

**SCIENTIFIC RESEARCH ON THE ANTARCTIC IN FRANCE**

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## ABSTRACT

France has no organism specialized in polar research. However, within laboratories depending on the "Centre National de la Recherche Scientifique" (CNRS), universities or other research organisms, some teams are dealing with specific problems about polar regions.

Three organisms coordinate on different accounts, the research efforts :

- The "Territoire des Terres Australes et Antarctiques Françaises" (TAAF), and especially its department "Mission de Recherche", chooses and finances the programs, upon advice of a Scientific Committee. Moreover, the TAAF takes charge of infrastructure and logistics. Its competence extends on Adélie Land (Antarctica) Kerguelen Islands, Crozet, Saint-Paul and Amsterdam (South of the Indian Ocean) as well as on "Marion-Dufresne", an oceanographic ship linking the various islands.
- The "Comité National Français de Recherche Antarctique" (CNFRA) corresponds to the SCAR. This organism introduces or co-ordinates international co-operation about antarctic or sub-antarctic research.
- The "Expéditions Polaires Françaises" (EPF) are in charge, on account of TAAF, of all operations in Adélie Land and of transportation to Antarctica. Their action covers the whole polar region, Arctic as well as Antarctic.

Foreign laboratories are entitled to participate in the various expeditions that the TAAF organizes, either on land or on the oceanographic ship. In the same way as the French projects, their requests are examined by the Scientific Committee. However, the TAAF does not finance the foreign projects.

Bilateral and multilateral co-operations are generally favoured. Consequently, some teams of Belgian biologists have been welcomed in Kerguelen and on board the "Marion-Dufresne".

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To begin with, I should like to describe to you the structure within which scientific research on the Antarctic and sub-Antarctic regions is being developed in France. It is original in that it is not the sort of research conducted by specialist multidisciplinary institutes, as is the case in most member countries of the Antarctic Treaty, but involves researchers in existing laboratories who are interested in the polar regions providing them with logistical means and co-ordinating their efforts.

I shall then look at the main lines of research which are being followed at present and point out the trends in the immediate future with particular reference to the Antarctic.

In 1955, France, which owned three groups of islands in the Southern Indian Ocean – the Crozet Islands, the Kerguelen Islands and the islands of Saint-Paul and Amsterdam – and claimed Adélie Land in the Antarctic, created by law an autonomous Overseas Territory bringing together these four elements.

The French Southern and Antarctic Territories, the TAAF, have no population of their own and the main activity carried out there is scientific research. They are governed from Paris by a Higher Administrator assisted by a team of fifty people split up into three departments : sovereignty, logistics and research. It is this last-mentioned department which I run and to which I shall be devoting my attention above all. Its role is to implement all the research operations financed by the Territories and to supervise external operations.

Its sphere of competence is first of all the Territories proper, i.e. a purely Antarctic area with Adélie Land but also with the activities undertaken outside Dumont d'Urville base, particularly in the field of glaciology, a sub-Antarctic area with Crozet and Kerguelen, both at a latitude of around 50° south, and finally an area which its latitude of 38° south could lead one to believe to be subtropical, that of Amsterdam Island and Saint-Paul, but which in fact has a climate similar to that of the Falklands and is frequented by typically sub-Antarctic seabird species.

Its second sphere of activity is in the ocean : the Marion-Dufresne, a relief vessel for the Southern Territories and also the largest French oceanographic vessel. It operates in the south of the Indian Ocean and in the Southern Ocean. It is not a polar vessel but is sufficiently reinforced to allow it to work within the polar circle when ice conditions permit. During the southern winter, it is used in tropical areas of the Indian Ocean and, exceptionally, the Atlantic Ocean. As regards the Polarbjorn, which is chartered in Norway to supply Dumont d'Urville and is a real polar vessel, its small capacity means that six return trips are necessary between Hobart and Adélie Land and it is therefore unable to take time off for oceanographic work.

Dumont d'Urville, in the Eastern Antarctic, is very isolated. Its closest neighbours are Casey 1,300 km to the west and Leningradskaïa 900 km to the east.

The coast of Adélie Land also has very little ice-free land, whilst the coastal region is an area of katabatic winds. At our old Port Martin base, for instance, the average wind speed is 40 knots, with the maximum exceeding 150 knots, and there are storms 220 days a year. It is therefore relatively difficult to set up there and the Pointe Géologie archipelago 10 km from the continent, where our current base is established, seems to be the only oasis in the region with a microclimate where numerous species can breed and man can work.

Crozet is the archipelago of birds, which find suitable nesting sites on its five islands and abundant food on the marine plateau surrounding them. The climate is harsher than on Kerguelen. Alfred Faure base on Possession Island houses some thirty people working on essentially biological programmes.

Kerguelen archipelago covers a wide area, 7,215 km<sup>2</sup>, and has an infinite variety of landscapes. Its isolated position in the southern Indian Ocean, 3,600 km from any inhabited land, Africa or Australia, has made it an indispensable platform for studying the Earth, either directly or via satellites. Its climate is extremely variable and is virtually always practicable. Its exploration, geological in particular, and the listing of its animal and vegetable populations are still incomplete. Port aux Français base is the largest in the Territories, with a population of 75 in winter rising to 130 or more in summer.

Amsterdam and Saint-Paul are two subactive volcanoes situated on the East Indian Ridge. Martin de Vivies, in the north of Amsterdam Island, houses a team of 30 people. Alongside biological and geophysical observation work, monitoring the pollution of the seabed is no doubt the most original activity on the island. The adjacent waters have substantial spiny lobster population exploited by the Territories, which make a not insignificant income from it and the stocks of which are strictly managed through my department.

The oceanographic equipment on board the Marion-Dufresne enables it to carry out all kinds of programmes. It has an oceanographic winch which, equipped with a kevlar cable, makes it possible to work with 25 tonnes per 7,000 metres of depth, allowing cores 50 m long by 117 mm in diameter or samples of 1 m<sup>2</sup> in section by 1 m deep to be taken without disturbing the sediment. The rear hydraulic gantry, with a capacity of 10 t, reaches down to water level. A fixed hydrology winch is equipped with a power-carrying cable. In addition to these fixed installations, numerous appliances on a 150 platform allow the vessel to be adapted for all types of purposes : fishing winches, trawling winches and seismic streamer winders, a boomer, hydrology winches, etc. The fixed installations also include containerized laboratories.

As I said at the beginning of this speech, the Territories do not have any scientific teams of their own. They are researchers from the "Centre National de la Recherche Scientifique" or Universities of the "Musée National d'Histoire Naturelle", or, less frequently, from the "Institut Français de recherche scientifique pour le développement en Coopération", better known as ORSTOM, or the "Institut National de Recherche Agronomique", and possibly foreign bodies proposing programmes in the Territories.

Before being implemented, these projects must pass through a number of evaluation stages.

First of all, the Research Department determines :

- the logistical constraints and the equipment needed;
- the personnel concerned;
- the possibility or necessity of grouping together with other projects;
- the cost and the financing schedule.

All this is recorded on a data sheet attached to the request to be submitted to the Scientific Committee for evaluation.

This committee has twelve members, all top-ranking scientists appointed ex officio by a number of research bodies or as experts by the Ministry of Research. The only condition imposed on their appointment is that they must not conduct any personal research in the Territories. The committee examines each programme proposed and draws up a report on :

- the scientific interest of the proposal;
- the proposer's ability to implement and exploit it;
- the acceptability of the scope of the project from the point of view of the resources and costs involved.

It may request additional information and suggest groupings.

Once in possession of all these reports, the Research Department establishes an operational project for the next campaign in accordance with the transport capacities on the vessels and the reception capacities of the bases, and the credits granted to it. This plan of operation is discussed by the Scientific Committee, which may amend it before approving it.

As I have said, the requests from foreign researchers are examined according to the same procedure. However, additional factors are taken into account – two primarily :

- Is there co-operation with a French team ?
- For what proportion of the logistics and the financing is the foreign team responsible ?

Lengthy discussions have been held – for a long while now – on the value of grouping together research teams working in the Southern Territories or the Antarctic, whatever their disciplines, within a Polar Institute. In the first stage, the exchange of ideas which would result from this grouping would certainly be beneficial to the development of the methods and techniques used in research at high latitudes. On the other hand, there is a risk within each discipline of the specialists in the polar regions, cut off from their usual community, becoming isolated.

It is a fact that horizontal integration is not seen in a good light in France. It is easier to gather people together around a theme than around a tool. Such is the case, for example, with oceanography, where, despite the creation of a specialized institute, research remains fragmented into multiple units.

The Research Department therefore has a role of promoting Antarctic research, a role of co-ordination and guidance. In a concern for efficiency and optimum utilization of the logistical means available, it must give priority to groups of programmes and multi-disciplinary operations and promote work within a framework of national, bilateral or multinational co-operation.

Guidance is necessary to avoid dispersion and to optimize the use of resources. It is provided through two processes. The Scientific Committee calls in a group of experts to form a think tank which draws up a medium-term policy report, typically for a period of ten years.

Every three years, alternating between Antarctic and sub-Antarctic, a one-week colloquium is organized to which are invited all the researchers who have been active in polar regions, or would like to be, or who are simply interested in reporting on their work and setting out their plans, moving away a little from the original guidelines if necessary. The latest of these was held in Strasbourg in September 1987. The previous one, devoted to the Antarctic, took place in Grenoble in 1984, and I have given the secretariat some copies of the notes taken on this colloquium, together with some copies of the medium-term guidelines.

With a view to summing up these lines of research without going into too much detail and drowning you in exhaustive information, I shall try to give you a synthesis illustrated by a few slides.

**First theme** : the observatories.

The geographical isolation of the islands of the Indian Ocean and of Adélie Land is such that it is essential to maintain systematic observation of physical or biological parameters even if there is no possibility of immediate scientific exploitation. The acquisition of a series of quality data over long periods is one of the most precious commodities that we can and must provide as a contribution towards our understanding of the universe.

Consequently, in each of our bases we have observatories recording meteorological, magnetic and seismological data and monitoring populations of seabirds and marine mammals in the form of reference colonies, studies on the ionosphere and cosmic radiation on Kerguelen and in Adélie Land, and the auroras in Adélie Land.

**The second theme** concerns the inventory. Exploration of our area is far from complete. For the islands in particular, not all the colonies of seabirds or marine mammals have been the subject of a census. The inventory also concerns terrestrial and marine flora and invertebrates, geology, cartography and bathymetry, gravimetry, etc.

These first two major themes are more obligations towards the world scientific community than purposeful choices. We have made these choices for a certain number of fields of activity to which we decided to give priority and which I shall now summarize :

Five themes in biology :

- Nutrient salts.
- Primary production, phytoplankton and trophic webs.
- Genetic differentiation and speciation.
- Physiological adaptation to environmental conditions.
- Evolution of populations introduced deliberately or not.

Whilst the Salmonidea introduced on Kerguelen are closely followed and carefully monitored, this is not the case with the cattle on Amsterdam Island, with rats, mice, rabbits and cats more or less everywhere, and even with sheep, mouflon and above all reindeer, whose recent ill-considered introduction is difficult to control.

Four themes in atmospheric physics :

- Study of the minor components of the atmosphere and pollution : a monitoring station, for CO<sub>2</sub> in particular, has now been in operation for some ten years on Amsterdam Island.
- Closely linked with the preceding theme but not yet really started, a study of the middle atmosphere and troposphere-stratosphere exchanges in the Antarctic. To obtain the best results from this study, it must be possible to work inside the Antarctic continent; I shall come back to this point. Linked up with this, however, are the ozone measurements which have just been resumed at Dumont d'Urville.
- Study of the katabatic winds, a programme conducted in conjunction with two American universities.
- Finally, palaeoclimatology and oceanic palaeocirculation, which undeniably represent the field in which we have made most efforts and also achieved most results. The reputation of French glaciology with Claude Lorius is already established and so is that of the marine sedimentology teams at Gif-sur-Yvette.

As regards the physics of the upper atmosphere, which for a long time constituted the essential part of our research work, we have retained only one theme : the physicochemistry of the auroras.

Finally, we are coming under strong pressure from our astronomers and astrophysicists to open up the Antarctic to them, which they regard as an ideal observation site. Here too, we do not have the means to meet their request immediately.

There are also some themes relating directly to oceanography :

- geophysics and structural geology - history of the Indian Ocean;
- marine chemistry and especially carbon and sulphur cycles;
- circulation and tropical monsoons, which takes us away from the Antarctic but allows us to make use of the Marion-Dufresne on its route, during the southern winter.

In conclusion, I should like to expand a little on our Antarctic projects. The coast of Adélie Land, apart from six rocky outcrops, is an ice cliff some thirty metres high, the rim of the ice sheet which in this sector has a long steep slope and is therefore deeply crevassed. It is a region affected by katabatic winds which carve out large sastrugas on the surface over about 200 km. Crossing the coastal area is therefore a long, difficult and dangerous process. Consequently, activities within the continent are currently limited to glaciology alone and to campaigns which are always too short.

Of the rocky sectors, only two have a sufficient extension to allow a base to be set up. Port Martin in the east, our first installation abandoned after a fire, has not been reoccupied because the climate is particularly aggressive there. In the Pointe Géologie archipelago, on the other hand, where the present Dumont d'Urville base is situated, 10 km from the coast in a cove sheltered by the glacial tongue of the Astrolabe, the meteorological conditions are relatively favourable.

Seven species of birds, including a colony of emperor penguins, take advantage of these circumstances. But, partly due to lack of space, human activity is limited there and of the priority themes selected only the observatory activities and the physiological study of adaptation, particularly of the emperor penguins, are developing satisfactorily.

Despite its quality, as I have said, glaciological research suffers from the difficulties in gaining access to the continent and really survives only within the framework of co-operation with the Soviets or the Americans.

Coastal marine oceanography has been slowly starting up again over the last two years. This too is short of resources for complex reasons relating to the functioning of the base for many years, but this situation should be able to evolve fairly quickly.

On the other hand, in so far as research into the physics of the middle and upper atmosphere or astronomy is concerned, we still do not have an infrastructure which would enable this work to develop. We have therefore planned a far-reaching equipment programme based on the opening up of an airstrip in the Pointe Géologie archipelago.

This study was long and delicate. We had to make sure that it was indeed impossible to construct this airstrip on the continent. This seemed obvious for numerous reasons, but every hypothesis had to be carefully analysed before acknowledging that it led to a technological impasse.

Constructing it in the archipelago posed the problem of competition with the species nesting on the islands which would be involved in the project. We ensured that neither construction nor use of the strip would affect the rarest species. Techniques have been developed to protect the species present whilst the work is in progress or to carry out the work in winter when the birds have left the Antarctic coasts. It is planned to lay out new areas where the displaced species can find accessible spots with an equivalent surface. This whole aspect of protection of fauna is followed very closely by the researchers at the "Centre d'Etude biologique des Animaux sauvages" of the CNRS, which is the most competent laboratory in France to deal with this sort of problem.

The strip will therefore be laid on a causeway linking up five small islands. It will be a little over 1,100 m long and will be able to take Transalls or C130s from Hobart, a journey over sea of 2,700 km. The work should be resumed this year and be completed by the end of the 1990-1991 summer campaign. A light aircraft fitted with skis, of the twin-otter type, will be permanently based at Dumont d'Urville for easy access to the plateau.

The second part of our project is the construction of an overwintering base for about fifteen people at Dome C, about 1,000 km from the coast. The project is progressing well, but we shall have to bring in aircrafts to complete it.

In fact, part of the equipment will be airdropped or parachuted in, whilst the heaviest loads will be transported overland in convoys relying on fuel dumps also deposited by plane. Essentially, this structure will be intended for programmes on the physics of the atmosphere and the upper atmosphere and astronomy. It will also serve to back up the summer glaciology programmes and will no doubt be completed by some observatory instruments.

We also think that we shall soon be able to open it up to foreign researchers. The project has been planned with a capacity for 15 people in winter, a figure which can be doubled in summer, but thanks to its modular design this capacity can be easily extended.

This reorientation of French operational logistics will also be favourable to oceanographic research. Since personnel transport will be entirely by air, the vessel chartered to carry the heavy equipment to Adélie Land will have to make only one trip a year for logistical purposes.

Consequently, and this is the third aspect of our project, our polar vessel can be allocated to oceanographic programmes working close to the continent in areas where ice prevents the Marion-Dufresne from gaining access.

The financing of these projects is well established and, without being over-optimistic, we can look forward to French research in the Antarctic making made a new leap forward within the next five years.