volved, either stopping such importation or providing such inspection and quarantine laws as are best adapted to the situation.

C. L. SHEAR,
Secretary-Treasurer

(To be continued)

SOCIETIES AND ACADEMIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

THE 679th meeting was held on April 9, 1910, Vice-president Fischer in the chair. Two papers were read.

Times of Abruptly Beginning Magnetic Disturbances as Recorded at the Coast and Geodetic Magnetic Observatories: R. L. FARIS, of the Coast and Geodetic Survey.

The speaker gave a brief review of the researches that had heretofore been made by investigators concerning the sudden beginnings of magnetic storms, with special reference to their times of beginning at different places, the general impression hitherto being that they are simultaneous, or so nearly so, all over the earth that the time scales of the records were too small to warrant any other conclusion. Dr. L. A. Bauer having recently found that there is a definite time element in the propagation of the magnetic disturbance in some special cases investigated by him, the speaker, at his suggestion examined a number of cases of suddenly beginning magnetic disturbances recorded at the Coast and Geodetic Survey magnetic observatories, which cover a quarter of the globe in longitude, with the result that the investigation showed that there is a persistent time difference for the storm beginnings at different places which is too large to be attributed to errors in the time determinations, thus confirming the results of Dr. Bauer's recent investigations.

The paper will appear in full in the June, 1910, number of the *Journal of Terrestrial Magnetism and Atmospheric Electricity.*

On the Analysis and the Propagation of Magnetic Disturbances: Dr. L. A. BAUER, of the Carnegie Institution of Washington.

An examination of the times of beginning of the magnetic disturbance which occurred on May 8, 1902, as coincidently with the Mont Pelé eruption as can be determined, revealed the interesting fact that they were not the same all over the globe, being, in general, earliest at European stations. The times next progressed going around the earth eastwardly, the complete circuit being made by the disturbance in about three and one half minutes. This fact led to an examination of other similar disturbances, such as the one of January 26, 1903, and it was again seen that this one also progressed around the earth eastwardly, the time for the complete circuit being about four minutes.

Mathematical analyses were next made and it was found that for both disturbances (May 8, 1902, and January 26, 1903) the systems of disturbance forces which it would be necessary to superpose upon the earth's own magnetic field, were precisely of the same character as the earth's. In other words, were we to assume electric currents as forming the disturbance systems, then, as is the case for the earth's field, the currents would have to circulate around the earth from east to west if they are positive ones, and in the contrary direction—from west to east—if they are negative, or such as would be produced by moving negative charges. Furthermore, for both disturbances the electric currents would have to circulate chiefly in the regions above the earth.

For the disturbance of May 8, 1902, there were a sufficient number of reliable determinations of the effect on the vertical intensity and accordingly it was possible, by means of the analysis, to separate the external system of currents from the internal (below the surface) one. And then the surprising result revealed itself, that the internal currents went in the same direction as the external ones, the latter being of about three times the strength of the former. Hence, were we to suppose that the disturbance is caused by the motion of negative charges around the earth eastwardly, then the internal negative currents also go in the same direction and, accordingly, they are not currents induced in the earth by the outer system.

If the earth's own magnetic field is likewise separated into an internal system and an external one, it is also found that for both systems the negative currents go in the same direction around the earth, viz., from west to east. The disturbance systems found above are therefore precisely similar in character to the earth's field. It should also be noted that the direction of the disturbance negative currents progress around the earth in the same way as did the times of beginning referred to above. The assumption is therefore a natural one that such disturbances as here investigated, which Birkeland in his recent important work[1] called "equatorial perturbations,"

[1] Birkeland, Kr., "The Norwegian Aurora Po-

might be due to the passage of negative charges around the earth.

Cathode rays coming from the sun and entering the earth's magnetic field at right angles as they would do for the magnetic equatorial regions, would be deflected and be made to pass around the earth in the form of a ring composed of negatively charged particles (corpuscles). Birkeland looks to such a ring as the cause of the said "equatorial perturbations." However, unfortunately the deflection of the solar cathode rays is not in the right direction, for they would be made to pass around the earth from east to west and not from west to east as required by the results of the analyses stated above. On the other hand, cathode rays coming from the earth would be deflected so as to pass around the earth from west to east, thus fulfilling one condition. But, if the radius is computed of the ring of moving corpuscles, it is found that the orbit of the latter would have to be distant from the earth's center 580 times the earth's radius or 3,700,000 kilometers or 2,300,000 miles, and thus the possibility of a terrestrial origin of the cathode rays is likewise eliminated. Furthermore, if we calculate the intensity of the current which at that distance could produce the observed effects of the disturbances of May 8, 1902, and January 26, 1903, it is found to be 5,900,000 amperes. Now Birkeland says on page 311 of his book:[2] "In the case of the greater storms, we found current-strengths that varied between 500,000 and 1,000,000 amperes, or even considerably more." Hence, to produce the comparatively insignificant magnetic disturbance effects here considered, by supposing a band of cathode particles circulating around the earth, would require a current at least six times stronger than that which Birkeland finds sufficient to account for the much larger storm effects!

The hypothesis was next briefly examined on which the disturbance effects considered might be referred to alterations in the electrical conductivity of the atmosphere and of the earth either brought about by the secondary effects from bombarding cathode particles, viz., the formation of Röntgen rays or say by the entrance into the earth's field of penetrating radiation (γ rays of radium). The ionizing effect and resultant alteration of electrical conductivity of the regions involved might either be due to the penetrating radiation from the sun or from the earth, if only *qualitative* results are considered. It is therefore at present not possible to state definitely whether the initial cause of the disturbance of May 8, 1902, was due to a terrestrial eruption or a solar one. First, further examinations will have to be made of the disturbances of May 20 and July 9, 1902, which were again closely coincident with Mont Pelé eruptions. The electric-conduction hypothesis appears to satisfy in general the observed phenomena and accordingly it is to be subjected to a further rigid examination. It seems also to explain why some of the disturbances take a westward path although the majority of them go eastward.

(The abstracts of the above papers are by their authors.)

R. L. Faris,
Secretary

laris Expedition 1902–1903," Vol. I., "On the Cause of Magnetic Storms and the Origin of Terrestrial Magnetism," First Section, Christiania, 1909.

[2] "The Norwegian Aurora Polaris Expedition, 1902–1903," Vol. I., "On the Cause of Magnetic Storms and the Origin of Terrestrial Magnetism," First Section, Christiania, 1900.

THE GEOLOGICAL SOCIETY OF WASHINGTON

At the 230th meeting of the society, held in the George Washington University, Wednesday evening, March 23, 1910, Mr. F. L. Hess presented an informal communication on "Mounds Formed by Crystallization." In a playa known as Salt Lake in the Mohave Desert, at Cane Springs, twenty miles west of Randsburg, California, mounds from 2 to 4 feet high and from 50 to 200 feet broad are formed in the moist lake bed through the crystallization of salts, mostly mirabilite with some epsomite. A few mounds are apparently formed through the crystallization of common salt. About six inches of earth forms the surface of the mounds, below which there is a spongy mass of the salts. Mr. E. S. Bastin spoke informally on the origin of the graphite at Lead Hill near Ticonderoga, N. Y. The graphite probably represents the original carbonaceous constituent of sediments which have been altered first by dynamic and then by igneous metamorphism due to the intrusion of granite pegmatite. A study of the quartz of the contact zone following the methods of Wright and Larsen shows that it crystallized below 575° C. This is the first test which has been made on contact-metamorphic quartz and gives a key also to the temperature of formation of the graphite, augite, scapolite, calcite, titanite, pyrrhotite and vesuvi-

anite with which the quartz is intimately intergrown. The contrast between the low temperature here indicated and the temperature at which graphite is produced in the electric furnace (certainly over 2000° C.) emphasizes the importance of the presence of other substances and possibly of the time element in crystallization under natural conditions. Mr. T. Wayland Vaughan announced the existence of two Miocene horizons at Porter's Landing, Ga., the upper one of which is definitely correlated with the Duplin Marl of North Carolina and the lower one of which is the approximate equivalent of the Calvert formation of Maryland.

Regular Program

Weathering of Coal in the Arid Region of the Green River Basin, Sweetwater County, Wyoming: ALFRED R. SCHULTZ.

Coal beds in arid as well as in moist climates show considerable deterioration along the outcrop and this deterioration in many places extends to the base of the belt of weathering or well down into it. The belt of weathering, from a geologist's point of view, is the surficial belt extending from the surface of the earth to the level of ground water. In this belt all the important reactions characteristic of the zone of katamorphism, namely, oxidation, carbonation, hydration and solution, exert their maximum activity. The zone of katamorphism is the zone in which alterations of rocks result in the production of simple compounds from more complex ones. This zone extends from the surface of the earth to a depth of 10,000 meters and is divisible into two belts: (1) an upper belt of weathering and (2) a lower belt of cementation, the two being delimited by the level of ground water. As the ground-water level in arid regions lies at considerably greater depths below the surface than in well-watered regions, it is but natural to suppose that the belt of weathering extends to proportionately greater depths in dry than in moist climates. It would then follow that the deterioration of coal should extend farther below the surface in arid regions than in regions where the top of the water table lies only a few feet below the surface of the ground. That the deterioration of the coal does not always extend to the bottom of the belt of weathering as above defined or even to a considerable depth into this belt is a fact not well known. In order to ascertain to what extent and depth the coal beds in the arid regions have been altered a total of 85 samples were collected and analyzed from the coal beds in the Rock Springs field. Of these 45 were collected from coal beds in the Rock Springs group, 20 from coal beds in the Almond group, 10 from coal beds in the Black Buttes group, and 10 from coal beds in the Black Rock group. The first two are of Montana age, the third "Laramie," and the fourth Tertiary.

Considered with regard to physical as well as chemical properties the coals occurring in these four groups fall into two classes, bituminous and subbituminous. The bituminous class includes all the high-grade coal of the Rock Springs group; the subbituminous class all the coal of the Almond, Black Buttes and Black Rock groups. The difference between these two classes is physical as well as chemical. The Rock Springs coal usually has a lower percentage of water, remains firm and compact on exposure to air, and stands shipping well without breaking down. The coals from the three overlying groups, although from different horizons and of different ages, have essentially the same physical properties and bear a regional resemblance to one another. On exposure to the sun and open air they alter very rapidly, lose their bright luster, air slack and break down into irregular blocks or powder. Cracks usually form along the bedding planes and somewhat irregularly in other directions. The coal does not stand shipping without breaking down or slacking, unless it is kept from the sun and circulating air while in transit. It is probable that the Rock Springs coal has undergone a more complete devolatilization, deoxygenation and concentration and does not assimilate oxygen so rapidly on exposure to the air as the other coals. The hydrocarbon compounds represented by the Rock Springs coal appear to be much more stable under atmospheric conditions than those represented by the higher coals. It is clearly evident that along the outcrop of a coal bed and down the dip at least three zones may be recognized—those of surface weathering, under-ground weathering and unaltered coal.

The results obtained in the Rock Springs field indicate that so far as coal decomposition or deterioration is concerned the belt of weathering in arid regions may be divided into two members. Coal in the lower member of the belt apparently shows no greater effect of weathering than the coal below the level of ground water, but coal in the upper member, or in the surficial belt of weathering, shows remarkable deterioration and decomposition. The protection of the coal above the level of ground water in the lower member of the belt of weathering may in part be accounted

for by the accompanying beds of clay and shale, which tend to shut out the oxygen and free circulation almost as readily as the ground water.

The analyses show that the proportions of the various constituents are about the same whether the sample of coal was taken near the surface or at a greater depth, the only exception being in the oxygen, which in every case is perceptibly higher near the surface than at greater depths and by its excess shows the extent of the surficial belt of weathering. The ash, sulphur and hydrogen content remain fairly constant. There appears to be a slight increase in the amount of hydrogen and ash in the samples obtained near the surface, with a corresponding decrease in the amount of sulphur. It appears from this that the belt of surficial weathering is one of marked oxidation and in this field for the most part lies near the surface, in few places, if anywhere, extending to the ground-water level. If the coal is not open or exposed to the air the weathered zone does not, as a rule, extend more than 150 feet down the dip of the beds, or 50 feet below the surface. Along slopes and mine or prospect entries the coal weathers back several hundred feet from the mouth of the mine and several hundred feet below the surface. It is known that in one old mine the coal has changed at least 20 feet back from the face of an old entry approximately 227 feet down in the mine and that deterioration extends back into the mine 575 feet from its mouth. It is very probable that in an abandoned mine remaining open to the air oxygenation in time extends throughout the mine and that the coals of lower grade show the effect of oxygenation much more than the high-grade coals.

Evidences of Paleobotany as to Geological Climate: David White and F. H. Knowlton.

On the climatological criteria offered by the fossil floras, their characters, distribution and changes, the authors base the following tentative conclusions as to general conditions and principles:

1. Relative uniformity, mildness (probably subtropical in degree) and comparative equability of climate, accompanied by a high humidity, have prevailed over the greater part of the earth, extending to, or into, the polar circles, during the greater part of geologic time since, at latest, the Middle Paleozoic. This is the regular, the ordinary, the normal condition. From a broad point of view these conditions are relatively stable.

2. The development of strongly marked climatic zones, at least between the polar circles, is exceptional and abnormal. It is usually confined to short intervals, or to intermittently oscillating short intervals, all within relatively short periods.

3. The periods of abnormal climatic differentiation are characterized by the development of extremes—*i. e.*, by extreme and abnormal heat or cold (glaciation), humidity or aridity—which are local or regional in their occurrence and variable or unstable.

4. The brief geological period in which we live is a part of one of the most strongly developed and unstable of these abnormal intervals of radical change. The assumption that climatic variations, contrasting extremes and complexity of combination and geographic distribution of climatic factors, such as now exist, are normal or essential, and that they were present also, though in slightly less degree, in all geological periods appears to be without paleobotanical warrant. The proposition that we are still in the glacial epoch is paleontologically true. We have no evidence that in any other post-Silurian period, with perhaps the exception of the Permo-Carboniferous glacial period, have the climatic distribution and segregation of life been so highly differentiated and complicated as in post-Tertiary time.

5. The distribution and characters of most of the great pre-Tertiary floras show that time and again during the great periods of relative uniformity and equable mildness, plant associations were able to pass from one high latitude to the opposite without meeting an efficient climatic obstruction in the equatorial region. The unchanged features of the species and the grouping of the latter show that the climatic elements of the environment must have been similar throughout the range of the flora. Therefore it appears that a climate essentially the same must have continued from one latitude to the other without the interposition at those periods of a torrid equatorial zone. The absence of the latter may also be inferred from the relative uniformity of distribution in other directions, as shown by the remarkable east-west and radial ranges of the floras.

6. The development and existence of torridity—*i. e.*, of a torrid zone in the equatorial belt or any other great region of the earth—is concomitant and causally connected with the development of regional frost. It would appear that the occurrence of a torrid zone is peculiar to abnormal or glacial intervals.

Edson S. Bastin,
Secretary