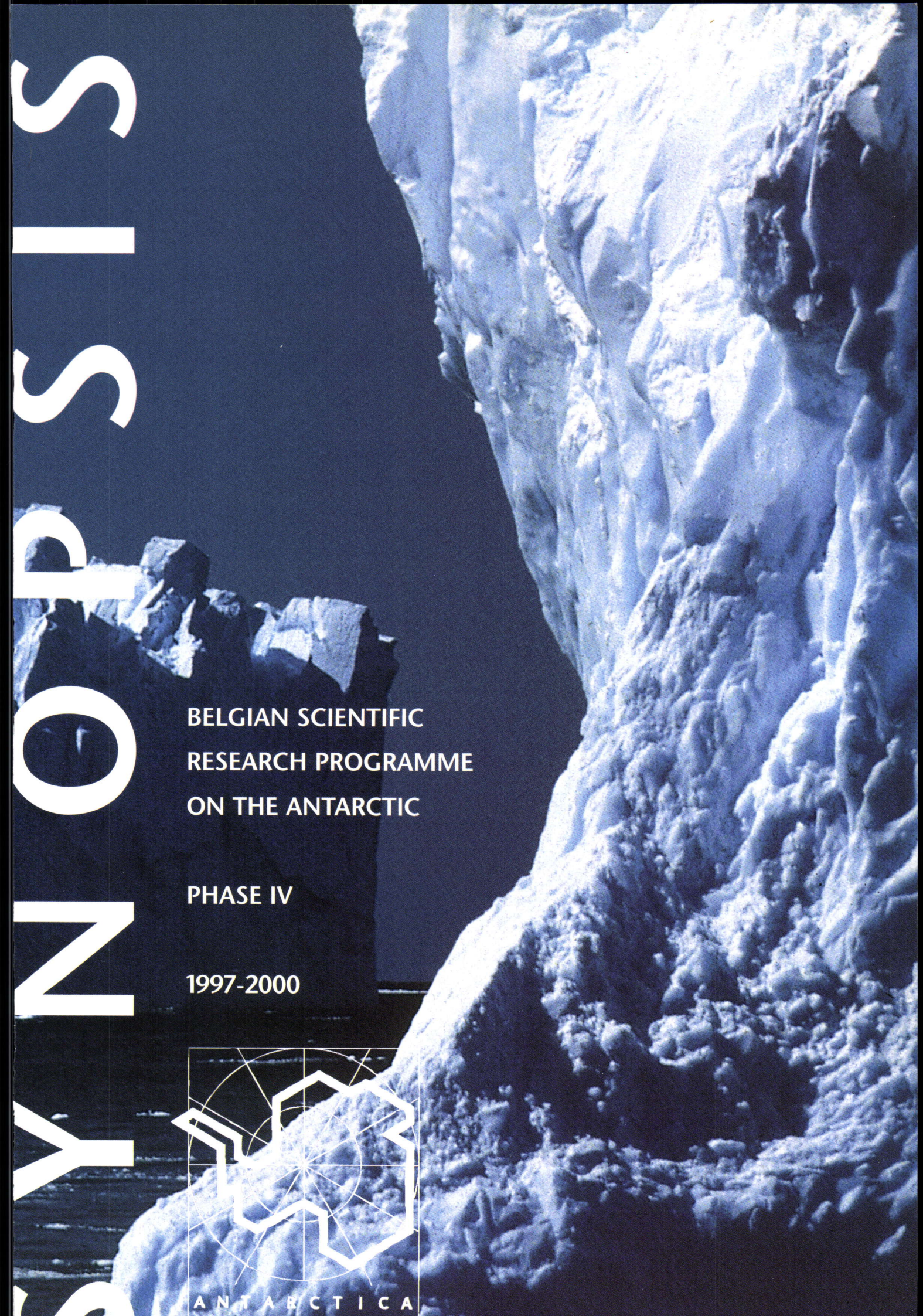
SYNOPSIS



BELGIAN SCIENTIFIC RESEARCH PROGRAMME ON THE ANTARCTIC

PHASE IV

1997-2000

ANTARCTICA

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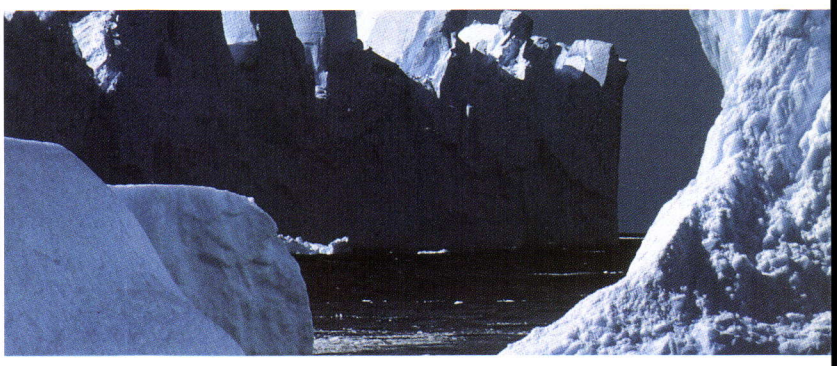

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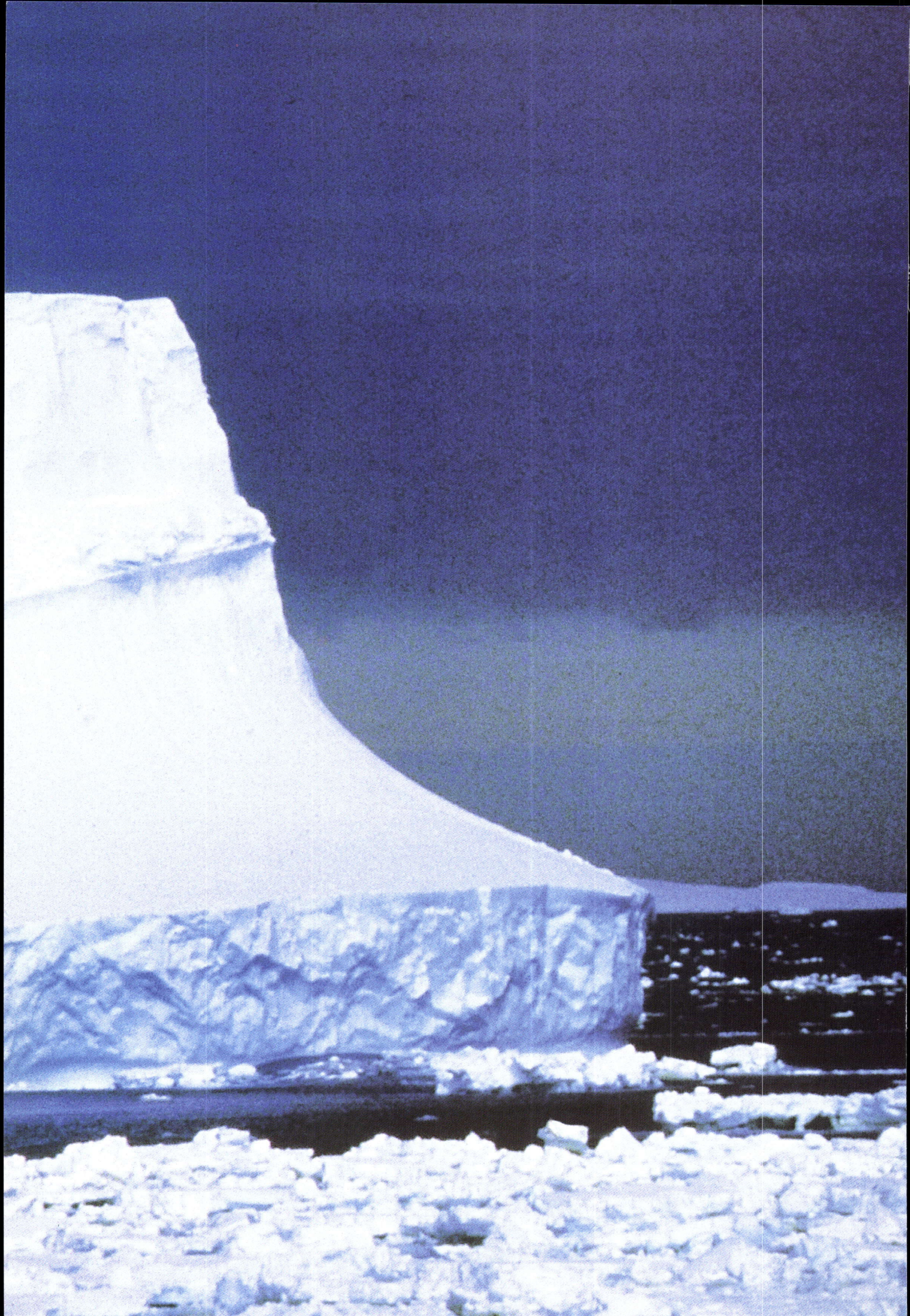


INTRODUCTION

The Antarctic Treaty concluded in Washington in 1959 is the crystallization of a unique international consensus on the peaceful use of this vast area on our planet[1]. Its principles are demilitarization, the ban on nuclear tests and on the disposal of radioactive waste material – the respect of which is guaranteed by a system of mutual inspection – and the promotion of international scientific cooperation. The approval in 1991 of the "Protocol on Environmental Protection to the Antarctic Treaty" (Madrid Protocol), turned the area into a natural reserve dedicated to peace and science. The Protocol prohibits any non-scientific activity relating to mineral resources and otherwise, makes provision for the realization of environmental evaluations to be based upon scientific evidences. Belgium has played an active role in the negotiations on this Protocol, thus acting in full line with its role of founder member of the Treaty.

The conduct of scientific activities remains the corner stone of the well functioning of the Antarctic Treaty System[2]. It is the condition for access to the decision-making process within such System and also to the full execution thereof.

Scientific research provides the terms of reference to the Antarctic Treaty System so as to pursue a policy of protection and rational management of the environment. On the other hand, the Antarctic provides unique opportunities to address some scientific issues most important to the understanding of the global dynamics of the Earth system – such as the dynamics of the global climate, the fluctuations in ocean level, the formation of oceanic deep waters or the evolution of continental margins.

In 1985, the Government took the initiative to organize a structured action of scientific research on the Antarctic with the will to insert it in a visible way in the concerns which are those of any founder member of the aforesaid treaty. It was the first time that Belgium established a national multi-annual programme specifically devoted to the Antarctic. Two subsequent phases of the Programme were implemented over the 1988-1996 period.

Belgium's involvement in Antarctic research is currently covered by the Fourth Phase of the Programme (1997-2000) which was launched under the federal "Scientific Support Plan for a Sustainable Development Policy".
Although sustainable development as such is not mentioned explicitly in the objectives nor in the strategy of the Antarctic Treaty System, the underlying concept appears to be fully in line with the System's preoccupations. This is clear from the battery of measures and actions from such System, to the effect of preserving the fauna and flora, creating protected areas, preventing marine pollution, eliminating waste material or protecting indigenous species. Being declared a natural reserve where human activity is severely controlled by the Madrid Protocol, the Antarctic presents itself as the model site where the sustainable development concept can be realized on a large scale.

[1] The Antarctic Treaty applies to the entire area south of the 60° south parallel. Such area includes the southern sectors of the Atlantic, Pacific and Indian oceans, constituting a hydrographical entity called the Southern Ocean.

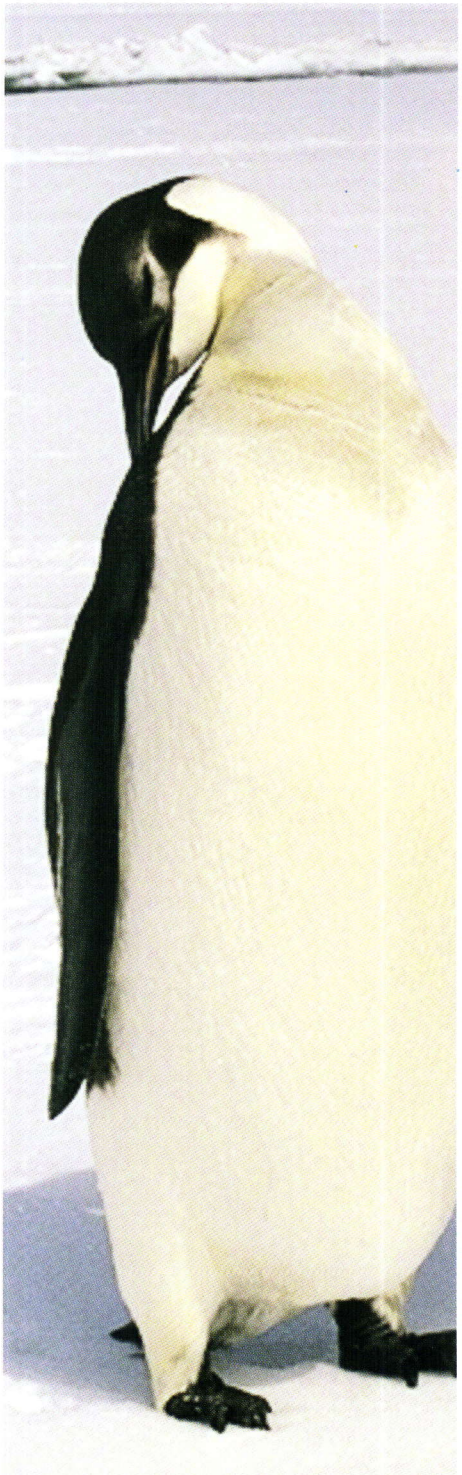
[2] The Antarctic Treaty System is the whole complex of arrangements, including the Treaty itself, made for regulating relations amongst Parties, e.g. the Madrid Protocol, the Convention for the Conservation of Marine Antarctic Marine Living Resources and the Convention for the Conservation of Antarctic Seals.

OVERALL OBJECTIVES

To honour Belgium's obligations as a founder member of the Treaty, by developing a research effort in accordance with the issues set out by the Antarctic Treaty System.

To contribute to the development of the knowledge required for a science-based conservation and management of the Antarctic environment and to the assessment of the mechanisms through which the Antarctic and the global climate interact.

To ensure an operational interface with the Antarctic Treaty System for matters of scientific or technical nature, or needing this kind of developments.



IMPLEMENTATION

A call for research proposals was issued in July 1996 among all Belgian institutions likely to be in a position to present proposals. Proposals were selected on the grounds of a scientific assessment carried out by foreign experts in accordance with the peer review method.

Research-work is implemented by means of four-years projects undertaken by teams of university- or federal scientific institute-based scientists. Emphasis is given on a multi-disciplinary approach of the dynamics of the global functioning of Antarctic main natural systems and of their evolution and interactions. Research topic and priorities are in full line with major international projects and programmes such as ANTOSTRAT, EASIZ, EPICA, GLOBEC, IGBP, ODP and SO-JGOFS.

Field activities are embedded in scientific expeditions organized by other Antarctic Treaty parties.

All research costs (personnel, equipment, travel, working and overheads) are financed by the Federal Office for Scientific, Technical and Cultural Affairs.

The overall budget of this new phase amounts to 235 MBEF (about 6 MECU). In addition Belgium contributes a sum of 20 MBEF (about 0.5 MECU) to the operational costs of the European Project for Ice Coring in Antarctica (EPICA).

Funding, management, coordination and diffusion of the Programme are in the hands of the O.S.T.C., at both administrative and scientific level. Scientific liaison with the Antarctic Treaty System is also the responsibility of the O.S.T.C.

An Antarctic Support Committee, with advisory status, is empowered to formulate opinions on the progress made in the course of the Programme and to put forward any suggestions on the measures that it considers should be taken to attain its objectives. It is composed by representatives of the following entities :

Federal Authority
- Agriculture
- Foreign Affairs (also national contact point)
- O.S.T.C. (also national contact point)
- Public Health and the Environment

Flemish Community
Walloon Region

RESEARCH TOPICS

Research is organized within seven research lines under three areas. They are:

Marine Biota and Global Change

Structure, functioning and resilience of key ecosystems
Ecofunctional biodiversity
Biogeochemical cycle of carbon and global changes

Dynamics of the Southern Ocean

General circulation in relation to the formation of deep waters
Dynamics of the marginal sea ice zone

Palaeoenvironmental Records

Ice cap (EPICA)
Marine sediments

STRUCTURE, FUNCTIONING AND RESILIENCE OF KEY ECOSYSTEMS

The mechanisms and the fate of marine primary production in function of the physical and chemical forcing are of essential importance to understand both the resilience of the ecosystems and the global effects of the "biological pump" in the sequestration of CO_2. The studies linking processes and models and integrating the dynamics of the ecosystems and the biogeochemical cycles constitute a fundamental approach to evaluate the way the marine biota responds to the variations in environmental conditions taking into account the respective role of natural and anthropogenic forcing. The determination of biogeochemical cycles and living communities in the present ocean also allows to decipher more easily the climate signals that are recorded in old sediments through biological production.

It is the study of phenomena and interactions occurring at ecosystem level, rather than at species level, that is more likely to produce the proper scientific answers.

Themes of research

Integrated studies of the biogeochemical, ecological and physical mechanisms responsible for biological production and its fate, and their development as a consequence of global change.

Development and application of ecodynamical / physical coupled mathematical models (biogeochemical cycles C, N, Si, P, S + ecology / ocean-ice-atmosphere interactions) in order to :

- determine the resilience of the ecosystems in function of the environmental conditions;
- simulate the evolution of ecosystem dynamics under the influence of modifications of the global conditions, and basically those related to the climate.

ECOFUNCTIONAL BIODIVERSITY

Among the most promising aspects of the study of biodiversity, the interactions with ecosystem functioning and biological production hold an important place. The study of biodiversity opens wide perspectives towards a better understanding of the response of the ecosystems to external stresses. It adds a new dimension to the attempts to articulate the ecological and biogeochemical mechanisms and their interactions, all the way from cell level up to ecosystem level. Biodiversity is however a field of research which is still new and some methodological developments are necessary, especially in the field of polar seas.

Themes of research

Identification and description of the mechanisms linking production and biodiversity in key ecosystems of the Southern Ocean.

Evaluation of the role of biodiversity in the resilience of marine ecosystems of the Antarctic with respect to global changes.

Analysis of the importance of trophodynamics in biodiversity, more in particular in the benthos, with respect to the interactions between the transience of nutrient availability and the physical forcing.

Development of innovative taxonomical, genetic and molecular tools and methods for the characterization of the biodiversity of the polar marine biota, and more in particular, of the cryptic biodiversity and the biodiversity of the cosmopolitan species (bacteria, picoplankton, etc).

BIOGEOCHEMICAL CYCLE OF CARBON AND GLOBAL CHANGES

It is now widely accepted that the Southern Ocean is far from homogenous in terms of ecological functioning and biogeochemical cycles. Four interdependent subsystems are distinguished, according to the specific habitats they represent, the underlying physical processes and their capacity to transfer carbon to deep waters. Considerable progress has been made in the identification of the mechanisms controlling these transfers of carbon. It is currently admitted that the sequestration of CO_2 not only depends on the primary production rate, but also on the specific composition of the phytoplankton communities conditioning the structure of the trophic web and the rate of biogenic sedimentation. The primary production rate in its turn depends on three interactive processes : the availability of micro-nutrients, the marine weather conditions and the type of "grazing".

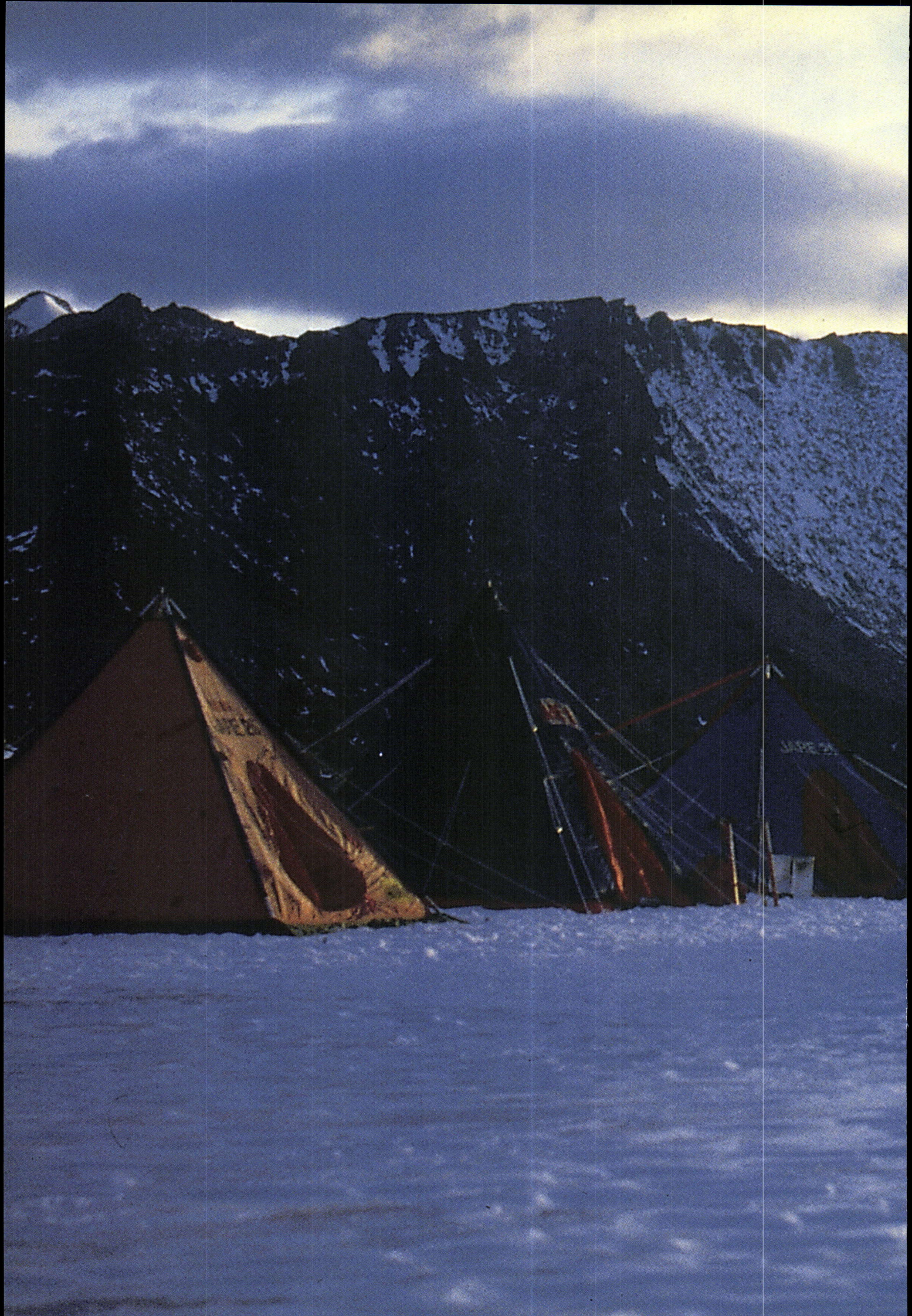
However, gaps in our knowledge are still too important to allow the establishment of a coherent global image of the ecodynamics of the Southern Ocean. It continues to be an international priority to try to determine whether the Southern Ocean constitutes a source or a sink of CO_2.

Themes of research

Mathematical modelling of the paths, the mechanisms and the fluxes of carbon circulation and exportation all along the key compartments of the trophic web and their response to the physical and chemical forcing (ecodynamical/physical coupled models) so as to determine, on the appropriate time and space scales, the role of the major subsystems of the Southern Ocean in the sequestration of CO_2, taking into account phenomena such as:

- the respective role of nutrients (micro-nutrients, such as Fe and Mn, and nitrogenous nutrients), the ocean-ice-atmosphere interactions and the composition of plankton assemblages on the rate, the variability and the fate of primary production;
- the respective importance of recycling and transfer of organic matter typical of each of the different sub-systems of the Southern Ocean in the global balance of carbon fluxes;
- the respective role of the dissolved (microbial loop) and particulate phase in the balance of carbon fluxes.

Quantitative evaluation of the balance of dissolved and particulate carbon fluxes, at benthos level and with respect to the sequestration of CO_2.




FREMANTLE AUSTRALIA

GENERAL CIRCULATION IN RELATION TO THE FORMATION OF DEEP WATERS

The Southern Ocean largely contributes to the production of deep waters of the whole ocean. The vertical component of the circulation is more strongly present in the Southern Ocean than anywhere else in the world and generates a large-scale mixing of the water masses coming from more northern latitudes. This way new water masses are being formed and spread all over the oceans. The major effects of this mixing process are : redistribution of heat between the hemispheres, ventilation of the oceans and renewal of part of their nutrient stocks. The Southern Ocean is thus involved in the exchanges between ocean and atmosphere, contributing to the control of the contents of CO_2 and other greenhouse gases in the atmosphere. It remains a matter of debate whether the Southern Ocean constitutes a source or a sink of CO_2.

Today the general ocean circulation models rather sufficiently take into account the large-scale processes. However, in their current stage of development, these kinds of models turn out to be less appropriate to reproduce a series of processes, playing a role in the formation of deep waters in the Southern Ocean. Their resolution in time and space is insufficient to understand phenomena such as, for example, the effects of small turbulences at high latitudes or the physical-chemical modifications to which the water masses are subject when flowing under the ice. The knowledge of such phenomena must allow a better parameterization of the large-scale ocean models.

Themes of research

Development and application of high resolution 3D primitive equation models of regional circulation for a better understanding of the formation and spreading of deep waters, in the light of the following phenomena :

- the ocean-ice-atmosphere interactions, and more in particular the effects of salt rejection due to the melting of sea ice, and the rheology of ice;
- the interactions between the ocean and the continental platform (effect of the relief on vertical transport).

Validation and calibration of the models for concrete cases, such as those found in the Weddell Sea.

Elaboration of algorithms for the processing of satellite images, so as to :

- calibrate and validate such models;
- better parameterize the physical phenomena that are important for the study of deep waters;
- obtain more realistic boundary conditions.

DYNAMICS OF THE MARGINAL SEA ICE ZONE

In the last couple of years, considerable progress has been made in the understanding and forecasting of the dynamics of marine ecosystems in the Southern Ocean thanks to the knowledge provided by coupled mathematical models experiments. These have more in particular allowed to emphasize the essential role of the meteo-marine physical forcing in the functioning of the ecosystems. However, the performances of the physical modules of coupled models are not always sufficient to provide modellers with realistic forcing input series, so that an effort in modelling is advisable. This is particularly the case for the marginal sea ice zone, playing an important role in the biological production, the fate of biogenic compounds and the ventilation of the intermediate and deep waters.

The melting of ice in spring generates a sea water layer with less density than that of the underlying layers. The layer, which is vertically stable this way, keeps the phytoplankton in a well-lighted area, and thus stimulates primary production. This physical control of primary production conditions the way in which the marine communities build up and develop in the Southern Ocean. The models that are actually used as physical modules linked to ecological modules, do not take into account any lateral transport. In addition, they are limited to a simulation of sea ice melting and not of sea ice formation. However, because of its bio-optical influence and its role in the seeding of plankton in the water column in spring, the latter must be taken into account, in order to allow a simulation of the complete annual cycle of primary production.

Themes of research

Elaboration of vertical circulation models covering the full annual cycle of ice-ocean-atmosphere interactions, particularly taking into account : the alteration of the physical and chemical features of sea ice as a result of biota activity, leads formation and sub-glacial topography.

Extension of the models to horizontal dimensions; adaptation of the models in view of the coupling with biogeochemical models of carbon, nitrogen, phosphorus and silicon circulation.

Palaeoenvironmental Records

ICE CAP

Research under this line of the Programme is fully integrated in the European Project for Ice Coring in Antarctica.
Its goal is the continuous, high-resolution reconstruction of environmental and climatic variations in the Antarctic extending from centuries up to several hundred thousand years BP based upon deep ice coring. Its final purpose is : (i) to clarify the cycles of stability/instability of the ancient global climate and their forcing; and (ii) to establish the coupling of climate between the hemispheres. The major benefit expected from EPICA is to improve the realism of our projections on the future evolution of the global climate.

Belgium's interest in EPICA has been materialized by the decision that was taken in December 1995 by the Minister of Science Policy, to contribute an amount of 20 MBEF to the operational costs of the project.

Themes of research

Study of the dynamics of the basal ice expected from the EPICA drilling, so as to determine the boundary conditions (glacier/bedrock) having an impact on the dynamics of the ice cap basis.

Analysis of the flow mechanisms of the ice cap and the drainage glaciers, combining site measurements, satellite images and mathematical modelling in view of reconstructing the dynamic response of Antarctica to the climate signals.

Modelling atmosphere/ice cap transfer functions, such as the accumulation and the ablation of snow and ice, so as to determine the forcing for regional ice cap flow models.

MARINE SEDIMENTS

The spatial structure of the marine sediments nearby the continental margins (continental platform, hill tops, peri-antarctic basins) constitutes an extremely important record for the dynamics of the ice cap and fluctuations thereof. Distal series for example, contain information which is analogous to that of deep marine sediments, but its resolution is higher because of the high sedimentation rate. Choosing areas where there is a maximum preservation allow to document the fluctuations of the ice cap all through history, going back even more than 500,000 years. This information is representative in terms of space, as the ice flux integrates the climate signals spread all over the basin. From this point of view, the pacific margin of the Antarctic Peninsula constitutes a privileged area of research, especially because of the pronounced subsidence of the margin and the existence of real sediment pitfalls, which subtract the sedimentary deposits from the erosion that is caused by the ice cover extension.

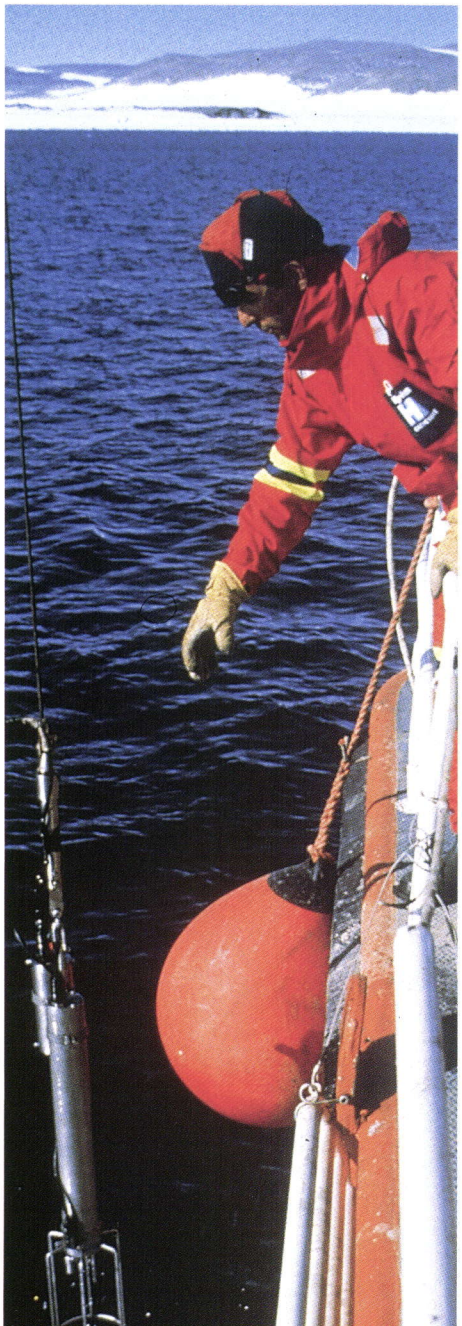
The evident tool to decipher the structure of sedimentary material of this nature is without any doubt the very high-resolution seismics. Seismics is characterized by an exceptional capacity for gathering data and it can be applied on sites where other methods fail to work. This way it allows an accurate and continuous analysis of

geological formations of very large size, which otherwise remain inaccessible. This kind of surveys, completed with data from very judiciously chosen drillings, should allow a better understanding of the role of the large orbital periods in glacial episodes of the Quaternary.

Themes of research

Very high-resolution geophysical studies of the structure and the genesis of sedimentary deposits nearby the ice cap (more in particular, in the sectors of the continental shelf with a high rate of preservation, on the slopes and in the periantarctic basins), in order to decipher what is recorded from the dynamics of the ice cap in response to the climate variations of the Quaternary.

Development of new technological approaches and innovative methods of analysis in geophysics, applied to the study of sedimentary palaeoclimatic records.



LIST OF PROJECTS

Marine Biota and Global Change

18	MEIOBENTHIC BIODIVERSITY AND FLUXES WITHIN THE ANTARCTIC BIOGEOCHEMICAL ENVIRONMENT	Prof. M. Vincx (RUG)	
19	ECOFUNCTIONAL BIODIVERSITY OF BENTHIC CRUSTACEAN TAXOCOENOSES IN THE SOUTHERN OCEAN	Dr Cl. De Broyer (RINS)	
20	AN INTEGRATED APPROACH TO ASSESS CARBON DYNAMICS IN THE SOUTHERN OCEAN Coordinator: Dr F. Dehairs	Dr F. Dehairs (VUB) Dr Ch. Lancelot (ULB) Prof. L. André (RMCA) Dr M. Frankignoulle (ULg) Dr E. Deleersnijder (UCL)	New and export production Study and modellisation of the planktonic system Barite geochemistry Air/sea exchanges 1D modelling of the sea-ice and water column
22	RESPONSE OF THE SOUTHERN OCEAN GLOBAL ECOSYSTEM TO PHYSICAL AND TROPHIC CONSTRAINTS Coordinator: Dr J.-H. Hecq	Dr J.-H. Hecq (ULg) Dr G. Pichot (MUMM) Prof. V. Demoulin (ULg)	Ecosystem functioning and modelling Physical modelling Role of the picophytoplankton

Dynamics of the Southern Ocean

25	STUDY OF CONVECTIVE MOVEMENTS IN THE SOUTHERN OCEAN	Dr G. Pichot (MUMM)

Palaeoenvironmental Records

26	MASS BALANCE OF THE ANTARCTIC ICE CAP (A CONTRIBUTION TO EPICA)	Prof. A. Berger and Dr H. Gallée (UCL)
27	EPICA BASAL ICE EASTERN ANTARCTICA	Prof. R. Souchez (ULB)
28	DYNAMICS OF THE ANTARCTIC ICE CAP AND CLIMATE CHANGES (A CONTRIBUTION TO EPICA)	Prof. H. Decleir (VUB)
29	ANTARCTIC SHELF-SLOPE DYNAMICS: AN INNOVATIVE GEOPHYSICAL APPROACH	Prof. M. De Batist and Dr J.-P. Henriet (RUG)

MEIOBENTHIC BIODIVERSITY AND FLUXES WITHIN THE ANTARCTIC BIOGEOCHEMICAL ENVIRONMENT

Promoter

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TOPIC The purpose of this project is to determine the role of the coastal zone and the deep sea ecosystems in the productivity and energy fluxes in the Southern Ocean. In the Antarctic, where the availability of the food resources – produced as well in situ as imported – strongly depends on the seasonal variations of the environmental conditions, the space and temporal variations of the various relations between the various communities have a fundamental importance. The structure and the functioning of the antarctic biota are also determined by typical phenomena resulting from the dynamics of the sea ice. One thinks here of the capacity of recovery of the biota subjected to disturbances due to the action of icebergs in the coastal zone and at the edge of the ice cap.

Special attention will be paid to the association between meiofauna, interstitial nutrients, organic matter (dissolved and particulate), pigments, sediments texture and bacteria.

Central to this study on the meiobenthos are the following topics: (i) seasonal, annual and long-term variations; (ii) biogeochemical interactions and carbon fluxes; (iii) feeding strategies; and (iv) life cycles. These topics are dealt with in a general framework of coupling benthos/pelagos, abiotic/biotic interactions and of biodiversity within the Antarctic ecosystem.

GOALS The overall objective of the project is to improve our understanding of the structure and dynamics of the Antarctic coastal and shelf marine ecosystems from the point of view of the meiofauna. It will be endeavoured to determine the complex but productive patterns of antarctic meiofauna according to the specific characteristics of an sea ice dominated ecosystem.

Specific objectives are:

- monthly evaluation of the seasonality of the meiobenthos in response to the pelagic contribution of the primary production;
- determination of the short-term effect (days) on the benthos of the direct supply of organic matter from the water column to the seabed;
- comparison of the seasonal variations of benthic activity within a low-Antarctic site (Signy) and within a high-Antarctic site (Rothera);
- study of the interactions between the composition and the structure of the meiobenthos, on the one hand, and the biotic and non-biotic south polar environment, on the other hand;
- improvement of the knowledge of the role of the meiofauna in the recycling and transport of the biogenic matter, thanks to the determination of carbon budget;
- identification of life history and feeding strategies of the dominant groups meiobenthic (nematodes) in a complete annual cycle;
- determination of the mechanisms of reciprocal coupling and decoupling of benthic strategies (feeding, reproduction);
- description of the structural biodiversity of benthic communities in specific polar biotopes (mattes of sponge spicules, bryozoan structures, "fluff", remainders of algae...);

- evaluation of the succession of the benthic communities in the process of recolonization (recovery) following disturbances caused by iceberg scouring;
- determination of the temporal variability of meiobenthic diversity in antarctic coastal ecosystems.

ECOFUNCTIONAL BIODIVERSITY OF BENTHIC CRUSTACEAN TAXOCOENOSES IN THE SOUTHERN OCEAN

Promoter

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TOPIC Description and evaluation of the role of biodiversity of the macrobenthos, in particular of the peracarid crustaceans, in the structure and functioning of the antarctic coastal and shelf ecosystem. In the Southern Ocean, the peracarid crustaceans represents the most speciose vagile macrobenthic group and probably more diversified in terms of habitats, trophic types and size spectra and the key-ecosystem is recognized like the most complex, most productive and probably most sensitive to global environmental changes.

GOALS To characterize the structural aspects of the peracarid crustaceans biodiversity (specific richness, distribution, bio-ecological features), and in particular of the amphipods, in the benthic communities of the "Antarctic Sea-Ice Zone", as well as their variability in space and time.

To develop a "reference centre" for the biodiversity of antarctic amphipod crustaceans, gathering specialized databases, validated reference collections and a network of contributing specialists. On this basis, to develop new synthetic tools to describe the biodiversity of the Southern Ocean peracarid crustacean.

To evaluate the ecofunctional role of the biodiversity of crustacean taxocoenoses in the benthic ecosystem of the "Antarctic Sea-Ice Zone". In particular, to evaluate the importance of the biodiversity in the production, by the study of the various trophodynamical roles, and the significance of the gigantism of the crustacean amphipods in two reference benthic communities.

AN INTEGRATED APPROACH TO ASSESS CARBON DYNAMICS IN THE SOUTHERN OCEAN

Promoters

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TOPIC This research attempts to determine the role – CO_2 source or sink – of the Southern Ocean on a regional and seasonal scale by implementing an integrated multidisciplinary approach which combines in situ measurements, studies of process in laboratory controlled conditions and numerical computation. It approaches the whole of the processes which govern the cycle of carbon in the Southern Ocean, from exchanges of CO_2 at the air/sea interface until to accumulation of carbon in the sediments.

It is based on a mechanistic scientific approach which aims at improving comprehension of the production process and of mineralisation of carbonaceous biomass in surface water as well as export towards the deep ocean. In particular, the roles of light and the availability in nutrients (major and minor) in the determination of the dominant phytoplanktonic community, and thus of the dynamics of the associated food chain and the carbon exportation, will be studied in areas dominated by various phytoplanktonic communities, namely the diatoms, the colonies of Phaeocystis and the nanophytoplankton. The role of aggregates as carbon conveyors, from surface to the deep water and the sediments, will be investigated with special attention to the following processes: the bacterial mineralisation of aggregates and the production and fate of the barite proxy.

The use of the barite as tracer of the exported carbon flux will be evaluated in order to improve the existing transfer functions. Acquired knowledge will then be integrated in a 1D physical and biogeochemical model able to simulate the cycle of carbon as well associated biogenic elements (N, Si, Fe, Mn, Ba) in the whole water column of the Southern Ocean over a seasonal cycle. All together, this study will contribute to establish a diagnostic and predictive model which will be used to evaluate the role of the Southern Ocean in a global perspective.

GOALS This integrated study has as overall objective to determine the role of the Southern Ocean – CO_2 source or sink – on a seasonal and regional scale. It more specifically aims at bringing an answer to the following questions:

- Which are the CO_2 source and sink areas in the Southern Ocean system, and which is the net flux of CO_2 between the ocean and the atmosphere?
- Which are the biological and physicochemical mechanisms controlling the distribution of CO_2 partial pressure (pCO_2)?
- Which are the mechanisms governing the production and the mineralisation of organic carbon in surface waters?
- By which mechanisms do light, inorganic nutrients (nitrate, ammonium, silica) and trace elements (Fe, Mn) control the photosynthesis and the growth of the three key-component of the phytoplankton of the Southern Ocean (diatoms, Phaeocystis, nanophytoplankton)?

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- Which are the mechanisms which determine the fate of organic carbon in surface water and in particular the factors controlling the formation of aggregates derived from the phytoplankton and their mineralisation by the micro-organisms which adhere to it?

- Which are the mechanisms of transformation of organic carbon during its transfer from surface to the sediment, in particular those implied in the degradation and the mineralisation of the aggregates in the first 500 meters of the water column?

- Up to what point are the geochemical tracers such as Ba-barite valid "proxies" of the export production?

- Up to what point the mechanistic model CLIO-1D/SWAMCO whose numeric code results from the assets of the project, allows the evaluation of the role – sink or source of CO_2 – of the Southern Ocean at seasonal and regional scale?

SPECIFIC EXPERTISE

Dr F. DEHAIRS (VUB)

- Space and time differentiation of phytoplankton functionality.
- Phytoplankton nitrogen uptake regime.
- Role of aggregates in the formation of barite.
- Kinetics of the uptake of Ba and other tracers (Sr, Nd, Ce, Th, Pb) by suspended matter and aggregates by means of isotopic dilution techniques (on board experiments).
- Dynamics of Ba uptake and remineralization in the water column.
- Space variability of $BaSO_4$ saturation rate.
- Ba-based transfer functions for estimating export production.
- Overall synthesis of results of the integrated project.

Dr Ch. LANCELOT (ULB)

- Physiological parameters characteristic of carbon metabolism in diatom- and Phaeocystis-dominated communities by means of an innovative protocol combining ^{14}C labelling and biochemistry.
- Diatom silica uptake (^{32}Si radio-tracer method).
- Assimilation and adsorption of Fe and Mn by the phytoplankton.
- Diatom/Phaeocystis-derived aggregate formation and microbial transformation.
- Sedimentation of diatom/Phaeocystis-derived material.
- Extension and upgrading of the mechanistic biogeochemical model SWAMCO.

Professor L. ANDRÉ (RMCA)

- Kinetics of the uptake of tracers (Sr, Nd, Ce, Th, Pb) by suspended matter and aggregates by means of isotopic dilution techniques.
- Kinetics of the uptake of tracers by aggregates by means of in vitro incubation experiments.
- Geochemical composition and vertical distribution of barite.

- Barium-barite geochemical and isotopic fractionation between particulate phase (sediment and suspended matter) and sea water.
- Morphology and geochemical composition of sedimentary barite.

Dr M. FRANKIGNOULLE (ULg)
- Methodology for the assessment of pCO_2, pH and O_2 in the polar environment.
- CO_2 fluxes through the ocean/atmosphere interface.
- Vertical distribution of carbon and oxygen in relation to organic matter production and mineralization.

Dr E. DELEERSNIJDER (UCL)
- One-dimensional adaptation of the CLIO-1 model and validation.
- On-line coupling of the SWAMCO and CLIO-1D models and calibration.

RESPONSE OF THE SOUTHERN OCEAN GLOBAL ECOSYSTEM TO PHYSICAL AND TROPHIC CONSTRAINTS

PROMOTERS

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TOPIC The research consists of a multidisciplinary study of the biodiversity and productivity of the global ecosystem of the Southern Ocean in a context of variation of the environmental and climatic conditions. It develops an approach based on the analysis of sub-ecosystems at specific time and space scales and on the interconnection of these systems by means of a proper modelling. The studied sub-ecosystems are:

- the planktonic ecosystem, which is the target of the study of the processes relating to biodiversity, dynamics and phyto-zooplanktonic interactions (specific scale: water column and ice layer);

- the pelagic ecosystem, with which is associated the macrozooplankton and in particular the krill (specific scales: Ross Sea and decade);

- the ecosystem of the higher trophic levels (specific scales: Southern Ocean and century).

It relates to the conceptualization, the parameterization and the validation of a coupled 3D numerical model integrating the whole of the physical and biological processes which control the dynamics and the variability of the global ecosystem of the Southern Ocean. The biological module of this model will be primarily centred on the zooplankton (in particular the krill) and the higher predators, but will take into account phytoplanktonic variables limiting the feeding of the herbivores. In a second step, the coupled 3D model will be applied to the evaluation of the response of this ecosystem according to various scenarios of forcing taking account of natural factors as well as anthropogenic.

GOALS To understand how the physical and biological processes coupled at various scales control the functioning and the evolution of the global ecosystem of the Southern Ocean. More specifically, the goal is to quantitatively determine

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how this ecosystem reacts to the whole of the physical constraints, be it directly – owing to the effects of the hydrodynamics, the vertical structure of the water column, the ice cover and the penetration of light in the water, or indirectly – owing to the trophic conditions, qualitative (the favoured species or group of species) and quantitative (the quantity and the productivity of these species) which are imposed by the physical constraints.

To determine, in a perspective of help to the decision-making process as regards environmental protection, how this system would respond to environmental and climatic changes, natural or anthropogenic.

These goals are pursued within the framework of an international programme on the global ecosystem of the Southern Ocean in the Ross Sea in collaboration with the Italian National Research Programme on the Antarctic (PNRA) and, in particular, during campaigns in the Ross Sea planned for 1997-98 and 1998-99.

SPECIFIC EXPERTISE

Dr J.-H. HECQ (ULg)

- Phytoplankton response to physical (light, including UV and water column vertical structure) and trophic forcing (grazing, biodegradation, biosedimentation).
- Extension of the 1D vertical ecological/hydrodynamical ECOHYDROMVG model to lower trophic levels.
- Phyto- and zooplankton response to physical forcing owing to sea ice.
- Modelling the dynamics of krill populations.
- Modelling of trophic processes.
- Phyto- and zooplankton distribution.
- Scenarios for evaluating ecosystem resilience and evolution in function of environmental and climatic forcing.
- Data collection and diffusion by means of telematics.
- Overall synthesis of the results of the integrated project.

Professor V. DEMOULIN (ULg)

- Molecular techniques for the characterization of picophytoplankton (cloning, sequencing and hybridation of marked probes relative quantification).
- Vertical structure of picophytoplankton diversity and abundance.
- Mesoscale horizontal structure of the diversity and abundance of picophytoplankton.
- Relationship between the diversity and abundance of picophytoplankton and the sea ice.

Dr G. PICHOT (MUMM)

- Numerical adaptation of the 1D ecological/hydrodynamical ECOHYDROMVG model.
- Introduction of the ie freezing in the ECOHYDROMVG model and simulation over a standard seasonal cycle.
- Introduction of biological equations in the OIL-SPILL-96 model.

- Extension of the ECOHYDROMVG model to a two dimensional horizontal model for the Ross Sea and adaptation of the MUMM-SEAICE model.
- Adaptation of the MUMM-3D hydrodynamical model to the Ross Sea circulation.
- Biological/hydrodynamical coupling of the adapted MUMM-3D model.
- Sensitivity experiments for assessing interannual and regional variability and ecosystem resilience.
- Scenarios for evaluating the response of the Southern Ocean to environmental and climatic forcing.

Dynamics of the Southern Ocean

STUDY OF CONVECTIVE MOVEMENTS IN THE SOUTHERN OCEAN

PROMOTER

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TOPIC The project aims at working out a mathematical model able to provide, at the regional scale of the Weddell Sea, an accurate representation of the hydrodynamics and the air/ocean interface usually covered by the ice pack. Detailed attention is paid to the zones surrounding the Filchner-Ronne Ice Shelf and the Maud Rise which are renowned, the former, for significantly contributing to the production of deep water and, the latter, for undergoing upwellings of relatively warmer water.

It comprises two main sections which are the numerical modelling and the use of satellite imagery and in situ data. The first deals with a detailed representation of the ice pack including its rheology coupled to a oceanic model calculating the temperature and salinity fields. The second one is centred on the direct validation of the results.

In a second step, it consists in implementing the model so as to study the convective phenomena characteristic of the Southern Ocean and their implications on the production of deep water in relation to the regulation of the global climate.

GOALS The following goals will be pursued during this study:

To contribute to the improvement of the comprehension of the convective phenomena which affect the Southern Ocean while attempting to identify:

- the zones contributing to the formation of deep water;
- the conditions favourable to this formation;
- the effects on the remainder of the world oceanic circulation in relation to the global climate.

To extend the coupled ocean/ice model developed at the scale of the Sea of Weddell to operational mode for the needs of potential end-users, in fields like the prevention and the control of pollution by hydrocarbons.

To make forecasts generated by the operational version of the model available to such users.

To circulate the global results of the study among the researchers in marine ecology and biogeochemistry, in particular by means of telematics.

MASS BALANCE OF THE ANTARCTIC ICE CAP (A CONTRIBUTION TO EPICA)

PROMOTER

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TOPIC This study makes part of the EPICA project (European Project for Ice Coring in Antarctica) which falls under the international research effort developed during the last decades in order to try to put forward a scientific response to the problems of the global climatic changes.

The two large polar ice caps of Greenland and the Antarctic are privileged actors of the global climate system. Not only their high capability to reflect the solar radiation influences the balance of the energy reaching the surface of the Earth, but they can contribute, by their possible melting, to the rise of the average sea level. These polar ice caps also constitute a record of the climatic system insofar as they register and preserve within their ices the past climatic variations.

The project intends to contribute to tasks specifically identified in the EPICA scientific plan. It relates primarily to the development of a climatology (characteristics of the climate, here the current climate) of the Atlantic and Indian sectors of Antarctica established on the basis of the application of a regional climatic model (RCM). This climatology is expected to bring new elements in the knowledge of the spatial distribution of the climatic parameters specific to the above-mentioned areas, and to contribute thus to the process of interpretation of the palaeoenvironmental signals extracted from EPICA ice cores. It has as an additional aim to develop a function "surface mass balance" which will be made available to glaciologists modellers participating in EPICA research-work.

GOALS The global objective of EPICA is to carry out a continuous and high resolution reconstruction of the global climate and past environmental changes, from the scale of the century to the scale of several hundreds of thousands of years, on the grounds of the analysis of ice cores sampled by deep drilling.

Two great stages of drilling are envisaged. The first, currently ongoing, relates to the central part of the Antarctic cap, namely the zone of Dome Concorde. The second targets the Atlantic sector of the cap, namely the Queen Maud Land. The final site will be selected according to the results obtained at Dome Concorde.

The objectives of this research are the following:

To establish a relation between the global climate and the local climate specific to the sites of EPICA drilling, relation which could be reversed during the reconstruction of the global climate based upon the analysis of ice cores.
In a more specific way, the research will tackle to such an aim:

- the identification of the relevant features (high rate of accumulation, significant climatic influence of the Atlantic Ocean) which will enable to select the most appropriate site of drilling in Queen Maud Land;
- the correct interpretation of climatological parameters of the ice core from Dome Concorde such as the $\delta^{18}O$ and δD;
- the quantification of the movements of the ice which are to be taken into account to correctly interpret the age of the ice core from Dome Concorde.

To provide the EPICA scientific community with a function of "weight breakdown of surface" of the Antarctic ice cap which should allow to reduce the uncertainty which still remains on the contribution of this cap to a possible elevation of the average level of the seas during the next century.

EPICA BASAL ICE EASTERN ANTARCTICA

PROMOTER

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TOPIC The subject of this research is to proceed to a detailed interpretation of the composition of the basal ices from the EPICA drilling at the Dome C and role of the possible interactions between the ice cap and the stretches of water detected at its base.

It appeared very clearly these last years that the composition of polar ices records key-parameters of the Earth's climatic environment. As the layers of ice are all the more old for being deeper, a drilling which crosses some 3,000 m of Antarctic ice and reaches the substratum makes it possible to obtain a record extending over a few hundred thousand years. Such is the main purpose of the European project EPICA in Eastern Antarctica, which will allow a particularly precise environmental reconstruction on such a time span.

The methods of absolute dating of the ices do not go beyond 100,000 years and the only method for assessing the age of the deepest ices remains the modelling of the flow of the ice cap.

In this context, the composition of the basal ices provides not only indications on the characteristics of the deformations which underwent the ice cap, but it also makes it possible to understand, like it has been done for the central part of Greenland, the processes which governed its development and which influenced its dynamics. Such information is fundamental for a correct modelling of the flow, which only makes it possible to work out a chronological scale beyond 100,000 years.

Near the site chosen for the first major EPICA drilling, namely Dome C in the Eastern Antarctic, radio-echo-surveys revealed the existence of stretch of sub-glacial water. It is thus extremely probable that very particular dynamical conditions, different from those of the centre of Greenland, prevailed and reign at the base of this ice cap because of the interactions between the ice and these stretches of water. The comprehension of these phenomena is essential to the deciphering of the palaeoenvironmental record beyond 100,000 years.

GOALS The following goals will be pursued during this study:

- The preliminary technical perfecting of some methods of analyses, being given the particular characteristics of the basal ices rich in remains and low in gas contents.
- A better comprehension of the physico-chemical processes which occur at the surface of contact between a glacier and a lake in Antarctica, thanks to the analysis of the composition of the ices which were formed there.

- A better comprehension of the physico-chemical processes which occur in Antarctica at the anchoring line, where the glacier looses from the substratum at the seawater interface, thanks to the analysis of the composition of the ices which were formed there.

- A better knowledge of the characteristics of Eastern Antarctica fossil ices buried within the ground in areas currently not frozen, in order to be able to determine their genesis. This knowledge could prove to be significant insofar as underground ices preceding the formation of the cap could exist at the base of the EPICA ice core.

- The application of the knowledge obtained within the framework of the preceding objectives to the analysis of the composition of the basal ices of the EPICA drilling at Dome C.

- The determination of the characteristics of the deformations undergone at the base of the ice cap in the area of Dome C and its implications on the chronological scale beyond 100,000 years.

This research should make it possible to better determine the importance of the deformations present at the base of Dome C. They should lead to an improvement of the chronological stratigraphy of the deep ices in the light of the analysis of their composition, which is essential to allow to reconstruct past climates beyond 100,000 years.

DYNAMICS OF THE ANTARCTIC ICE CAP AND CLIMATE CHANGES (A CONTRIBUTION TO EPICA)

PROMOTER

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TOPIC Major drillings, as well Greenland as in the Antarctic, make it possible to exploit single files for better understanding not only the history of the total climate but, in particular, the evolution of the ice caps and the variations of the sea level which are associated for him.

With project EPICA, the European Community ambitions to provide a fundamental contribution to these problems and, that, by the realization of two major drillings in Antarctica. It is mainly major drilling at Dronning Maud Land which must make it possible to examine the relation climate/ice cap/sea level, especially in the Atlantic sector. This Atlantic sector is significant by the fast and radical variations observed in the northern part (Summit, Greenland) and by its relevance for Europe.

In order to forge a coherent idea of the history of the climate and physical environment, it is necessary to associate the direct data resulting from drilling, on the one hand, with atmospheric circulation and, on the other hand, the dynamics of the ice cap.

This research project primarily aims at providing a contribution to this last

aspect of project EPICA using a numerical modelling and of a data acquisition by remote sensing as well as suitable ground observations.

GOALS Study of the regional behaviour of the Antarctic ice cap:

- Specific function of the marginal processes (processes at the base of the cap, interactions ice-ocean, dynamics of the grounding-line, etc)
- Role of the continental ice fluxes in the stability of the ice cap.

Implications of the marginal processes for the environment of the future EPICA drilling site and for interpretation of EPICA signal.

Reconstructing of the glacial history of the cap in the zone of Dronning Maud Land (interactions climate/ice cap/ocean) at the end of the Cenozoic.

ANTARCTIC SHELF-SLOPE DYNAMICS: AN INNOVATIVE GEOPHYSICAL APPROACH

PROMOTER

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TOPIC The purpose of this research is the geophysical study – at very high-resolution – of the internal structure and evolution of Antarctic continental margins, in order to better understand the relation between, on the one hand, the dynamics of the ice cap and, on the other hand, the processes of sedimentary deposition and remobilisation on the continental slope. It aims at exploiting in an optimal way the seismic-reflection using large-band sources, like the "sparkers", which were used successfully within the framework of the studies carried out on the large lakes and more recently also on the European continental terraces.

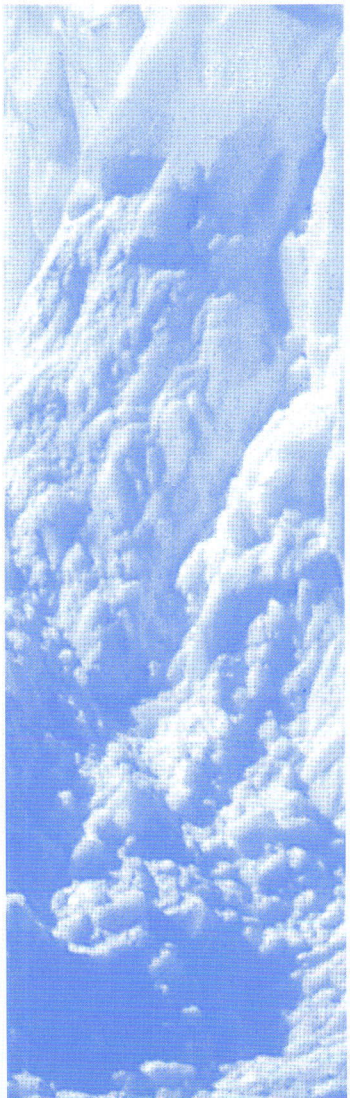
GOALS In accordance with the recommendations of SCAR/ANTOSTRAT, the research is centred on a number of specific scientific objectives:

- on the shelf even: analysis of the possible sedimentary residual deposits like potential witnesses of smaller pulsations of the ice cap, which would not have reached the edge of the plate itself;
- on the outer part of the shelf and the higher parts of the continental slope: the space relation between the zones of progradation of the "through-mouth-fans", deposited in front of the discharge system of large ice flows;
- the space and chronological relative relation between the deposits on the continental slope even and those of the base of the slope;
- the space and chronological relative relation, at large scale, between instabilities ("debris flows") on the continental slope and the normal growth of the "through-mouth-fans", in order to be able to determine whether these processes are phased or outphased.

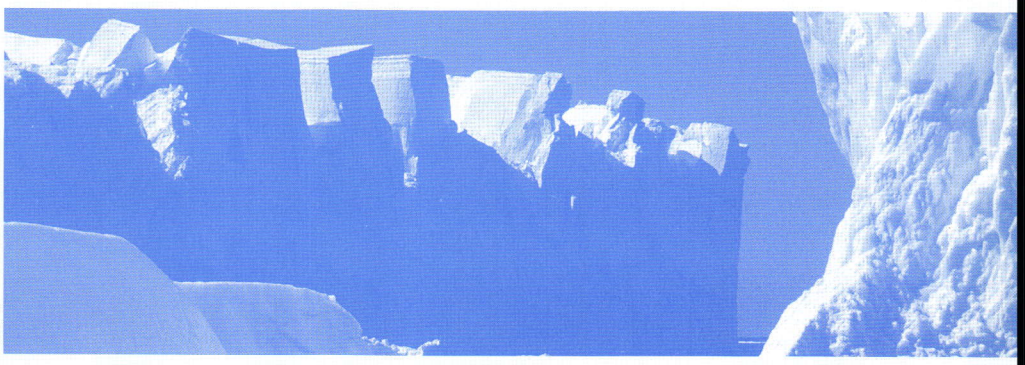
With the aim at being able to project these processes in an optimal way on an absolute chronology of the glacial evolution of the Antarctic margins, the above-mentioned efforts of research – within the framework of the operational possibilities – will follow upon the new phase of the ODP Antarctic activities planned for the forthcoming years.

Regarding methodology, these scientific objectives imply the development of a technique of seismic-reflection able – in polar water – to preserve the optimal characteristics of broad band as well as a maximum signal-to-noise ratio in the useful bandwidth. To this end, it is necessary to let towel at least one of the components of the seismic system on some 300 meters under the surface of water, in combination with a surface "streamer" when the atmospheric conditions allow it. In a second step, one will also aim the immersion of a "sparker" source, which implies the study of the behaviour of a "sparker" system within the framework of a "subtow" configuration with an significant length of cable.

A detailed attention will be given to the examination of the possibilities of valorization of this new methodology, in particular in the field of geotechnics of the sites located on the continental slope (preparation of drilling sites, study of ground instabilities).



ABBREVIATIONS AND ACRONYMS



ANTOSTRAT	Antarctic Offshore Acoustic Stratigraphy Project
EASIZ	Ecology of the Antarctic Sea Ice Zone (SCAR)
EPICA	European Project for Ice Coring in Antarctica
GLOBEC	Global Ocean Ecosystems Dynamics Research
IGBP	International Geosphere-Biosphere Programme
MUMM	Management Unit of the Mathematical Model of the North Sea
ODP	Ocean Drilling Program
OSTC	Federal Office for Scientific, Technical and Cultural Affairs
PNRA	Programma Nazionale di Ricerche in Antartide
RINS	Belgian Royal Institute of Natural Sciences
RMCA	Royal Museum for Central Africa
RUG	Universiteit Gent
SCAR	Scientific Committee on Antarctic Research
SO-JGOFS	Southern Ocean Joint Global Ocean Flux Study
SWAMCO	Seawater Microbial Community Model
UCL	Université Catholique de Louvain
ULB	Université Libre de Bruxelles
ULg	Université de Liège
VUB	Vrije Universiteit Brussel

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Additional information on the Belgian Scientific Research Programme on the Antarctic is available on Internet http://www.belspo.be/antar

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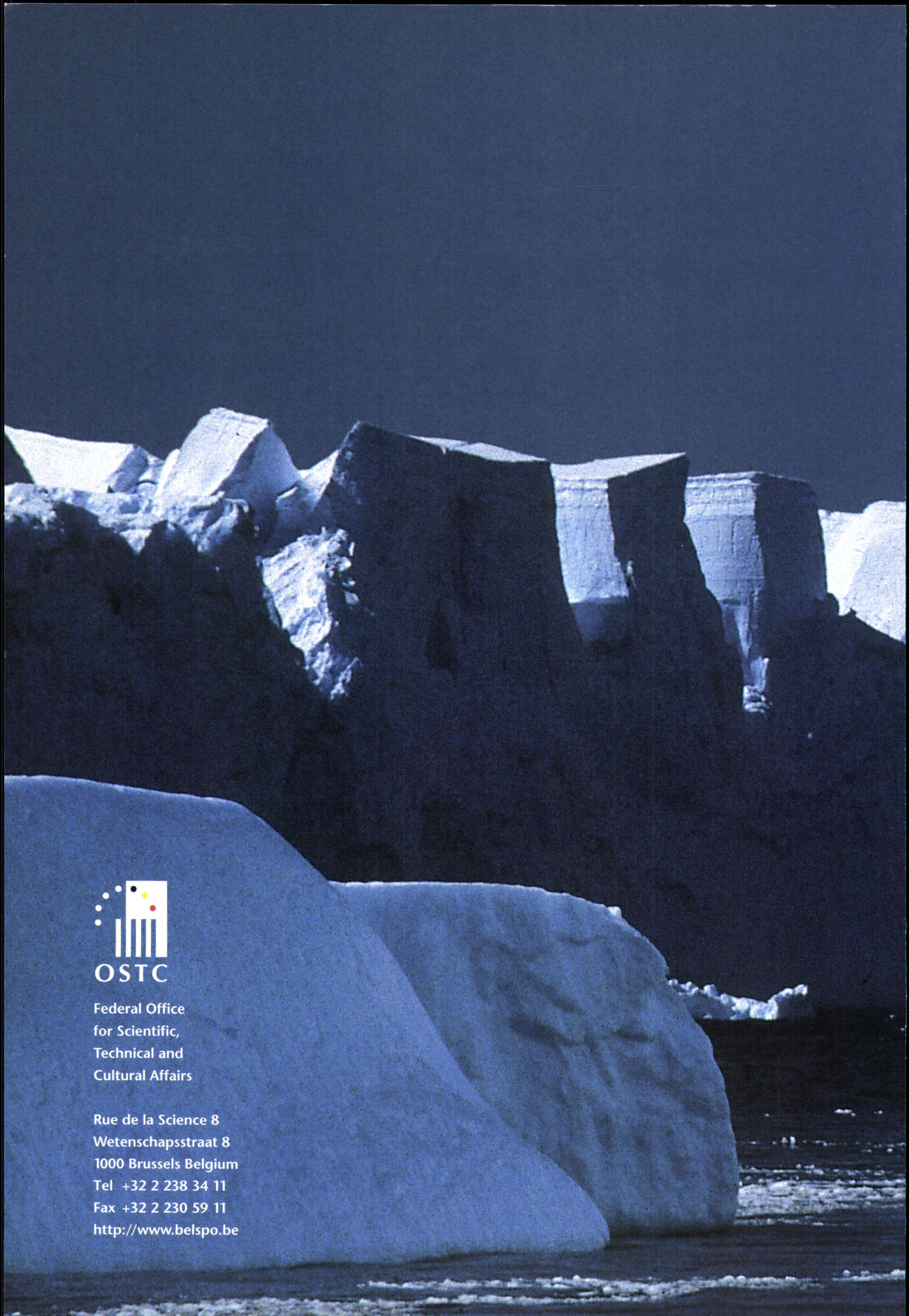

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