On the scientific results of Dr. Nansen's expedition

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In conclusion, General Annenkoff advises that measures should be taken to direct the flow of immigration into Central Asia, for when left to themselves colonists often wander for months without finding suitable spots on which to settle, thus exhausting their resources and physical energy.

Doubtless many people wish to emigrate to Central Asia ; indeed, a certain number have already appeared there, but they arrive without knowing where to go, how to distinguish between cultivable and really sterile lands, ignorant of the local methods of agriculture and the tools to employ, and, in short, of all the laws of existence in the country and the proper method of beginning work. Thus, Government co-operation would be of immense value to the emigrants in the following directions :—

(1.) Preparing exact topographical maps showing the lands fit for colonisation.

(2.) Studying the best systems of irrigation, and carrying out the projects which up to the present have been found practicable.

(3.) Organising in the most important centres schools of agriculture according to the type elaborated by the Crown Lands Office. To these model-farms should be attached, the chief object of which ought to be to instruct the colonist in the cultivation of those crops which offer the best chance of success, and, consequently, have the greatest tendency to promote the well-being of the agriculturist.

ON THE SCIENTIFIC RESULTS OF DR. NANSEN'S EXPEDITION.

I.—GEOLOGY.

BY PROFESSOR J. GEIKIE, D.C.L., LL.D., F.R.S.

IN the Appendix to his most interesting and instructive work, *The First Crossing of Greenland*, Dr. Nansen treats of the scientific results of his remarkable journey. The detailed enumeration of these results, he tells us, would have been out of place in a general account of his expedition, but will appear in due time elsewhere. Hence he confines attention in his present work to such questions as are of most obvious interest, such as the extent, outward form, and elevation of the inland ice of Greenland. By way of introduction his readers are presented with some account of the geological history of the country, which, although it contains nothing that was not already familiar to geologists, will doubtless prove interesting to others. After indicating that Greenland would appear to be composed almost exclusively of Archæan schists and granitoid eruptive rocks, the author glances at the evidence which the Mesozoic and Cainozoic strata of the west coast have supplied as to the former prevalence of genial climatic conditions. Heer is cited to show that during the formation of the Cretaceous beds the mean temperature of North Greenland was probably between 70° and 72° F., while in later Cainozoic times it could not have been less than 55° F. in 70° N.L. Of course these conclusions are based on the character of the fossil floras. Now the mean annual temperature on the west coast of Greenland, where

the relics of these old floras occur, is about 15° F., from which it is inferred that there has been a decrease of 40° since Cainozoic times. In those times, says Dr. Nansen, "the country must have rejoiced in a climate similar to that of Naples, while in the earlier Cretaceous period it must have resembled that of Egypt." He then refers to the well-known fact that, long after the deposition of the Cainozoic beds of Greenland, intensely Arctic conditions supervened, when the inland ice of that country extended much beyond its present limits. This was the glacial period of geologists, during which all the northern regions of America and Europe, down to what are now temperate latitudes, were likewise swathed in ice. Various hypotheses have been advanced in explanation of these strange climatic vicissitudes, and some of them are very briefly discussed by Dr. Nansen. None of the suggested solutions of the problem quite satisfies him; but he appears to look with most favour on the view that great climatic revolutions in what are now polar regions may have resulted from movements of the earth's axis. He admits, however, that there are certain strong objections to this hypothesis, and concludes that we have not yet got any satisfactory explanation to cover all the facts of the case. In discussing the question of a possible wandering of the pole, the author cites certain astronomical observations to show that the position of the axis is even now slowly changing, the movement amounting to half a second in six months. This is not much; but if the change, as he remarks, were to continue at the same rate for 3600 years, the shift would amount to one degree. Thus in a period of no more than 72,000 to 108,000 years Greenland might be brought into the latitude required for the growth of such floras as those of Cainozoic and Mesozoic times. Geologists will readily concede these or longer periods if they be required, but they will have graver doubts than Dr. Nansen as to whether any such great changes in the axis are possible. The astronomical observations referred to, even if they were fully confirmed, do not show that the movement is constant in one direction. They indicated, as he mentions, a slight increase of latitude during the first quarter of 1889, followed in the second quarter of the same year by a decrease, which continued to January 1890. Since the publication of Professor George Darwin's masterly paper on the influence of geological changes on the earth's axis of rotation, geologists have felt assured that the great climatic revolutions to which the stratified rocks bear witness must be otherwise explained than by a wandering of the pole. Indeed, the geological evidence alone is enough to show that profound climatic changes have taken place while the pole has occupied its present position. Thus, there are no reasonable grounds for doubting that during the Glacial period the pole was then just where we find it to-day. For, under existing geographical conditions, could a sufficient lowering of temperature be brought about, snow-fields and ice-sheets would gather and increase over the very same areas as we know were glaciated in Pleistocene times. Further, we have only to recall the fact that several extreme revolutions of climate supervened during the so-called Glacial period, to see how impossible it is to account for the phenomena by movements of the earth's axis.

If it be true that the great climatic changes of the Pleistocene period did not result from a wandering to and fro of the pole, then it is not at all likely that the Mesozoic and Cainozoic climates of Greenland were induced by any such movement. But does the geological evidence justify us in believing that the climates in Greenland during Cretaceous and Tertiary times really resembled those of Egypt and Southern Italy? It may be strongly doubted if it does. Palæontologists, like other mortals, find it hard to escape the influence of environment. They are apt to project the actual present into the past, without, perhaps, fully considering how far they are justified in doing so. Because there occur in Cretaceous and Tertiary strata, within Arctic regions, certain assemblages of plants which find their nearest representatives in Southern Italy and Egypt, surely it is rather rash to conclude that Greenland has experienced climates like those now characteristic of Mediterranean lands. All that the evidence really entitles us to assume is simply that the *winter temperature* of Greenland was formerly much higher than it is now. That great caution is required in comparing past with present climatological conditions may be seen by glancing for a moment at the character of the flora which lived in Europe during the inter-glacial phase of the Pleistocene period. The plants of that period are for the most part living species, so that while dealing with these we are on safer ground than when we are treating of the floras of periods so far removed from us as those of Tertiary and Cretaceous times. Now, in the Pleistocene flora of Europe we find a strange commingling of species, such as we nowhere see to-day over any equally wide area of the earth's surface. During Pleistocene times many plants, which are still indigenous to Southern France, flourished side by side in that area with species which are no longer seen in the same region; some of these last having retreated because unable to support the cold of winter, while others have retired to the mountains to escape the dryness of the summer. Similar evidence is forthcoming from the Pleistocene accumulations of Italy, Northern France, and Germany. In a word, clement winters and relatively cool and humid summers permitted the wide diffusion and intimate association of plants which have now a very different distribution, temperate and southern species formerly flourishing together over vast areas of Southern and Central Europe. And similarly we find that during the same period the regions in question were tenanted by southern and temperate forms of animal life—elephants, rhinoceroses, and hippopotamuses, together with cervine, bovine, and other forms, not a few of which are still indigenous to our continent—that ranged from the shores of the Mediterranean up to our own latitudes. We cannot doubt, indeed, that the present geographical distribution of plants and animals differs markedly from anything that has yet been disclosed by the researches of geologists. The climatic conditions of our day are exceptional as compared with those of earlier times, and the occurrence in Greenland of southern types of plants, therefore, does not justify us in concluding that climates like those of Southern Italy and Egypt were ever characteristic of Arctic regions. It is a low winter temperature rather than a want of great summer heat that restricts the range northward of southern floras. If Greenland could be divested of

its inland ice—if its winter temperature never fell below that of our own island—it would doubtless become clothed in time with an abundant temperate flora.

Judging from what is known of the various floras and faunas that have successively clothed and peopled the world, from Palæozoic down to the close of Cainozoic times, the general climatic conditions of the globe, prior to the Glacial period, would seem to have been prevalently insular rather than continental as they are now. The lands appear to have been formerly much less continuous, and ocean currents from southern latitudes had consequently freer access to high northern regions than is at present possible. In no other way can we account for the facts connected with the geographical distribution and extent of the fossiliferous formations. But are we to infer, from the occurrence of similar assemblages of marine organic remains in Arctic, Temperate, and Tropical latitudes, that the shores of primeval Greenland were washed by waters as warm as those of the tropics? Surely not: an absence of very cold water in the far north is all that we seem justified in assuming. And so, in like manner, the presence in Greenland of fossil floras having the same general facies as those that occur in the corresponding strata of more southern latitudes, does not compel us to believe that conditions at all similar to what are now met with in warm-temperate and sub-tropical lands ever obtained in Arctic regions. A relatively high winter temperature alone would permit the range northward of many tribes of plants which are now restricted to southern latitudes. Yet, under the most uniform insular climatic conditions that we can conceive of, there must always have been differences due to latitude—although such differences were never apparently so marked as they are now.

In order to appreciate the character of the climate which must have prevailed when the lands of the globe were much more interrupted and insular than at present, we have only to consider how greatly isothermal lines, even under existing continental conditions, are deflected by ocean currents. In the North Atlantic, for example, the winter isotherm of 32° F. is deflected northward from the parallel of New York to that of Hammerfest—a displacement of at least 30° of latitude. The Arctic Sea now occupies a partially closed basin, into which only one considerable current enters from the south. But in earlier ages the case was otherwise, and there were often communications across what are now our continental areas. Instead of being girdled, as at present, by an almost continuous land-mass, the Arctic Sea seems to have formed with the circumjacent ocean one great archipelago. Thus freely open to the influx of southern currents, it is not difficult to believe that the seas of the far north might never be frozen, and that an “inland ice” like that of Greenland would be impossible. The present cold summers of that country, as the late Dr. Croll has insisted, are due not so much to high latitude as to the presence of snow and ice. Could these be removed, the summers would be as warm at least as those of England. Now the occurrence in Arctic regions of Palæozoic and Mesozoic marine faunas is strongly suggestive of the former presence there of genial waters having free communication with lower latitudes; and it is to the presence of

these warm currents, flowing uninterruptedly through polar regions, that we would attribute the high winter temperature and uniform climate to which the fossil floras and faunas of Greenland bear testimony.

If these views be at all reasonable, it seems unnecessary to call to our aid hypothetical changes in the position of the earth's axis. It may be admitted, however, that the climate of the Arctic regions must have been from time to time more or less affected by those cosmical causes to which Croll has appealed. So long, however, as insular conditions prevailed, the changes induced by a great increase in the eccentricity of the earth's orbit would not necessarily be strongly marked. Dr. Nansen objects to Croll's well-known theory that "it cannot account for the recurrence of conditions so favourable as to explain the existence in Greenland of a climate comparable to what we now find in Tropical regions." No doubt it cannot, but, as we maintain, there is no good reason for supposing that tropical or sub-tropical climates ever characterised any area within the Arctic Circle. The remarkable association in Europe, during so recent a period as the Pleistocene, of southern and temperate species of plants and animals, ought to warn us against taking the present distribution of life-forms as an exact type of the kind of distribution which characterised earlier ages. It is safe to say that were our present continental areas to become broken up into groups of larger and smaller islands, so as to allow of a much less impeded oceanic circulation, the resulting climatic conditions would offer the strongest contrast to the present. And as the lands of the globe were apparently in former times more insular than they are now, it is hazardous to compare the climates of the present with those of the past. It is reasonable to infer, from the occurrence in Greenland of fossil floras which find their nearest representatives in Southern Europe and North Africa, that the winters of the far north were formerly mild and clement. But we cannot conclude, from the same evidence, that the Arctic summers were ever as hot as those of our present warm-temperate and sub-tropical zones.

But if the recent expedition has thrown no new light on the disputed question as to the cause of the high temperature which formerly prevailed in Greenland, it is needless to say that it has added considerably to our knowledge of the present physical conditions of that country. The view held by many that Greenland must be wrapped in ice has been amply justified, and we can now no longer doubt that the inland ice covers the whole country from the 75th parallel southwards. A section of Greenland in the latitude at which it was crossed by Nansen and his comrades "gives an almost exact mathematical curve, approximating very closely to the arc of a circle described with a radius of about 6500 miles. The whole way across the surface coincides tolerably accurately with this arc, though it falls away somewhat abruptly at the coasts, and a little more abruptly on the east side than the west." Taking the observations of other Arctic travellers with his own, Nansen is led to the conclusion that "the surface of the inland ice forms part of a remarkably regular cylinder, the radius of which nevertheless varies not a little at different latitudes, increasing markedly from the south, and consequently making the arc of the surface flatter and flatter as it advances northwards." He points out

that this remarkable configuration must to a certain extent be independent of the form of the underlying land-surface, which, to judge from the character of the wild and mountainous coast-lands, probably resembles Norway in its general configuration—if, indeed, it be not a group of mountainous islands. The buried interior of Greenland must in fact be a region of high mountains and deep valleys, all of which have totally disappeared under the enveloping *mer de glace*. It is obvious, as Dr. Nansen remarks, that the minor irregularities of the land “have had no influence whatever upon the form of the upper surface of the ice-sheet.” That form has simply been determined by the force of pressure—the quasi-viscous mass attaining its maximum thickness towards the central line of the country, where resistance to the movement due to pressure must necessarily have been greatest. Thus although the larger features of the ice-drowned land may have had some influence in determining the position of the ice-shed, it is not by any means certain that this central line coincides with the dominant ridge or water-shed of the land itself. For, as Nansen reminds us, the ice-shed of the Scandinavian inland ice of glacial times certainly lay about 100 miles to the east of the main water-parting of Norway and Sweden. Similar facts, we may add, have been noticed in connection with the old ice-sheets of Scotland and Ireland.

The greatest elevation attained by the expedition was 9000 feet. How deeply buried the dominating parts of the land-surface may be at that elevation one cannot tell. It is obvious, however, that the *mer de glace* must be very unequal in thickness. According to Dr. Nansen the average elevation of the valleys in the interior cannot much exceed 1000 or 2000 feet, so that the ice lying above such depressions must have a thickness of 5000 or 6000 feet. It cannot, of course, lie so deeply over the mountain ridges. The eroding power of such a glacier mass must be enormous, and Dr. Nansen does not doubt that the buried valleys of Greenland are being widened and deepened by the grinding of the great ice-streams that are ever advancing towards the sea.

The expedition met with no streams of surface-water on the inland ice; indeed, the amount of superficial melting in the interior was quite insignificant. And yet, as is well known, many considerable streams and rivers flow out from underneath the inland ice all the year round. It is obvious, therefore, that this water supply does not come from superficial sources, as, according to Dr. Nansen, it is usually supposed to do. But surely it has long been recognised that such rivers as the Mary Minturn must be derived from sub-glacial melting. And the various causes to which our author attributes this melting have already frequently been pointed out. Earth-heat—the influence of pressure in lowering the melting-point of ice—and the friction induced by the movement of the ice itself have all long ago been recognised as factors tending to produce the sub-glacial water-drainage of an ice-sheet.

Dr. Nansen's speculations on the origin of the “drumlins” and “kames” of formerly glaciated areas will interest geologists, but are not so novel as he supposes. His description of what are known as “drumlins” is not quite correct. These long lenticular banks cannot be

said to lie upon boulder-clay, but are merely a structural form of that accumulation. And it is hardly the case that geologists have "performed the most acrobatic feats" in trying to explain the origin of the banks in question. The usual explanation is that they have been formed underneath the ice as ground-moraine—the upper surface of which varies in configuration—being sometimes approximately even, as in broad mountain valleys; at other times ridged and corrugated, as in open lowlands. And these modifications of surface are supposed to have resulted from the varying movement and pressure of the overlying ice-sheet. The drumlins, in fact, would appear to be analogous to the banks that accumulate in the beds of rivers. Many drumlins, indeed, are composed partly of solid rock and partly of boulder-clay, which would seem to have accumulated in the lee of the projecting rock, much in the same way as gravel and sand gather behind any large boulder in a stream-course. Dr. Nansen, apparently, to some extent confounds drumlins with "kames" and "âsar," of which certainly many strange and conflicting explanations have been hazarded. These, however, differ essentially from drumlins, for they consist exclusively, or almost exclusively, of water-worn and more or less water-assorted materials. And the most generally accepted view of their origin is that they have accumulated in tunnels underneath an ice-sheet. This is practically the same view as Dr. Nansen's. He thinks that when an ice-sheet has its under surface furrowed by running water, the ground-moraine will tend to be pressed up into the river-channels. The water will, in this way, be compelled to hollow out the roof of its tunnel to a greater degree, and as the stream continues to work upwards the moraine will follow it, so as to partially fill the tunnel and form a ridge along the back of which the sub-glacial stream will run. The material forming the upper portion of the ridge will thus come to be composed mainly of water-worn and stratified detritus, derived from the erosion of the ground-moraine. This is an ingenious suggestion which may be of good service in some cases, but it is certainly inapplicable to most kames and âsar. If it were a complete explanation we ought to find these ridges consisting of an upper water-assorted portion and a lower unmodified morainic portion (boulder-clay). But this is not the case, for most kames consist entirely, from top to bottom, of water-assorted materials. They are found running across an even or gently undulating surface of boulder-clay, and sometimes they rest not on boulder-clay but solid rock.

Dr. Nansen considers another geological question which has given rise to much controversy, and is still far from being settled—namely, whether the oscillations of level which have left such conspicuous traces in northern regions are in any way connected with the appearance and disappearance of great ice-sheets. Can a big ice-sheet push down the earth's crust by its weight? and does the crust rise again as the ice melts away? Could a thick ice-sheet exercise sufficient attraction upon the sea to cause it to rise upon the land, and thus explain the origin of some of the so-called raised beaches of this and other formerly glaciated lands? Can the weight of a great ice-sheet shift the earth's centre of gravity, and, if so, to what extent? Each of these questions has been

answered in the affirmative and the negative by controversialists, and, until the geological evidence has been completely sifted, each, doubtless, will continue to be alternately affirmed and denied. All that need be pointed out here is that some of the movements which occurred during the Pleistocene period were on much too large a scale to be explicable by any of the hypotheses referred to.

OBITUARY: 1890.

BERGHAUS, HERMANN.—No name is better known to geographers than that of "Berghaus"—uncle and nephew—who have, each in his time, produced the most famous cartographical works of the century. The uncle, Dr. Heinrich Berghaus, who died in 1884, at the ripe age of eighty-seven, was the author of the first great Physical Atlas, well known in this country as being the basis of Keith Johnston's. The nephew, Dr. Hermann Berghaus, who died at Gotha, 3d December 1890, may be said to have continued and completed the work of his uncle. The third son of the Evangelical preacher Johann Berghaus, he was born at Herford, in Westphalia, 16th November 1828. Most of his life was spent at Gotha, where in 1850 he entered the Geographical Institute of Justus Perthes, just four years before Petermann went there. In Gotha he led an active life of study and work, which has been prolific in producing many valuable and original maps. Among his first works may be mentioned the physical map in *Stieler's Hand-Atlas* and *Stieler's Schul-Atlas*, also many miscellaneous school atlases, maps, and physical wall-maps. In 1861 he produced his *Karte des Oetzthales Gletschergebietes*; in 1863 his well-known *Chart of the World*, which has gone through many editions; in 1875, *Physikalische Wandkarte von Europa*; in 1878, *Karte der Alpen*; in 1881, *Physikalische Wandkarte von Afrika*. These works, however, are of but minor importance compared with his last work, *Berghaus Physikalischer Atlas*. Planned and worked out with the assistance of all the leading scientific geographers in Germany, it is undoubtedly the greatest work on physical geography at the present day, and will prove a lasting monument to Hermann Berghaus, although he has not lived to see it completed.—J.G.B.

BURTON, SIR RICHARD F., K.C.M.G.—By the death of Sir Richard F. Burton England has lost one of her most daring and successful travellers and explorers, a scholar of rare literary and scientific acquirements, and a gifted writer. He died on the 20th of October at Trieste, where he had filled the office of British Consul since 1872. He was born in 1821 at Barham House in Hertfordshire, and was the son of Colonel Netterville Burton of the 36th Regiment. He is said to have inherited from both sides of his parentage the wilful disposition and the love of unfettered action which were predominant elements in his character, and which had a great influence in the shaping of his destiny. In his early years he was left very much to his own devices. His education also was of the most desultory nature, and but little calculated to train him to habits of subordination. The most part, in fact, of his boyhood and youth