AN ADDRESS DELIVERED
BY
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# FUNDAMENTAL PRINCIPLES OF SCIENTIFIC ARCTIC INVESTIGATION.

GENTLEMEN,

When I venture to claim your attention for a few moments, I do so with the purpose of presenting for kind consideration to you, the German representatives of Natural Science, the varied experience gained during a long voyage and the opinions based upon it, concerning Scientific Arctic Investigation, the real objects to be sought and the most suitable means of attaining them.

If a general and complete view of the scientific results of former Arctic Expeditions be taken, it is at once seen that they bear no proportion to the enormous sums expended upon them. Within the last 50 years, England and America alone have sent out more than 25 large or small expeditions at a cost of far beyond a million of pounds sterling. With astonishing perseverance and tenacity, and with incredible labour and exertion, the Archipelago which lies buried in ice, North of America, has been crossed on sledges in all directions and at length, the object so long sought — the connection of Baffins bay with the Western Icy sea — was proved. The value of this discovery lies rather in the immense expense of labour and sacrifice which it cost, as a proof of what man is capable in pursuit of an ideal object, than in any scientific acquisitions obtainable from the narrow icebound channels which join the two seas.

The most important scientific results of this long series of costly expeditions are the discovery of the magnetic pole, the determination of the physical constants for a number of points, a more extended knowledge of the Natural History of high Northern regions, and finally the topography in detail, of a cluster of islands of little importance.

On a closer analysis however, the scientific value of these results shrinks greatly. The gains to Natural History are locally far too limited considering the number of voyages, nor have the researches been systematically conducted, while the physical observations, owing to the manner in which they have been made, offer us little more than unconnected average values, which through local influences and annual fluctuations, neither to be avoided nor overcome, possess less value than generally has been accorded to them. On the other hand, the determination of the point of greatest magnetic inclination is of high scientific importance.

It is probably not saying too much when we assert that the Polar regions are the most important portions of our globe for the study of the Natural sciences. The extreme conditions under which the forces of Nature act in the vicinity of the Poles, produce phenomena, which offer us the best means of investigating the nature of the forces themselves. There is hardly a branch of Natural Science which is not deeply interested in Polar research.

At the head stands Terrestrial Magnetism, both one of the obscurest and most interesting questions of physics. The time has long since past, in which only a secondary importance was attributed to this force; yet in spite of all our industry, in spite of all our sagacity, we have advanced but a few steps beyond elementary principles towards a knowledge of it.

The investigations of General Sabine have proved that the Terrestrial Magnetism is subjected to cosmical influences; Professors Wolf and Schwabe have shown a connection between its perturbations and solar spots; Professors Lamont and Airey have demonstrated the existence of terrestrial galvanic currents and, finally, direct observations have exhibited the connection of magnetic disturbances with the Northern lights and earthquakes. We have therefore before us in Terrestrial Magnetism a force, which is subject to cosmical, atmospherical and terrestrial influences and as, throughout Nature, action and reaction are reciprocal, probably also exerts the same influences.

The importance of magnetism in physics is the greater from its indissoluble connection with electricity and galvanism, - forces whose significance in the economy of Nature we can only divine from the fact that there is hardly a mechanical or a chemical process in which one or the other cannot be proved to be concerned.

The disturbances to which the Earth's magnetism is exposed, form the fittest and almost the only means for extending our knowledge of it. If we are once able to discern their causes, we shall be in the best way to fathom the nature of the force itself. One theory, beautiful for its simplicity, refers all the phenomena of magnetism to galvanic currents which circle the earth. The great perturbations about the Poles can yield us positive information on this point.

In our regions, where the needles exhibit little more than their diurnal and annual variations and where the disturbances are but rare and comparatively feeble, the conditions are not sufficiently favourable. To attempt to deduce from them the laws to which they are subject, - just as well we might seek in our summer breezes the laws of tropical hurricanes. The key to the true theory of magnetism probably lies there, where the needle hardly ever comes to rest, where Terrestrial Magnetism is subjected to constant stormlike changes, that is to say, in the thorough study of their causes in those regions.

This is equally true of that grand phenomenon, that riddle in physics, which Nature has written in letters of fire on the Arctic heavens – the Northern light. He, who has seen this phenomenon in its full splendour, when in the vast silence the entire vault of heaven seems to consume in flames of intense colours, when streams of fire, furious and frantic,

in wild chase all around, rush upward to the zenith, he who has observed the excitement which in such moments manifests itself in the elements of Terrestrial magnetism – to him it must become a life task to aid in removing the thick veil which shrouds this mysterious exhibition of Nature's power. Although in most intimate connection with the disturbances of Terrestrial Magnetism and utterly inseparable from it, still it is out of our power to discern the links which chain them together. Theory after theory has been proposed, but none is adequate; the obscurity which lowers over this indescribable phenomenon is as intense today, as a hundred years ago.

For Meteorology, the conditions in the neighbourhood of the rigid Polar zones are of decided importance, for, as we all know, the general movement of the air in our atmosphere arises from the exchange of cold and warm, of dry and humid air between Poles and Equator. How enormous must be the influence of the huge masses of Polar ice upon the distribution of the Earth's heat, is obvious, and this distribution of heat is one of the corner stones of Meteorology. Greenland and Iceland afford proof how the movements of ice, driven by winds and oceanic currents, may affect the climate of a country. But our knowledge of these is very defective. Now it is possible that the ice of the Polar regions may be the regulator of our climatic conditions. The origin of many of those furious hurricanes, which in winter sweep destructive over Northern Europe is to be sought in the distant North.

Astronomy and Geodesy have also an interest in Polar investigation through the flattening of the Earth and the abnormal refractions observed in those regions.

It is hardly necessary to mention the importance of the Polar flora and fauna. Animal and vegetable life under conditions so extreme, the circumstances attending to the migration of animals to their ultimate stations – leaving entirely out of view the importance of descriptive Natural History – must be of high scientific interest. The expeditions of recent times have raised scientific treasures from the bottom of the sea, with every cast of the dredge net, and have proved the existence of submarine life there, in some spots actually richer, than in our own waters.

I venture farther to call attention to the importance of the Polar regions for the science of Geology and for the study of the phases through which our globe has past. Siberia with its animals of a former world, Nowaja-Zemlja, Spitzbergen and Greenland with their fossils, ate precious abundant mines for paleontologic science, and as it well known, have given rise to entirely new views in this field.

These leading points, so briefly noted, of what is desirable and necessary to learn from the Arctic regions, touch nearly all the branches of Natural Science and for some of them, are actually decisive. And yet in all these fields, what *has* been accomplished is insignificant in comparison with what might have been done!

For instance, today we are still wanting from the Arctic regions even one series of observations upon the disturbances of the three magnetic elements. The data furnished by the expeditions are confined to absolute determinations – sadly wanting in accuracy,

because exposed to ever casual disturbance – and to observations upon variations of declination. The disturbances of the horizontal intensity and of inclination have been utterly neglected. Of the relation in which the horizontal and vertical components of the Earth's magnetism stand to each other during the disturbances, we know nothing and are therefore unable to decide, whether the total force may not rather simply change in direction, and not in degree of strength. As to intensity and inclination, there is not a point from which we possess sufficiently accurate data to serve, after a lapse of years, as a basis for determination of secular changes.

It is true, great progress has been made in the study of Terrestrial Magnetism; but for this we owe less thanks, where above all they ought to have been due – namely to the Arctic expeditions – than to the observatories established near the Polar circle.

Similar remarks apply to the observations on the Aurora borealis.

In the treatises upon the magnificent physical phenomena whose home is in the Polar regions we see, notwithstanding the numerous Polar expeditions, that each new theory finds its basis and support in those exceptional and feeble imitations of these phenomena occasionally witnessed in our parts. This fact stamps the character of Arctic exploration.

The data for Meteorology and Natural science are, at the outset, defective, because confined within so comparatively narrow limits. While in the desolate Archipelago of the North of America numerous winter stations are found hard by each other, the rest of the Arctic region, so vast in extent, remained with a few exceptions, unheeded. Now, to undertake, on the basis of observations made in a comparatively so small space, to form conclusions upon the conditions of the unknown interior, is utterly inadmissible.

Unfortunately we might almost say, that we know not much more of Nature's doings in high Northern and Southern latitudes, than just enough to show us, how important a thorough scientific investigation of these regions is to Natural philosophy in all its branches.

If we enquire why, notwithstanding the so evident importance of the questions above specified – notwithstanding the readiness with which men and money have always been furnished – the scientific results obtained are so scanty, we discover that the fault lies less in the observations made, than in the generally false principles, on which hitherto Arctic expeditions have been sent out – principles which in most cases have actually been direct hindrances in the way of true scientific research.

The grand fault has been than the first object of almost all the expeditions has been geographical discovery. Every thing else has been made subordinate to this, and pure scientific research thrust thereby entirely into the background.

Originally it was pecuniary gain in the form of fur and oil producing animals, which induced voyages to the Arctic ice. In place of this came later the fame of geographical discovery so dazzling to the public eye. The mania for this has reached such a pitch, that

to-day Arctic exploration has become a sort of international steeple-chase with the North Pole for a goal, to the neglect, in all branches, of true scientific discovery, which is accessible only to a small number. The mere conquest of physical difficulties has usurped the place of real scientific labour. Everywhere the Arctic question is discussed, everywhere the best way to the Pole is a matter of dispute; but few enquire concerning the treasures of science, which lie scattered along that way.

Knowledge of our globe must, of course, possess deep interest for every cultivated mind; but in those unhabited and uninhabitable latitudes, which by force of their physical conditions, are important for science alone, descriptive Geography has value only in so far, as the meteorological, physical and hydrographical phenomena of the earth are influenced by the character of the land; broad and general sketches therefore suffice. Arctic Geography in minute detail is in most cases but a merely secondary matter; but when the true object of the expeditions – scientific research - is pushed aside and nearly stifled by it, as so often has been the case, it is positively objectionable. In the Arctic region, topographical Geography must subordinate itself to the physical. Geographical discovery is made valuable only by the scientific discovery associated with it.

The geographical object of former expeditions must bear the blame, that the stations of observations are crowded so one-sidedly within a single region. In the search for a North-West passage and in the attempts to reach the North Pole, the same routes have been continually adopted with little variation, and all else overlooked. To be sure, some of those expeditions had specially the sad object of seeking the remains of Franklin's disastrous expedition. In these, the employment of the sledge attained that extraordinary development which has excited such universal wonder and imitation. But where the sledge stands out prominent, scientific research can play but a secondary part. The journeys occupy the best time in spring and autumn and never admit of that repose which is essential to thorough observation. When actually journeying by sledge, scientific observation is, of course, out of question.

To what extent scientific research has been neglected in the greed for discovery, the best proof is, that it is only two years that the first party has wintered for purposes of science in the Archipelago of Spitzbergen, geographically well known and approachable even in 80º Lat, every year almost without obstacle, although these islands form one of the most important and favourably situated points for observation in the Arctic regions. It is to the expeditions to Spitzbergen and Siberia, fitted our at comparatively small cost, that we owe our most thorough studies of the flora and fauna of this and the antediluvial world, of the effects of the Arctic conditions on animal and vegetable life, etc.

The investigation of those vast unknown regions about the Poles will and must be pursued, regardless of cost of money and human life, so long as man makes any pretension to progress. But its great object must be a nobler one, than mapping and naming icebound islands, bays and promontories in this or that language, or reaching a higher latitude than any predecessor. Descriptive Geography neither can nor should be exluded, but must not stand as the object first in rank.

The Antarctic expedition conducted by Sir J.C.Ross was a model voyage and its results mark an epoch.

A second cause of inadequate results lies in this, that all expeditions have been single and independent and afford no synchronous observations for comparison.

Where and whenever the forces of Nature and the physical phenomena which they produce are the object of study, simultaneous observations on many points are a fundamental condition of success. In peopled countries, this condition in a degree fulfils itself over the greatest possible extent of surface through the multitude of chance observers. In the Polar regions the observer must depend on himself; the simplest and most important data are wanting; for instance, the extent of territory covered by a phenomenon. In a far higher degree is this true in regard to those phenomena not perceptible by the senses and only perceived by the aid of instruments. Nothing but simultaneous and most careful observations made at numerous stations more or less widely separated, can yield decisive results.

After Gauss and Weber had introduced the synchronous magnetic *termdays*, the science of Terrestrial Magnetism very soon burst the narrow bounds, in which until then it had been restrained. Animated by their success, England established her colonial observatories and by them proved the subjection to natural laws of all magnetic phenomena. But none of these stations reached the Arctic regions, the most northerly being in latitude 61°. However interesting and important their observations are, still they do not suffice to give us that view of the joint action of the combined forces of Terrestrial Magnetism in high latitudes – the extensive home of disturbance – which is absolutely indispensable to a sound theory. They leave us in the dark as to the position of the centres of disturbance, as to the limits of particular movements, as to their synchronism at different distances, as to the manner in which the separate oscillations exhibit themselves along the same parallel in different longitudes. Hence all conclusions as to the influence of local circumstances upon the strength and character of the disturbances, fail.

The English observations have proved that perturbations at various places in various years cannot be compared, since for instance in Toronto, they, in one year, amounted for the declination to three times and for the horizontal intensity, to six times as much as in another. It would therefore lead to utterly false conclusions if the Toronto, Sitka or Athabasca observations of different years be compared in the matter of intensity.

What may be said of magnetic disturbances is equally applicable to the Northern light. There are many reasons to believe that this phenomenon in high Northern latitudes has but a very local character, a point only to be decided by synchronous observations. For here, also, it would be false to compare different years at different points with each other. Different places that same year, or different years for the same places can only be compared. Through the frequent neglect of this axiom in analysing Auroral phenomena, many an error has crept in.

The entire meteorology of our day rests upon comparison; all the successes of which it can boats – the laws of storms, the theories of the winds – are results of synchronous observations. The average values of the meteorological constants of particular places are most important to the knowledge of the Physical conditions of the Earth, but they suffice no longer as soon as the question is: what are the laws which govern the changes to which they are subject? They can answer the 'how", but are rarely equal to the "why".

In following up any natural phenomenon to its origin, in the investigation of its causes, and thus of the phenomenon itself, in most cases nothing but the grouping together and the comparison of the greatest number of synchronous observations, can give decisive results.

It is obvious, that the influence of Arctic physical and meteorological conditions upon those of our own regions, can only be determined by comparison. Disconnected series of observations are utterly insufficient to this end.

The accessibility of the Arctic interior from different quarters is constantly discussed in all scientific circles. It has been common to draw conclusions from the favourable or unfavourable experience of Arctic voyagers by different routes and at different times, which conclusions have afterwards proved to be mistaken, because the difference in the condition of the ice in different years has not been taken into account.

In the years 1871 and 1874, the ice on the same meridian near Nowaja-Zemlya began at 78º latitude, but in 1872 it reached 6º farther South. Now it is probable that on the opposite side of the Arctic basin – the American coast – the case during this period was precisely the reverse. But this we cannot decide with certainty, because we do not know whether the exceptional increase of ice on this one side is necessarily conjoined with a decrease on the other; or whether perhaps the Arctic basin does not contain totally different amounts of ice in different years. We need that general view of the entire mass of ice and its movements, which can only be gained by simultaneous observations at various points. One sided judgements formed at a single point, whose conditions depend on the accidents of the year, will never enable us to draw correct conclusions as to the accessibility of the Arctic interior.

For the descriptive branches of science, synchronism is of less importance; these demand continuous systematic study. "*Voyages have enlarged the catalogues*" – Prof. C. Vogt writes me – "*but only continued observations on the spot produce the deeper scientific results*." To this the unscientific man is inadequate, however industrious a collector he may be. If our object be genuine progress in Natural History, the aid of the man of science is absolutely necessary, which we have had in but few instances.

In view of the ever increasing interest in Arctic research and of the readiness with which governments and private individuals are continually furnishing the means for new expeditions, it is desirable to establish the principles on which they should be sent out, so that their utility to science may be in proportion to the great sacrifices made, and they be

relieved of that adventurous character which does indeed charm the great public, but can only be prejudicial to science.

The following points meet the requirements set forth above:

I. *Arctic research is of the highest importance to the knowledge of Nature's laws.*

II. *Geographical discovery in those regions has a higher value in so far only, as it opens the field to scientific research in the narrower sense of the term.*

III. *Arctic topography in detail is but of secondary importance.*

IV. *The geographic {Pole has for science no greater significance than any other point in the higher latitudes.*

V. *Stations of observation are – without regard to their latitude – the more favourable in proportion to the comparative intensity of the phenomena under investigation.*

VI. *Independent series of observations have but secondary value.*

These requirements may be met without spending those enormous sums, which almost all Polar expeditions hitherto have cost, and which have made it impossible for the less wealthy nations to take part in Arctic discovery. It is not necessary to extend our sphere of observations into the very highest latitudes in order to secure scientific results of the greatest importance.

For instance, stations at Nowja-Zemlya (76º), Spitzbergen (80º), East- or West-Greenland (76º-78º), North America East of Berings Strait (70º), Siberia at the mouth of the Lena (70º) would give us a zone of observation quite around the Arctic regions. Greatly to be desired are stations near the centres of magnetic intensity. The observations there would be connected with our own through the stations already established near the Polar circle, which only need to be strengthened. The means expended on any one of the more recent attempts to reach the highest latitude would be amply sufficient to sustain all these stations for a year.

The object of these expeditions would be: With instruments precisely alike, governed by precisely the same instructions, and for a period of one year at least, to record a series of the utmost possible synchronous observations.

Attention should be directed above all to the various branches of Physics and Meteorology as being of the highest degree of importance, then to Botany, Zoology and Geology, and lastly to geographical details as being of secondary interest.

Should it be possible to establish in connection with these Arctic stations of synchronous observations one or more in the Antarctic regions, we might expect results of inestimable value.

The expenses of these limited expeditions might, through the accessibility of the stations, be kept within such reasonable bounds as to be easily borne, if divided among several nations.

The results, which might e expected from such a combination of minor expeditions are overshadowed above. But there is no necessity whatever of giving up the greater voyages of discovery, if they are only organised on a truly scientific basis.

Systematic synchronous observations – everything else apart – are so absolutely necessary on the one hand to farther progress in the Arctic interior, and on the other, top the study of Terrestrial Magnetism, that they must certainly, earlier or later, be undertaken. *They* will first point out to us in what direction hereafter our efforts must be made.

Although it would be exaggerating to affirm that the scientific problems above considered may thus be solved at a blow, yet it may confidently be foretold that the data so collected will throw a clear light on many obscure points. In the solving of one problem, others will arise, which will demand new observations in other directions. Step by step and constantly availing ourselves of previous results – so only can we expect to draw near the solution of Arctic physical enigmas.

If however, the principles hitherto followed are not discarded, if Arctic research be not conducted on a systematic and truly scientific basis, if geographical discovery be still made the main end and aim, and all our labour and exertion be devoted to it – in that case, whatever new expeditions are sent forth, the results will still be little more than the gain of a bit of land buried in ice, or a few miles of advance, wrestled with infinite exertion from the ice – matters almost of no account in comparison to the grand scientific problems, the solution of which still and ever, without rest and faltering, occupies the mind of man.

The views here expressed pretend to no novelty, but so far as I know, this is the first time that they have been, in distinct form, presented to the public.

I beg you, Gentlemen, to be assured, that I have no design, in what I have said, to undervalue the services of my Arctic predecessors, for few can better know how to appreciate the sacrifices which they have cost, than I. In truth, when I give public expression to these principles, I accuse myself and pronounce sentence upon the greater part of the results gained by my own bitter toil.

In conclusion, I take the liberty of communicating to this learned meeting, that the concurrence of Austria is assured, in case the project here presented in such rough outlines, should come to execution. A gentleman, to whom our thanks are due for the former expedition and who has himself already taken part on Polar Exploration, has again, in noble zeal for the farther pursuit of the grand object, offered, not only a very large donation towards the expenses of establishing one of the proposed stations, but also to accompany the expedition in person.