peat layers from the forest meadows and clearings, and so on.

Under such conditions manures must play a great part in northern agriculture. Chemical fertilizers provide ready food for plants at the time when the active horizon of soil does not allow extensive bacterial life, and organic manures enrich the poor microflora.

Dung spread on the fields in autumn according to the old system of manuring loses its potency during the 8 winter months as it is weathered by winds and leached away by the spring thaw. In my experiments at Kureika the biennial use of dung was introduced: in the first year it was laid into the hot beds, and in the following year its un-decomposed remains were mixed with chemical fertilizers and spread over the fields.

CONCLUSION

The main problems of northern agriculture are: 1) The reaction of plants to the short vegetative period and to the long polar day; 2) The influence of permafrost on the soil and on plant life.

Proper methods of cultivating and manuring help to surmount these difficulties and to develop to some extent the production of vegetables for the use of people living in the Arctic. Vegetable production in the Far North is at the moment only of strictly local importance, but the populated regions of the Arctic are growing as a consequence of scientific and technical progress. Electrification, aeronautics and radio were factors which improved the living conditions of people in the North. Mining provided a basis for the development of industry. Agriculture and cattle breeding followed industry to ensure adequate food supplies when transport from the south was difficult.

These new methods of plant culture have opened up new horizons in the Far North not only in USSR, but also in Canada and in the Arctic Islands. Northern agriculture in its circumboreal meaning will play an important part in the future world economy.

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The Icefield Ranges Research Project, 1969

The Icefield Ranges Research Project (IRRP) — as was visualized nearly ten years ago — becomes each year more and more a complete study of the environment dominated by the St. Elias Mountains, Canada/Alaska.

Since 1967, IRRP has been composed of three closely-integrated research units, planned to achieve the proposed aims of IRRP as defined by Dr. W. A. Wood, the original Project Director, accepted by the Arctic Institute's Board of Governors in 1961, and endorsed by the IRRP Advisory Committee.

This report reviews the work accomplished by a total of over 65 scientists, their assistants, and support personnel, during the 1969 summer field season which opened in mid-May and ended the first week in September. It is composed of post-field summaries by principal investigators researching in the disciplines of glaciology, geophysics, physical geography, botany, zoology, archaeology and physiology.

FOX GLACIER ACTIVITIES

The program on Fox Glacier, one of the International Hydrological Decade (IHD) glaciers in Canada continues, but at a lesser pace than in 1967 or 1968. The emphasis in 1969 was on mass balance and flow studies.

Mass Balance Studies.

Ablation, and snow and ice density measurements were made between 20 June and 10 August to establish the 1969 Fox Glacier mass balance. It was apparent early that the "year"

was an extraordinary year since almost no accumulation remained from the 1968-69 winter. In June a maximum of 42 cm. was measured at one stake where 232 cm. had been found in 1968. By mid-July all accumulation from the previous winter had ablated.

Even though this budget year resulted in no accumulation, the period of observation was not characterized by rapid or extreme ablation. In fact, frequent snow precipitation during the end of July and August masked the lower part of the glacier to the extent that the 1969 late July and early August ablation rate at a representative location was 0.8 cm./day compared to 4.8 cm./day in 1968. It now appears that the budget year ended during the last week in July this year compared to the first week in September 1968. Thus we see the paradoxical situation of a strongly negative budget year with an abnormally early end.

Moraine Features Map.

A plane-table map was prepared showing various small features on the most recent Fox Glacier terminal moraine. This study indicates that no glacier motion has occurred in the lower part of the glacier since shortly after the moraines were formed as crevasses and shear plane fillings pass untruncated from moraine to glacier. The upper limits of recent Fox lateral moraine can be estimated. (It may be interesting to compare the areal distribution of the Fox Glacier crevasse fillings with those in regions of Pleistocene glaciation.)

Geological Map of Fox Valley.

All the observed rock outcrops around Fox Glacier valley were visited and about sixty were sampled to prepare a geological map of the region. A low-angle thrust fault with a N-S strike was recognized on the west side of the valley which emplaces Paleozoic marble over Tertiary volcanics. In one location volcanics were seen to overlie a buried soil which may be a till. Further work is planned.

Thermal Drilling and Englacial Temperatures.

Six locations were occupied for thermal drilling and ice temperature studies. At four locations the bottom of the glacier was reached at 30 to 50 m. Thermistor strings were fixed in all the holes, and cooling curves were obtained at various depths to determine length of time before equilibrium was reached. All temperatures were below 0° C. but final figures await accurate reduction from the thermistor calibration data.

Survey.

A resurvey of the 68 marker poles (accumulation/ablation/motion) placed in the Fox Glacier in 1967 and the 26 in the Hyena Glacier was completed by the end of July. In addition, two new reference stations were established for the Hyena Glacier survey. All raw data have been completed and show movement of from about 6 m. to less than 0.5 m., the most rapid in the upper reaches of the Fox Glacier.

KASKAWULSH GLACIER STUDIES

Research on the Kaskawulsh Glacier was minimal. As in the past, however, synoptic weather was recorded and radioed to Kluane base station where it, in turn, was transmitted to the Department of Transport weather station in Whitehorse.

Pit Studies.

In mid-July a standard snow pit study was made to 4.5. m. depth in the firn at Divide Camp (elevation 2630 m.). A depth-load curve derived from the density measurements places the study within the percolation facies but very close to the saturation line and the wetted facies. As in previous summers during the period of least stability, firn temperatures through the annual layer of firn accumulation hovered around the 0° C. mark. In a 14.7 m. core hole the temperature was — 0.25° C.

From each metre depth vertically down the pit wall, to between 6 and 7 m. and 70 cm. apart longitudinally, samples of firn were carefully collected for analysis of Ca, Na, Mg, and K ions by atomic absorption method. This program was begun in 1966 and shows some promise of aiding researchers in interpreting circulation and source of precipitation in the Icefield Ranges — i.e. whether marine or continental. In addition, samples of precipitation during storms were collected both at Divide Camp and at Kluane Base.

Thermal Drilling.

During the first week in August a hot point drill was employed at Divide Camp to test the design, component parts, and drilling concepts and procedures in this particular environment. The drilling was successful in that we were able to penetrate continuously to a depth of about 130 m. (425 ft.) meeting with very minor difficulties. Some additional apparatus, a small design change and change in drilling procedure will be necessary before next year's effort is attempted. It is hoped that funds will be available for an all out effort in 1970. A thermo-couple string was fixed in the hole, but Divide Camp was abandoned before temperature equilibrium was reached. The thermocouples were left in place and will be read in 1970.

STEELE GLACIER STUDIES

Forward movement of the terminus of the

Steele Glacier was no longer apparent in 1969. However the upper accumulation zone and Hodgson Glacier, the main tributary, continued to be active. Also it is reported that the middle third of the main trunk of the Steele is thickening.

In the latter half of July, at the request of Surveys and Mapping Branch, Department of Energy, Mines and Resources, Ottawa, reidentification and marking of ground control stations was carried out in the Steele watershed by helicopter. This was necessary to prepare for a planned aerial photo survey by Range Aerial Surveys, Calgary. Although 3 of 18 stations were not reached because of high winds, and plans had been made to mark them when the weather allowed, too much snow and continually changing weather never allowed a proper opportunity to complete the Steele Glacier program.

ARCHAEOLOGICAL RECONNAISANCE

During late July and early August a reconnaissance of the archaeology of the Gladstone Lakes region was achieved. Several sites were found which are stratified and indicate the occupation of present and ancient lake shores by several distinct prehistoric Indian cultures. The diverse topographical locations of the sites poses an interesting ecological problem regarding seasonal utilization and cultural preference in subsistence activities. Intensive work in and about these multi-component sites is planned for the next few summers and may lead to the establishment of a valid chronology for human occupation and migration in the southwestern Yukon.

ZOOLOGY STUDY

During the summer field season a study was initiated of the hematology, blood chemistry, and plasma proteins of grizzly and black bears in the area, for the purpose of assessing the general health and nutrition of the animals. Hematology was performed in the field; however, serum and washed red blood corpuscles from each bear were frozen and stored at the Experimental Farm, Canadian Department of Agriculture. In late August the samples were packed in dry-ice and transported by air to the Marshfield Clinic Foundation, Marshfield, Wisconsin, where laboratory analyses of plasma and serum will be conducted. About thirty bears were processed; i.e. tranquilized, weighed, samples taken and released.

ROCK GLACIER STUDIES

This research was started in 1965. This summer coring into the rock glacier on Sheep Mountain was initiated with a drilling crew from Arctic Diamond Drilling, Whitehorse. Drilling was difficult but progressed to a depth of about 19.5 m. The hole was cased and temperatures were read — probably before equilibrium was reached. Temperatures top to bottom ranged from 3.3° C. to 1.0° C. A motion survey of the 1966 stakes was also made, and preliminary data indicate that since then surface motion along the centre line is about 1 m.

SHORT-TERM STUDIES AND VISITORS

Several distinguished scientists, often from far afield, visited the base and contributed much in informal seminars to the IRRP personnel. They included Dr. R. Gilbertson, University of Arizona; Dr. Orson Miller, U. S. Department of Agriculture; Dr. and Mrs. D. Murray, Memorial University, Newfoundland; Dr. Hugh Bostock, formerly Geological Survey of Canada; Dr. J. Dickson, Cambridge University; Dr. E. Nishibori, Institute of Electrocommunications, Tokyo.

In many cases poor weather and/or flying conditions severely limited their attempts at field work.

Messrs. Peters, Mercier and Leibel from Limited Warfare Laboratory spent five days of stormy weather on Divide testing tents. The weather was ideally miserable for any tent testing purposes. Winds reached 55-60 mph in peak gusts and drifting was a constant problem around the tents and Versadome hut.

On 19 and 20 July personnel from Canada and the United States interested in environmental research and high mountain physiology visited Kluane Lake base station. The Mount Logan and Chitistone Pass camps were visited by air, and in the case of the Mount Logan camp (elevation 17,600 ft. 5,360 m.) some visitors were landed and had a short time to talk with personnel and glimpse the laboratory and living facilities.

HIGH MOUNTAIN ENVIRONMENTAL PROJECT

The Project completed its third year of research in 1969. As in past years, there were two phases to the project: (1) environmental studies in the classical alpine landscape at Chitistone Pass, Alaska, and (2) high altitude environmental studies on Mount Logan.

Operation of the Chitistone camp was generally successful. Contrary to previous years, a very warm early spring was helpful to getting studies underway, but a wet July and a cold, snowy August hampered the completion of various studies.

CHITISTONE PASS FIELD RESEARCH

Ice-cored moraine study.

The ice-cored moraine study initiated in 1968

was continued. The investigation was undertaken to determine the thermal and geomorphic relationships which exist for buried ice under morainic cover. Theodolite and plane table surveys were made, and five specific moraine sites were instrumented for temperature observations along a vertical profile. Each profile extended from the atmosphere — through the moraine cover — to the buried glacial ice. Short-wave radiation was also recorded at these sites using an Epply pyrheliometer. Mass movement measurements, using painted rocks and creep pins, provided an analysis of geomorphic processes on the ice-cored moraine. Prostrate willow samples for dendrochronological purposes were taken from various points on the moraine. Selected sample sites were repeatedly photographed through the two summer field seasons to detect general geomorphic change through time. Ablation and movement of the wasting ice-core were recorded for the two year period. Measurements were also made of the annual retreat of the present glacial terminus.

Channel Adjustments of Suparglacial Streams.

In the summer of 1969 supraglacial streams on a small glacier near Chitistone Pass were examined by J. Dozier, Department of Geography, University of Michigan, within the framework of energy loss theory. Effects of glacial structure and movement and of climatic variables were also investigated. Streams on ice are well-suited to an examination of channel adjustment, because the amount of downcutting per unit of time is much greater than in ordinary rivers, and significant changes can be observed during a summer field season. For example, one of the small streams under study downcut more than 3 metres in 60 days.

Preliminary analysis of the data indicates that curved reaches of supraglacial streams have less variance of energy loss than straight reaches, and that the stream channel adjustment over the summer is such that variance of energy loss is reduced for both curved and straight reaches. In addition, the beginning of a bend was observed in a straight reach at the end of the field season. More will be published shortly on this interesting subject.

Reconnaissance of Soils in a Periglacial Environment.

Soil samples were taken from 29 different sites (80 samples in all) in Chitistone Pass. A majority of the samples were associated with three transverse profiles in the Pass. Each profile was different in angle, aspect and surficial characteristics. The purpose of the sampling was to relate the characteristics of the soil to the ongoing geomorphic processes.

A partial size analysis of the samples was done in the field by using U. S. Standard sieves. Approximately 500 grams of sizes 2 mm. and smaller were brought back for a more complete analysis.

Local Microclimatology.

Objectives of this research are to: 1) study variations in the heat balance between nearby stations at the same elevation (one is on ice, one over alpine meadow), 2) determine variations in the temperature field and their relationships to slope, exposure, elevation, and surface material.

Microclimatological stations were maintained at the Chitistone Pass station and over a nearby glacier. An 11-unit thermograph network was also maintained over the glacier and its environs. Ten days of continuous observations were completed for both stations. Three-hourly readings were taken between June 30 and August 9 at the Chitistone site.

Related Environmental Studies.

Meteorological observations were taken every three hours from 25 May to 14 August and reported by radio during the day to Kluane Base Station. Studies of snow-melt conditions were continued following 1967 and 1968 procedures along an ablation measuring transect across Chitistone Pass. Panoramic photographs of snow-melt patterns in the Pass were taken regularly as in previous years.

Study of geomorphic processes at work in the Pass were continued from previous years with measurements of mass wasting of particles from a bedrock outcrop and movement of a rock polygon in an area of patterned ground. Movement and thermal relationships on small mud-boils affected by diurnal needle-ice growth were observed.

MOUNT LOGAN FIELD RESEARCH

In cooperation with the Mount Logan physiology program, limited environmental studies were accomplished in 1969.

Climatology.

Icefield Ranges Research Project climatological observations were continued during the 1969 summer season at two stations. These were Kluane Lake base camp (27 May — 14 August), and Divide Camp (10 June — 14 August). Observations were also taken at Chitistone Pass, Alaska (25 May — 14 August) and Mount Logan (28 June — 27 July).

Synoptic weather observations of shelter temperature, humidity, winds, atmospheric pressure, precipitation, and short wave solar radiation were taken at three hour intervals. Reports were forwarded to the Meteorological Branch, Department of Transport, Canada.

Only daytime observations (6 readings daily) were made at Kluane, Divide, and Logan while 24 hour observations (8 readings) were recorded at Chitistone Pass. The limited observations were due to the reduced scale of the IRRP climatology program this year.

The summer climatic record was notable for extremes at all stations. The period of approximately 1 June — 20 July was marked by abnormally high temperatures e.g. 87° F. (31° C.) at Kluane and 53° F. (12° C.) at Divide and sparse precipitation. The second half of the summer was cold and wet. Outstanding occurrences were a record low (−6° F.) at Divide and snow flurries at Kluane in early August. The climatological summary for 1969 is now in production.

Ice and Snow Studies.

Investigations of the high altitude Mount Logan snowpack were continued in 1969. Included were measurements of density, water content, stratigraphy, and distribution. Snow profiles were obtained in both pit and crevasse locations. Local glacier morphology and movement were accomplished from base lines determined in 1968.

In addition, a deep core hole was drilled for temperatures, stratigraphic interpretation, and O^{18}/O^{16} analysis.

MOUNT LOGAN HIGH ALTITUDE STUDIES

The high altitude studies were started in 1967 as a logical extension of work in the physical and biological sciences conducted by IRRP since 1961.

Mount Logan was chosen as the site of a high altitude laboratory because its enormous summit plateau offers a unique theatre for work at altitudes ranging from 15,000 to 19,000 feet (ca. 4500 to 6000 m.). The site chosen for the laboratory on this summit plateau is approximately 75 miles (120 km.) from the base camp at Kluane Lake.

The summer of 1967 was spent in construction of what we hoped would be a permanent, all-weather building at 17,590 feet (ca. 5360 m.). Despite bad weather a building was erected, stocked and occupied. During the following winter drifting snow buried it completely, but in 1968 it was found and occupied. The team demonstrated that reliable and sophisticated studies could be done, and the project supported almost at will by air.

We had three objectives for 1969:

1. To study the effects of high altitude upon the circulation of the brain, eye, and kidney.
2. To compare the efficacy against acute mountain sickness of two medications widely advocated by others.
3. To observe the ability of troops to operate at high altitude without acclimatization.

30 individuals were involved in the effort this summer, of whom 25 spent time at altitude. Field operations planned by the Canadian Armed Forces were also successfully completed. Complementary work was done in meteorology, glaciology, and other physical sciences.

Much of our accomplishment at Mount Logan was due to the 8 members of the support group. They were carefully selected, had climbed together during the winter, and arrived at Kluane well equipped and already a team. These 8 climbers (2 girls and 6 men) were cheerful, enthusiastic, and ran a thoroughly competent camp — a group indispensable to a safe and successful project.

Transport was supplied by the Arctic Institute's two Helio Courier aircraft. A Canadian Forces DeHaviland Buffalo para-dropped equipment and supplies for 10 men for 15 days, all undamaged in nine passes.

The important advantage of the Mount Logan Laboratory over other well-established laboratories is the considerable difference in human physiological reaction between the 14,000 ft. (ca. 4300 m.) altitude of most laboratories and the 17,590 ft. (ca. 5400 m.) altitude of this station.

Research Studies.

Kidney studies involved collection of twelve-hour urine specimens at Kluane base camp and Logan Laboratory from each subject to provide new insights into differential filtration action of the kidney at high altitude. Another indicator of "sieving action" of the kidney will come from measurements in urine of a special material (PVP) given intravenously at altitude and at sea level. These kidney studies were made on nine of the ten volunteer subjects, and on most of the support group as well. They will be correlated with clinical observations, and with the other studies.

High altitude causes changes in the circulation of blood to the brain. Conventional methods of measuring cerebral blood flow are difficult and complicated at sea level, and probably impractical on Mount Logan. A new and simple method for approximating cerebral blood flow was developed and used. Measurements were made at Base Camp and at altitude, and will also be correlated with the clinical and other observations.

In 1968 some unusual retinal pathology was observed. Similar observations were reported by others, and led to a plan to study the retinal circulation this year. Although retinal photography is a precise and also demanding task,

success was achieved in taking such photographs on most of the experimental subjects, the investigators, and all of the support party. In addition retinal capillary permeability using fluorescein was measured in a number of individuals, and these observations will be correlated with those made on the kidney — also an indirect measure of capillaries. Retinal pathology was observed in nine of the twenty-five individuals who went high. We believe that such abnormalities are common, not peculiar to Mount Logan or to rapid ascent, but that they have gone unrecorded simply because they have not been sought.

Five of the Canadian Forces volunteers were given furosemide (Lasix) on arrival at high altitude. The other five were given acetazolamide (Diamox) before the ascent. Both of these drugs have been advocated to decrease the symptoms of acute mountain sickness. Although this was a small and uncontrollable study, our experience shows that Diamox is far more effective a preventive measure than is Lasix, and indeed the latter seemed to make symptoms worse rather than better.

Observations:

Once again it was recognized that dehydration is a serious problem at high altitude, requiring unusual effort to keep fluid intake high. The team of physicians agrees with the findings of others that important shifts of fluid within the body contribute to symptoms of high altitude sickness, and they believe that Lasix increased dehydration more than Diamox and was far inferior to Diamox at altitude.

Potentially serious altitude effects are unavoidable in the mountains and are seen with increasing frequency among climbers. When individuals are transported in less than an hour from a lower altitude to one where the oxygen available is less than half that at sea level, certain risks and symptoms are inevitable.

In 1967 and in 1968 retinal hemorrhages were observed in several individuals, accompanied by symptoms suggestive of cerebral edema. Such conditions have since been reported from India and Alaska and were made a major study at Kluane and Mount Logan in 1969. A number of retinal photographs were made at high altitude, and controls were made at base camp. In some subjects more sophisticated studies were also made, and it is believed that these studies will contribute considerable new information.

The first group of Canadian Forces volunteers was taken directly to the high camp without pre-medication, and given Lasix on arrival and for several days thereafter. All members of this group were seriously affected by altitude; one required emergency evacuation. After three days the condition of those that continued at high camp had not improved significantly, in fact they were not able to take care of themselves and had to rely on the support group.

By contrast, the second group of five volunteers was given two days of pre-medication with Diamox at Kluane base camp and no medication at the Mount Logan high camp. Though all had some symptoms, none were seriously affected. They were able to take complete care of themselves and perform simple military manoeuvres. Although other variables existed between the two groups, and although their numbers are too small to be significant, the contrast is too striking to be discounted.

As is so often the case with incompletely understood phenomena the physiology studies have raised more questions than they have answered. It is believed that this altitude enables researchers to examine important physiologic changes, some of which (retinal hemorrhage) may be far more common than has heretofore been suspected. The relationships between fluid balance and shift from one tissue to another, changes in capillary blood flow, and changes in the permeability of blood vessels comprise a fascinating and unexplored area.

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Rockwell Polar Flight November 1965

The scientific report of this first flight over both poles around the world in a north-south direction is now available. It deals with navigation, meteorology, cloud studies, radiation measurements and data on ozone and carbon dioxide distribution. Copies may be obtained gratis by writing to:
Professor Serge A. Korff, New York University, University Heights, New York, New York 10453.