ART. XLIX.—*On Local Subsidence produced by an Ice-sheet;* by W. J. McGEE.*

THE influence of a polar ice-cap on the earth's center of gravity has been computed by Croll and others on the supposition of an inflexible crust. But geological investigation has demonstrated that the terrestrial crust is flexible, and hence subject to local deformation. Now the problem requiring the influence of an ice-cap on the earth's center of gravity, on the supposition of a flexible crust, is so complex as to be incapable of solution in the present state of knowledge; but the local deformation may be considered.

The subsidence of areas of deposition is a well-known phenomenon, attested by unequivocal evidence in many parts of the globe. The single instance, cited by Dutton ("Geology of the High Plateaus of Utah," p. 13), of the subsidence of the terrestrial crust in Utah during the Cretaceous-Eocene time to the extent of 6,000 to 15,000 feet, may be here referred to. From

* Supplementary note to p. 267 (line 33) of the last number of this Journal.

this and other instances it appears that a mass of sediment produces a deformation equal to its own thickness. Now since the specific gravity of ice to average rock is something over 1 : 3, it follows that an ice-sheet three miles in thickness ought to depress the subjacent strata about a mile.

But *time* is an important element in the motion of all imperfectly fluid bodies. The approximate numerical equivalence between cause and effect in cases of subsidence with deposition indicates that if sufficient time be given the rigidity of the terrestrial crust is practically *nil;* though it is probable that the function is variable and represented by an infinite series, no terms of which are known. The time of continuance of quaternary ice to that of the deposition of the Cretaceous and Eocene sediments in Utah is as some unknown ratio, probably between 1 : 100 and 1 : 10,000;—say 1 : 1,000. If, however, the deformation during various times is represented by an infinite series, the ratio between quaternary and Cretaceous-Eocene subsidence is much higher—say 1 : 10. The subsidence produced by an ice-sheet three miles in thickness ought accordingly to be only 500 or 600 feet. It will be understood that while it is certain that subsidence would occur, very little value can be attached to this estimate of its amount.

The hydrostatical principles in accordance with which deformation beneath a thick ice-sheet must occur, equally demand that the crust should return to its original form after the melting of the ice; and it is manifest that as much time would be required to produce this secondary as the primary deformation. Assuming then that the periods of advance and retreat, or of growth and decay of the ice are of like duration, it follows that *the earth's surface must continue below the normal level at any latitude, after the withdrawal of the ice, for as long a period as that during which the ice remained stationary at that latitude.*

Should the application of the principles sought to be elucidated in the paper on "Maximum Synchronous Glaciation" to any single continental area ever be attempted, the foregoing considerations will afford a means of testing their accuracy; for late-quaternary depression, being accompanied by submergence in all low-lying areas, has left unmistakable traces, not only of its occurrence but of its extent, in many localities.

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