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PATTERNED GROUND IN THE MARITIMES, CANADA

Abstract

Polygonal ground patterning expressed by the distribution of tree species has been widely observed in the Maritimes, Canada. The differential distribution of trees arose because poorly drained peripheral gullies contrasted with drier polygon centres. This patterning shows the closest similarity with polygonal ground structures forming today in the arctic, and so they probably originated during deglaciation at the close of the Pleistocene.

INTRODUCTION

Polygonal ground patterns were widely observed in the Maritimes of East Canada. Where the land had been cleared for farming this patterning was revealed by wet troughs (Pl. 1), but generally it was delineated by a differential distribution of trees (Pl. 2). Two areas, "The Barrens" or lakelands region of western Nova Scotia and the Chiputneticook Lakes region of western New Brunswick, have been selected for special examination. Forest cover on the Barrens was largely discontinuous, and most trees were confined to near, or in, geometrically distributed, shallow, bouldery valleys or gullies. The forest cover in the Chiputneticook Lakes region was more continuous, though locally the distribution of hardwood and softwood species delineated a rough geometric pattern similar to that on the Barrens. The geomorphology and vegetation of both selected regions was determined by using vertical air photographs, while the general distribution of patterned ground in the Maritimes was viewed from the air.

Pleistocene ice sheets advanced across the Maritimes and most of the area is mantled by till, in which the polygonal ground patterning has developed. Today patterned ground is characteristically associated with arctic and alpine regions te.g. Pl. 3), and WASHBURN (1956) has reviewed descriptions of these patterns and (he explanations of their various origins.

OBSERVATIONS

THE BARRENS

Traces of a polygonal ground pattern discerned widely in Nova Scotia were seen clearly in the southwest of the Province. Vertical air photographs revealed

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a polygonal network over most of the Barrens. The polygons varied in size from 70 to 800 yards (65 to 730 m) across, and were often hexagonal. Smaller polygons on steeper slopes were elongated in the direction of slope. At their centres, larger polygons had a star pattern, usually three- or six rayed (Fig. 1). In the largest polygons, a faint, secondary smaller polygonal network could be discerned. On the ground it was difficult to appreciate the continuous nature of the polygonal net, though individual polygons could be seen as domes, the smaller completely, the larger in part. While boulders were scattered everywhere, they were concentrated in peripheral gullies which were choked with them, yielding the most obvious expression on the ground of polygonal outlines. These gullies could be seen wedging downwards into the till, though the bottom was not seen in any of them because of the difficulty of excavating bouldery substrate. Where central, radiating star patterns occurred, they were also defined by shallow gullies choked with boulders.

THE CHIPUTNETICOOK LAKES

Traces of a polygonal ground network were discerned in many of the less hilly parts of New Brunswick, particularly in the Chiputneticook Lakes region. The polygons could be larger than those in the Barrens (300 to 1,000 yards across, 275 to 915 m). The smaller polygons showed elongation in the direction of steeper slopes as in the Barrens, and on low hills they were arranged radially around the apex. Larger polygons possessed a faint secondary polygonal network and, sometimes, an indistinct tertiary network (Fig. 1). On the ground most polygons appeared domed, and the large ones were prominent features of local relief (Pl. 1). The domes of some polygons appeared to have collapsed locally, parts of the peripheral areas rising gently towards the centre, but giving way to broad depressions. Though never as abundant as in the Barrens, boulders occurred everywhere in the till which blankets the study areas. Boulders were more numerous in gullies, although they never completely obscured the soil. The gullies could be seen wedging downwards, but their size made excavation impossible.

DRAINAGE AND VEGETATION

Gullies around polygons were moister than the domes, and the natural drainage of an area tended to occur as discontinuous streams. Bigger streams in larger, steeper-sided valleys associated with elongated polygons usually followed contiguous polygon sides. Waterlogged centres of collapsed polygons and gullies around domed polygons in wetter sites had stagnant water, whereas running water usually occupied the gullies around domed polygons on drier sites (e.g. Pl. 2). On cleared land, farm buildings were usually located on the drier dome centres, clear of the wet troughs delineating the polygons (Pl. 1). Where a star fracture occurred at the centre of one of the larger polygons, each ray was more moist than the surrounding land.

Where soils were coarse-textured, as over granite in the Barrens, more trees were observed in the smaller polygons, an almost continuous cover being associated with the smallest ones. As the size of the polygons increased, so trees generally

Pl. 1. Patterned ground, with large polygons near Canterbury, New Brunswick, cleared of forest and exposing broad gullies around polygons, and farm buildings on drier polygon centres

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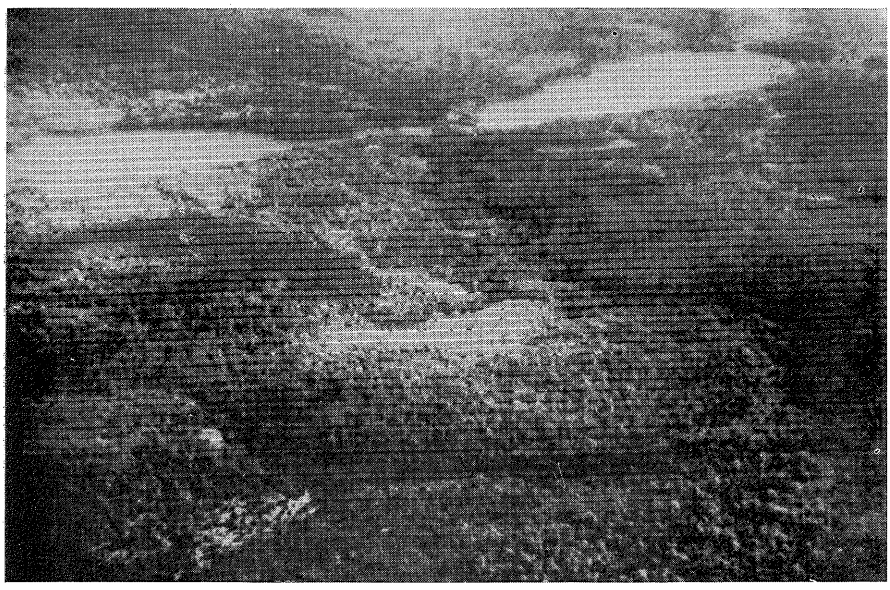
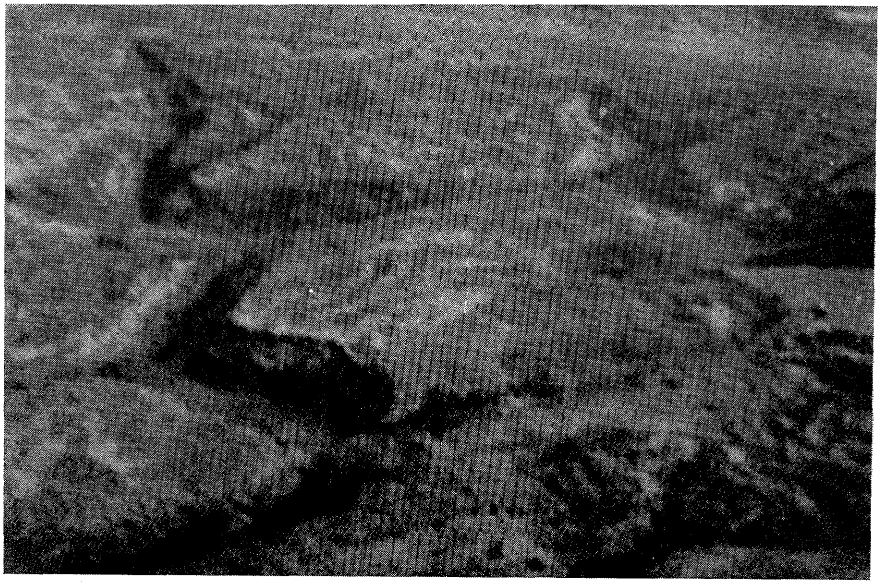


Pl. 2. Large polygons near Cartleon Mountain in northern New Brunswick, with mostly black spruce in the gullies and mixed hardwoods on higher parts



Pl. 3. Polygons near Anderson River, Northwest Territories, with ice wedges melted after disturbance of insulating vegetation and organic layer

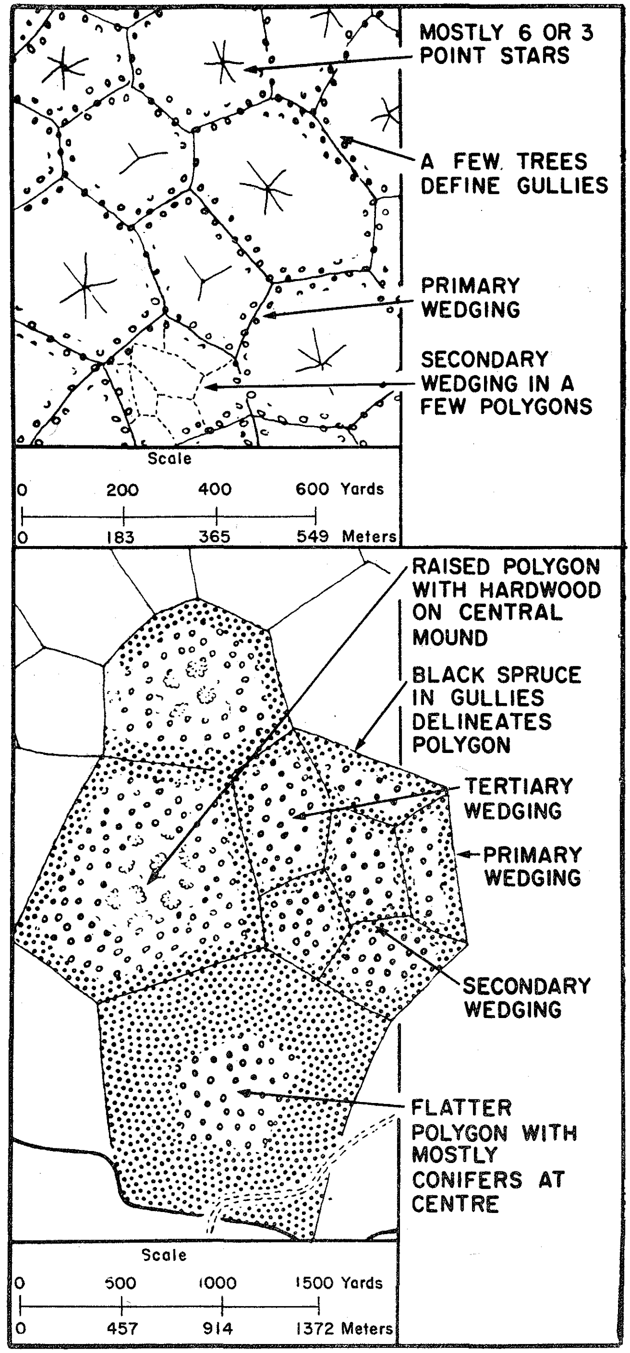


Fig. 1. Polygonal ground patterns in the Barrens of Nova Scotia (upper) and the Chiputneticook Lakes region of New Brunswick

became more and more restricted to peripheral gullies, until only a few trees delineated the peripheries of the largest polygons which were otherwise tree-less. Where soils were medium-textured, as over slates and grits cropping out in the Barrens and the Chiputneticook Lakes region, tree cover was mostly continuous.

Whereas the driest polygons were completely tree-less and were delineated by boulders piled in gullies, red maple or black spruce or both occurred locally in gullies where there was some collection of moisture, especially in the Barrens. Wetter gullies often had mixedwoods of alder and black spruce in them, although the centres of domes could still be dry and mostly tree-less. Fresh, moist domes were occupied by either hardwoods, mostly red maple, or mixedwoods with birch, balsam fir and red spruce. Softwoods with mostly black spruce and some balsam fir occurred in gullies. Collapsed polygons had softwoods at their centres and mixedwoods along their margins.

DISCUSSION

COMPARISON WITH OTHER FOSSIL POLYGONS

Wedge casts are generally supposed to define polygons, even when the polygons are not seen. Hence, BORNS (1965) speculated that ice-wedge casts in northern Nova Scotia had formed as part of a polygonal ground pattern. In Germany (SELZER, 1936), northern Britain (DIMBLEBY, 1952) and Canada (e.g. MORGAN, 1972), a polygonal ground pattern was related to wedge casts, with proposed similarities to structures forming in tundra regions today. DIMBLEBY described the largest structures in Britain as being associated with the lowest-lying and wettest land. Most polygons were slightly domed and their centres carried a vegetation associated with drier soils than their peripheries. Some had a secondary polygonal network, as was also observed in the north-central United States by BLACK (1957 and 1969).

COMPARISON WITH THE STRUCTURE OF POLYGONS FORMING TODAY

There is a great variety of form in polygons developing today and attempts have been made to classify them (e. g. WASHBURN, 1956). Tundra polygons have large diameters and ice-filled wedges delineating their margins (CORTE, 1962), sometimes possessing secondary and tertiary cracking (CABOT, 1947), with centres often domed on higher, drier land and often depressed in wet, low-lying areas (DRURY, 1962). Stone polygons are usually similar except that they are smaller and have stones in the peripheral wedges (POLUNIN, 1934; BILLINGS and MOONEY, 1959). They are often elongated downslope (BILLINGS and MARK, 1961). Mud polygons may also have secondary and tertiary cracking, but are characterized chiefly by a central radial fracture through which mud erupts (ELTON, 1927; HOPKINS and SIGAFOOS, 1951). Tundra polygons occur in arctic permafrost, while stone and mud polygons can occur in either arctic or alpine tundra conditions.

EXPLANATIONS OF POLYGON FORMATION

LEFFINGWELL (1915) proposed that when wet ground freezes, it expands, but that when temperatures fall below about −15°C, it contracts. He commented that thermal contraction during extremely cold arctic winters causes polygonal cracking, which may be audible. TABER (1943) objected to LEFFINGWELL'S (1915) theory because tension cracks have not been seen penetrating the permafrost. However, LACHENBRUCH (1961) reported that tension cracks can penetrate 10 to 20 feet (3 to 6 m) into the permafrost. The deeper the cracks, the wider the polygons.

When spring thawing starts at the surface, water enters the cracks, freezes, and forms ice wedges. The summer temperature rise produces expansion and heaving. Freezing itself may contribute to heaving. Whatever the mechanism is, the strata between ice wedges may be domed up if the system works as a unitary mass and, if not, the strata immediately on either side of the ice wedge may be bent upwards by ice expansion, or by the rise of the wedge itself. Next winter's falling temperatures and consequent contraction open up cracks along pre-existing planes of weakness, the ice wedges, which then grow yearly. BLACK'S (1952) measurements of thermal contraction and growth of ice-wedge polygons in Alaska supported LEFFINGWELL'S (1915) contraction hypothesis for their origin. PÉWÉ (1966) states that active ice wedge formation requires −6°C to −8°C. Infilling of cracks by debris from the sides as the ice melts tends to inhibit any possibility of the collapse of polygon domes.

CONCLUSIONS

Polygonal ground patterning in the Maritimes has similarities with patterned ground elsewhere on the North American continent, and in Europe, although polygons in the Maritimes can be very large and display a greater structural variety than that described by others. The polygons in Maritime patterned ground show features of several different structures forming in arctic and alpine tundra today. They may be domed or sunken, as in tundra or stone polygons, with an accumulation of coarser fragments in furrows along polygon margins, as in stone polygons. Larger polygons may contain secondary and tertiary polygonal cracking, as in tundra, stone and mud polygons, and sometimes they possess a central radial cracking like mud polygons.

FROST (1952) described large-scale patterned ground as one of the chief identifying features of permafrost. Although the Maritime polygonal structures cannot be correlated precisely with any particular structure forming in the arctic today, they show sufficient similarities to allow the hypothesis that they formed during tundra conditions existing at the close of the last glaciation. Once raised up, some polygons collapsed when the ice melted, while others remained stable as coarse debris entered the wedge shaped cavities left by the melting ice. Today, polygonal ground patterning is expressed chiefly by the distribution of tree species. The wedge casts form bouldery or stony gullies into which today's precipitation drains, and the gullies usually contain trees characteristic of wet sites, whereas the domed centres of polygons typically contain trees characteristic of drier sites.

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