REVIEW ARTICLE

A STUDY OF THE EAST GREENLAND AND ASSOCIATED ICE

THE EAST GREENLAND ICE. By LAUGE KOCH. *Meddelelser om Grönland, vol.* 130, *No.* 3. *Copenhagen,* 1945. 10½ x 6½ *inches;* 374 *pages; diagrams, maps, and illustrations.*

With the growth in importance of the Arctic in recent years, Dr. Lauge Koch's comprehensive treatment of the ice of an important part of the Arctic in his recent paper: "The East Greenland Ice", is of particular value. The title of this pleasingly voluminous work belies to some extent its contents, however, even to those who would rightly assume that the treatment would include the ice off the southwest coast. The impact which the ice conditions off Iceland and off Southern Greenland coasts have made on local settlements is also covered in some detail.

Dr. Koch is careful to point out the reservations with which his results must be used and the possible sources of error which he lists in great detail. "Nobody knows better than myself" he writes, "the uncertainty of much of the material utilised in the present paper; even information on the ice conditions within the present century should often be employed with great criticism. However, in spite of this uncertainty, it grows constantly clearer the more one deals with the subject that the reports on the ice down through the ages contribute to our understanding of changes in the climate in the past centuries." This statement implies that while many essential features of daily, weekly and sometimes even monthly ice variations have often gone undetected, the broad outlines of the variations from season to season, year to year, and especially from one longer-period interval to another, have been recorded by those who have lived or sailed in these regions over a period of many years.

In the first chapter of the paper, Dr. Koch, by way of introduction, presents a concise ice terminology which is followed up with a brief discussion of the broad types of ice found in the Arctic and of the drift of the components that make up the East Greenland ice stream. In the second chapter: "Recent ice observations in East Greenland," he gives in great detail the little known facts about the ice along the East Coast and in the principal fjords, drawing heavily on his own experiences in that region within the 25-year period, 1913-1938, and on the reports from expeditions and from others since about the middle of the preceding century. This information should be of great interest to anyone actively concerned with the region. The chapter continues with a discussion of the glaciers and their production of icebergs from northeasternmost Greenland as far south as Angmagssalik. Here Koch draws the very interesting and reasonable conclusion, based on observations first made by Peary, that from 1892 to sometime in the middle 1930's the two northerly fjords, Independence and Hagens, have not been free from ice. The great accumulation of bergs (for this region) observed in these fjords in 1933 and 1938 would accordingly be the result of nearly half a century's production. This conclusion implies that the marked rise in temperature observed in other parts of the Arctic and elsewhere in recent decades has also occurred in northeasternmost Greenland since the freeing of so many bergs could only have occurred with a melting of the ice that held them.

The remaining three chapters form the main theme of the paper and deal with the year to year or longer interval variations in the ice in that part of the Arctic around east and southern Greenland and Iceland. The comprehensive and in some ways novel treatment of the subject in these chapters supersedes to a great extent all the earlier treatments of ice conditions in those regions, including Meinardus' classical paper early in the century and Speerschneider's

work that followed it, and should be of much interest to students of the long-term variations in the oceanic and atmospheric circulations. The results obtained appear to provide the only usable oceanographic and meteorological records in that region that go back for any length of time before 1845, when temperatures, for example, started to be regularly recorded at Stykkisholm.

In Chapter III, Koch discusses the ice conditions during 1898-1939 in the area between Spitsbergen and Greenland and the waters off Iceland and southwest Greenland, and gives a detailed analysis of the six very severe and six very mild ice years. These, in order of their severity and mildness, are respectively: 1918, 1917, 1907, 1934, 1912, 1906 (severe) and 1933, 1925, 1930, 1931, 1904, 1936 (mild); a finding that agrees very closely with independent investigations in the same general area. Unlike most other analyses which were derived from a consideration of the southerly position of the ice edge only, Koch's results were based on a sub-division of the entire area into 29 small units.

Chapter IV: "Statistical treatment of the ice around Iceland and southern Greenland", contains an analysis of the ice conditions off Iceland by considering the width of the ice-belt to the north during the month when it reaches its maximum without reference to its duration as was done by Thoroddsen. Actually Koch considers in addition the degree that Iceland is surrounded by ice. The results, covering the period 1877-1939, indicate that during the 20-year period 1880-1899 there were but 2 very light ice years off Iceland; during 1900-1919 8 such years, and during 1920-39 fully 17.

In the final chapter: "Ice conditions in the past centuries," there is first a critical analysis of the ice data that were compiled by Thoroddsen as far back as 1781. Although Koch has used more stringent criteria for estimating the ice conditions off Iceland, he generally arrives at basically the same results. Going further back and relying on information in the Icelandic annals, including the very sparse references during the time of the early settlement, he constructs several graphs showing the occurrence and duration of ice off Iceland down to the ninth century, and concludes that there have been great changes in the climate of the region. Considering the very marked rise in the temperature and diminution of ice measured in recent decades in that general region, his conclusion seems entirely valid. It should be explained that, until only about 30 years ago, it was generally held that no marked changes in the climate of Iceland and surrounding regions had occurred.

In viewing the results obtained by Dr. Koch, it is disappointing to find that, with one or two exceptions, they are shown by graphs only and one may hope that the tables upon which the graphs were based will some day be published for those who wish to use them.

One of these exceptions is the values derived from a special statistical treatment by the Danish meteorologist E. Hovmöller which are included in Koch's paper. Using a summation curve he finds, as a measure of the ice around Iceland, 45 units for the period 1781-1840, 2 units for the very mild period 1841-1854 (regular observations of temperatures at Stykkisholm were made since 1845), 53 ice units for 1855-1896, 18 for the years 1897-1918, and again 2 for the period 1919-1939, confirming the very mild period in that region about the middle of the last century as suggested by Meinardus.

The very interesting problem of the role of polar ice in the circulation of the ocean and the atmosphere has not been studied by Koch, this task having been undertaken by his colleagues, E. Hovmöller and A. Kiilerich, in two papers that have since been published in the same series, (*Med. om Grönland*, vol. 144, Pt. 1. 1947; Pt. 2. 1945). His own attempt to explain the causes of the long-term variations in the ice on the basis of a decrease in the depth of

the cold upper-layer in the Arctic ocean as has, for example, occurred between the time of the *Fram* and the North Pole-Sedov expeditions, is inadequate as he has omitted the atmosphere from consideration.

A special point of interest in Dr. Koch's paper is his classification of the broad types of pack ice of which he distinguishes six: Palæocrystic, the oldest, found in a narrow zone extending from off north Greenland southwestward to Alaska; North Pole, next oldest, which occupies the greater part of the Arctic ocean; Siberian; Spitsbergen, which, as shown on his Fig. 4, is the ice to the south and to the southeast and includes the ice in the Kara Sea; Baffin Bay ice; and lastly, the Atlantic ice which forms late in winter and early spring between Iceland and Spitsbergen outside the thick ice edge. This classification is essentially correct although it appears wrong to have included the Kara Sea ice under Spitsbergen, since as was pointed out by Wiese, the ice from this region drifts for the most part northward, to merge with the main Siberian ice masses which move first northwestward thence westward between the Pole and Spitsbergen, and finally towards the main exit of the Arctic ice masses as a component of the East Greenland ice stream. The ice west of Novaya Zemlya and to the south of Spitsbergen is, except for the regions immediately bordering these lands, considerably less thick than the ice of the Kara Sea and the commonly used designation of Barents Sea ice for this type of ice is, on the whole, to be preferred.

In his paper Dr. Koch has made a real contribution to the problem of Arctic ice by giving us, with much insight and understanding, as accurate a statement of the facts as could apparently be made. From this we obtain a picture of the ice conditions off Iceland and in that general region over a long period of years. The information he gives should prove of great value for the study of inter-relations between the ice and the oceanic and atmospheric circulations of the Arctic, and also of the circulation trends of the adjacent large ocean and land areas affected by the circulation of the Arctic to a marked degree. The information should also prove valuable for studies in other fields in which the ice plays an important part.

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