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INSTRUMENTATION FOR MASS-WASTING AND PATTERNED-GROUND STUDIES IN NORTHEAST GREENLAND

Abstract

A brief description is given of instrumentation and procedures adopted for mass-wasting and patterned-ground studies in the vicinity of Mesters Vig, Northeast Greenland.

INTRODUCTION

By necessity many studies in the Arctic have been handicapped by being conducted during the summer season only, whereas many of the critical processes are most effective during the break-up and freeze-up periods. Also, few investigations have been carried out with a view to obtaining quantitative results over a period of years. Through the courtesy of the Danish Government and Nordisk Mineselskab A/S, the writer has had the privilege of undertaking a geomorphic research program in Northeast Greenland that overcomes some of these handicaps. The program was started in 1956 and is based at Mesters Vig, on the south side of Kong Oscars Fjord in latitude 72° north.

Mesters Vig is the site of a lead-zinc mine operated by the Nordisk Mineselskab A/S. As a result of the favorable logistics resulting from the presence of the mine, the writer and his family have been able to commence work prior to break-up and to continue it after freeze-up without having to winter in the region, and most important, to return to the same area over a period of years. The program covers most geomorphic processes in this arctic environment and includes a cooperative botanical study, relating to these processes, which is being carried out by Dr. Hugh M. Raup, Director of the Harvard Forest.

Twenty experimental sites have been established in the Mesters Vig area for the study of various kinds of mass-wasting, frost action, and patterned ground. The sites are instrumented with mass-wasting targets, dowels, thermocouple strings, cryostatic pressure gages, and mass-wasting-meters as described below. Observational results are being currently assem-

bled and evaluated, and it is anticipated that the program will be continued in 1959. The present discussion of the instrumentation is prepared in the hope that it may be useful to others planning similar studies.

INSTRUMENTATION

MASS-WASTING AND PATTERNED-GROUND TARGETS

The mass-wasting tergets consist of orange-colored wood cones, mounted on wood pegs that are screwed into the base of the cones (pl. 1). The cones have a basal diameter and a height of ca 10 cm. Pegs are of two lenghts — 10 and 20 cm. They are creosoted to preserve them and notched to promote anchorage in the ground.

The targets are pleced on slopes of similar material but of differing gradient and differing moisture and vegetation conditions. The targets were alined approximately parallel to a contour, and in one area two target lines are placed on the same slope (fig. 1) in order to facilitate comparative studies. Targets are generally spaced two meters apart, and with alternate length of pegs so as to evaluate possible differences in rate of movement as between the material above and below a depth of 10 cm. Alinement was made with a Wild T-2 theodolite, reading directly to one second. At the principal target lines, the theodolite station is on bedrock and the lines were sighted in towards a distant reference point. Some of the experimental sites have over 40 targets alined across a slope in this fashion. Sighting is to the tips of the orange cones, and in general displacements of as little asafraction of a centimeter are easily measureable. At the principal sites, theodolite readings are being made on the average of about every two weeks from the time the cones are first revealed by disappearance of the snow in the spring until they are covered again in the autumn. A record is also maintained of target tilting and the amount they are raised by frost heaving.

Wood dowels, 3 mm in diameter, are used instead of the orange cones at some experimental sites. These dowels are ringed at 10 cm above their base by a black circle to facilitate uniform penetration. They are generally spaced some 20 cm apart, and are designed to measure small-scale displacements within restricted areas. They were alined with reference to a string or wire stretched tight between end posts, and their displacements are recorded with reference to these end posts.

The same kind of dowels are utilized in the study of patterned ground. Here they are arranged in a grid pattern in sorted and nonsorted circles

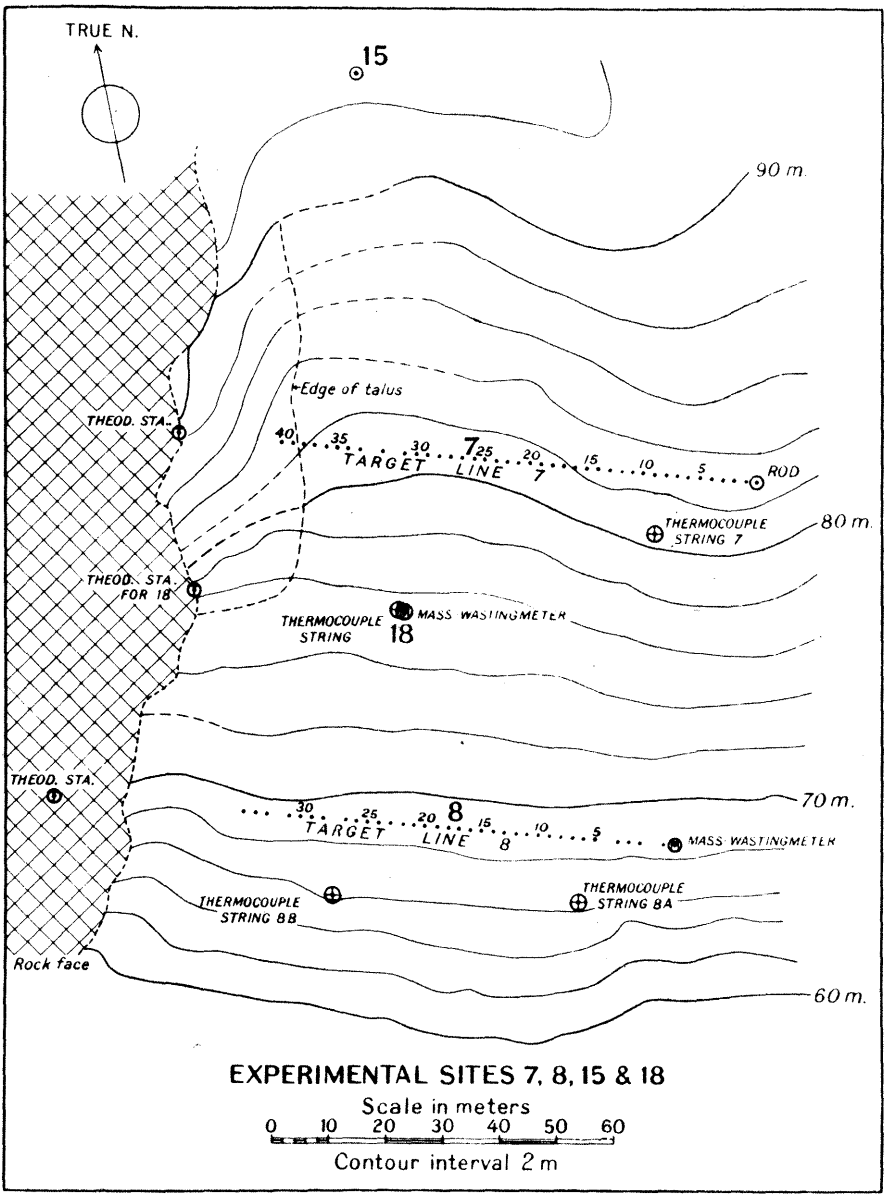

Fig. 1. Mesters Vig, Northeast Greenland

and nets. The dowels were spaced 10 cm apart with over a hundred being placed in some features (pl. 2). As with the cones, records are kept of the tilt and heave of the dowels.

MASS-WASTINGMETERS

The mass-wastingmeters were engineered by the Thayer School of Engineering at Dartmouth College and by the Thermal Dynamics Corporation of West Lebanon, New Hampshire.

Each instrument consists of an 183-cm-long aluminum tube of 3,8-cm outside and 2,5-cm inside diameter, through which wires pass over small pulleys to dial gages mounted within a transparent weatherproof hood at the top of the tube (fig. 2). There are three wires, each attached to a different dial and leading out from holes in the tube at three different heights above its base, the end of each wire being attached to a rectangular brick measuring $4 \times 5 \times 9$ cm. These bricks are buried at different depths downslope from the aluminum tube. The tube was inserted vertically, approximately to the permafrost table, and the position of the tube accurately determined by theodolite or tape so that any change of position could be measured. Any displacement of the bricks after emplacements causes the dials to indicate the amount of movement in degrees of arc. Calibration is such that 18° (in one model) or 23° (in a second model) corresponds to a change of 1 cm in length of wire from brick to tube.

Four mass-wastingmeters are installed at the experimental sites, each in association with a line of mass-wasting targets so as to obtain information on subsurface movements that might not be recorded by the targets. Although these mass-wastingmeters provide quantitative data regarding time and magnitude of subsurface movements, they do not differentiate between downslope movement and heaving of a brick, so that the final position of the bricks as compared with their initial attitude must be determined by their excavation upon completion of the project.

THERMOCOUPLE STRINGS

The thermocouple strings were manufactured by the Thermo Electric Co., Inc., of Saddle Brook, New Jersey. They consist of copper-constantan thermocouples spaced every 10 cm, except for a 5-cm interval near the surface of the ground in some strings. Most of the experimental sites have one to two thermocouple strings in close proximity to a mass-wasting--target line. Strings are also installed in and adjacent to sorted nets and circles. All the strings are confined to the active layer, and at most of

the sites they reach approximately to the permafrost table. Geese provided an unanticipated difficulty in that they succeeded in biting through the leads of some strings!

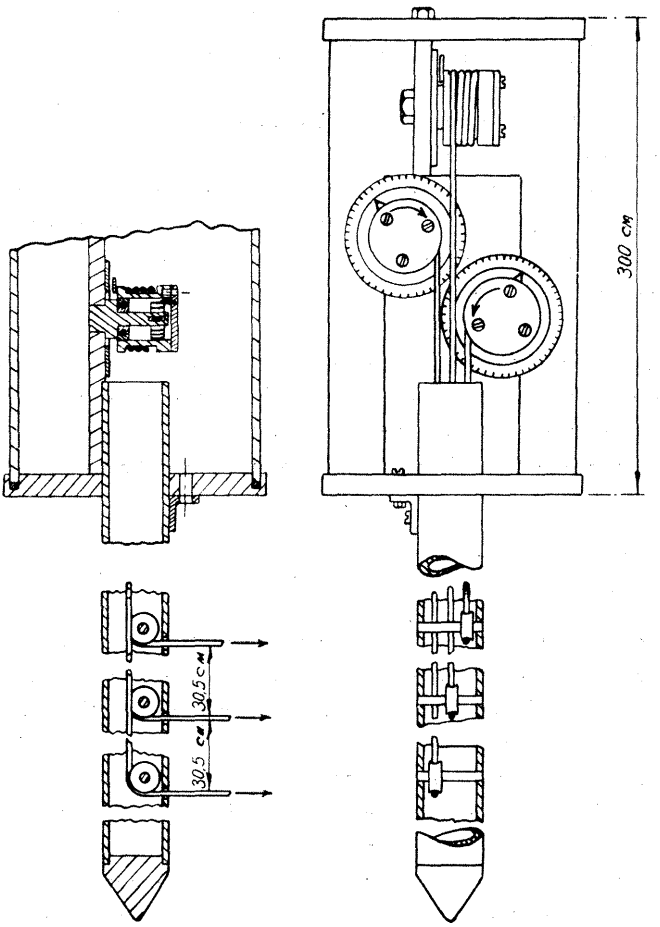

Fig. 2. Drawing of mass-wastingmeter, illustrating its construction

A special pyrometer-potentiometer, developed for the purpose by the Thermo Electric Co., is used to read the thermocouples. It is a compact lightweight unit powered by mercury cells, and is designed to read temperatures directly to 0,1° C. It can be used either with or without an ice bath as a reference junction, but in practice an ice bath is used as affording the most accurate check.

CRYOSTATIC GAGES

The cryostatic gages were designed to measure possible pressures between the downfreezing active layer and the permafrost table (cryostatic pressure). The instruments were made by the Thayer School of Engineering at Dartmouth College, after a design developed by the U. S. Army Corps of Engineers, Snow, Ice and Permafrost Research Establishment (SIPRE). They consist of a metal-encased synthane tube filled with silicon fluid and having a pressure gage at its top, calibrated to read pounds of pressure in quarter-pound divisions. The base of the tube has a small-diameter hole through which fluid pressures can be transmitted, and the hole is small enough so that the tube can be inserted vertically in the ground without losing its silicon. After the instrument is installed any changes in fluid pressure in the ground are theoretically transmitted to the gage.

Cryostatic pressure gages are associated with thermocouple strings at one of the experimental sites for the study of patterned ground. Previous and present experience with the instrument suggests that it may not be completely satisfactory and that modifications may be necessary.

CONCLUSION

Judging by experience to date, the mass-wasting and patterned-ground targets, the mass-wastingmeters, and the thermocouple installations are providing valuable data. The cryostatic gages, on the other hand, appear to be less satisfactory.

In addition to the above instrumentation, routine soil mechanics equipment and procedures are being utilized in connection with analysis of slope conditions at the different experimental sites. Thus, detailed grain-size analyses, moisture determinations at different times of the year, strength of the ground as measured by penetrometer, and related data are being gathered. These and the instrumental observations are being coordinated with the detailed botanical studies that are being carried out at the experimental sites by Dr. Raup.

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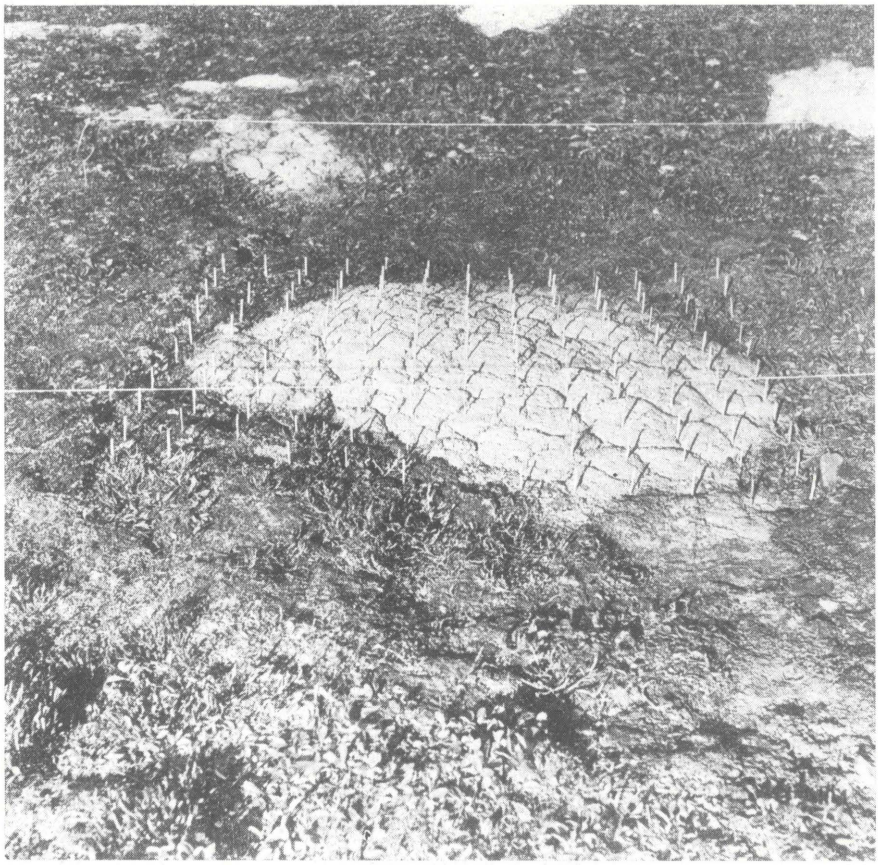
Pl. 1. Mass-wasting targets. Pegs are 10 and 20 cm long. Rule length is 30 cm.



Pl. 2. Mesters Vig, Northeast Greenland. Wood dowels in patterned ground at Experimental Site 9. Dowels are spaced 10 cm apart