Some Geological and Glaciological Observations during Reconnaissance of the Terrain South of Dakshin Gangotri Station, Antarctica

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ABSTRACT

During the course of reconnaissance of the terrain conditions south of Dakshin Gangotri, and possible vehicular route across Wohlthat mountains towards further south, some observations of geological and glaciological interest were made enroute, in addition to the performance appraisal of the snow mobiles. The efficiency of the vehicles under various terrain and ice conditions was studied and also exercises in establishing communication links between different locations during reconnaissance were carried out. The surface features and secular changes in different types of the Antarctic ice were recorded and glacio-geomorphological studies were carried out in Schirmacher Oasis. Geological studies were also carried out which revealed the existence of olivine basalt, hornfels, pyroxenite and skarn rocks in the Skaly IGA nunatak area.

INTRODUCTION

During the Fourth Indian Expedition to Antarctica, the author was a member of reconnaissance survey team whose objective was to explore a possible route for a vehicle based Expedition to the south pole.

The members of the reconnaissance survey team were: 1. Lt. Col. J.K. Bajaj, Leader (Mechanical Engineer), 2. Sq. Leader Dr. Ranjit Kumar (Physician), 3.C.V. Sangewar (Glaciologist and Geologist), 4. Lt. Cdr. A.P.A. Robin (Meteorologist), 5. Lt. P. Chauhan (Navigator) and 6. Chand Singh (Wireless Operator).

During the period of the team's stay in Antarctica the following exercises and studies were carried out by the author:

PERFORMANCE OF THE SNOW MOBILES

Evaluation of Ski-doo

Snow scooters were run over fast ice, shelf ice and on the polar ice sheet/polar glacier to assess the gradient these can negotiate; their load carrying capacity; navigational performance; wireless link with the base camp and the communication from them with the other stations. All the features were tested. Exercises carried out reveal that the Ski-doo can be utilised for traverses on the shelf from the station within a radius of 40-50 km, depending upon the availability of fuel. Their full performance on the polar ice could not be tested.

Evaluation of pisten bulley vehicles

Evaluation of the pisten bulley vehicles over the sea ice, shelf ice, polar ice sheet and polar glacier-their navigation, load carrying capacity with and without sledge, VHP and HP wireless link-up with the base camp, negotiation of the crevassed areas were carried out. It was observed that the pisten bulley vehicles are not ideally suited for work on polar ice and need to be modified for long polar journeys. For movement on hard polar ice some gripping attachment shall have to be added to the track of the pisten bulley vehicles.

Communication

Exercises were carried out to establish a wireless link between the ski-doo and pisten bulley, between pisten bulley and base camp and from one pisten bulley to another pisten bulley. Hand held Walkie-talkie (PUNWIRE make), 5 kW set also of PUNWIRE and HF set of MOTOROLA (last two being mounted in the pisten bulley) were used. These equipment tested were found to be satisfactory for the required job.

NAVIGATION IN ANTARCTICA

In high latitudes, direction changes quickly with the movement of the observer, meridians converge and the excessive longitudinal curvature renders the position fixing difficult. Information on

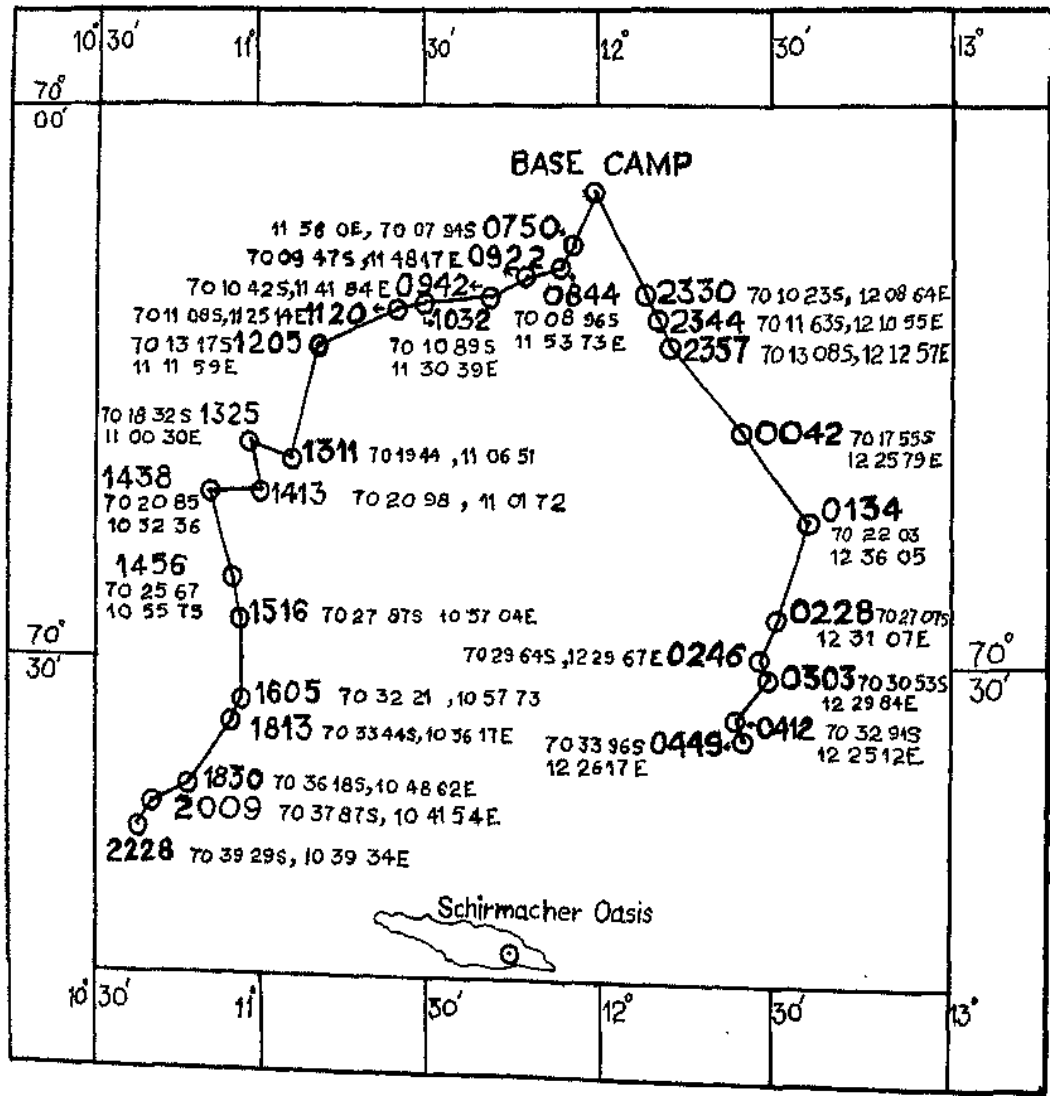

Fig.1. **Reconnaissance of area between Base Camp Dakshin Gangotri and Dakshin Gangotri Landmass (Schirmacher Oasis) for route to South Pole across Wohlthat Range on pisten bulley vehicles.**

topography of different areas is scarce. Exercises in position fixing and navigation were carried out with a Magnavox 4102 instrument fitted in the pisten bulley, Brunton compass (after correction) and sextent.

All these exercises were done in the form of reconnaissance survey, for the possible routes, using pisten bulley vehicles between the base camp and the Schirmacher landmass and 78 km eastward and 124 km westward (Fig. 1). The author, besides the exercises noted above, also carried out certain scientific studies.

GLACIOLOGY

These studies were carried out on fast ice, shelf ice and polar ice.

The thickness of the fast ice, in the coastal areas close to the sea during the month of January '85 was measured and found, on an average, to be about 1.75 m. The contact between the fast ice and the ice shelf was found to be cracked and fractured apparently due to tidal wave action. It was observed that the top surface of the fast ice is made up of sacchroidal drift snow, whereas the underlying portion is formed of frozen sea water.

On the shelf ice, the previous years annual snow layer was found to be, on an average, 0.50 m thick and the upper crust of the snow was found to be sacchroidal. Glassy ice had developed in the low lying areas. The ice shelf was observed to be crevassed near the coast both in the direction of the flow as well as perpendicular to it. Some of the crevasses extend over long distances and were about 3 m broad. Sastrugis had developed all over, trending NNW-SSE and these were generally 2-3 m long. Thickness of the ice shelf along the coast was of the order of 50 m above the sea level which continued to be southward upto about 40 km. From there onwards, it showed a gradual slope downward till near the northern face of Schirmacher landmass where it comes down to sea level near the epishelf lake. Beyond 45 km from the coast, towards the landmass, the shelf ice exhibits a dendritic network of water channels (melt-water over the surface), and also shows the development of lakelets and moulin like features.

The polar ice sheet merges the shelf ice, east and west of the Schirmacher landmass, over-riding the rock surface. The polar ice here has developed supraglacial channels and cryoconite holes. These supraglacial channels from a distance appear as rivulets on the alluvial fan; they also contain sediments, sand gravel and supraglacial moraine. Cryoconite holes in the lower part of the glacier are closely spaced, and vary in size from a few cm to 1 m in diameter and upto 0.70 m deep often exposing a stratigraphic column of glacier ice.

Supraglacial moraines and lateral moraines were observed over the polar ice demarcating the individual glaciers. The *Enzusty* glacier has a lateral moraine ridge having boulders arranged in a linear fashion with a surface width of about 5 m. Individual boulders have given rise to large depression in the ice now filled by frozen blue ice. Crevasses have developed all over the glacier from snout upwards upto south of nunataks (Skaly IGA area) and extend over more than a kilometre in length with a width of 10 m or so at the top. A few sastrugi with an orientation of NW-SE were observed to have developed over the glacier surface.

An interesting feature seen across was a dead ice mound near the snout of the polar ice in the Schirmacher Hill Range signifying the recent retreat of the ice in this area. The height of this dead ice mound was 2 m with a circumference of about 20 m. The sediment layer, covering the dead ice, was about 10 cm in thickness.

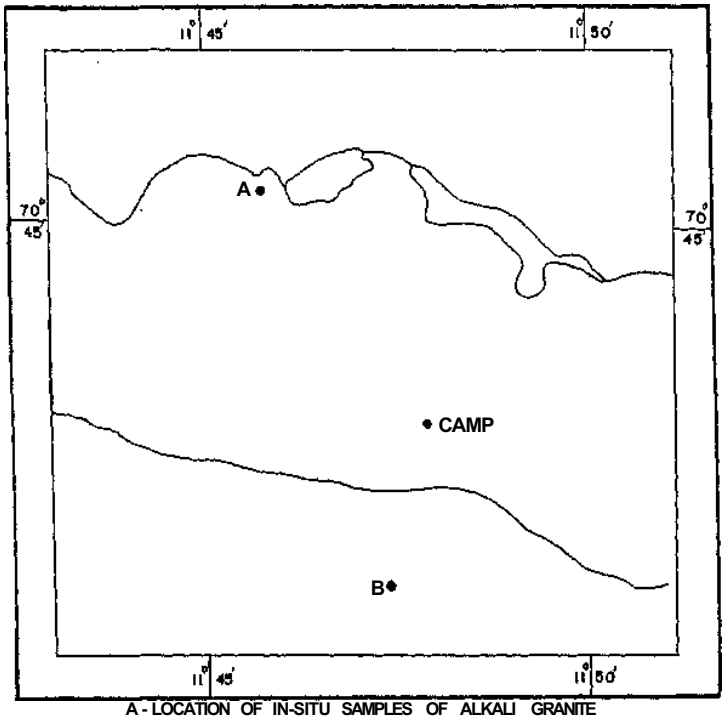

Fig. 2. Map of eastern part of Schirmacher Oasis, Queen Maud Land, Antarctica.

A close examination of the polar ice front close to the landmass revealed the development of stratigraphic banding in the ice with convoluted structures probably representing sun cusps and infolded depth hoar.

Ablation study of the polar ice revealed melting rate of 2.5 cm per day. The observation stake (Fig. 2) had been fixed during the month of February '85 at 240 m above sea level.

GEOMORPHOLOGY OF THE SCHIRMACHER LANDMASS

The Schinnacher landmass must have been covered with polar ice sheet till upto recent past. At present, due to the retreat of the polar ice at the southern periphery, a number of glacier outlets over-ride the rock surface. Exotic boulders and other morainic debris have spread over whole of the entire landmass. Glacial straition has been observed at number of places indicating the spread of polar ice sheet towards north in the past.

With the recession of the polar ice a number of lakes have developed in this area due to the depression/glacier eroded cavities which are filled with the melt water.

An interesting feature observed was the distinctive land form: patterned ground in polygonal form, with coarse stones arranged on the periphery of polygon and finer fractions forming the centre. These sorted patterned polygons were observed to be more frequent in depressions.

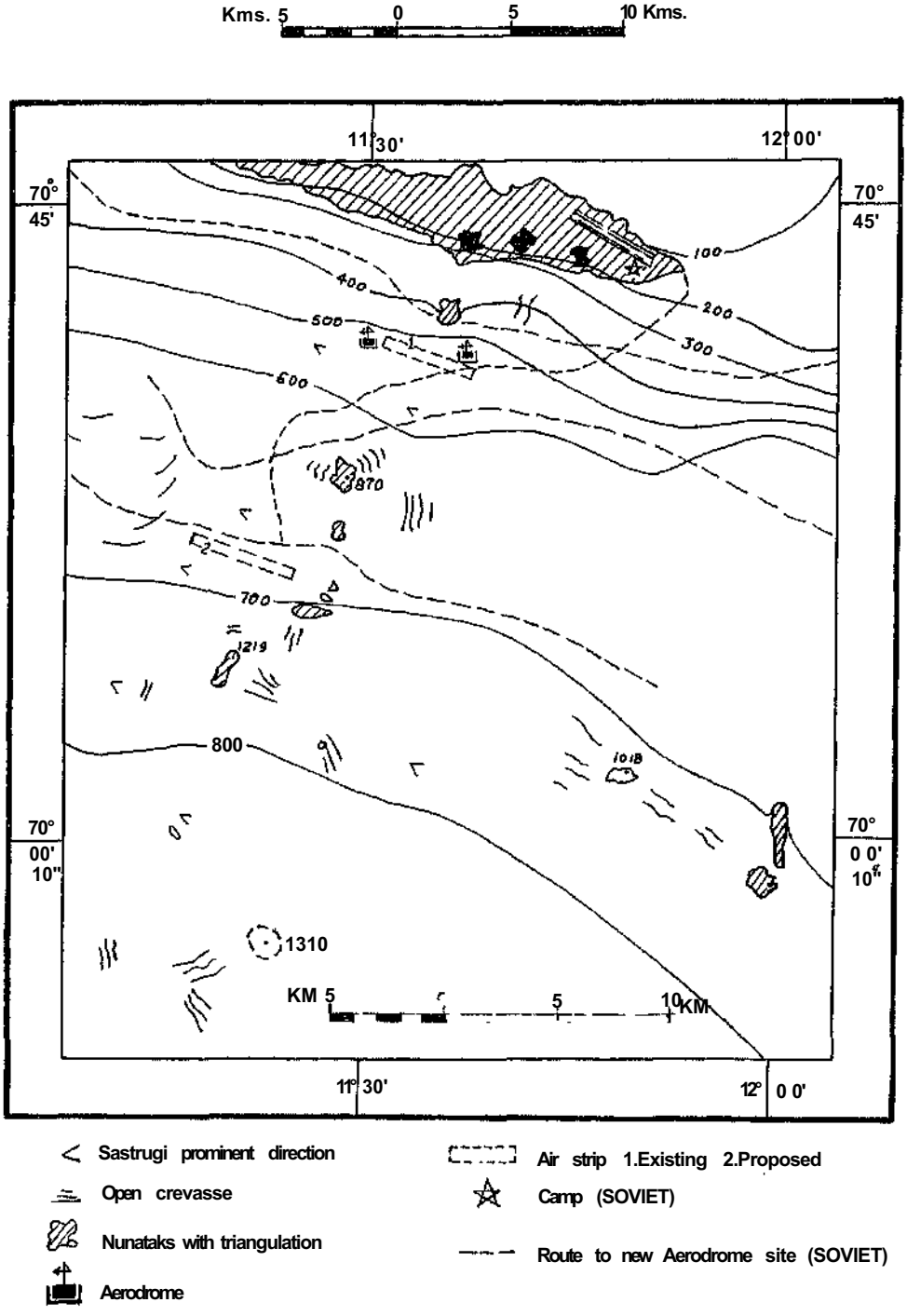

Fig. 3. Map of nunataks, Skaly IGA area.

GEOLOGICAL INVESTIGATION

During the course of reconnaissance survey, besides the geological mapping of the Nunatak 882 m in Skaly IGA area, SSW of Schirmacher (Fig 3), rock samples were also collected, both in situ and from moraines, for petrographic studies.

The nunatak comprises, primarily, banded garnet biotite gneiss, infolded calc silicate rocks and intrusive olivine basalt and calcite veins. Gneisses trend NW-SE with foliation dip varying from 55° to 60° south-westerly.

DESCRIPTION OF THE THIN SECTIONS OF THE ROCK SAMPLES COLLECTED

Olivine basalt (Nunatak): Rock shows a fine grained, sub-ophitic texture with phenocrysts of olivine. The latter is highly birefringent, showing a biaxial figure. Euhedral crystals show straight extinction and alternation along the cracks. Fine grains of magnetite along with plagioclase and augite form the matrix.

Marble-cordierite hornfels (Nunatak): Mainly composed of clacite crystals. The latter are highly birefringent, showing uniaxial negative character, and inclusions of rutile — light brown in colour and uniaxial positive. Cordierite crystals present show a low relief, low birefringence and are biaxial.

Skarn rock (Nunatak): The web has a granular texture. Andalusite crystals are showing two directional cleavages. Pleochroism is feeble optical axial figure is biaxial, sign is difficult to determine, relief is very high. Birefringence is high in slide. Crystals are length fast. Calcite crystals are highly birefringent showing uniaxial negative figure. A few crystals of amphibole which are brown, pleochroic, showing rhombic cleavage, are also present.

Pyroxenite (Schirmacher landmass): Rock is composed entirely of pyroxene-hypersthene which shows pleochroism from light brown to green; second order interference colours but marked by body colour. Extinction straight; two sets of cleavages at almost right angles; Orientation-length slow. Distinctive figures (optical axial figures) could not be obtained, however movement of isogyres shows biaxial character; sign of the biaxial figure could not be determined. A few grains with high birefringence are present (possibly of rutile).

ROCKS COLLECTED FROM MORAINES

Qnartz-cordierite hornfels: Rocks exhibit a granular hornfelic texture. Garnet porphyroblasts are light pink in colour and isotopic. Quartz grains show low relief; low birefringence with interference colours-grey of first order. Cordierite grains show strong polysynthetic twinning; generally are turbid and altered to sericite. A few grains of green pleochroic chlorite are also seen.