CHAPTER-1

THE ANTARCTIC REGION: A GEOGRAPHICAL INTRODUCTION

Antarctica is the southern most continent of the earth. It is the highest continent, averaging more than 2 kilometres above the sea level and at the same time, it is also the most isolated continent, as its relative location is 990 km from the southern part of South America and 2000 km from New Zealand. Antarctica forms roughly $\frac{1}{10}$ of the earth's land surface and its surrounding ocean, that is the Antarctic Ocean, forms $\frac{1}{10}$ of the earth's oceans. Some 98% of the continent is covered by an ice-sheet with an average thickness exceeding two kilometres. At some locations the ice-sheet is more than 4.5 kilometres thick. This is the most important feature of Antarctica. The ice sheet represents more than 700,000 years of snowfall and contains important information on the development of the world climate. The continent contains information about the events that occurred 400 million years ago. It is also the coldest, the windiest and the driest continent of the earth. The lowest temperature ever measured is $86.6^\circ\text{C}$, measured in 1983 at the Russian research station Vostok. Occasionally the wind speed may exceed 250 kilometres/hour.

There is not a single village or town, not a tree, bush or blade of grass on the entire continent but far from being merely a white wasteland, a useless continent, Antarctica is vital to life on earth. It is both an important venue for determining global changes and is clearly
influenced by them. The region holds many secrets of the earth's past. It may also be the best monitoring zone for global pollution in the future, a vantage point from which to observe the degradation of the earth's natural system.

Antarctica is no longer a remote corner of the world reserved for reclusive scientists and dare-devil adventurists. It has been increasingly recognized as an integral component of global atmospheric, oceanic and geophysical processes vital to support the life on earth. It is indicated that Antarctica plays an important role in the global environmental system by acting, among other things, as one of Earth's "refrigerators". This clearly affects global weather patterns, atmospheric conditions and ocean circulation. The formation of Antarctic ice sheets and the associated cooling process have not only profoundly affected global climate patterns but the development of marine and territorial biota also. At the same time, the ice-sheet has proved to be an important repository of detailed records of past global climate and atmospheric make-up, covering hundreds of millennia. Further, it is widely known that this ice-sheet contains enough water to raise the world-wide sea levels by up to 60 metres. South polar waters also have a particularly important role in the exchange of carbon dioxide between the ocean and the atmosphere. These processes are affected by sea-ice formations and biological productivity.
One of the major challenges for the geographers is the definition of the outer boundary of Antarctica. "In 1945, the Royal Geographical Society proposed to regard latitude 66° 30' South as the northern boundary of the (Antarctic) Region. Vallux, on the other hand, recognised the line at 35° South, MacEwen at 40° South and Boucart, on the basis of bottom water topography, at 60° South".¹ Herm J. de Blij advocated that the northern limit of the Antarctic region is the sub-tropical convergence lying approximately at 40° South latitude.² However, one of the widely recognised view is that the borderline dividing the Antarctic waters from the water masses of the adjacent sectors of the Atlantic Ocean, Indian Ocean and Pacific Ocean is the outer boundary of the Antarctic Region. This is known as the Antarctic convergence and is the boundary of the Antarctic and sub- Antarctic surface waters. The Antarctic convergence is a zig-zag unbroken circle passing through all the sectors of the Antarctic Region and is best determined by the rapid change in the temperature of the water. Across the convergence, the temperature rises northwards from 4°C to 6°C in summer and from 1°C to 3°C in winter. This zone of convergence "varies in position from year to year and from season to season by upto 100 miles, but on the whole, it is well defined and marks the limit to the northern range of many plankton organisms, fishes and even

¹ V. Lebedev, *Antarctica* (Moscow, n.d.), p.132.
bottom dwelling animals". In the Atlantic and the Indian oceans the position of the convergence is generally 50° South and in the Pacific Ocean, it is 57° South.

According to Deacon, the position of the convergence is determined by the flow of deep water. However, the proposition is not universally accepted. Sverdrup believes that the light surface water of the sub-Antarctic zone are carried south by currents, set up by differences in density due to temperature and salinity, whereas Antarctic water is carried north by wind, and that the meeting of the two forms the convergence.

EXPLORATIONS TO THE ANTARCTIC REGION

The Antarctic Region has always been a mystery for the civilized world right from the time of Greeks and Romans. The ancient Greeks postulated the existence of a continent to the south because otherwise the world would not be in balance. They gave this Southern continent the name 'Anti Arcticos', from where the name Antarctica was derived. However, "the first deliberate attempt to sail in this area was made by Edmond Halley in 1700 on a vessel paramour". Though he touched the Antarctic convergence but could not move south of 52° 30' South due to adverse climate and impending icebergs. Next to encounter Antarctic icebergs was Jacob Roggeveen, a Dutch explorer sponsored by the Dutch East Indian Company. Sailing south of Falkland Island, he saw

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4 Lebedev, n.1,p.133.
solid lines - Cook

dashed lines - Bellingshausen

Shaded area - Unknown area at the time Cook started his voyages
scores of icebergs around 60° South latitude. This made him believe that there must be some continent further south. Between 1772 and 1775 Captain Cook undertook two great voyages to the Antarctic Region in his vessel *Resolution*. He was accompanied by Tobias Furneaux in the *Adventure*.

They circumnavigated almost the entire Antarctic Ocean facing numerous icebergs and discovering several islands. It was Captain Cook who reported the abundance of seals and whales, which brought many ships to the Antarctic. In 1819-21, two Russian ships *Vostok* and *Mirnyi* made a voyage around the Antarctic water under captain Theddaus Von Bellingshausen. He discovered several islands and the Bellingshausen sea is named after him. In 1840, two French ships *Astrolabe* and *Zelec* under the command of Admiral Dumont d'Urville, discovered the continent of Antarctica by sailing through the Antarctic Ocean. The expedition led by James Clark Ross, in the ships *HMS Erebus* and *HMS Terror* in 1840-41, "made comprehensive studies of the ocean as well as remarkable geographical discoveries, particularly of the deep embayment now known as the Ross Sea".²

In the later part of the nineteenth century, three major scientific expeditions took place. The French Vessel *Belgia* in 1897-99 made valuable physical, biological and geological and meteorological observations. The German Deep-sea expedition *Valdivia* (1898-99) found that Antarctic water has three-layer structure on the basis of temperature: Antarctic surface water, warm deep water and cold
bottom water. It also found that there was low salinity of the surface water, high salinity of the warm deep water, and a slight decrease in salinity in the cold bottom water. The third expedition was of the *Southern Cross* which sailed in the Antarctic waters between 1898-1900.

In the 20th century, Germany sent south polar expedition in 1901 under Erich Von Drygalski. It was basically a scientific expedition. One of the most significant findings was the recognition by the expedition’s meteorologist Wilhelm Meinardus that the west wind drift has a natural division into two parts. The southern part is a cold water region, directly influenced by Antarctic freezing and melting and the northern part is a mixed water region in which the temperature rises more rapidly towards the north. In the transition zone the cold water sinks and mixes with the warm water. It came to be known as Meinardus line and later the polar front or Antarctic convergence. Besides, in the early part of the twentieth century Scott made his last expeditions to Antarctica.

Other important expeditions during this period were the Swedish South Polar expedition, *Antarctic* in 1901-03, led by Otto Nordanskjold and the two other German expeditions *Deutschland* and *Meteor*. All these expeditions threw new light on the bottom relief of the ocean and the types of flora and fauna.

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6 ibid, p.28.
Britain became the first country to start systematic expeditions to Antarctica. "Systematic British expeditions to the Antarctic were began in 1925 by the Discovery committee, which was set up by the British Government in 1923 for the purpose of enhancing the Empire's economic and political positions ----".⁷

The ship *Discovery* which was substituted by *Discovery II* in 1929 along with *William Scoresby* made comprehensive observations for over two decades upto 1950. It furnished a mass of scientific data that has enabled the broad details of ocean circulations to be worked out. It has also provided an unrivalled accumulation of materials for studies of the marine life of the Antarctic Ocean. Since then, many countries including Germany, France, Norway, New Zealand, Australia, erstwhile USSR (now Russia) and USA have been sending systematic scientific expeditions to Antarctica and Antarctic Ocean. Some of the important research vessels are *USNS Eltanin* and *USNS Hero* of USA and *Ob* and *Lena* of erstwhile USSR. "Towards the end of the 1920's aircrafts began to play an important part in Antarctic explorations. Planes were used by Britain, USA, Australia and Norway".⁸ The first flight over the Antarctic was made on November 16, 1928 by Sir Hubert Wilkins. Since then, innumerable flights have taken place. These flights have provided significant information on glaciers, ice-shelves, planktons, migration of whales etc.

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⁷ Lebedev, n.1,p.32.

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INDIA'S EXPLORATIONS

"India's advent into the realm of polar science began with its first ever scientific expedition landing on the icy continent on January 9, 1982." Since then, India has already sent more than twenty-three explorations in the region. "These include two expeditions to the Southern Ocean; one to Weddell Sea and another one for the assessment of Antarctic Krill. More than forty-five national institutions and about 1200 personnel have so far participated in these expeditions." They have conducted several scientific experiments in the field of geology, meteorology, oceanography, living marine resources etc.

Antarctic Ocean along with Indian Ocean separates India from the continent of Antarctica. Antarctic region has special significance for India because of several factors. Indian Ocean circulation is affected by the circulation of the Antarctic Ocean, which affects the Indian monsoon. Even the atmospheric circulation over the Antarctic Ocean has a bearing on the Indian monsoon. Further, the location of islands and considerable Indian population in some of them make this region important for India. In addition to it, this region is a vast reservoir of living marine resources like krill, and mineral resources which can be harnessed by India in the future.

8 Lebedev, n.1, p.134.
9 A. Mitra, India in Antarctica, Seminar, (New Delhi, 1996), vol.448, p.32.
India’s interest in the Antarctic Ocean can be traced from mid-1950’s. In 1956, India proposed that Antarctica be included in UN General Assembly agenda. It again raised the question of Antarctica in UN in 1958. However, when Antarctic treaty was signed in 1959, India was not included either in the drafting negotiations or in the resultant signing conference. It was the result of India’s stand against signing of the treaty.

In the early 1980s India emerged as an Antarctic player that could no longer be excluded from the affairs of the region. It started with Indian first expedition to the Antarctic continent in December 1981. This expedition, popularly known as operation Gangotari I, was headed by Dr. S.Z Qasim. It reached the Antarctic continent on January, 1982. They established an unmanaged weather station at Dakshin Gangotari in the Norwegian sector during this expedition. Other early achievements include discovering the sea mount renamed Indira Mount, and land surveys in minerology and petrology. Dakshin Gangotari was later converted into a permanent scientific station in 1983-84. The December 1981 expedition was the first to be sent by any country outside the treaty framework. In fact, India was the first country to send an expedition to the Antarctic region without having a historical presence there. All these factors made the inclusion of India...

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Annual Report, Department of Ocean Development, Government of India, (New Delhi, 1998), p.2
in the Antarctic Treaty System inevitable. India acceded to the Antarctic Treaty on August 19, 1983 and gained the consultative status in the following month.

Thus, India’s role as an important player in the affairs of the Antarctic region was recognized. Since then, India has been actively involved in the affairs of the Antarctic region. It has sent Antarctic expedition almost every year for scientific research and has established a permanent station in the landmass of the continent known as *Maitri*. In recognition of her role, India was elected the chairman of the Commission for Conservation of Antarctic Marine Living Resources (CCAMLR) for two years in 1998.

**PHYSICAL SETTINGS OF THE ANTARCTIC REGION**

The Antarctic Region presents a very complex physical setting. The entire region can be divided into a landmass, surrounded by the Southern sea from all the sides. In the centre of the Antarctic lies the mountainous continent which falls within the Antarctic circle.

This great continent is 143,070,000 square kilometres in extent, of which 930,000 square kilometres are covered by the continental shelf-ice protruding into the Ocean and 40,000 square kilometres by
the shelf-ice of Alexander I Land which is welded into the common mass on the continent.

Antarctica is obscured by a thick mantle of ice, which somewhat smoothes out the elevations and depressions of the land surface and strengthens out the coastline. The average thickness of the ice-cover is not yet known but in the past few years the figure has risen from 550 metres to 2000 even 3000 metres.

The three main curves in the continent's coastline are in the Atlantic and Pacific sectors. They are Graham Land, lying between 55° West and 70° West and stretching northward via Trinity Peninsula to 63°7' South, and the Weddell and Ross Seas, whose bays cut into the continent upto 78° South, where they are held back by continental ice barriers. Scientists divide the continent into two uneven parts. They are the West and East Antarctica, drawing the boundary along the Southern shores of Weddell and Ross Seas. The area of the West Antarctica (without the shelf-ice) is 2,690,000 square kilometres and of East Antarctica - 10,410,000 square kilometres, or three - fourths of the entire continent. The shores of East Antarctica are very little dissected and border almost evenly on the Antarctic Circle in the Indian Ocean.

The coastline is probably made even by the ice-cover. Seismological soundings have shown that there are fjords and rocky

archipelagos under the ice. East Antarctica is a vast ice-encumbered plateau.

The central part of the continent - the South Polar Plateau- is on the average 2,700 metres above sea level in some places and upto 3,500 metres in others. The geometric centre of the continent is 4,200 metres above sea level.

In the Atlantic and Pacific sectors East Antarctica is fringed by rocky ranges, crescentic in shape, with the outer arc turned towards West Antarctica. At the Atlantic end of the crescent lie the Queen Maud Land ranges. This vast mountainous region, with summits rising to 4,200-4,300 metres, is 200 kilometres inland between 10°E and 25° W. The mountains farther east slope away. In Enderby Land and Kemp Land, there are some peaks 1,900 and 2,200 metres high, but elsewhere they are much lower.

The Pacific "end" is in the north of the Victoria Land. Stretching South and South-east are the Britannia Range with summits rising to 3,228 metres and the Queen Alexandra Range. Off the Southern and Southeastern inner edge of the ice barrier lies the Commonwealth Range with summits rising to 4,054 metres. It is not known whether the pacific and of the crescent is connected with the transatlantic mountain barrier which runs parallel to the zone dividing West and East Antarctica.

Nothing is as yet known of the rock basement of the central, ice-capped region of East Antarctica. Research done by the French
Figure-3
Reconstruction of Gondwanaland

SOUTH AMERICA

AFRICA

INDIA

ANTARCTICA

AUSTRALIA

source: Colbert (1970)p.131
expedition in Greenland in 1948-51 showed that the rock floor under
the ice was basin shaped, the depression being at the same level with
the sea. The rock floor of the East Antarctica is now believed to be the
same.

Physically, West Antarctica is also divided into an ice plateau and
mountainous region. But the mountains predominate. The young folded
ranges - the Antarctandes - stretch from one end of Graham Land to
another. Almost parallel with this range, though north of it and on a
different longitude, are the Executive Committee Mountains. The
Antarcticandes are formed by Alpine folds, in places marred by
geosynclinal sediments.

South of this mountainous country is the ice plateau rising in
some places to 2,000 metres and then sloping down in two directions:
to the Ross Sea and to the zone dividing West Antarctica and East
Antarctica. There are active volcanoes both in the West Antarctica and
East Antarctica. On the off-lying Ross Island is the 4,023 metre-high
Mt. Erebus.

Antarctica is the biggest and the most lifeless of the ice deserts
on the Earth. The ice-free area constitutes less than four percent of its
surface, with plains and hills occupying about 2000 square kilometres
and the rest is occupied by the steep mountains. Even in the summer,
the temperature in the central regions rarely rises above -30° C.

The uniqueness of the Antarctic Region can be understood
properly if an attempt is made to reconstruct its past environment.
Geologically Antarctica can be divided into two parts - East Antarctica and the West Antarctica. The geological evolution of East Antarctica ceased abruptly in the Jurassic period, whereas that of West Antarctica continued uninterrupted from that time until the recent. So "the rocks of west Antarctica are generally younger than those of East Antarctica, and the area is topographically lower than East Antarctica".\footnote{P.D. Rowley, (et.al), "Metallic Provinces of Antarctica" in R.L. Oliver, et al, ed. Antarctic Earth Science (Cambridge, 1983),p.414.}

An attempt to interpret the palaeogeography of Antarctica has been made by geologists like R.J. Adie (1970) who has discussed briefly the climatic fluctuations in relation to environmental, structural and tectonic considerations. The early Paleozoic environment of East Antarctica appears to have been primarily marine, as a result of fluctuating transgressions of the sea prior to the Carboniferous. At the onset of glacial conditions in the late Carboniferous, most of East Antarctica suffered refrigeration under an ice-sheet environment. The deposition of tillites on the land and the transportation of quantities of detritus to the adjacent Andean geosyncline of the West Antarctica characterized this period. During lowermost Permian "a great depositional basin (analogous to the terrestrial Karroo Basin of Southern Africa) had formed over most of the central East Antarctica. As the climate gradually warmed, the vegetation cover became more
luxuriant, and rapid erosion of the higher parts of the continental block proceeded in sub-tropical conditions".13

By the Triassic, there was the complete desiccation of the continent. However, in the late Triassic the Antarctic Peninsula was first formed by the most important mountain - building movements recorded in Antarctica. By the Middle Jurassic the climate in the Antarctic Peninsula region had become subtropical and giant ferns comprised the main flora.

Perhaps the most important volcanic activity in the history of Antarctica terminated the Jurassic. In East Antarctica, the major territorial basin was flooded by lava and its sediments were infected by the basic sheets, whereas in West Antarctica lava eruptions were punctuated by explosive ash phases. The geological history of East Antarctica ceases abruptly after this period.

Nevertheless, for West Antarctica there is an exceptionally continuous history till the present. The later part of the Cretaceous saw the intrusion of the vast Andean batholiths of the Antarctic Peninsula and Byrd Land. By the beginning of the Territory, there was renewed volcanism in the South Shetland Islands, where thick sequences of basic lava and ashes were intercalated with local freshwater sediments.

In the lower Miocene rejuvenated but short-lived marine deposition, under far cooler conditions than in the Cretaceous, began.

13 Raymond J. Adie, "Past Environments and Climates of Antarctica" in M.W. Hodglate, ed.,
The volcanic activity that had continued uninterrupted in the South Shetland Islands since the early Tertiary, was renewed with vigour in the Middle Miocene not only in the north of the Antarctic Peninsula but throughout much of West Antarctica. These eruptions led to numerous changes in the sea-level which were primarily due to increasing tectonism and block-faulting over the whole of Antarctica. By the onset of the Pliocene, glacial conditions had been all ready established with a consequent lowering of the sea-level.

"The stratigraphic records of East and West Antarctica have been interpreted from environmental and climate viewpoints, and it appears that the continent has undergone a distinctly cyclic history, ranging from extreme refrigeration to desert conditions, and returning to glaciation in the course of 300 million years".14

East Antarctica "is a stable continent block made up of pre-Cambrian to Jurassic sediments. Outcrops of these sediments are most prevalent in the Transantarctic Range. It has been observed that in this range, such outcrops are composed of marine and lacustrine sediments deposited in shallow waters. Much of this sediment is of \textit{a priori} interest from the standpoint of petroleum. West Antarctica - an archipelago buried under the ice cap - is the active margin of

\begin{footnotesize}
\begin{itemize}
\item[Ibid, p. 14]
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Figure – 4
Currents and Water masses in Antarctic Ocean

Source: Hatherton (1965), P. 122.
Gondwanaland, formed by accretion over the Pacific Ocean plate, and it retained its characteristics after that continent broke up".15

Antarctica, separated from the other continents by a vast ocean belt, is approximately 800 kilometres from South America, 3,400 kilometres from Africa and 2,900 Kilometres from Australia. The Antarctic waters basin is 37,800,000 square kilometres in area. The average depth is 4,000 metres.

The ocean surrounding the continent has three layers.16 These layers are the surface water, warm deep water and the bottom water. The surface water is characterized by variable salinity and temperature with time and place. In winter, it is cooled and its salinity increases as a result of ice formation. Temperature varies from near freezing point in the Southern limit to about 1°C at the convergence. In summer, the temperature rises and due to the melting of the ice the salinity decreases (Figure-4).

The surface water is underlain by warmer, denser and more saline water layer known as warm deep water. Its temperature is always above 0°C and salinity upto 34.7 per thousand. It is found in the depth of about 400 metres to 3,500 metres and the salinity is the greatest at a depth of 700-1,300 metres.

The lowest layer is the bottom water, which is characterized by a temperature of around - 0.4°C and salinity of 34.66 per thousand. It is

16 As discovered by the German Deep Sea Vessel *Valdivia*. 
Figure - 5

Distribution of Temperature and salinity in a Vertical Section Along 30° West

Source: Deacon (1984), P. 96
Figure - 6
Antarctic Ocean : Sea Floor Deposits

Source: Hatherton (1965), p. 105
believed that in specific places like the Weddell Sea and the Ross Sea, local circumstances lead to the formation of very cold high density water that sinks at the continental margin and forms the bottom water. So unlike the warm deep water, it moves from south to north (Figure-5).

Ocean deposits of the Antarctic Ocean was "charted by Murray and Reward in 1891", on the basis of the information collected by *HMS Challenger* between 1872 ands 1876. There is a circumpolar belt of terrigenous deposits extending north to latitude 60° South from the Antarctic continent boundary. However, between approximately latitude 50° and 60° South lies a belt of Diatom Ooze succeeded northwards by Globigerina Ooze in intermediate depths. Red clay is also found in the abyssal plain with the terrigenous deposits. But areas close to land masses and around islands, terrigenous deposits are dominant. These terrigenous deposits are mostly in the form of glacial sediments (Figure-6).

The land margins of Antarctica are fringed with a continental shelf that is everywhere narrow except in the two large embayments occupied by the Weddell and Ross Seas. "The Antarctic continental shelf is notable for the great depth at which the break in slope lies." The usual depth is 400-600 metres and at places like Ross Sea, it is up to 800 metres.

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18 Ibid, p. 110
With small exception, the continental slope descends up to depth of at least 3000 metres all around Antarctic. Some complexities can be seen in the north end of Graham Land, the Scott Island-Balleny Islands area, north and west of the Ross Sea and the Kerguelen Ridge.

Continental slope is followed by ocean ridges and deep basins. The most extensive features are the basins. There are three prominent basins. The Pacific-Antarctic Basin extends eastwards as an elongated triangular area bordering the Antarctica continent and extending to Southern Chile form near the Scott Island in latitude 68° South and longitude 180°. The other basin stretches from the Scott Island-Balleny Islands area west to the Kerguelen Ridge. It is known as the Eastern Indian- Antarctic Basin. The largest basin is the Atlantic-Indian-Antarctic Basin, which encircles the remaining Antarctic continent to the Scotia Ridge.

There are three main Ridges in the Antarctic Ocean. The crests of these ridges lie in less than 3000 metres and the general trend of these ridges is circumpolar. The Atlantic-Antarctic Ridge lies in about Latitude 52° South and extends from mid-Atlantic towards Kerguelen Ridge. The Indian-Antarctic Ridge extends from the mid-Indian Ocean in 50° South to the Balleny Islands area. Finally, the Pacific - Antarctic Ridge extends form the vicinity of Scott Island north and east towards Eastern Islands. Besides, there are three north trending ridges that separate the three major basins. They are Scotia Ridge in the Atlantic.
Antartic Ocean: Sea floor relief

Figure - 7

Source: Hatherton (1965), P. 120.
Sector, Kerguelen Ridge in the Indian Ocean Sector and Macquaire Ridge in the Pacific Sector (Figure-7).

ANTARTIC ICEBERGS

The Antarctic Ocean is a sea of icebergs. All through the year there are dense accumulation of hundreds of icebergs floating in the Ocean. These icebergs are mostly found up to the Antarctic convergence. Therefore, it can be considered as the northern boundary of the icebergs. However, it does not mean that the icebergs do not move further north. Some of the icebergs have been seen up to "the 30th degree in the Atlantic, and to the 40th degree and beyond in the Pacific."19

Most of these icebergs are tabular in shape and are of huge dimensions. They are generally 12 to 40 metres high and 100 to 400 metres in length. Some of the tabular icebergs observed in the Antarctic waters were from 100 to 500 kilometres long. They are extremely voluminous and submerging to the depths of hundreds of fathoms. These icebergs "exert a considerable influence on the temperature, salinity and distribution of plankton in the Antarctic Ocean."20

On the basis of origin these icebergs can be broadly divided into two types: Barrier on Shelf berg and Continental or Glacier bergs. Shelf bergs are most numerous. They are mostly white in colour. The crests

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19 Lebedev, no.1, p. 93
20 Ibid, p. 103
and troughs of waves cause the barrier ice to crack vertically. These cracks are enlarged and deepened by new waves and subsequently gets detached and start floating as icebergs.

The Glacier bergs are not so white due to the presence of continental particles and fragments carried by the glacier. Glacier bergs colve from the land ice descending from the interior of the continent. The glacier projects ice-tongues for many icebergs due to the action of the swells, waves, differential melting of the ice and thermal influence of the water. This process is facilitated by the crevasses, which are often found as the glaciers descend the share into the sea.

FLORA AND FAUNA

"Due to extent of glaciation, the largest forms of vegetation on the continent are a small grass and a small green cushion plant, which grow along with some 75 kinds of moss, 35 kinds of innerwort, and 300 kinds of lichen. The associated land fauna include two small midges and a diversity of soil insects, mites, and nematode worms." All the surrounding ocean is endowed with abundant and beautiful fauna like Sea birds, Penguins, seals and fishes, which is considered as living resource.

In this way, we find that the physical features of the Antarctic Region are quite complex and unique. Both the landmass and the

21 Martin W. Holdgate, “Antarctica- Ice under pressure”, Environment, Vol.32, No.8, p.6
surrounding seas are characterized by distinctive physiographic, meteorological, hydrological and ecological features. This uniqueness can also be seen in the resources of the region.