NOTES

Report on the Third Annual Conference on Atmospheric Chemistry, May 28—30, 1956

By W. A. MORDY, International Meteorological Institute in Stockholm

The third in a series of conferences on Atmospheric Chemistry was held at the Meteorological Institute, May 28—30, 1956. The two previous conferences have been reported in Tellus (1954, No. 3 and 1955, No. 3).

The purpose of the third conference, in addition to the necessary discussions related to the maintenance, extension and improvement of the European atmospheric chemical observational network, was to formulate ideas and recommendations for the types, numbers, and locations of atmospheric and geochemical observations needed during the International Geophysical Year.

In attendance at the conference were 27 scientists representing 18 scientific organizations as listed below:

J. Bouquiaux, Ministère de la Santé Publique, Brussels, Belgium.
G. Brodin, R. Agr. College, Uppsala, Sweden.
K. Buch, Helsingfors, Finland.
H. R. Byers, University of Chicago, U.S.A.
L. K. Coachman, Institute of Zoophysiology, Oslo, Norway.
L. J. L. Deij, Kon. Ned. Meteor. Instituut, Holland.
H. Egnér, R. Agr. College, Uppsala, Sweden.
E. Eriksson, Institute of Meteorology, Stockholm, Sweden.
S. Fonselius, Institute of Meteorology, Stockholm, Sweden.
R. M. Goody, Department of Meteorology, Imperial College, London, England.
E. Gorham, Freshwater Biological Association, Ambleside, England.
Edv. Hemmingsen, Institute of Zoophysiology, Norway.
S. L. Jansson, R. Agr. College, Uppsala, Sweden.
O. Johansson, R. Agr. College, Uppsala, Sweden.
F. Koczy, Oceanographic Institute, Gothenburg, Sweden.
F. Koroleff, Institute of Marine Research, Helsinki, Finland.
J. Låg, Agr. Coll. of Norway, Vollebekk, Norway.
J. Van Mieghem, Inst. Royal Météorologique de Belgique, Belgium.
W. A. Mordy, Institute of Meteorology, Stockholm, Sweden.
G. Neumann, Institute of Meteorology, Stockholm, Sweden.
H. Riehm, Landw. Versuchsanstalt, Augustenberg, Karlsruhe, Germany.
C.-G. Rossby, Institute of Meteorology, Stockholm, Sweden.
E. Schmacke, SMHI, Stockholm, Sweden.
P. F. Scholander, Institute of Zoophysiology, Oslo, Norway.
C. O. Tamm, Forest Research Institute of Sweden, Stockholm, Sweden.
S. L. Tierney, Meteorological Service, Dublin, Ireland.
H. Wexler, US Weather Bureau, Washington D.C., USA.

The conference was supported largely by funds granted by the International Union of Geodesi and Geophysics.

The first day of the conference was devoted to reports and discussions on the present state of and future plans for the networks in the different countries. This was followed by a general discussion aimed at formulating recommendations from the group concerning the desirable observational density, techniques and frequency, analysis control, network extension and data publication, and also means of financing and obtaining the necessary cooperation in the analysis of the gas and precipitation samples.

United States

Dr. Wexler, US Weather Bureau, reported on four aspects of the atmospheric chemistry and geochemical programs under way or planned by scientists in the U.S.: atmospheric investigations; oceanic investigations; the chemical composition of river waters, and investigations of the chemical composition of glaciers.

Atmospheric chemistry:

Dr. Junge has been analysing precipitation samples for Mg and Cl from 63 stations scattered over the United States. As these stations are much more widely separated than the Swedish stations a different scale of geographic variation in these constituents has been noted and therefore different patterns. As Dr. Junge's primary interest in this work has been in its relation to condensation nuclei, he now feels that he has no further need for the continuation of the network. Dr. Wexler indicated that the Weather Bureau is prepared to take over the network for the IGY as soon as necessary when provision can be made for the analysis of the precipitation samples. Three possible cooperating agencies for this work, he mentioned, are the U.S. Department of Agriculture, the U.S. Public Health Service, and the U.S. Geological Survey.

In addition to the program in the United States, 6 stations have been planned for the IGY in Antarctica. Samples of precipitation from these stations will be collected and analysed on return of the Antarctic parties to the United States.

In reference to CO_2 in the atmosphere, observations are currently being made on the West Coast of the United States and they are planned for selected stations in Antarctica during IGY. Dr. Charles Keeling, working with Dr. Harrison Brown at the California Institute of Technology, has been using a new technique for the measurement of CO_2. An instrument, developed by the Research Corporation of Pasadena, California, operating on the principle of infra-red absorption and subsequent heating of CO_2, records continuously the content of this gas with an accuracy of 0.3 ppm by volume. It is hoped that this instrument will work satisfactorily in Antarctic conditions although there are some complications related to corrections necessary for water vapor in the atmosphere. One instrument will be installed at Little America. Bottled samples for CO_2-analyses will be collected at inland stations in the Antarctic and Arctic as well as samples collected by reconnaissance aircraft of the Air Weather Service during IGY. In this regard Dr. Wexler mentioned the very cooperative attitude of Brig. Gen. Thomas Moorman of the USAF Air Weather Service toward assistance during the IGY.

Some interesting results of Dr. Keeling's work in California and Washington have been his determination that the variability of CO_2 decreases with altitude (even though the total amount seems to be generally the same as at sea level) and that different ratios between C^{13} and C^{12} exist at high and low altitudes. C^{13} is present in relatively large amounts at high levels. A diurnal effect is also seen in this ratio which reflects the diurnal effect in CO_2 near the earth's surface. CO_2 is rather more abundant at night as is C^{12} hence the ratio goes down, even at higher levels.

Oxygen (O_2) *measurements* are planned also for a number of stations. Dr. Wexler said that the objective of these measurements was to investigate further the annual variation in oxygen and to try to resolve certain differences in these measurements which appear in the literature. Glückauf has reported values of approximately 20.5 % by volume in summer and 20.8 % in winter. Kanwisher & Wolf have reported 20.83 % in summer and 20.95 % in winter. Observations will be made in Antarctica by bottled samples which will be sent to the US for analysis.

Ozone measurements by means of the Dobson ozone spectrophotometer will be made at Fairbanks, Alaska and Ice Island T-3 in the North. In the Continental United States,

observations are planned at Washington, D.C., Caribou, Maine, Green Bay, Wisc., Bismarck, N.D., Flaggstaff, Ariz., and Forth Worth, Tex. A Dobson instrument is also planned for Mauna Loa, Hawaii. An instrument has been shipped to Little America, Antarctica.

The Canadians are planning ozone measurements with the Dobson instrument at Alert, Resolute, Moosonee and Edmonton.

In reference to ozone it was reported that there has been some success in the United Kingdom in using the moon as a light source. It is hoped that this method will be established for use during the IGY. Total O_3 at the surface will also be measured at Little America using the chemical method developed by V. Regener.

Particulate matter is being investigated in air pollution research by Dr. James P. Lodge of the U.S. Public Health Service on the Farallon Islands, 40 miles west of San Francisco and at San Nicolas Island and Point Piedras Blancas in Southern California. The US Weather Bureau recently began investigations of the relationship of these particles to meteorological conditions. Of interest to date has been the fact that amounts of this particulate matter have been greater for air approaching from the open sea than from the land.

Oxidants are being measured in California at Mt. Hamilton, San Clemente Island, Crescent City, and numerous points in Los Angeles using the phenothalein-colorimetric technique. In addition approximately 30 locations in California are making oxidant measurements using the Haagen-Smit "rubber-band" method.

Measurement of water vapour by infra-red absorption is planned for the Antarctic and Arctic.

Tritium is being measured in precipitation samples for a number of locations by Dr. Libby, Atomic Energy Commission.

Dr. Irving Friedman of the U.S. Geological Survey is making measurements of *Deuterium* in sea water, precipitation and rivers.

Radioactivity measurements made over the world by U.S. scientists will be reported shortly in *Science* (Sept. 14, 1956). These show the world-wide extension of radioactive clouds from the Pacific experimental explosions.

Oceanic investigations:

The exchange of CO_2 between the sea and the atmosphere is an important question in meteorology and oceanography. During the IGY oceanographers will be making many routine analyses of the *chemical constituents of sea water*. Cores of *ocean sediments* will be analysed.

Chemical composition of river waters:

Dr. Friedman hopes to furnish kits to willing cooperators in an effort to get a world-wide sampling of river waters. Mr. William Rubey (US Geological Survey) is interested in salts contained in river waters as indicated by their chemical constituents.

Glaciers:

A 1,000 ft bore into the Greenland icecap is planned for the summer of 1956. Other deep drillings are planned in Antarctica during the IGY. A series of pits 5 to 10 meters deep may yield information on the annual accumulations of snow and the average annual temperature for Polar regions. O^{16}—O^{18} determination will be made of about 200 samples of snow and ice.

Professor Rossby said that he was concerned that nothing had been planned for synoptic measurements of CO_2 in the continental US and the Pacific.

Dr. Wexler answered that 10 or 15 stations were included in the original plans. These plans will be revised later.

Mexico

Following Dr. Wexler's paper Professor Rossby read from a letter from Dr. Fournier D'Albe, now a UNESCO adviser to Mexico, which reported that *precipitation samples* were being analysed from two stations (Mexico City, and a 4,160 m station not far from the city). They hope to extend the network soon.

Belgium

Dr. Van Mieghem reported that four routine stations are now in operation at Uccle, Bruges S:t André, Dorubes and Botrange. Air and precipitation samples are being taken. He mentioned some practical problems related to power transmission which appear to be correlated with atmospheric-chemical variations. Corona discharges occur from the power lines when the weather is foggy, the winds light and the relative humidity high.

Trial measurements of *radioactivity* by air filter samples are being made at Dourbes, Uccle and Moll. It is hoped to establish two additional

stations shortly. Measurements of radioactivity of the residue of large filtered rain samples are being made in Moll.

Dr. Bouquiaux reported on the analysis of the samples from the four Belgian stations made by the Public Health Service.

The Netherlands

Dr. Deij reported that radioactivity measurements in air and precipitation have been made for more than a year at the Medical Biological Laboratory of the National Defence Organization of the Netherlands. In the near future it is planned to augment these measurements with the filtered rainfall method in use elsewhere. Two new atmospheric chemistry stations are planned which will make routine measurements.

Germany

The German network was reported on by Dr Riehm. He hoped that twelwe stations in Austria, Switzerland and Germany will be in operation by August of this year, with the Germans doing the analyses.

Ireland

An Irish network is planned, according to Dr. Tierney, for the near future. It is expected that the network of these stations will be essentially the same as the synoptic network for Ireland. Observations will first consist of precipitation constituents and later, it is hoped, aerosols. Radioactivity measurements using filtered rainwater have been made for several months at Valencia. Background counts of air radioactivity are also being made.

England

The proposed English network was discussed by Dr. Goody, who mentioned problems in arranging for the analysis of samples. The density of the English network will necessarily depend upon analysis facilities but Dr. Goody requested recommendations about what would be desirable.

Norway

Norwegian stations were described by Professor Låg. Three precipitation stations are currently in operation and 10 new stations, including a 3,000 meter altitude station, are planned.

Finland

The Finnish network, as described by Professor Buch, includes 4 precipitation stations at present and will add 2 more, one at Sodankylä in the north, and one in the southeast. Beginning in July the analysis of Finnish samples will be done in Helsinki by Dr. Koroleff.

After the network reports were presented practical problems connected with the maintenance of the chemical program were discussed.

1. *Elements to be sampled*

At the present time the Scandinavian network is analysing precipitation samples for Na, K, Ca, Mg, H_3N, NO_3, S, and carbonates. The pH and the conductivity of the samples is also determined.

Gas samples are examined for the same factors, except, NO_3, and, of course carbonates, pH, and conductivity.

Because of their importance in agriculture it was suggested that boron and phosphorus determinations should be added to current measurements. Iodine was also mentioned but is to difficult to sample and measure reliably.

Eriksson mentioned the desirability of measuring organic matter and separated, particulate matter. A quantity of approximately 5 mg/l of organic matter, probably from the sea, and 5 mg/l of inorganic matter including atmospheric dust and insolubles, has been found in Finnish snow. The possible importance of these organic and particulate materials is demonstrated by the fact that 1 to 5 μ silica particles have been found in snow in Sweden and that there is no known adjacent source for these particles. They must come from great distance, possibly the Sahara, and doubtless could provide important information about the origin and history of air in which they are contained.

Dr. Scholander asked if *living matter* in sufficient quantities for identification exists in the rainwater. Eriksson mentioned the appearance of spores and pollen in some samples. Quite a number of pollen counts have been made, Dr. Gorham mentioned, and would be interesting to look at from the standpoint of air trajectories.

The concensus was that boron should be sampled at a few stations, but other suggestions

were left pending further preliminary investigations.

2. *Sampling techniques*

A small committee was set up to bring forth sampling recommendations six months before the beginning of the IGY. The Group, which was later appointed, was Dr. Egnér (chairman), Dr. Låg, Dr. Koroleff, Dr. Bouquiaux, Dr. Goody and Dr. Riehm.

3. *Frequency of measurements*

Although there is no established criterion for optimum observation frequency, a number of practical matters dominate this decision. Weekly observations would quadruple the work of analysis, and this task is the major bottleneck in the present program.

Eriksson suggested that a rather dense network of *annual stations* could be established with relatively little additional work, which could provide results of climatic and agricultural interest. Occasional daily sampling will be made at six stations in southern Sweden this fall.

It was felt that very little could or should be done to change the frequency of observations at the present time.

4. *Density of Stations*

Dr. Van Mieghem requested a group recommendation concerning station spacing so that recommendations for atmospheric chemical stations could be prepared for CSAGI. The subject has been discussed also in connection with WMO recommendations for a hygroscopic nuclei survey.

After discussion it was agreed that a spacing of stations roughly corresponding to the spacing of stations on the synoptic meteorological charts would be desirable. Highest station density should be in coastal areas because of the role of sea salt particles.

5. *Control of analysis*

A method of comparing analytical techniques was suggested through the exchange of samples between analysis centers. Essentially the same techniques are now in use in all of these places so that only this exchange is required.

6. *Extension of the network.*

When Ireland and Great Britain have been added to the net it was felt that the network would be satisfactory for current objectives.

The second day of the Conference began with a paper by S. Fonselius concerning recent work on the variation of CO_2 in the Atmosphere in Scandinavia. (FONSELIUS & KOROLEFF 1956: *Tellus*, **8**, 3, pp. 176—183).

Following Mr. Fonselius' paper Dr. Buch indicated his belief that the CO_2 measurements which have been reliably made, tend to show an increase in CO_2 with the growth of industry.

Professor Rossby asked if a selection of reliable observations could be made objectively.

Dr. Tamm asked if meteorological data for the times of the CO_2 samples were available. Mr. Fonselius indicated that they were.

Dr. Scholander asked how high above the ground the samples were taken. They were taken at chest height by a man standing on level, bare ground, Mr. Fonselius said. The time of day (1300) was chosen to avoid, as much as possible, a local vertical CO_2 gradient.

Professor Rossby mentioned that emphasis in this work has been to get cheap and reasonably accurate results. When looking for large scale variations, more accurate methods may not be necessary. Because they are also more expensive and difficult they limit the possibility of developing an extensive network of stations.

In the next paper Dr. Goody presented an argument for the measurement of gases by spectrographic methods. He pointed out that the advantages of this method are that it is accurate, it is absolutely specific, and the measurements do not disturb the sample. He mentioned the importance of the work done on ozone as an example of the use of this method.

In illustration he gave an account of the work which he and his colleagues had done measuring nitrous oxide concentrations in the atmosphere. He showed that it was possible to do a very complete job of reasoning about the source, distribution, and destruction of this gas using spectroscopic measurements.

Mr. Eriksson remarked that it is apparent from spectroscopic measurements that nearly all the NH_3 must be in particulate form, and that this is quite important in considering the transport of NH_3 in the air as it must mean that the sea is an important source.

Dr. Goody emphasized that it is important to distinguish between gaseous and particulate NH_3.

Mr. Eriksson said that although Dr. Junge had filtered air through millipore filters he nevertheless found appreciable amounts of NH_3 in the filtered gas. Dr. Egnér added that ammonia cannot exist as a gas very long in the atmosphere as it is combined with acids to form ammonium salts.

Professor Rossby asked Dr. Goody what the "Umlaufzeit" was for nitrogen forms in soil to become N_2O.

Dr. Goody estimated it about 100 days although it is very dependent on moisture.

In a paper by Dr. Egnér the balance of cations and anions found in precipitation was discussed. In most cases this balance is excellent, in some cases there is a slight imbalance of cations over anions. To calculate the balance it was necessary to determine the bicarbonate in the samples. This was done by titration to a pH low enough to ensure that all bicarbonate ions were converted to carbonic acid.

It was pointed out that such a titration would also affect weak organic acids, like fatty acids, when present in precipitation. Therefore one would expect good agreement between cations and anions using this method, even if there were organic acids present. When comparing the carbonate determined by titration with that calculated from pH and a normal concentration of CO_2 in the air, the titration values were always much greater than those calculated, indicating the presence of some organic compounds.

Dr. Tamm said that the agreement which Dr. Egnér had shown was very impressive. He wondered whether the measurements had been made at their given pH or adjusted to a particular pH.

Dr. Egnér indicated that they were not adjusted and went on to say that caution should be exercized in translating determinations from one laboratory to another. Using the same spectrophotometer is not enough. A slight difference in the atomizer, use of a different gas as fuel etc. can influence results.

Dr. Koczy asked if it was not possible from a titration curve of precipitation to determine whether organic acids were present or not. Dr. Egnér thought this was possible.

In his paper Dr. Gorham described the work he had been doing in England with precipitation samples. Collecting daily samples of rainwater at two hill locations, at top and bottom of a 65 foot tower, Dr. Gorham studied chloride/sulphate variations in relation to wind, season and rainfall conditions. Ratios of the elements in precipitation were in general agreement with those found in sea water except in the cases where there was reason to believe that industrial smoke was present. "Sulphate rains" dominate there in summer when winds are more commonly from industrial areas. In winter the rains were primarily "chloride". Sulphate rains were more common when the rainfall was moderate. Chloride rains occurred both for very heavy and very light rains. Salt content of the precipitation water was higher at the higher elevation station.

Dr. Egnér asked whether the sampling funnels were covered (they were not) between rains and if there were hills between the sea and the sampling stations. The stations were located in hilly country approximately twenty miles from the sea.

Prof. Rossby said that he felt three points in Dr. Gorham's lecture should be considered together.

1) The fact that the Cl to Na ratio was in nearly perfect agreement with sea water.
2) The Mg to Cl ratio agreed with the Mg to Cl ratio in sea water.
3) The chloride deposits and wind speed are related.

Each of these factors seems to point to a local source for the sea salts. Dr. Goody commented that the sampling stations were well inland but that for similar distances in Sweden the changes in the Cl/Na ratio were much greater.

Professor Byers said that chloride decreases inland in Puerto Rico and the sea spray could be seen to be the main source there even at some distance inland.

Mr. Rooth suggested that differences in the samples taken at high and low elevation might be due to the evaporation of small drops between the higher and lower stations.

Mr. Mordy asked about the difference in wind between the low and high station. Since the funnels were not covered any coating of salt by impingement might be expected to be greater with increased wind speed. This could perhaps be seen by comparing first and second day's rains after a dry period.

Professor Rossby asked if the Cl/Na ratio as well as the proportion of sulphur in lake waters in the vicinity was in agreement with the sea water ratio. Dr. Gorham said they were but there were significant variations in the ratio of Mg/Cl and K/Cl which could be accounted for by rock weathering and the washing down of minerals by rain.

Mr. Eriksson asked about the possibility of industrial sources for the chloride. The Cl content of coal is fairly small, and as the ratio of S/Cl is around 30—50 the contribution by combustion should not be very great.

In a lecture describing the chemical work done in connection with the University of Chicago Cloud Physics Research Professor Byers first decribed measurements of condensation nuclei. These measurements were made by Dr. Lodge with the use of membrane ("millipore") filters treated after the collections with appropriate reagents which provided enlarged spot tests where particles impigned. Particles larger than 0.1 μ are caught in this way. Samples are taken by drawing air through the filters. Professor Byers showed optical and electron photomicrographs of spots produced by the different chemical components of nuclei.

As the interest of the Chicago group was largely in the precipitation process, measure-

ments in Puerto Rico were made only of Mg and Cl particles. The measurements were generally in agreement with those made by Woodcock earlier in similar climates.

Measurements of SO_4/Cl and some other particles were also made from aircraft over the middle western part of the United States. The Chicago group expected to find a gradient in the salt particle concentration inland from the Gulf of Mexico Coast but this was not found. Professor Byers indicated that at high levels almost as much salt was present in the middle west as in Puerto Rico.

Professor Byers described work done by T. Larson and I. Hettick at the Illinois State Water Survey in measuring chemical content of rainwater. Cations are found in slightly less quantity than anions. CO_2 content varied greatly with the length of storage of the samples. (No pH determinations were made although acidity causes deviation in the ion balance.)

During the discussion Mr. Eriksson pointed out that the strong decrease in numbers of chloride particles, near the ground must indicate the ground itself could not be the source. Professor Byers answered that this was true for the giant nuclei. Mr. Eriksson also pointed out that the size distribution itself was not a good guide for the mass of chloride in the air without some related mathematical considerations. It therefore should not be concluded that there was no decrease in mass from the Gulf of Mexico to Illinois even if the number of particles were about the same. Professor Byers agreed that the number could not be used to infer the amount of chloride in the air but he attributed the depletion of particles near the ground to the sweeping up of nuclei by vegetation.

The next lecture was given by Mr. Eriksson who discussed the geochemical balance of chloride and sulphur between sea and land. From data available on volcanic production, weathering, and human activities it is not possible to account for the rather large amounts of cloride and sulphur in river water without assuming a substantial transport of these two from the sea to land via the atmosphere. In the case of chloride this has been realized for some time. As to sulphur, the lack of balance was first pointed out by an Irish scientist, Conway, who suggested that H_2S produced in the blue mud of the continental shelfs diffused into the air, was oxidized to SO_2 and SO_3 and precipitated. The sulphur could be accounted for in this way. From the rainwater analyses on sulphur made at various places in the last fifty years, the amount precipitated would be sufficient, but it is necessary to accept the hypothesis of Conway to account for it. A great deal of specific study on this mechanism has yet to be made but it seems acceptable by quantitative reasoning.

In the discussion Dr. Egnér mentioned that the sulphur in precipitation was not the only quantity of sulphur brought to the ground. Much direct absorption takes place. This furnishes more evidence of the importance of the sea as a source for sulphur.

Dr. Gorham asked about the possibility of sulphur being released over land from soils. Mr. Eriksson said that he thought that sulphur is probably released everywhere anaerobic conditions exist, i.e. in bogs, swamps and marshes, but that it is difficult to estimate the quantities involved. They are presumably great but also do not effect the balance between the sea and land which has to be maintained anyway.

On the third day, conferees were guests of Dr. Egnér at the Agricultural College, Uppsala, In addition to the discussions and the presentation of papers, the day's activities included a pleasant boat trip into Lake Mälaren, and a visit to the laboratories where the techniques Dr. Egnér uses for the analysis of air and precipitation could be seen at first hand.

The first paper of the day, presented by Prof. Rossby, was a resumé of some large scale synoptic variations observed in the precipitation analysis. He showed the geographic variation in the ratio between chloride and sodium (Cl/Na), and maps of sulfur in precipitation. Prof. Rossby pointed out the difference in the gradients on the Cl/Na maps and the sulphur maps and how these gradients can give indications of the source region.

The geographic variation of the Mg/Na ratio was quite similar to the Cl/Na ratio. This distribution is strikingly different from the patterns of sulphur distribution.

Finally Mr. Eriksson commented on a chart of the geographic variation of sulphur as found in river waters in Sweden. This chart was quite similar in configurations to the chart showing sulphur found in rain water.

In the discussion following, Dr. Koczy mentioned that in considering the sea as a source for sulphur, one should keep in mind seasonal variations in the sea which could influence the quantity liberated to the atmosphere, principally variations in the thermocline and resulting changes in convection and eddy diffusivity. The most favorable convection periods in the sea are March-April and October-November. He asked whether these periods showed an increase in sulphur.

The highest sulphur content in rainwater was found in March, Prof. Rossby replied, but in his recollection

the winds were in the wrong direction for it to have come from the sea.

A paper by Dr. Koczy described some oceanic characteristics favorable to surface film formation and some observations of them. Surface films reducing surface tension by as much as 6 to 12 dynes/cm were common in coastal regions while in harbors he had measured a reduction as high as 22 $^1/_2$ dynes/cm. The normal surface tension of sea water is slightly higher than that of distilled water (max. 72 dynes/cm), whereas a characteristic value in an open sea area is only 66 dynes/cm. These surface films can often be observed as a streak on the sea and are largely formed by fatty acids. They gradually become oriented in streaks parallel to the wind. This orientation is largely due, Dr. Koczy felt, to long horizontal wind vortices or convective wind cells which separate them, i.e. Bernard cells.

Motion pictures were shown of the formation of similar streaks on the sea under various conditions.

In discussing this paper Dr. Welander questioned the explanation given the formation of the film streaks. He did not feel that they were reflection of the presence of Bernard cells, but possibly of wind shear.

Dr. Koczy said he had not made a theoretical investigation of this phenomenon. The streaks, he said, are very stable and last many hours.

Prof. Rossby asked whether it wasn't equally probable that they are convection cells in the water, which might be produced by evaporation.

Mr. Eriksson then gave a brief description of the molecular nature of the fatty acid molecules and made a particular point of their polarity in reference to their affinity to water, and different orientation resulting when in monomolecular as opposed to multimolecullar films.

He then mentioned that 20 % of the materials produced by phytoplankton were of this chemical nature. Such films would preferably absorb calcium from sea water and, as they are carried into the air by spray the calcium would also be carried away.

Dr. Egnér described some investigations which Prof. Köhler, and later he, had tried in bubbling air through sea water to determine whether any separation of sea salt components would take place. The experiments were unsuccessful as there was no detectable difference between the sea water samples and the tiny droplets collected. In this case, however, there was probably not enough surface material present to get separation.

Dr. Tamm asked if methods were worked out for collecting organic material in sea water.

Mr. Fonselius mentioned that he had been successful in extracting fatty material from fresh water lake samples.

In his lecture to the conference Dr Riehm paid tribute to M. Nessler whose method of ammonia detection had made the present microanalysis of rain water possible.

Dr Riehm then went on to emphasize the importance of boron in agriculture and to show the surprisingly large amount which can be received in rainwater. In the rainwater for December 1955 he found 8.9 γ/l of boron and in April 1956, 1.2 γ/l.

The rapid method used by Dr. Riehm in his boron determinations was described in detail.

In the discussion which followed this paper Dr. Egnér added additional emphasis to Dr. Riehm's contention that boron measurements should be started. He also mentioned that boron fertilization is needed in sugar beet production in southern Sweden.

Prof. Rossby asked what the possible sources of boron are. Because boron distribution by the atmosphere is probably quite irregular and because deficiencies exist over wide areas, it should be quite interesting to look at data which could show seasonal or annual variation in the boron deficiencies.

Dr. Philipsson said that in the samples analysed in Ultuna he had found 5 to 8 γ/l in rainwater (7 week collection period) and that these values had been nearly constant with only a 10 % variation.

The final lecture was given by Dr. Egnér who discussed the results of air sampling by Dr. G. Arrhenius from Scripps Oceanographic Institution in the South Pacific during the "Capricorn" cruise. The samples were taken by scrubbing air with dilute nitric acid solution. The sea salt components in these regions were several orders of magnitude higher than in other regions. An exception to this was ammonia. In the doldrums, only one sample was taken, but concentrations were similar to continental regions. The composition of the sample was similar to sea water when concentrations were high but differed significantly for lower concentration samples.

In the discussion Eriksson gave figures on total atmospheric salt concentration in oceanic regions. He mentioned that Hawaiian rainfall contained different proportions of salts than sea water. These proportions were similar to the one example Arrhenius gave for the doldrums.

Dr. Koczy mentioned that divergence in the sea occurs in this area south of the equator. This would favor surface film formation due to the amount of organic material brought to the surface in the divergence area.

The conference reflected a considerable increase in interest and activity since the work in atmospheric chemistry began a few years ago.