

THE CONTRACTION THEORY OF ICE-WEDGE POLYGONS*

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Ice-wedge polygons play an important role in many natural processes in permafrost; in addition, their differential thawing represents the most important single cause of road and airfield failure in many areas. Despite their importance, however, the distribution of ice wedges is not well known and their origin is incompletely understood. Currently there is probably no serious objection to the general view that ice wedges result from the freezing of water in seasonally recurring thermal contraction cracks. Theoretical methods may be used to test certain implications of this contraction theory and to gain insight into the controlling mechanical and thermal processes.

Any linear first-order differential relationship between thermal stress and strain (elastic, Newtonian, Kelvin, or Maxwell models) seems to lead to contradiction with the loose restrictions imposed on the contraction theory by qualitative field observations. It is possible, however, to find a reasonable nonlinear deformation law, consistent with the thermal requirements and leading to polygonal dimensions compatible with those observed. The theory suggests that rate of cooling as well as total amount of cooling is important in generating the tensile stress that ultimately causes fracture of the ground. Both depth and spacing of the fractures are sensitive to properties of materials and to distribution of temperature at the time of initial cracking. Such an analysis can also be applied to the related problems of polygonal jointing in cooling basalt and in drying mud.

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