Origin and Significance of Wet Spots on Scraped Surfaces in the High Arctic*

In the western Queen Elizabeth Islands, Northwest Territories, where most of the petroleum exploration in the High Arctic is being conducted, much of the low lying land is covered with sorted and non-sorted circles and polygons 0.5 - 2.0 m. in diameter.[1] The central parts of these islands are usually considered as true Polar Desert with shallow lithosols and little or no vegetation.[2,3] The coastal areas are referred to as Polar Semi-desert, since the marine sediments support a fairly complete cover of lichens, mosses and a few scattered flowering plants, usually concentrated at the margins of the non-sorted patterned ground features.[3] Much of the oil-camp construction takes place on the coastal lowlands on polygonal surfaces composed of sandy to silty loams. When these surfaces are scraped and reworked for camp areas and air strips in summer, it is common for them to have numerous wet spots which become soft and spongy and of jelly-like consistency when equipment is moved across them (Fig. 1). Although surfaces are often scraped daily, the abundance of these soft spots may force the abandonment of air strips, or even yard areas, for much of the summer.

Since the authors have observed numerous places in the islands where it is difficult to maintain air strips in summer due to these wet spots, a small study was conducted in 1972 at the Sunoco Camp no. 3002 on the northeast side of King Christian Island (77°44′N., 101°15′W.), approximately 3.5 km. from the sea. There the surface soils consist of fine marine sediments intermixed with small pebbles. The entire camp area and the Hercules landing strip are built on a surface covered with non-sorted polygons. On 17 July the active layer was 30-50 cm. deep in undisturbed land 200 m. from camp.

In these Polar Semi-desert landscapes 20-40% of the surface is often bare because of the active polygons. Flowering plants constitute about 15% cover, lichens 15%, mosses 25%, and dead plants (litter) 5% at this site. The dominant flowering plants are *Papaver radicatum, Alopecurus alpinus, Luzula nivalis,* and *Draba alpina.* Mosses appear to initiate plant succession and to act as a sponge in holding water for flowering plants in an environment that is typically quite dry after snowmelt.

Excavations were made on both the disturbed surface, where the damp spots occurred, as well as in the undisturbed area adjacent to the camp. One relatively large wet circular area 1.0 - 1.5 m. in diameter was excavated in the work area (Fig. 2). The upper 10 cm. were slightly drier and more dense and cohesive than the underlying material, which was wet and sticky. The centre of the wet spot was found to be underlain by an ice-rich domed area approximately 50 cm. in diameter. The depth to the apex of the ice-rich base was 47 cm., while the surrounding frozen ground was 52 cm. below the surface (Fig. 2). When the base of the excavation was scraped with a shovel, many small ice veins 1 - 5 mm. wide and 20 - 50 cm. long could be seen radiating across the convex area, but essentially none occurred in the surrounding frozen base. The authors could not ascertain

FIG. 1. Wet spots occurring on scraped surface in work area of Sunoco Camp no. 3002 on N. E. King Christian Island. This area was initially cleared during the spring of 1971. Photograph taken on 17 July 1972.

*Devon Island International Biological Program ecosystem study, paper no. 26.

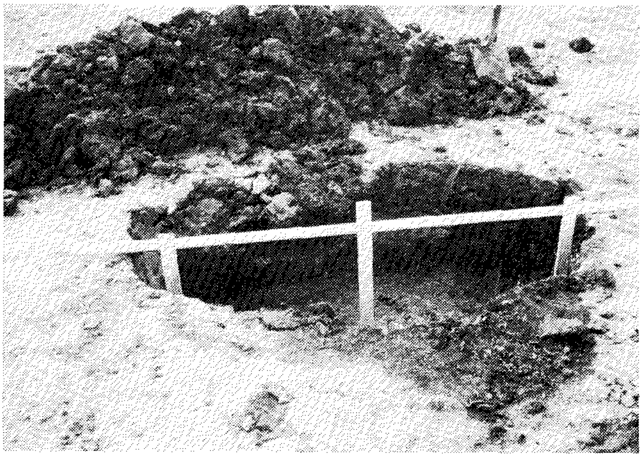

FIG. 2. Excavated wet spot from disturbed site at Sunoco Camp. The vertical wooden stakes are 56 cm. long and reflect the doming of the ice-rich area of the underlying ground.

the depth of penetration of the ice veins, but from their size and from other observations in the region assumed that they did not penetrate more than 0.5 - 1.0 m. below the active layer. Such depths of this ice-rich zone have been observed in cuts made on other islands with similar soils.[4] The ice-rich and slightly domed area was centred immediately below the wet spot on the surface, so the source of the moisture was clearly identified. Moreover, the evidence seemed to support the initial observation that the wet spots coincided with centres of the non-sorted polygons, although this was later found not to be the case.

Two excavations were then made in the undisturbed area adjacent to the camp. These were done in such a way as to transect the centre and margins of the patterned ground features. The camp area itself was nearly level, but the surface was inclined 1° - 3° to the northwest, and the polygons were slightly elongated in the direction of the slope. Ice-rich slightly domed areas were also discovered here but, it is important to observe, they coincided with the margins and intersections of the polygons, not the centres. The active layer was on average 12 cm. shallower in the non-disturbed area as opposed to the disturbed site, and there was less difference between the levels of the ice-rich and ice-poor areas. The depth of the active layer above the ice-rich base was 36 cm., while it was 39 cm. to the surrounding frozen ground. There were no wet spots in the undisturbed site, and the material was friable and easy to excavate. There was also no unfrozen water at the base of the excavation at the zone of contact with the ground ice. It began to melt quickly as soon as it was exposed, however.

From the information obtained during the excavations in each of the areas described, it is possible to understand more clearly the mechanisms responsible for the features. The wet spots in the cleared work-area are located at the foci of ground-ice accumulations which occur at the margins and intersections of the non-sorted patterned ground. The occurrence of ground-ice at the perimeters of the non-sorted polygons is explained by the contraction cracks which form and outline the patterned ground. Moisture from the scanty precipitation (especially blowing snow) accumulates in the cracks and eventually becomes incorporated in the underlying frozen ground as ice veins. Since the cracks are areas of greater moisture (as well as microhabitats), the plants tend to congregate in them and in turn reinforce the moisture content by (1) their greater moisture-holding capacity, (2) more efficient moisture entrapment, and (3) retarding the rate of thaw owing to the slightly greater insulation they provide.

Once such a surface is disturbed, as it was in this case by light blading with a bulldozer, the vegetation is destroyed (at least the above-surface parts). Greater thawing may then occur, during which the moisture is drawn to the surface by capillary action as melting of the ground ice takes place. These bladed areas increase soil compaction and therefore thermal conductivity, and so melt is accelerated.[4] In addition, the organic matter and remaining live plant material in the crack act as a "wick" drawing the moisture to the surface.

A last but very important factor is the movement of heavy equipment over the surface. It was found during the field reconnaissance of 1972 that the wet spots did not occur in the sleeping-quarter area or on the runway, although in the previous year, and also in 1973, the air strip contained numerous wet areas. Their main area of concentration was in the work area in front of the camp where there was continual movement of equipment. The repetitive application of pressure over an area rich in ground ice (such as by a fork-lift when unloading aircraft) has a "pumping" action whereby moisture is slowly forced to the surface. This constant agitation distributes the water throughout the mass, and the material becomes "quick" owing to the reduction of intergranular pore pressure.[5] This results in loss of cohesion, and the material becomes spongy and jelly-like when pressure is applied.

The practical significance of this brief investigation is that the wet spots will probably not increase in size or the surface deteriorate further, but in fact there should be an improvement. It appeared from discussion with camp managers on two islands that, after two or three summers of use of the surface and scraping, the wet spots dry out. The best approach to the use of these vegetated (and therefore ice-rich) non-sorted, patterned ground surfaces in the High Arctic is to clear the areas before thawing occurs in the spring, and if possible not to use them heavily during the first one or two summers. By the second or third summer much of the ground ice will have thawed, so there should be less chance of major problems with wet and soft spots — unless the summer is unusually wet, as it was in 1973.

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The Use of APT Satellite Imagery in a Subarctic Airborne Oceanographic Survey

GENERAL

During an airborne oceanographic survey of ice conditions in the east Greenland driftstream in April 1972, earth-oriented satellite photographs were received aboard the research aircraft *Arctic Fox* of the U.S. Naval Oceanographic Office. These photographs, broadcast directly from the satellites *Nimbus 4* and *ESSA 8* (Environmental Survey Satellite) were received by means of an APT (automatic picture transmission) satellite receiver station[1] equipped with a specially-modified airborne satellite communication antenna.

The satellite photographs showed the ice and cloud conditions for the Greenland Sea as they existed during each flight. This information was used both as a planning and operational aid during the survey and as a post-survey data source of ice and cloud conditions.

SATELLITE AND APT STATION DESCRIPTION

The satellites used during the experiment were in polar orbits. This north-south orientation of orbit created an overlap between each consecutive orbit that increased towards the poles. In the latitudes of the study area, the overlap in the paths of each consecutive orbit was approximately 50 per cent. Thus, it was possible during the experiment to use the early morning satellite photographs in the pre-flight planning sessions to examine the general conditions of ice distribution and weather over the entire Greenland Sea, and to locate regions within the study area having the specific ice and cloud conditions required for that day's survey. Photographs obtained late in the morning and early in the afternoon were used to delineate the exact extent of the ice and cloud conditions in the chosen survey region. As mentioned earlier, these later photographs were retained as a data source of the survey region's ice and cloud conditions.