locally with either coal or glacial till. They contain no red, and but little brown, material, no saline deposits, no aluminous clays, and probably not even pure quartz sands. The marine deposits are similar in many respects but differ in others. They are not yet so well known.

Looking back over the geologic column of the upper Yukon Valley, and passing over the Pleistocene sediments, which we should readily presume were made under a climate no milder than the present, we first come to the Kenai (upper Eocene) formation in which black and gray shales and graywackes alternate with occasional beds of coal, and contain fossil leaves of the poplar, birch, sequoia and oak. These all suggest a moist temperate climate.

The next oldest formation of the district is the Upper Cretaceous, which here consists of dark grey or black carbonaceous shales varying through silt-rocks to complex blackish graywacke and conglomerate. In the coarser beds of this formation many fresh silicate minerals are visible under the microscope, testifying to the absence of effective chemical decomposition, and to the abundance of slowly decaying vegetable matter at the place of their formation. The Lower Cretaceous rocks of the Upper Yukon are almost exactly like those just described, except that they are much thicker. In 15,000 feet of beds exposed in a single section no bed of any color except black and dark gray could be seen.

Passing over the Triassic oily shale and limestone, and the Permian white limestone-marine strata the climatic significance of which may be different, although as yet uncertain—we come to the National River formation of Pennsylvanian age. This consists of several thousand feet of blackish shale and silt rock alternating with dark muddy graywackes and graywacke conglomerate. The sandy layers contain abundant fresh particles of feldspar, slate and mica, and shreds of woody fiber —the appropriate product of a moist and cool or temperate climate.

The Mississippian formations, being marine, are somewhat less positively interpreted, but even in them the prevailing rock is black shale rich in carbonaceous matter, and it is significant that the many intercalated beds of black limestone are devoid of reef corals or other organisms that are confined to tropical waters.

The Devonian consists largely of black coaly shales, cherts, dark limestones and unweathered volcanic greenstones, all of which are consistent with the supposition of a moist temperate or cold climate. In certain beds, perhaps of Devonian age, the shales and cherts are associated with a bed of glacial tillite containing striated subangular boulders.

The Silurian consists in part of massive gray or white limestones and dolomites, and so probably constitutes an exception to the monotony of the black formations. The return seems to be made to the Alaskan type, however, in the Ordovician where basaltic breccias and tufas have remained to this day with scarcely a trace of chemical decay. Even the olivine crystals preserve clear, sharp outlines, and the feldspars show no clouding.

In rocks which are probably not younger than early Paleozoic, and may prove to be of Lower Cambrian age, other beds of glacial tillite have been found in two places in association with the typical black and gray slates, graywackes, and limestones. Even in rocks which are believed to be of pre-Cambrian age, similar types persist; for the dark schistose graywackes, slates and chlorite schists contain much undecayed feldspar and ferromagnesian constituents darkened with a fine graphitic dust.

In order to see how districts outside of those with which I was personally familiar compared in this respect, I examined the stratigraphic sections in the geological reports on seven districts well distributed over the territory. Out of some twenty-two different formations described, there were four which differ from the typical Alaskan group of sediments. These were white limestone, buff sandstone, gray limestone, and red and green cherts. All the other formations consisted of black or dark gray carbonaceous shales, dark colored arkoses, graywackes, graywacke conglomerates, undecayed pyroclastics, tillites, etc. If the examination had been continued to include all of the Alaskan districts which have been studied in some detail, the results would not have been very different. This seems to show clearly that there is not only a characteristic modern type of Alaskan sediments, but that in earlier periods, back even to the pre-Cambrian, this type predominated. Carbonaceous shales, silt-rocks, and graywackes are characteristic, instead of the purer sandstones and clay shales of eastern United States.

As a corollary, it is significant that throughout Alaska there is an absence or rarity of certain types of sedimentary rocks. Among these are the saline deposits characteristic of desert regions, the red bed facies now generally ascribed to the influence of hot climates with alternating seasons, as well as the pure white limestones, coral reef rocks, and oolites, which are today forming in tropical seas.

In short, the combined evidence strongly suggests that the cool, moist climate of modern Alaska—oscillating now and then toward the glacial Arctic condition on the one hand and toward the moist temperate on the other—has been persistent, with but few real interruptions, throughout the known geologic history of Alaska. If this proves to be a sound conclusion, it will have to be reckoned with by those who have suggested the wandering of the earth's axis through 90 degrees or more of latitude, and also by those who may still favor the hypothesis that the earth has been progressively cooling off ever since it was organized as a planet.