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## A PROPOSED EXPEDITION TO THE NORTH MAGNETIC POLE.\*

By Captain ROALD AMUNDSEN.

THERE are, as you are aware, magnetic forces in the Earth which cause the compass-needle to assume a certain position at each place on the Earth's surface. The north end of the needle points northwards, but not exactly in the direction of the geographical north pole. At some places it points east of the true north, at others west. If we were to imagine expeditions starting from various places on the surface of the Earth, and each moving forwards always in the direction indicated by the north end of its compass-needle, these expeditions would at last all meet at a point situated on Boothia, the most northerly peninsula of the American continent. This point is called the magnetic north pole of the Earth. If, on the contrary, these expeditions had taken the direction indicated by the south end of the needle, they would have met at last at a point on the antarctic continent—Victoria Land, near the south pole. This point is called the magnetic south pole of the Earth. These two magnetic poles are also remarkable from the fact that a so-called magnetic dipping-needle—that is to say, a magnetic needle that is movable about a horizontal axis—will at these places assume a vertical position, with the north end downwards at the magnetic north pole, and with the south end downwards at the magnetic south pole, while everywhere else its position is oblique; that is to say, making more or less of an angle with the horizontal plane. This angle is called the magnetic dip. Thus the dip at the Earth's two magnetic poles is  $90^\circ$ . The lines passing through all places with the same dip are called isoclines. The isoclines run round the Earth from east to west in the form of continuous lines. The isocline passing through all places at which the inclination is  $0^\circ$ , in other words, at which the needle assumes a horizontal position, is called the Earth's magnetic equator. It intersects the geographical equator in two points, in such a manner that about half of it, on the western hemisphere, lies south of the equator, and the other half, on the eastern hemisphere, north of the equator. The farther we withdraw from the magnetic equator, the greater is the dip of the north end of the needle in the northern hemisphere, and of its south end in the southern hemisphere, until we come to the magnetic poles, where, as I have said, the inclination is  $90^\circ$ .

In August, 1897, the Belgian South Polar Expedition, with its ship, the *Belgica*, on which I had the honour of being first officer, set out for the antarctic waters. The aim of the expedition was to reach South Victoria Land, and there endeavour to determine the exact locality of the magnetic south pole, of which the position is only approximately known. Plans subsequently made, however, carried us into the ice about Graham Land and Alexander Land, where we lay for thirteen months, frozen into the antarctic drift-ice west of Graham Land. It was here, in  $72^\circ$  S. lat., that the idea of getting to the magnetic north pole and exploring its surroundings first presented itself to me. During the long and comparatively idle winter, our original plan, of determining the position of the magnetic south pole, was of course constantly discussed, and this raised in its turn animated discussion of the question of terrestrial magnetic matters in general, and the situation of the magnetic north pole in particular. Some of the scientific men on board were of opinion that the position of the magnetic north pole was

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\* A Lecture delivered before the Norwegian Geographical Society in Christiania, November 25, 1901.

fixed by the determinations made by Sir James Ross in 1831; while others thought that it probably moved a little in the course of time. These discussions awakened a keen interest in me, as I daily had the opportunity of seeing the magnetic instruments we had with us in use, and also now and then of assisting in the taking of the observations. I gradually became more and more desirous of going up myself to arctic North America, and of investigating the conditions around the magnetic north pole, where no one has been since Ross.

Upon my return from the Belgian Expedition in 1899, I immediately began to collect all the works upon this subject that were to be found. The book I sought for longest, but did finally obtain, was Sir James Ross's account of his journey and his investigations on the subject of the magnetic north pole. On reading this book, my longing to find the so-little-known magnetic centre was still further stimulated, and I determined to confer at once with men versed on the subject, as to whether my project could possibly bring to magnetic science any results worth mentioning. With this view, I first applied to the assistant director of the Meteorological Institute in Christiania, Hr. Axel Steen, whom I knew to be at that time engaged in working up the magnetic observations of the *Fram* expedition. Hr. Steen, who immediately expressed his entire sympathy with my plan, and kindly promised to assist me with advice and information, was of opinion that I ought first to make myself acquainted with the magnetic instruments in the observatory in Christiania and with their employment, and then seek an opportunity for more advanced magnetic study at the Deutsche Seewarte in Hamburg. When, acting upon this advice, I applied to the director of the Christiania Observatory, Prof. Geelmuyden, I was received in the most kindly manner, the professor himself showing me the instruments, and giving me some valuable instruction in the various methods used in the determination of the terrestrial magnetic elements.

In the autumn of 1900 I went to Hamburg to see the director of the Deutsche Seewarte, the renowned magnetician Prof. Neumayer, to whom Hr. Axel Steen had kindly given me a letter of introduction. I shall not soon forget my first meeting with the celebrated Geheime Admiraltätsrath, and I must be permitted to describe it in a few words. I was announced and shown into a characteristically furnished workroom, where I found myself in the presence of an elderly man with long white hair. After the usual exchange of civilities, I soon became aware that my stock of German words was becoming exhausted. In vain did I tax my memory to the utmost; I was completely at a loss. How agreeable was my surprise, therefore, when the professor, quickly grasping the situation, came to my rescue by continuing the conversation in English. I now managed comparatively well, and laid my plan before him. To my question as to whether a closer investigation of the position of the magnetic north pole would be of great interest, he replied, "An exact determination of the Earth's magnetic north pole will be of immense value to science." Whatever doubts I may have previously entertained about venturing upon the realization of my contemplated undertaking, they were instantaneously dispelled by this answer, coming as it did from the greatest authority of the present day on the subject of terrestrial magnetic investigations. During the time that I now worked at the Deutsche Seewarte, I was treated more as a welcome guest than as an unknown stranger; and the kind old director himself superintended my studies all the time. The magnetic laboratory was placed at my disposal, with the necessary instruments. The laboratory was the same in which Captain Scott-Hansen, of the Norwegian Navy, had worked before his departure in the *Fram*. I worked there every day, and soon became acquainted with the instruments and methods of observation. The calculation from observations I learnt under Prof. Neumayer's assistant, Dr. Maurer. It was with sincere

regret that I bade farewell a couple of months later to the *Deutsche Seewart*, with its agreeable and obliging staff. On my return to Christiania, I called upon Prof. Nansen, and laid my plan before him. He promised me his valuable advice in the matter of equipment. Being myself so inexperienced, I am deeply grateful for this kind offer from the greatest polar explorer of the age.

In January of the present year (1902) I went to Tromsø to look for a vessel that would be suitable for my contemplated expedition. I there purchased the whaler *Gjøa*, which is renowned as one of the strongest and best sailing-vessels in the arctic fleet. The reason of my buying it so early was that I wished first to make a voyage in her in the Arctic ocean, and become acquainted with her before starting on the actual voyage. On this arctic trip, which lasted from April to September, I had plenty of opportunity of judging of the qualities of the vessel.

Acquaintance with the various ways in which the Earth's magnetic forces manifest themselves dates back to an early period of history. It is true that the inventor of the mariner's compass is said to have been an Italian, Flavio Gioia, who lived at the beginning of the fourteenth century; but the Chinese are said to have known and employed a special form of this instrument long before our era. It was not, however, until the beginning of last century that the study of terrestrial magnetism, and the consequent collecting and working out of observations from various parts of the Earth, began to increase. I will here only mention the names of my countryman, Hansteen, and the German, Gauss. The numerous English expeditions sent out in search of a north-west passage brought the question of the position of the magnetic north pole into frequent discussion; and Ross's, Parry's, and Franklin's expeditions made it their special aim to obtain observations for the determination of the Earth's magnetic elements. This question, it is true, played a very secondary part in comparison with that of finding the desired north-west passage; but quite a valuable collection of magnetic observations was nevertheless obtained.

The honour of having practically determined, by his investigations, the position of the magnetic north pole is due, as I have already said, to the Englishman, Sir James Clark Ross. His uncle, Sir John Ross, was the leader of the expedition, James being the second in command. The object of the expedition was to find and force its way through the so-called north-west passage with the paddle-steamer *Victory*. It left England in 1829, and passed through Lancaster sound southwards through Prince Regent inlet, where it was hoped a way would be found westwards. The vessel was frozen fast in the ice in the Gulf of Boothia, and the expedition was forced to spend four winters in this region. During this long detention in the ice, they frequently met with Esquimaux who had never seen a European before. The *Victory* never came out again, and officers and crew had to make their way back by the aid of the ship's boats; and were at last rescued at the mouth of Lancaster sound by the barque *Isabella*, which had been sent out in search of the missing expedition. Though unsuccessful in its main object, the scientific results obtained were brilliant. It was after one of the winters thus spent in the ice that James Ross, on May 27, 1831, started on a sledge-expedition with the magnetic north pole as its goal. I will not weary you with details, but only quote a few fragments of his description of the journey. On June 1 he writes: "We commenced, therefore, a rapid march, comparatively disencumbered as we now were; and, persevering with all our might, we reached the calculated place at eight in the morning of June 1. I believe I must leave it to others to imagine the elation of mind with which we found ourselves now at length arrived at this great object of our ambition; it almost seemed as if we had accomplished everything that we had come so far to see and to do; as if our voyage and all its labours were at an end, and that nothing

now remained for us but to return home and be happy for the rest of our days." After expressing his opinion as to how another expedition ought to proceed in order to determine more accurately the position of the magnetic north pole, he says: "Having thus therefore stated, however briefly, what yet remains for future observation—having pointed out what, I may fearlessly say, is still wanting, and which, as such, claims the attention of those who have the power of promoting a work of this nature, I can only express my wishes, if I dare not indulge in hopes, that the same nation which has already carried its discoveries so far, that our own Britain which has already established its supremacy in scientific and geographical researches, will not now abandon them, and leave to others to reap the crop of which it has in this case sown the seeds."

James Ross thus arrived on June 1, 1831, at a spot where the dipping-needle showed an angle of  $89^{\circ} 59'$  with the plane of the horizon—in other words, was only deflected one minute from an absolutely vertical position. Practically this one minute is of little consequence, and Ross himself considered that he had now really reached the magnetic pole, whose geographical position he accurately determined to be  $70^{\circ} 5' N. lat., 96^{\circ} 47' W. long.$ ; and, satisfied with this result, he ceased all further investigations, and has thus contributed nothing towards the solution of the question that has since presented itself, namely, whether the magnetic pole is actually only a point, or whether possibly the peculiarity of the needle assuming a vertical position extends over a large area. Theoretical study of recent times points decidedly to the latter supposition. Another question that also demands a practical solution, and which I have already briefly touched upon, is whether the magnetic pole is stationary, or changes its position. It is the solution of these two questions that I have set myself the task of attempting.

I will now pass on to a brief account of the equipment, the route, and the manner in which I have thought of carrying out my plan. I shall start in the spring of 1903 in my vessel, the *Gjöa*. We shall be seven men on board, all told. The reason of my preferring a small vessel like this is that the waters which we shall navigate are very frequently narrow and shallow, and it is thus important to have a vessel that does not draw much water, and at the same time is capable of turning in its own length. A small vessel, especially one of the sloop build, requires a smaller crew, and is in consequence cheaper to fit out. The *Gjöa* is only a sailing-vessel, but I am going to have her fitted with a petroleum engine next year. This I regard as quite necessary, considering the difficult waters we shall have to navigate. The equipment will consist of the usual things required for a polar journey, such as fur clothing, tents, ski, snowshoes of various kinds, sledges, kayaks, etc., as also provisions for four years. Among the magnetic instruments is a travelling magnetometer of Prof. Neumayer's construction. This instrument will resemble that on board the *Fram*, but will be furnished with even more improvements. It has now been in the hands of the Deutsche Seewart's instrument-maker, Hr. Carl Seemann, for a year, and will not be ready until the spring. Owing to the warm interest he takes in my expedition, Prof. Neumayer has designed it especially for this occasion, and has personally superintended its construction. There is, therefore, no doubt but that this instrument will be perfect in every respect. There is also an inclinorium under construction at instrument-maker Dover's in London. Dr. Charles Chree, the director of the Kew Observatory, has most kindly promised to superintend the construction of this instrument. Thus as regards magnetic instruments, I think I may safely say that I am taking as complete and up-to-date an equipment as the fulfilment of my task can require. The meteorological instruments are barographs, barometers, and thermometers.

The oceanographic instruments I hope to be able to take, are sounding-machines,

deep-sea thermometers, and appliances for taking water-samples and bottom-samples. Among other instruments may be mentioned those necessary for navigation and sledge-journeys, such as sextants, artificial horizons, chronometers, and good watches. Petroleum will be used for the heating of the vessel when under way. I shall also take as much coal as space will permit, for use in the galley. During the winter I hope to be able to supplement our store of fuel with drift-wood. On our way westwards, it is my intention to visit one of the Danish colonies on the west coast of Greenland, for the purpose of taking thence some Esquimaux dogs, which will be of great service to us. We shall then make for Lancaster sound, where I hope to be by the middle of July. The course will continue through Lancaster sound and Prince Regent inlet to Bellot strait, where McClintock was stopped by the ice in 1858, when searching for the Franklin Expedition. Should the ice-conditions prove favourable, I intend to go on through Bellot strait, and make my way along the west coast of Boothia, leaving a depôt, if possible, at the spot where Ross found the magnetic north pole in 1831, and then seek for a suitable winter haven, either in Matty island or King William Land. Magnetic observations will be taken as often as opportunity affords. The autumn, 1903, will be employed in making depôts for the coming year. The winter will be employed in making magnetic and meteorological observations. I shall give special attention to the action of the magnetic forces during the occurrence of aurora borealis. Daily observations of ice-information, high and low water, etc., will also be taken. I have thus no doubt but that every man's time will be occupied. As soon as the severest part of the winter is over, I shall set off with three men, two sledges, and as many dogs as we may have, and make for the place on Boothia at which Ross observed the inclination-needle to make an angle of  $89^{\circ} 59'$  with the plane of the horizon, making observations all the way. Here, in the first place, a long series of careful observations will be made, after which, taking this spot as the starting-point, I intend to investigate the surrounding region in all directions regarding its magnetic conditions, with determinations of variations, intensity, and inclination, endeavouring, by a choice of stations, to encircle the magnetic north pole, or the region within which the needle assumes a vertical position. The second sledge will be sent back as soon as its aid can be dispensed with, with orders to see to the maintenance of the depôts. I hope, before the winter sets in, to have carried out the principal part of my programme, and in that case I intend to pass the following winter, 1904-5, with one companion, as near as possible to the magnetic north pole. The matter of supplies for my companion and myself, I think of arranging by replenishing the depôts so much during the summer months that they will also be sufficient for winter needs. As observatory and dwelling-house for my companion and myself during this winter, I intend to erect snow-huts after Esquimaux fashion. If my intention is carried out, we shall not be the first civilized men who have passed a winter under a snow-roof; for Dr. Rae, a traveller for the Hudson Bay Company, spent an entire winter with his men here on the north coast of North America, and found it an excellent way of wintering. I have myself had an opportunity of making experiments in this matter, and have found that even in a temperature of  $-40^{\circ}$  C. a dwelling of this kind forms a warm and comfortable abode. Both the first and the second winter, I shall try to set up both the inclinorium and the declinorium as variation-instruments, so that regular hourly readings may be taken in connection with aurora borealis observations. The meteorological observations will always be attended to on board.

In the spring of 1903, I think of repeating the work of the previous summer as a check, visiting systematically the old observation points, and there, or in

their immediate neighbourhood, taking a new series of absolute determinations of terrestrial magnetic elements. If this can be accomplished, I shall consider that the object of my journey has been fully attained. Our concern will then be to get back to the ship, and if this is accomplished in the still navigable part of the season, and the ice to the west should prove to be possible of penetration, I shall continue in that direction with the vessel, still taking magnetic observations as frequently as possible. I hope to be able to keep up the meteorological observations all the time without interruption. It is then my intention to make the return voyage, if all goes well and circumstances are favourable, by way of the north-west passage. I have now briefly sketched the plan of which it is my purpose to attempt the realization. It is, of course, possible that circumstances may compel me to alter it in some important points, and I am not blind, moreover, to the numerous difficulties with which I shall have to contend; but I set out with confidence, hoping to return with results which, to some extent at any rate, may prove valuable for scientific investigation.

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## REVIEWS.

### EUROPE.

#### BRITAIN AND THE BRITISH SEAS.

By HUGH ROBERT MILL, D.Sc.

WE welcome this first volume\* of a new and important series with a pleasure enhanced by anticipation and not diminished by perusal. The book is new, fresh, and forcible, abounding in unexpected theses handled with the skill one looks for from the author. It is obviously the fruit of thought and of wide reading, and invites the geographical public to enjoy its well-elaborated substance, while it tempts the critic to investigate its structure by dissection. The book, and presumably the series, does not compete with any other in the field, but approaches the desirable ideal of illustrating geographical principles by the facts associated with particular localities without giving an exhaustive geographical description. We are much accustomed to geographical writings in which ill-drilled details are put together anyhow, and drift aimlessly to no particular end. There is nothing of that kind here. Every fact brought forward points like an arrow on a map of the winds to a definite conclusion.

Of the two philosophical methods which might be employed in such a work, Mr. Mackinder has apparently chosen the deductive, which is indeed the only way by which a great body of material can be dealt with in a very limited space. It is by far the more attractive also, for it allows of great definiteness of treatment and the citation of a minimum of data, while it gives to the reader the pleasure of discovering

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\* 'Britain and the British Seas.' By H. J. Mackinder, M.A. With Maps and Diagrams. London: William Heinemann. 1902.