Schirmacher Oasis: Environment, History and the Indian Station "Maitree"

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ABSTRACT

At a distance of less than 100 km from the Indian permanent station "Dakshin Gangotri", a small Antarctic oasis exists that was located as late as 1938 by the German expedition team headed by Schirmacher. The area appears to be a good site for a permanent Antarctic station. An account of the history of the Antarctica oases and their origin have been discussed with a special emphasis on Schumacher Oasis. A brief description of the environment and geology of the Schirmacher Oasis has been presented, The importance of geochronological studies in the Oasis for the study of Gondwanaland break-up has been emphasized. The environmental factors of the "Maitree" station have also been discussed. The "Maitree" station is expected to play an important role as a base also for any large scale aerial survey (including the aerial geophysical surveys) of the adjoining areas covering as big an area as 1,50,000 to 3,50,000 sq. km.

INTRODUCTION

"Delightful now was the green sight of Teyma, the haven of our desert; we approached the tall island of palms.....We entered between grey orchard walls overlaid with blossoming boughts of palm trees; of how much amorous contentment to our parched eyes".

This was the feeling of the renowned English explorer and poet CM. Doughty after crossing the northern Arabian desert and entering the oasis of Teyma in late 1870's (Doughty, 1937). To any travellers of the deserts, "an oasis is a haven of life in a wasteland of death. A green mote in infinity of sand where there is water there is life in the desert, whether it be a burning sand sheet in Arabia or a frigid ice sheet in Antarctica"(Pickard, 1986).

Of all the continents, Antarctica is the fairest, white and unspoiled, spacious and austere, fashioned in the clean, antiseptic quarries of an ice age. Thus it is unique among the continents. More than 98% of its surface is composed of a single mineral—ice. It is the coldest, windiest and driest continent but it contains more than 70% of the world's fresh water. In spite of it, the combination of ice, cold and aridity is a lethal mix for most forms of life. Few organisms can survive in a freezing desert. However, there are little patches in this desert of ice where temperatures rise above freezing and where water flows over the rocks and soil. These are oases in a vast icy desert (Fig. 1).

Oases in Antarctica had been known since the early explorations of the continent in the beginning of this century. Rocky areas served as stable camp sites and navigational beacons. The enormous dry valleys of Victoria Land, when first discovered on 18 December, 1903 by Robert F. Scott, was considered as deserts rather than oases. It was later termed as Taylor Valley. Scott wrote "......from our elevated position we could now get an excellent view of this extraordinary valley, and a wilder or in some respects more beautiful scene it would be difficult to imagine. Below lay the sandy stretches and confused boulder heaps of the valley floor, with here and there the gleaming white surface of a frozen lake and elsewhere the silver threads of the running water; far above us towered the weather-worn, snow splashed mountain peaks, between which in places fell on graceful

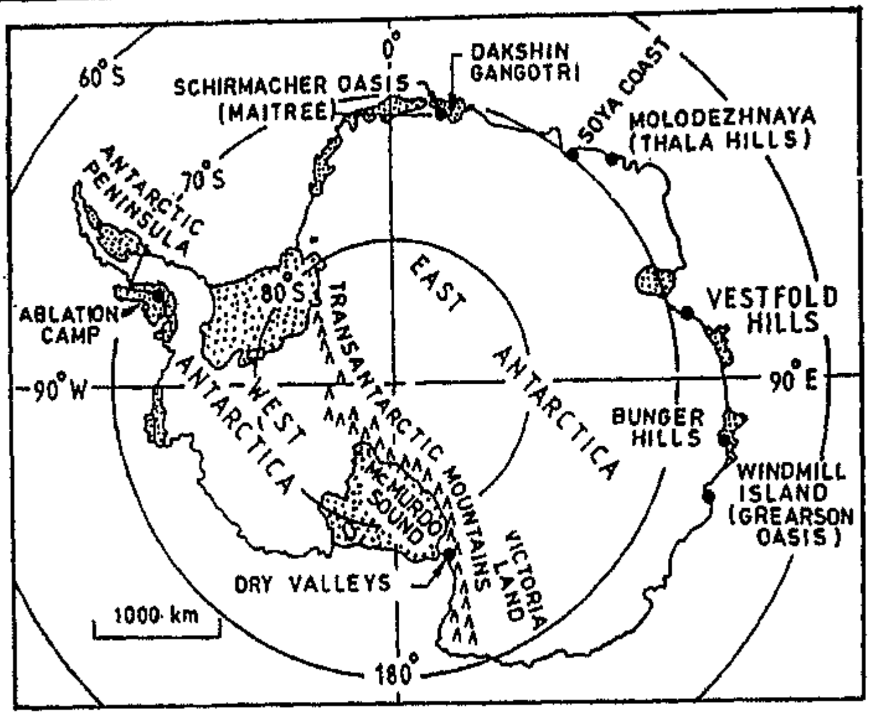

Fig. 1. Map of Antarctica showing location of major oases (dotted areas).

curves the folds of some hanging glacier_these steep slopes had a general tune of sober grey. This colour was therefore predominent, but everywhere at a height of 3,000 ft above the valley it ended in a hard line illustrating in the most beautiful manner the maximum extent to which the ice had once spread. I cannot but think that this valley is a very wonderful place. We have seen today all the indications of colossal ice action and considerable water action, and yet neither of these agents is now at work. It is worthy of record, too, that we have seen no living thing..... It is certainly a valley of the dead: even the great glacier which once pushed through it has withered away" (Scott, 1905).

In October, 1936, A. Stephenson, a member of the British Graham Land Expedition (1934-1937) camped on the eastern side of Alexander I Island at a site he called Ablation Camp. He wrote, "It seemed we had suddenly come into an oasis, for instead of the usual mass of snow with occasional patches of rock there were large valleys of exposed rocks, with scarcely any snow to be seen" (Stephenson, 1938). This was the first reference to oases in Antarctica.

The term oasis was adopted in the popular press of the west during the United States Navy Operation High Jump on February 11,1947. It may be worth quoting a few lines from Byrd (1947): "Early in February the crew of the flying boat commanded by Lt. Cmdr. David E. Bunger of Colorado, California, found themselves above a land-scape which made them question their own eyes-a land of blue and green lakes and brown hills in an otherwise limitless expanse of ice. This so called oasis was by far the most important-as far as public interest was concerned-single geographical discovery of the expedition".

As compared to the mountain oases, the low altitudes coastal oases are mere specks on the coast of Antarctica. Their areas are mostly in tens and occasionally in hundreds of square kilometres, altitudes of a few hundred metres and topography is gently undulating. The largest of these low oases is the Bunger hills (area: 482 sq. km; max. elevation: 172 m). Both the mountains and low oases

have the same essential features: substantial areas kept free of permanent ice and snow by ablation. The oases and nunataks can be differentiated by the ablation of snow only. Nunataks are snow-free due to wind blowing the snow away. The nunataks, therefore, are generally in the accumulation zone of the glaciers whereas oases are separated from the ice sheet by a distinct ablation zone (Shumskiy, 1957).

Oases are difficult to define. Below a minimum size, ice free areas are best regarded as usual physiographic features: nunataks, beaches, moraines etc. (Markov, et al., 1970). However, the area alone cannot be a sufficient criterion to define an oasis. Many large mountain massifs have more ice-free surface than 10 sq. km. Pickard (1986) restated the definition provided by Shumskiy (1957) as "An Antarctic Oasis is a substantial ice-free area separated from the ice sheet by a distinct ablation zone, and which is kept free from snow by ablation due to low albedo and positive radiation balance".

All oases are essentially continuous ice-free areas of rocks but their physiography is diverse. Two features are essential: till cover; and at least one boundary is the ice sheet, and at least one is an active outlet glacier. These indicate that although the ice once flowed over the oasis, the ice flow is presently deflected around it. A consequence of the exposed rock of low albedo is because the oases are the only areas in Antarctica with positive radiation balances. General physiography varies from low hills to coastal headlands and peninsulas. Most oases have lakes, both fresh and saline, thawed in summer or perennially frozen. It is due to these wide range of features that the origin of oases has been debated (Pickard, 1986).

ORIGIN OF ANTARCTIC OASES

Sudden appearance of ice-free patches in Antarctica arouse curiosity and obviously demands explanation. It is clear that oases were covered by the ice earlier and, therefore, the origin must explain the mechanism that removed the overlying ice cap. The theories, so far, put forward (Pickard, 1986) can be grouped in five categories.

1. Geothermal heating

(a) Fire in subterranean coal (Solopov, 1969)

(b) Radioactivity (Solopov, 1969)

(c) Volcanic activity (Solopov, 1969; Freidrich, 1976)

2. *Lowering of the Antarctic ice sheet*

(a) Progressive ice recession (Ferrar, 1925)

(b) Lowering of the ice sheet due to decreased atmospheric precipitation and increased snow drift (Solopov, 1969)

3. *Orographic and Climatic*

(Apfel, 1948; Alberts and Blodgett, 1956; Avsyuk et al., 1956; Shumskiy, 1957)

4. *Dust from nearby mountains and decrease in albedo*

(Stephenson, 1938)

J. *Orographic and lowering of the ice sheet*

(Solopov, 1969)

Geothermal heating due to fire in the subterranean coal, radioactivity or volcanic activity though suggested, but has to be substantiated. The major exception being the slopes of the active

volcano Mt. Erebus near the famous McMurdo sound. The lowering of ice sheet was suggested by Ferrar (1925) to explain the ice recession in the Dry Valleys. Shumskiy (1957) propounding the climatic causes for the origin of Bunger oasis stated "Our observations allow us to assert that solar heat is the source of heating in the 'oasis'. However, this alone does not provide a mechanism sufficient to remove hundreds of metres of ice unless other climatic conditions change". Apfel (1948), Alberts and Blodgett (1956), Avsyuk et al. (1956) and Shumskiy (1957) propounded the orographic hypothesis incorporating both topography and climate. Apfel states that "deflection of glacial drainage around the area, low humidity and low snowfall, together with high insulation in the summer keep the area ice-free". It may be noted here that the hypothesis does not really explain the origin of the oasis. Stephenson (1938) explained that dust blown from nearby hills and mountains lowered the albedo and caused the snow to melt. This hypothesis like that of Apfel and others is not an explanation of the origin of the oasis. Solopov (1969) combined the orographic and global climatic change hypotheses. According to him "the oases formed as a result of unusual orography of the terrain, and the secular climate changes towards a general warming". Thus Solokov's hypothesis lays two essential features for the origin of an oasis: *(a)* a relatively high block of land, and *(b)* a retreating or thining ice sheet. Due to the lowering of the ice sheet, the flow of ice would be around the block instead of over it. The ice above the block would continue to reduce due to the lack of input and thus the rock underneath it gets exposed. Solopov (1969) linked the lowering of ice as a global phenomena as he feels secular climate changes towards a general warming. The maintenance of the oasis is relatively easy to explain. The low albedo of the exposed rock gives rise to the positive radiation balance in the oases, warming the rocks which in turn acts as a source of heat to melt the residual snow fall that is not blown away by the wind.

Thus out of the five hypotheses mentioned above the first (geothermal heating) is untenable. The theories mentioned in 24 merely state the possible mechanism that is sufficient for the maintenance of oases and do not explain in any way the origin of oases. Even then these are plausible mechanisms and are fiercely debated. Solokov's hypothesis (1969) of orographic and lowering of ice sheet makes an attempt to explain the mechanism of 'initiation' as well as maintenance of the oases.

SCHIRMACHER OASIS

On February 3,1939 the crew of the Dornier-Wal 'Boreas' plane, that was under the command of Schirmacher made a special discovery while returning from a photographic reconnaissance flight in the Wohlthat massif to the floating base of the German Expedition of 1938/39 (Richter, 1984). A narrow rock barrier with a large number of clear and blue lakes of different shapes and sizes was located (Fig. 2) which was later named "Schirmacher Seenplatte" (Ritscher, 1939).

The preliminary report of the expedition stated that the glacial lakes are not due to volcanic causes but are due to the "storage of heat derived from intense insolation" (Ritscher, 1939). The origin of the Schirmacher oasis can at best be explained by Solokov's hypothesis (1969) mentioned in the earlier chapter.

The physico-geographical conditions of the oasis have been described in detail by Simonov (1971). The Schirmacher oasis has a maximum width of 3.5 km, a length of about 20 km. It is oriented approximately in east-west direction. The coordinates of the oasis is (Atlas Antarktiki 1969; Richter, l984):70°46'04"E-70°44'21"E;11°49'54" (±48")-11°26'03" (± 02"). Its size is approximately 35 sq. km. of solid bedrock and firn and ice fields accounts for 27 sq. km. and 3 sq. km. respectively. The lakes, ponds and pools in the lake district cover a total area of about 2 sq. km representing the essential part of the surface waters. The elevation of the oasis ranges between 0 to 228 m with an

average of about 100 m. The Schirmacher oasis is, therefore, one of the smallest East Antarctic oases and is considered to be one of the typical oases near the shore (Atlas Antarktiki, 1969). Its surface is undulating. The gentle slopes and plain areas are covered with a mostly thin blanket of moraine debris. The northern end is characterized by steep slopes and has a large number of bays due to the block patterns caused by disturbances. The classification of ice bodies in the region surrounding the Schirmacher oasis is shown in Fig. 3. The morphology of the subglacial zones obtained from the geophysical data (Stroev and Frolov, 1966) and that of the present ice cover are apparent from Fig. 3. It is possible to distinguish two large bodies of ice from one another. These are: *(a)* the 200 to 500 m thick and about 100 km wide ice shelf slab north of the Schirmacher oasis, and *(b)* approximately 1000 m thick and 50 km wide firn basin glacier between the nunataks "Skaly 16A" and Wohlthat massif in the south (Hermichen et al., 1984). The steeply inclined inland ice part lies between these two. On the southern edge of the Schirmacher oasis, it terminates as a 10 to 40 m high escarpment while it shows a smooth transition to ice shelf both west and east of the area. The rate and direction of the flow on the inland ice surface are apparent from Fig. 4 (Kruchinin et al., 1967).

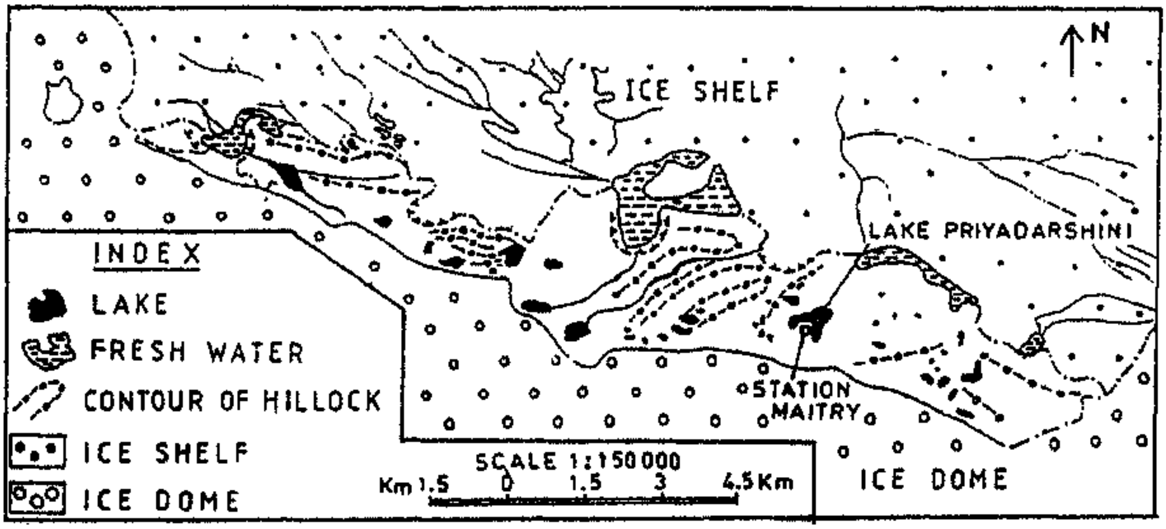

Fig. 2. Map of Schirmacher Oasis.

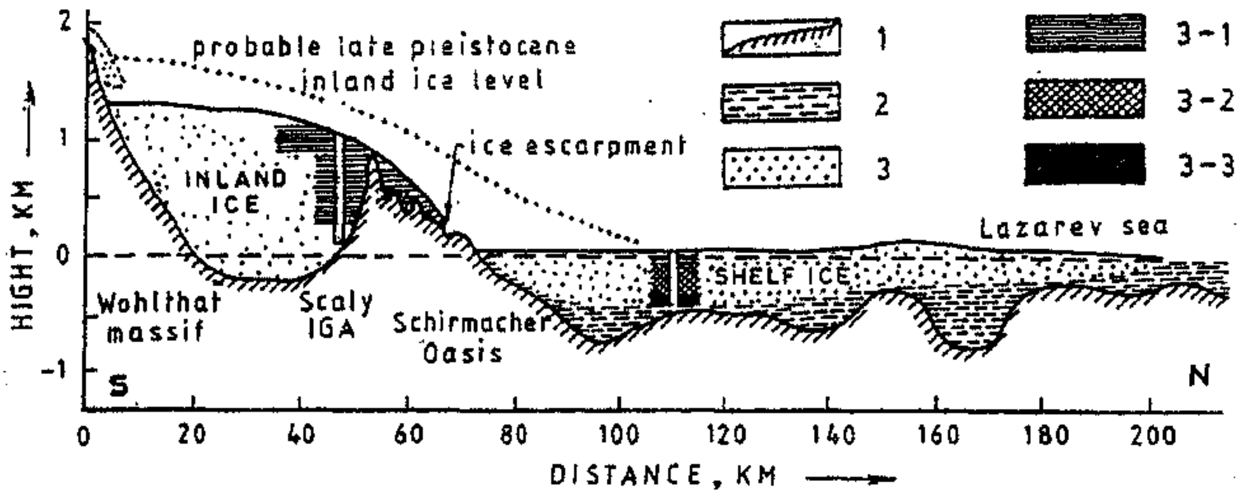

Fig. 3. **Classification of ice bodies in the region surrounding the Schirmacher Oasis (after Hermichen et al., 1984). 1. Subglacial rock surface; 2. sea water; 3. firn/ice (unclassified); 3-1 to 3-3 6m ice (classified).**

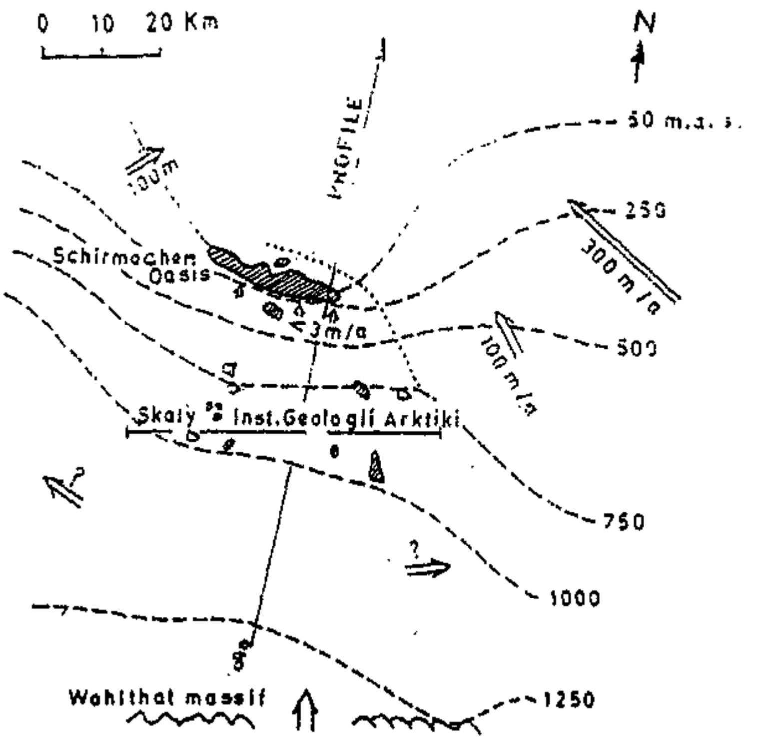

Fig. 4. **Recent flow conditions in the region of the inland ice sheet in the neighbourhood of Schirmacher Oasis (after Hermichen et al., 1984). Double arrows: ice streams; Double arrows with question marks: hypothetical ice stream; Dotted line: medial moraine; Shaded zones: rock exposures.**

Major climatological parameters can be summarised from the observations made at the Soviet station 'Novolazharevskaya'. The average annual temperature is - 10.5°C for the period of 1961 to 1980. The warmest month is January and the average temperature is about-0.9°C. The maximum is 0.7°C (1971) and minimum -2.5°C (1966). The average July temperature is - 17.8°C, the maximum being-12.8°C (1980) and the minimum-22°C (1972) (Handbook of Antarctic Climate, 1976; Additional information collected from the Soviet station). The mean wind velocity is about 10 m/s. The most prevalent wind direction is east-southeast. The average precipitation is between 250-300 mm. The relative air humidity is about 50 percent. The climatic zone of influence in the Schirmacher oasis extends to about 1000 sq. km. It extends and covers 80 km wide ice shelf Outside the influence of katabatic wind, this area is marked by an extensive accumulation of precipitation. At some distance from the Schirmacher oasis the temperatures are generally 5°C lower. On the northern edge, adjacent to the oasis, on the ice shelf there are large flat lakes constantly covered with ice, which so far have remained practically unexplored. South of the Schirmacher oasis, snow accumulation begins at 500 m above the sea level going up to the slope of the Wohlthat massif. There, in a giant basin, lies the mountain oasis whose climatological conditions are not clearly known.

GEOLOGY OF SCHIRMACHER OASIS

The geology of the Schirmacher oasis has been mapped in 1:25000 scale (Atlas Antarktiki, 1969; Sengupta, 1986) and the area has been mapped in 1:10000 scale also (Wand, 1983) by the GDR expedition team. In the Schirmacher oasis the Precambrian crystalline basement of the East Antarc-

tica platform is exposed over an area of about 30 sq. km (Ravich and Kamenev, 1972; Geologic Map of Antarctica, 1976). The polymetamorphic rock sequence consisting dominantly of biotite-garnet gneisses and pyroxene bearing granulites with minor intercalation of marbles and calc-silicate rocks, ultramafics, amphibolites and other metabasites is traversed by a number of distinctly younger basalt (dolerite) dykes (Grew, 1976). The rocks have undergone multiple episodes of metamorphism, migmatization and deformation.

The basalt dykes strip NW-SE and N-S and dip invariably steep to vertical to NE, E and ESE. Their thickness ranges from a few centimetres to approximately 10 m, rarely exceeding 1 m. They crop out for short distance only. The basalts are generally fresh. The presence of vesicular rock types with amygdales of quartz, zeolite, calcite and feldspar indicate that a late stage hydrothermal alteration are probably rare. The basalts are either aphyric or contain olivine, pyroxene and plagiclase phenocrysts. In some cases, xenoliths (metamorphic rock fragments) can be observed. The olive and pyroxene phenocrysts, partly more than 10 mm in diameter, are often very fresh.

The age of these basalts determined by the conventional K-Ar method showed that the dykes were emplaced generations of basalt intrusions - an Upper Carboniferous (~300 Ma) and a Jurassic one (~150 Ma). It is interesting that the dykes of two different periods can be observed within the small area of the Schirmacher oasis. The wide spread recurrence of Mesozoic tholeitic lavas and dykes in Antarctica is generally of Mesozoic theoleitic lavas and dykes in Antarctica is generally related to the break up of Gondwanaland (Cox, 1978; Scrutton, 1973; Smith and Hallam, 1970). Prior to Jurassic time, Southeast Africa and Antarctica still formed a continuous land mass (Smith and Hallam, 1970; Dietz and Holden, 1970), and the onset of drifting between Africa and Antarctica along the Southwest Indian Ridge is considered to have taken place in the late Early Jurassic (Barron et al., 1978). However, some basalt dykes in the Schirmacher oasis appear to represent an older magmatic event (Upper Carboniferous?/Lower Permian) which may be interpreted as Palaeozoic break-up of Gondwanaland (Ordovician initial rifting along the Malgash Rift) (Fairbridge, 1978). The rifting and continental igneous activity could take place long before the dispersion of the continents (Scrutton, 1973). The Schirmacher oasis thus provides a scope of further geochronological studies.

Disseminated grains of pyrite, Chalcopyrite, galena and some associated sulphide minerals are present in the calc-gneisses and the associated migmatites. Surficial limonitic incrustations, malachite strains and graphite rich bands are noted in various parts of the Schirmacher oasis.

INDIAN STATION (MAITREE) IN SCHIRMACHER OASIS

Schirmacher oasis is an ideal place for locating a permanent station due to the availability of ice-free rocky areas, relatively better climatological conditions, availability of fresh water in the lakes and relatively short distance of the oasis from the coast of Antarctica. One of the major tasks of the Fourth Expedition was to construct a small station (three separate cottages) in the oasis. A suitable site was selected near a big lake about 3.75 km away from the Soviet (and GDR) Novolazharevskaya station. Two major factors were decisive in selecting the site: *(a)* easy availability of water from the adjacent lake round the year, and *(b)* an extensive flat ground for easy landing of big helicopters including MI-8 types and for large scale extension of the station in future, if required (Fig. 5-16).

It is a beautiful site resembling Alpine or Himalayan health resort. Three wooden cottages were erected in record time by the Indian Army engineers. The station has been named 'Maitree' (Friendship), the adjacent lake - 'Priyadarshini' and the water-stream during the summer between the two lakes - 'Chitradhara'. The co-ordinates* of 'Maitree' station are 70°45'39.4"S and 11°44'48.6" E

***Determined by Lt. Cdr. P. Chouhan of the Indian Navy.**

(error ± 6"). The co-ordinates have been determined on the basis of five celestial observations of the sun. The elevation of the station is 105 m above m.s.l.

It may, however, be mentioned that transportation of material from the coast (from the ship) to 'Maitree' station cannot be done by sledges during the summer. The entire transportation will have to be done by helicopters. The lake water is ice-free for about four months (middle of November to middle of March). For the rest of the year the lake has a blanket of 2-3 m ice. Water can be supplied to the 'Maitree' station from below with the help of a heated pipe.

The 'Maitree' station can serve as an important place for any aerial operation over Wohlthat mountain ranges or aerial geophysical surveys in and around the oasis covering an area of about 1,50,000 to 3,50,000 sq.km.

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The author expresses his sincere thanks to the Leaders of Soviet and GDR expeditions stationed in Novolazharevskaya station for providing many details about the Schirmacher oasis.

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Fig. 5. Lake *Priyadarshini* (Photograph: B.B. Bhattacharya)

Fig. 6. Foundation of a cottage at *Maitree* station is ready for the erection of structure (Photograph: B.B. Bhattacharya)

Fig. 7. **Cottages of Maitree station under construction (Photograph: B.B. Bhattacharya)**

Fig. 8. Maitree **station more than fifty percent complete (Photograph: B.B. Bhattacharya)**

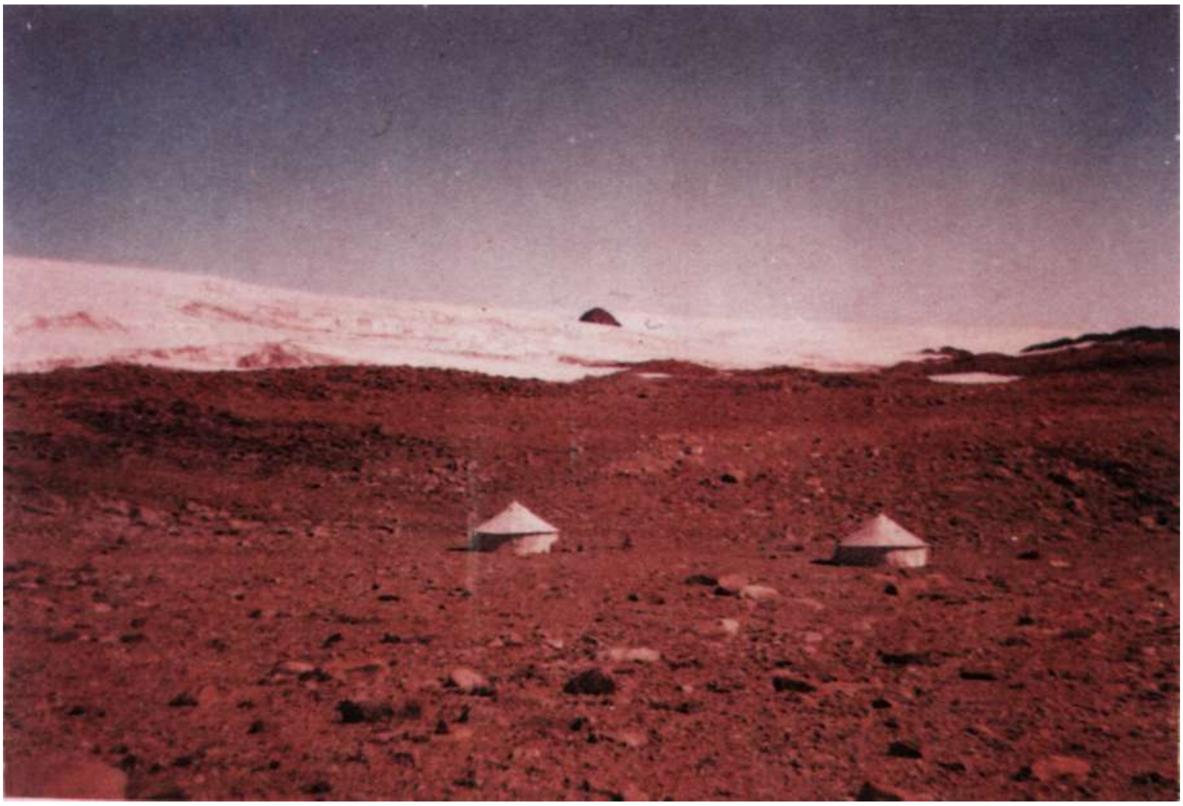

Fig. 9. **Camp at *Maitree* station (Photograph: B.B. Bhattacharya)**

Fig. 10. **A skua (eagle of Antarctica) keeping a watchful eye on the activities (Photograph: B.B. Bhattacharya)**

Fig. 11. **The glacier feeding the *Priyadarshini* lake and *Chitradhara* (Photograph: B.B. Bhattacharya)**

Fig. 12. **Indian Navy helicopter transporting supplies to *Maitree* station. Helicopter is the only mode of transportation to Maitree station during summer (Photograph: B.B. Bhattacharya)**

Fig. 13. **Geological studies in oasis (Photograph: M.P. Sinha)**

Fig. 14. **Upper atmosphere studies at Maitree station (Photograph: B.B. Bhattacharya)**

Fig. 15. **Collecting samples from the bottom of a lake of Schirmacher Oasis (Photograph: M.P. Sinha)**

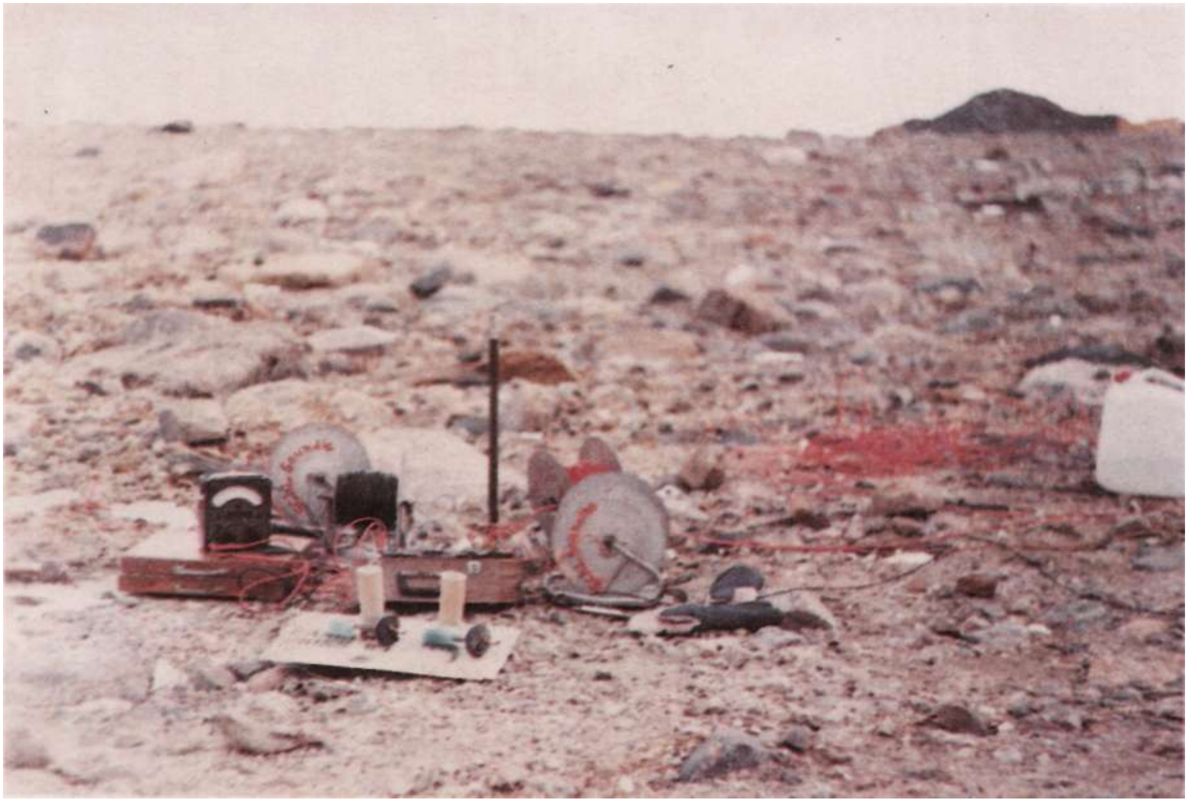

Fig. 16. **Resistivity and self potential field set up**