the surface of contact of sphere and fluid being conducting, currents will be incited in the fluid that will pass into the sphere and out again.

In the case of the earth there is no fluid with reference to which the solid earth performs a *total* differential rotation; still there are *partial* differential rotations due to moving streams, ocean currents, tidal waves and air currents. Such a field, if it exist, can be differentiated with the aid of the potential theory.

Purely local disturbances would constitute a fourth—the 'anomalous field.'

We as yet have no satisfactory answer as to the *origin* of the earth's primary magnetic field, neither has the astronomer an answer to the query 'Whence the moon.' He, however, accepts the moon's existence and computes its disturbing effects upon the earth's motions. Just so it is with the earth's magnetism. We do not know whence it has come, but we know it is there. We know that to-day the magnetic earth is rotating about an eccentric axis, and so let us ask ourselves *What is the effect of the self-inductive action of the rotating magnetic earth? How is the principle of the conservation of energy when applied to the motions of the magnetic earth to be fulfilled?*

L. A. Bauer.

ON A DEVONIAN LIMESTONE-BRECCIA IN SOUTHWESTERN MISSOURI.

The brecciated limestone which it is proposed to describe in this paper outcrops near the base of Eagle Ridge, on the west side of the valley of Dry Creek, five miles west of the town of Galena, county seat of Stone County, Missouri. The several members of the Devonian strata in this portion of the State are, in their normal condition, very regular and evenly bedded, and are perfectly conformable, from their base, to and with the overlying Kinderhook Group. They rest, with slight local unconformity, on the magnesian limestones of the Ozark Series, and then out toward the east, at the expense of the lower members, each stratum overlapping that which is under it. In the vicinity of the limestone breccia they present the following sections: 1. Green Shale, 7 feet. 2. Shaley Limestone, 10 feet. 3. Speckled Crinoidal Limestone, 3 feet. 4. Basal Conglomeratic Sandstone, 4 inches.

Proceeding south along the west side of the valley we find the first indication of a disturbance in the form of a gentle undulation of the upper portion of the shaley limestone, No. 2 of the section. A few hundred yards further we encounter the first of a series of huge masses of breccia, consisting of the light gray, amorphous limestone and thin shale of No. 2, broken into angular fragments of various sizes, and recemented, partly by a similar substance, and partly by the subsequent infiltration of calcareous matter occurring now in the form of calcite. The original bedding planes have been mostly obliterated, and the breccia weathers out along the hillside in boulder-like masses, 10 to 20 feet thick, and 50 to 100 feet in width. A stratum of shaley limestone at the base of these masses partially retains its original appearance, and from its relation to the more massive breccia overlying it the whole is seen to have been subjected to violent contortion and fracture, such that boulders of hard limestone have been forced into the midst of calcareous shale. There are about half a dozen of these masses exposed along the valley side, in a distance of about 1000 feet; then the undulations decrease, and at one-half mile from where the first disturbance in the strata was noticed they entirely cease, and from thence down the valley the strata are in their normal condition.

There is no indication of the action of water in the formation of the breccia. All the fragments are sharply angular, and frequently a fossil has been broken through

and the positions of the pieces slightly changed, but not widely separated as they would inevitably have been had the brecciated masses been accumulated by wave action on a seashore. The hypothesis that the brecciation and contortion were produced by undermining of the strata and by subsequent crushing from the weight of the superincumbent rock is inconsistent with the facts. The lower members of the Devonian strata are undisturbed, and in the central portion even the whole of No. 2 seems to be present and perfectly horizontal and the breccia rests on it increasing the thickness of the Devonian strata from its normal 20 feet to 40 feet in the central portion of the disturbance.

In short, the only theory which will explain all the phenomena is that which has been applied, in explanation of the manner of formation of similar but vastly more extended Devonian limestone breccias in Iowa, viz., by lateral pressure produced by the 'creep' or sliding on a sloping sea bottom of the displaced strata immediately after their deposition.

From a study of the strike of the undulations, displacements and other attendant phenomena, it becomes evident that the pressure was applied from the northeast. The Devonian strata at present rise in that direction at a rate not exceeding 8 or 10 feet per mile, and during the Devonian age were doubtless still more nearly horizontal. It is remarkable that so slight a slope could have given rise to a sliding of a portion of the sea bottom, but it is undoubtedly the fact that, while the deposition of the Devonian strata had proceeded without interruption to the top of the shaley limestone No. 2, the upper 2 or 3 feet began to slide on the underlying stratum. About the western line of Stone county the resistance overcame the weight of the 'creeping' strata, and the tension becoming too strong, at one place certainly and perhaps at others not yet discovered, that they suddenly gave way, were contorted, brecciated, forced forward and hurled in boulder-like masses on to other undisturbed strata.

Considering the intensity of the force and the conditions under which it was applied, it is surprising that the area of the disturbance should be so small; on the opposite side of the valley, one-eighth of a mile distant, there is not the slightest sign of it, and in the next valley, one-fourth of a mile southwest from it, the Devonian strata are undisturbed. Its areal extent cannot be greater than one-fourth square mile.

The lithification of the shaley limestone was practically complete at the time of the displacement, for the fragments are all sharply angular and must then have been very hard. And as the relation of the overlying strata shows that the period of the disturbance immediately succeeded that of deposition of No. 2, deposition and lithification must have proceeded contemporaneously.

The green shale, which is the upper member of the Devonian in this region, thins out in the hollows between the dome-shaped prominences of the surface of the breccia, and totally disappears over the higher portions of the disturbed area. The points where it is absent are not now and never were more than twenty feet higher than the surrounding sea bottom, where the green shale was deposited in very regular laminæ, without wave action. The areal distribution of the green shale is such as to show that it was deposited in a comparatively small and shallow esturine basin, connecting with the sea toward the south, and supplied with fine sediment from the land on the east and north. The limited extent of this body of water accounts for the feebleness of its waves, which did not affect the green shale at the depth of only twenty feet around the elevated area formed by the breccia. The higher prominences

of the breccia were slightly eroded by wave action during the deposition of the green shale in the surrounding water, but the leveling had not proceeded far when the Devonian age came to a close; the entire region was depressed, and the Louisiana limestone (formerly known as the Lithographic limestone), or basal member of the Kinderhook Group, was laid down over the breccia. It is usually a regularly bedded, dark gray limestone, everywhere perfectly conformable to the green shale, but over the distributed area it is irregularly bedded and slightly arched, but soon succeeded, by thickening in the hollows and thinning over the prominences, in leveling off the ancient sea bottom. The Lower Carboniferous strata are here locally unconformable with the Devonian. We have thus seen that the thinning of the green shale over the area of disturbance fixes the time of said disturbance at the period between the deposition of Nos. 1 and 2 or the shaley limestone and the green shale. From a general resemblance between the shaley limestone of this region and portions of the Cedar valley limestone of Iowa, and from the fact that this peculiar mode of brecciation obtained in both regions, I wish to suggest that the light brown or gray, amorphous, shaley limestone of southwestern Missouri may be the equivalent of the Cedar valley limestone of central Iowa.

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CURRENT NOTES ON PHYSIOGRAPHY (X.)

LEY'S CLOUDLAND.

This long expected work (Stanford, London, 1894. 208 p.) is an effort to establish a classification and terminology of clouds on a genetic basis. While such a plan has much to commend it, and must eventually be adopted in fully developed form, its presentation now is perhaps premature; for there is yet much to learn regarding the origin of certain cloud forms, and much difference of opinion still prevails on the subject. Four chief classes are recognized in Ley's scheme: clouds of radiation, such as ground fogs; of inversion, such as cumulus, dependent on overturnings in an unstable atmosphere; of interfret, such as waving stratiform clouds formed at the contact of layers of different temperature; and of inclination, such as pendent cirrus wisps, caused by the settlement of particles from one atmospheric stratum into another. The illustrations, reproduced from photographs by Clayden, are for the most part excellent. The chief deficiency of the work is the absence of comparative tables, by which the terms proposed by Ley may be translated into those adopted by the International Meteorological Congress. In a number of passages exceptions must be taken to the manner of physical explanation of cloud formation, especially to statements concerning the relation of water and ice particles in cumulus and cirrus clouds, and to the repeated implication that the liberation of latent heat in the condensation of vapor actually warms the air. The chapters on the theory of atmospheric currents and on the prevailing winds of the globe are hardly relevant to the rest of the book and add little value to it. Remembering that the author has devoted years of observation to cloud study, and that latterly his work has been much interrupted by ill health, it is doubly a regret that his book cannot be more highly commended.

BUREAU CENTRAL MÉTÉOROLOGIQUE.

The latest series of *Annales* of this important Bureau contain as usual a volume of memoirs in which, besides the statistical studies of thunder storms in France by Fron and several reports of magnetism, there are essays by Angot on the advance of vegetation and the migration of birds in France for ten years, 1881–1890, and on the meteor-