TRATADO ANTARTICO

XIII REUNION CONSULTIVA

TRAITE SUR L'ANTARCTIQUE

XIII REUNION CONSULTATIVE

ANTARCTIC TREATY

XIII CONSULTATIVE MEETING

ДОГОВОР ОБ АНТАРКТИКЕ

XIII КОНСУЛЬТАТИВНОЕ СОВЕЩАНИЕ

BRUXELLES

1985

7-18 octobre

ANT/XIII INF 14
October 10, 1985
Original : French

Belgian programme of scientific research concerning the Antarctic

(Information document submitted by the Belgian Delegation)

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BELGIAN PROGRAMME ON ANTARCTIC SCIENTIFIC RESEARCH

September 1985

I. INTRODUCTION

For some years interest in the Antarctic has been growing in the international Scientific Community, and more particularly within the Antarctic Treaty System.

This interest takes the form of a considerable expansion of scientific research activities concerning this region.

Belgium is aware of the need to improve scientific knowledge about the Antarctic continent and the surrounding ocean and is keen to contribute to the international research effort in this field.

On a proposal by the Minister for Science Policy the Belgian Government has therefore approved the implementation of a research programme with a planned duration of three years. The programme will take the form of a specific national action, incorporating individual and coordinated scientific studies.

This programme has been drawn up to take account, on the one hand, of the considerable progress made since the first expeditions, on both the scientific and logistic fronts - which has led to more sophisticated means being used and a new approach to research objectives and strategy. On the other hand, Belgium's participation must comply with the priorities of national and international science policy and keep within limits which are compatible with the budgetary resources of our country.

In this connection it should be noted that the economic application of the results of research activities concerning the Antarctic does not represent a feasible objective today for a country of Belgium's size.

The national priorities, objectives, content and method of implementing the programme have been determined in accordance with the Belgian State's overall R & D Policy, the principal aims of which are to ensure that its support for research teams active in key areas is both coherent and directed at specific objectives.

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The objectives of the Belgian contributions to furthering scientific knowledge about the Antarctic are set out below:

a) to enlarge on the nucleus of competence and expertise in Belgium so that our country can participate in the scientific activities at international level to study the Antarctic, in keeping with the spirit of the Antarctic Treaty;

b) to focus the main research effort on two main areas for which there is a broad international consensus that priority development is required because of the scale of their practical implications and taking into account the state of knowledge. These two areas are the ecology of plankton, a key link in the entire marine food chain, and glaciology in relation to its climatological implications. These are two of the areas in which Belgium possesses a scientific potential of great value;

c) to contribute scientific "added value" to the research currently being carried out by a number of excellent university teams (notably working on international R & D programmes and programmes of "concerted research actions"). By means of appropriate management and coordination it will be ensured that their research activities at international level have an impact in areas of tangible interest to Belgium (such as oceanology, climatology and remote sensing).

The management and coordination of the programme will be provided by the Science Policy Office (SPPS).

The follow-up of the research activities will be the responsibility of a support committee set up by the Government and comprising of representatives from the following departments : Economic Affairs, Agriculture, Foreign Affairs and Development Cooperation, Public Health and the Environment, Public Works, National Defence and Science Policy Office.

The research is being carried out by teams from Belgium's six full universities and one Public Service research unit.

For the purposes of this programme it is planned to integrate some of the research with programmes organized by other countries, by taking up spare places on their ships or at their bases. The resources for this purpose have been earmarked in the programme budget.

II. DESCRIPTION OF THE FIELDS AND TASKS OF RESEARCH

The Antarctica is the last vast region of the planet which has been virtually untouched by the activities of Man. It therefore constitutes a particularly suitable place for establishing reference levels for contamination and for increasing knowledge of the "natural" operation of ecosystems. The comparison and extrapolation of the results of such studies may contribute to laying the necessary scientific foundations for combatting pollution and for the rational management of some natural resources in industrial areas.

The regional dimension of such studies should not in any case be disregarded.

Indeed the Antarctic environment is probably very vulnerable to pollution which could constitute a direct or indirect threat if there should be an increase in the activities of Man or ocean-borne and atmospheric impacts, the mechanisms and effects of which are as yet little-known.

The Antarctic and the ocean surrounding it play an important role, moreover, in regulating the Earth's climate. The way in which this develops in the long term depends in particular on the dynamics and end result of exchanges between ocean, ice, and atmosphere, the effects of which are exported on a global scale. To be able to predict this evolution scientifically implies understanding the mechanisms of these phenomena at present and in the past.

In the light of the research strategy defined in the Introduction above, the field and subjects of research adopted in the programme are as follows:

1. Plankton Ecology :

1.1 Biochemistry of the nutrition of phyto- and bacterioplankton.
1.2 Biochemistry and ecodynamics of zooplankton.
1.3 Plankton ecotoxicology and activity.

2. Marine Geochemistry :

2.1 Biogeochemistry of barium.

3. Marine Geophysics :

3.1 Seismic stratigraphy and clay dynamics.

4. Glaciology and Climatology :

4.1 Isotopic composition of regelated ice.
4.2 Sea ice modelling.
4.3 Ice cap dynamics.
4.4 Ocean-ice-atmosphere interactions.

The details of the research tasks are set out below.

FIELD 1 - PLANKTON ECOLOGY

Belgian oceanography has developed a considerable body of knowledge in the area of marine living resources. This probably represents one of the most tangible areas of economic potential in the Antarctic.

In this respect it would be useful to examine the suitability of methods and general applicability of concepts acquired in the North Sea at other sites affording more favourable hydrological and physico-chemical conditions for conducting and, above all, interpreting ecological observations.

The Antarctic waters lend themselves well to these purposes, notably by offering a broad spectrum of nutritive conditions ranging from extreme oligotrophy to nutrient-rich levels similar to those encountered in the North Sea coastal zone.

Over the last ten years oceanographic research in marine environments has revealed the existence of complex food chains in which planktonic bacteria and microzooplankton play a key role in the utilisation of organic matter produced by phytoplankton. This discovery thus overturns the established belief in a single linear food chain : phytoplankton --> zooplankton --> fish. An understanding of the trophic structure of a marine environment therefore calls for an understanding of the mechanisms of formation and utilisation of organic matter in the first links of the food chain (phytoplankton, zooplankton and planktonic bacteria).

The dynamics of the environment must, however, be taken into account as well.

It has, for instance, been shown that when zooplankton is subjected to fugacious feeding conditions they store substantial quantities of lipids, the biochemical nature of which depends on hydrological and trophic conditions.

Furthermore, the understanding of the structure and operation of the marine food chain presupposes knowledge of some of the flows associated with planktonic respiration and real net primary production.

Far-removed from the activities of Man, the Antarctic also offers an opportunity to establish baseline levels of contamination by pesticides and heavy metals with a view to assessing contamination observed in industrialised regions. Similarly, it is to be hoped that this will lead to a better understanding of the ways in which marine organisms are poisoned by studying an environment such as the Antarctic for the reasons already outlined. This aspect is closely linked to an understanding of the metabolism of lipids in so far as pesticides are concerned.

The research conducted in this field forms a coherent whole with the aim both of contributing to a better understanding of how the bottom of the food chain operates in the Antarctic marine environment, and of acquiring more general concepts on the ecology of the plankton. This knowledge could be used in an endeavour to clarify various problems relating to the food chain observed in the North Sea and to the nature of the factors governing the operation of the food chain. This will assist in defining how and to what extent plankton are poisoned in various ecosystems.

The field relating to plankton ecology can be sub-divided into 3 themes which differ in the methodologies applied and the segments of the food chain under consideration, but which are complementary with regard to the concepts developed:

1. Biochemistry of the nutrition of phyto- and bacterio-plankton (Dr. BILLEN, ULB):

   Characterisation of chemicals metabolised by phytoplankton in response to the supply of nutrients and light and definition of the role played by planktonic bacteria in the recycling of organic matter.

2. Zooplankton biochemistry and ecodynamics (Dr. HECQ. ULg):

   Study on the evolution of the properties and storage of potentially utilizable lipids in the segments of the plankton chain in terms of time, space and environmental parameters, from nutrient-enriching sources.

3. Plankton ecotoxicology and activity (Dr. JOIRIS, VUB):

   Definition of reference contamination levels and identification of the transfer mechanisms of organochlorine residues and mercury in various marine subsystems (water, plankton, etc); determination of the respiration of total plankton and phytoplankton and evaluation of real net primary production.

FIELD 2 - MARINE GEOCHEMISTRY

Rational management of the marine environment presupposes a knowledge of the nature and the rate of all the reactions controlling the concentration and the retention time of chemical elements and their compounds in the various compartments of this environment.

This knowledge allows models of geochemical cycles to be constructed, particularly of biogeochemical cycles which have extensive applications in the prevention of and the fight against all kinds of pollution.

The Antarctic circumpolar waters constitute one of the largest oceanic reservoirs of living matter and a zone of substantial exchanges with all the oceans.

Little is yet known about the behaviour of numerous chemical elements in this area.

The construction of models of specific cases of biogeochemical cycles is useful in the development of concepts essential for improving this knowledge.

In this respect, the biogeochemical behaviour of barium is open to methodological extrapolations, especially with regard to the use of radium 226 as a tracer of the ocean circulation.

It is therefore proposed to attempt to throw light on the role played by the remineralization of organic matter in controlling the content of particulate barium in the surface waters of the circumpolar region, in order to obtain a better knowledge of the biogeochemical cycle of this element.

The purpose of the research to be conducted by the team led by Dr. DEHAIRS (VUB) will be to evaluate the part played by the remineralization of organic detritus in the phenomenon of barium production in the upper part of the water column in the subtropical convergence zone and in the Antarctic convergence zone.

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To this end, high-resolution vertical profiles of barium concentration will be achieved. These data will be interpreted within the context of the geochemistry of barium and with more general reference to trace elements in the marine environment.

FIELD 3 - MARINE GEOPHYSICS

The continental shelf of the Antarctic partly consists of sedimentary wedges the formation of which is linked to plate tectonics.

Investigation of prisms in the western part of this shelf has revealed the existence of thick sedimentary series, which it is supposed must theoretically have similarities with known series in the adjacent continents ("counterparts" linked to the continental drift).

These latter series contain mineralized levels, some of which are mined commercially.

There are still large gaps in our knowledge of the nature and origin of the sediment of peri-Antarctic wedges. It would therefore be interesting to study these characteristics with a view to attempting to establish lateral equivalences between potentially mineralized geological layers and to confirming the dynamic effects due to plate tectonics.

Of the different geophysical methods, the seismic method has proved to be particularly well suited to geological studies of vast accumulations of sedimentary layers which have not been explored to any significant degree. But above all, it allows indirect access to the layers forming the sea floor.

Finally, through the methodological adaptations which it involves, the application of the seismic technique to studies on peri-Antarctic wedges offers an opportunity for diversification to researchers who have developed this tool in the North Sea.

The team led by Dr. HENREIT (RUG) will define the stratigraphic and structural characteristics of sediments of peri-Antarctic prisms on the basis of the interpretation of seismic profiles. To this effect, they will adapt the measurement techniques developed for the North Sea. The sedimentation and deformation mechanisms of these prisms will also be studied taking the regional geological and tectonic context into account. Analogies with the sediments of the neighbouring continents will also be considered.

FIELD 4 - GLACIOLOGY AND CLIMATOLOGY

The Antarctic plays an important role in regulating the earth's climate. Unlike most other regions, it does not store up the heat provided by solar radiation. This phenomenon is due to the ice cap, which reflects almost all this radiation. The Antarctic therefore acts as an enormous heat pump supplied through atmospheric and oceanic circulation.

With other factors such as the carbon dioxide content of the atmosphere also playing a part, it is the dynamic balance of interactions between various phenomena on which the earth's climate ultimately depends.

Although knowledge of the mechanisms involved is still sketchy, many experts are finding it increasingly probable that this balance can be disturbed by human activity in the long term, to the point at which climatic conditions may beproduced giving rise to a substantial reduction of regions fit for habitation and cultivation.

Studying such an evolution could not be attempted on scientific bases without a thorough knowledge of the natural trends in the past and present evolution and regulation of the earth's atmosphere.

The field of glaciology and climatology envisaged in this programme falls within the scope of this research, with particular emphasis being placed on aspects inherent in the Antarctic, and allows an operational Belgian scientific project to be utilized.

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This field is characterized by the unity of the research concept and methods applied.

Four themes will be tackled, dealing with the additional aspects of the interactions between the three basic systems defining the climatic role of the Antarctic, namely the ocean, the ice and the atmosphere. In this field, extensive use will be made of mathematical modelling, which is widely developed in Belgium in its applications to natural environments. Consequently, it can be hoped further to increase the operational capacities of the research units involved, which will have the opportunity, in studying the Antarctic, of comparing methods and concepts developed for other environments.

The field concerned has been subdivided into four research themes concerning the interactions, to differing degrees, between glacial and climatic phenomena:

1. Isotopic composition of regelated ice (Prof. SOUCHEZ, ULB):

   The isotopic composition of meteoric ice reflects the climatic conditions prevailing at the time when it was formed. The base of the Antarctic glaciers holds such information concerning ancient climates about which we know very little.

   The successive processes of regelation occurring at this base alter the original isotopic composition in accordance with the degree and the speed of freezing, thus affecting the palaeoclimatic information.

   The study will tackle this phenomenon of isotopic fractionation in order to develop a method of reconstituting the original isotopic composition of regelated basal ice. This method will also be used to determine the speed at which ice is formed from sea water.

2. Sea ice modelling (Prof. BERLAMONT, KUL and Dr. PICHOT, UGMM):

   The periodic expansion and contraction of floating ice-fields is one of the most characteristic natural phenomena of the circumpolar seas.

The presence of this ice makes access to the Antarctic continent, and navigation in polar seas in general, difficult and all the more dangerous in that we have little knowledge of the evolution of these ice-fields. It would therefore be useful to be able to establish predictions with regard to this evolution.

The development of this phenomenon in time and space is closely linked with a complex system of ocean-atmosphere interactions giving rise to heat transfers and the circulation of air and water. Sea ice dynamics must therefore be approached taking into account both ocean and atmosphere dynamics.

These teams will have the task of jointly constructing a model describing the evolution of the edge of the sea ice in time and through the seasons, taking the above-mentioned interactions into account. This model will be constructed for an idealized system and will then be adapted to a region of the Antarctic.

The operational potential of the predictive aspects of this model will also be considered.

3. Ice cap dynamics (Prof. DECLEIR, RUG/VUB):

This team will analyse the interactions between the level of the ice cap, the ice flow and the variations in sea level by applying the data obtained from remote monitoring from space and land-based observations.

A model of the integrated dynamics of these phenomena will be constructed and applied to the analysis of their interactive links with climatic phenomena.

The team will also evaluate the respective performances of Landsat and SPOT data application in terms of the objectives of this research.

4. Ocean-ice-atmosphere interactions (Prof. BERGER, UCL):

During the formation of sea ice, a large quantity of salt is deposited in the underlying ocean. This increase in salinity, and therefore in the density of the upper layer of the ocean, can lead in some cases to the formation of deep water.

Furthermore, the cold dry air that flows over the Antarctic ice cap and becomes even colder as it passes over the fast ice causes substantial turbulent flows of latent sensible heat when it reaches the ice-free ocean. This would seem to lower the temperature and increase the salinity of the sea water, thus causing the formation of deep water.

The aim of this research is to evaluate the respective roles of these two phenomena in the formation of deep oceanic waters which occurs at the edge of the Antarctic and contributes to the heat exchanges which play their part in the regulation of the climate.

Apart from describing these phenomena, this mathematical modelling will also allow the sensitivity of their interactions to be analysed.