TEN O'CLOCK MARKS[1]

SOME fifteen years ago while engaged in the reconnaissance survey of western Texas and southeastern New Mexico leading to a search for suitable potash core-drill sites, the writer while examining the terrain became conscious of a faint linear arrangement of patches of light sandy-loam soil which appeared on clear winter mornings following a frosty night. The peculiar lumpy condition of the soil was plainly due to frost action, but the origin of the faint-grained pattern superimposed upon this matte of raised soil was less certain.

The pattern once noticed is easily recognized elsewhere. It appears as a series of parallel straight lines as if the surface had been raked into small ridges and furrows about an inch or more from crest to crest and three-eighths to three-quarter inch deep. Wherever these striated surfaces were seen, the lines always pointed in a southeasterly direction which accords with the position of the sun at about ten o'clock on a winter morning in the vicinity of latitude North 30°. This suggested that some action of the sun was the cause of the pattern and as it had been seen always on ground sparsely covered by small bunch and buffalo grass, it was assumed the long, low-angle shadows cast by the grass had caused the differential melting of the frost in the soil. Consequently the subject was dismissed as of little importance until one day a year or two later I chanced to see a wide spread of frost-lifted loam with well-developed striae out in the middle of a broad playa, far removed from anything that could possibly cast a shadow. All the striae were oriented in line with the position of the sun in mid-morning. It was plain that two events had occurred between nightfall and late morning to change a previously smooth sandy-loam surface into this roughened and striated condition. Patches of ground containing a proper amount of moisture had frozen during the night raising lumps of soil above the level of the flat and in the morning the warmth of the sun in drawing the frost had caused a differential collapse of the raised material. The thawing and collapse on an exposed surface occurs at a critical moment and all within a few minutes of time. To one's imagination it appears as if streams of quanta had bombarded the supports from beneath rows of pedestalled soil but left other rows untouched.

Where moisture is supplied from beneath the surface and not from the atmosphere during a night of freezing temperature, frost-lift of soil is a common occurrence. It is most conspicuous in the southeastern states where saturated sandy soils oozing water during a night of freezing temperature grow carpets of slim, columnar, ice crystals which carry up with them the overlying surface material. When the ice on a level surface melts, the soil and debris fall back into place without giving suggestion of a regular or linear pattern. On a sloping surface the material drops down grade, thus serving the process of soil creep.

One winter, some years later, I came upon a smooth northwesterly-facing embankment with a four-foot radius of curvature. It was covered with frost-striae, but the lines did not have a constant direction. It was evident that this surface became progressively exposed to the sun from the upper to the lower part of the slope and that during this period of advancing exposure, the sun had moved through a wide arc to the west. Thus tangents to the curved striae were found to point in the direction of the sun at the time of initial exposure. This example gives further emphasis to the strange relation that the sun's rays have to these striae.

In all previous cases the effect was produced by the morning sun that by about ten o'clock on a winter day had warmed the air and the ground sufficiently to melt the frost. Those seen on the curved surface were formed in the afternoon. To produce and preserve these striae required an evenly balanced temperature throughout the day, one in which the air near the ground remained slightly below freezing in the shade but was raised slightly above freezing in the direct rays of the sun. The pattern progressively developed as the frozen surface emerged from the shadow.

This spring I happened to see straight striae on snow in Washington. The surface was dirty, but no relation existed between the arrangement of the dirt and the course of the striae. Their trend was also toward the position of the late morning sun. Foreign material, especially dark rock fragments, often make conical holes in ice and snow which point to the sun, but there seem to be few parallel examples of ablation effects[2] to serve as an explanation as to how these ten o'clock marks are formed. That these striae are repetitional realities is certain, for they have served the writer as a compass on overcast days, when the marks will persist a day or two under favorable conditions. The solution of the problem of their origin requires more detailed observation than it was possible for the writer to give to them in the fulfilment of his other duties.

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THE DEANE COLLECTION OF PORTRAITS OF ORNITHOLOGISTS—THE DEVELOPMENT OF AN IDEA

RUTHVEN DEANE was a retired business man of

[2] C. K. Wentworth, *Am. Jour. Science*, 238: 2, 112–116, February, 1940.