where it cools the metallic parts with which it has contact, and by so doing induces strains which complicate the problem of boiler maintenance. Moreover, a locomotive which is thus filled is not in good condition for the start, notwithstanding the fact that the gauge may show full working pressure; for at the start there is imposed upon the boiler the double task of supplying steam and of raising to the maximum temperature of the boiler the water which was fed into it during the stop. The result is that the boiler pressure soon falls, and considerable time is required in which to restore it.

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SOIL PRODUCTIVITY

IN a discussion of the "Secular Maintenance of Soils" before the Geological Club of the University of Chicago on January 9, the undersigned expressed views as follows:

That the era of soils began at an early but indeterminate period in the history of the earth; that the Proterozoic lands were probably mantled by soils and clothed with vegetation; that soils certainly prevailed on the land in the Paleozoic era; that sufficient soils and vegetation mantled the earth through all later eras to support the continuous evolution of land life; that the total eon of productive soils may be assigned a period of at least tens of millions of years; that therefore there must be some efficient natural process for the maintenance of soils.

That the origin of the soil body lies chiefly in the granulation of rock; that soils are wasted at the surface by wind and wash; that wind and wash also distribute granules and mix soils and give to nearly all soils some of the essential soil constituents; that progressive granulation of rock adds soils below; that progressive solution removes soil matter from soils and from the rock beneath; that by these composite processes the body of the soil is at once enriched and impoverished; that so long as the *body* of the soil is maintained, any impoverished or anemic condition that may arise can be rectified; but if the *body* be lost, its restoration is tedious, laborious, or expensive.

That the film-water that surrounds the granules of the soil when in a normal moist state is the specific soil water; that this is to be distinguished from the ground water that lies below the water-table, though these grade into one another; that the soil swells with the growth of the films in thickness; that there is an optimum of film-water when the soil is most swollen; that addition of water beyond the optimum destroys the surface tension of the films and leads to the shrinkage of the soils, the packing of the granules and to unproductivity;[1] that the solutions in the film-water are formed with facility because of the greatness of the surface contact relative to volume; that the concentrations of the solutions are controlled by the laws of equilibrium.[2]

That the soil air is inversely proportional to the soil water approximately; that the soil air is to be distinguished from the earth's atmosphere, though grading into it and interchanging with it through diffusion and soil breathing; that, occupying the spaces between the film-coated granules of the soil, the soil air has great relative contact; that it acts at special advantage on both films and granules; that the union of minutely granulated earth, film-water under tension and interstitial air gives a combination of exceptional solvent and reactive power.

That the soil is the home of minute life, plant and animal; that these intensify and modify the inorganic activities; that the forms of life are with little doubt more or less predatory and parasitic on one another; that these relations are probably in some cases pathogenic, and that these give rise to unsanitary states of the soil which affect its productivity; that progress is being made by Whitney and his associates in the discovery of toxic exudations that affect productivity; that plant societies are perhaps in part a result of mutually beneficial relations in respect to exudations and by-products; that the soil thus is little less than a world in itself; that its

[1] Cameron, *Journal Physical Chemistry*, 1910.

[2] Cameron, *loc. cit.*

productivity is measured more by the efficiency of its complex of activities than by any mere measure of its inorganic constituents.

That the capillary cycle, a sub-factor of the drainage cycle, is an important agency in maintaining the supply of potash and phosphorus in the soils; that the selective action of clays and of ferric oxides aid in a specific way the concentration of potash and phosphorus surfaceward; that at 592 localities in France analyses showed 68 per cent. of the surface soils to be as high or higher in phosphoric acid than the subsoils, and 47 per cent. as high or higher in potassium than the subsoils, and similar facts are observed in America;[3] that the phosphate rocks in the sedimentary formations are largely *secondary concentrations;* that the formation of ferric and aluminic phosphates is a phase of concentrative action; that some of the phosphoric and potassic compounds are to be grouped with the silica and the aluminic and ferric oxides as the rock-elements that tend to stay in the soils, while the compounds of soda, lime and magnesia are more liable to go down to the sea, and the carbon and nitrogen to go off into the air; that these capillary and selective actions jointly are efficient factors in productivity; that Cameron's recent estimate[4] probably lies in the direction of the facts of the case, though confessedly only a tentative estimate based on elements not fully determined at present, viz., an annual drainage loss for the area of the United States of about 3,500,000 tons of potassium and 1,200,000 tons of phosphoric acid (PO_4); a possible crop-removal (reckoned at 1 ton per acre for the *entire* United States, carrying 1 per cent. K, and 0.6 per cent. PO_4) of 24,000,000 tons of K and 14,000,000 tons of PO_4, while, on the other hand, the capillary waters are carrying *toward* the surface 48,000,000 to 100,000,000 tons of K and 18,000,000 to 40,000,000 tons of PO_4.

That the plant-cycle cooperates with the capillary cycle in concentrating potash and phosphorus toward the surface by carrying these up into the plants whence they are deposited on the surface or in the soil; that the well-known rotation of legumes and cereals that enriches the soil in nitrogen may be supplemented by a *long-period rotation of trees and annuals* for the enrichment of the soil in potash and phosphorus.

That the capillary cycle and the plant cycle conjointly contribute to a potash cycle and a phosphorus cycle by which these rise from the depths, pass into the plants, are shed as leaves, fruit and dead fiber on the surface—or pass through animals and are ultimately deposited on the surface—thence reenter the soil and are again taken up by plants, and so continue in the cycle until some intervening agency bears them out of it; that the length of this cycle is indeterminate and, in the absence of intervention, theoretically indefinite; that it is not, in the main, the *material substance* of the soil that is needed for food but *the energy* locked up in the grains, fruits, and so forth, by the anamorphic processes of the plants; that the real food comes chiefly from the sun and the material substance that temporarily embodies it is returnable to the soil indefinitely to be used again and again; that the really vital thing is the promotion of the cycle formed by plant anamorphism (solar energy going in) and animal katamorphism (solar energy coming out); that the contingencies of loss lie chiefly in the removal of the katamorphic products before they again enter into a new anamorphic process, contingencies that man emphasizes.

That the SzeChuanese of West China, occupying a hilly sub-mountainous sandstone region whose area is less than that of Texas, a people numbering 68,724,800 according to the Chinese census, embracing more farmers probably than does the entire United States, have cultivated their soils continuously from an undetermined date before the beginning of the Christian era and quite without rock phosphates apparently, and yet have maintained a productivity exceeding, area for area, that of the virgin soils of America; that with little doubt this fertility can be maintained

[3] Bureau of Soils, U. S. Department of Agriculture.

[4] *Journal of Physical Chemistry*, 1910.

by the present mode of treatment until the country is base-leveled; that the SzeChuanese have thus demonstrated one mode of effective secular maintenance of the soil productivity; that their method is closely analogous to the natural method of the geologic ages; that a Chinese expert would criticize western practise as influenced unduly by prejudice respecting the use of the katamorphic products of human food-consumption.

That notwithstanding the loss due to this prejudice respecting the use of human katamorphic products, the soils of western nations generally show increases of productivity in the later years compared with the earlier; that, in particular, the data furnished by the Bureau of Statistics and the Bureau of Soils that the productivity of the soils of the United Kingdom, France, Belgium, Netherlands, Denmark, Germany, Austria, Hungary, Roumania and Russia show rather steady and notable increases in productivity for the last two or more decades that are covered by the statistics; that the lands most densely inhabited and most intensively cultivated, such as those of England, France, Germany and neighboring states, are more productive, unit for unit, than those of Russia, which are less densely occupied and less closely and persistently cultivated; that the old soils of Europe are more productive, unit for unit, than the newer soils of America; that in the United States the productivity of the last forty years shows general increase per acre; that the increase per acre in the older states, as the New York-New England group or the middle states, is more marked than in the southern or in the western groups, notwithstanding the larger proportion of virgin soil recently brought under cultivation in the last group; that while these and all similar statistics are subject to many qualifications in interpretation and application, they do not offer substantial grounds for an alarming forecast, applicable to an industrious and intelligent people willing to be guided either by oriental experience or by western scientific research.

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NOTES ON METEOROLOGY AND CLIMATOLOGY

THE effect of the recent construction of high buildings in New York City upon the United States Weather Bureau's records of wind velocity and direction for that city are discussed by Mr. E. S. Nichols, the local forecaster, in the October number of the *Monthly Weather Review*. Since the anemometer and the windvane were placed upon the American Surety Building at an altitude of 350 feet above the street in 1900, several new "skyscrapers" have been erected in the immediate vicinity, vitiating to a greater or less extent the wind records since obtained. A comparison of the bureau's records with those of the New York Meteorological Observatory in Central Park, where the environment has not been greatly changed in forty years, shows that there has been a decrease of 16 per cent. in the hourly wind movement directly attributable to the recent construction. North winds have been affected the most; northeast and east have not been changed materially; while other directions have been considerably reduced. The number of days upon which gales have been recorded has decreased noticeably, and wind direction has been more or less deflected. Partly because of a desire to prevent the recurrence of such a condition in other cities, the bureau is gradually erecting appropriate buildings of its own in localities where future changes in the environment are not likely to affect the records obtained.

FROM an investigation of the relation between solar activity and terrestrial temperatures, Professor Humphreys has come to the conclusion that the decrease in the ultra-violet radiations received by the earth during the period of sun-spot maximum causes a similar decrease in the amount of ozone formed in the upper part of the earth's atmosphere. Moreover, since ozone allows the solar heat rays to penetrate it freely but absorbs most of the returning earth reflection, spot maxima indirectly produce diminished terrestrial temperatures. Abbot and Fowle had already concluded that spot maxima are accompanied by terrestrial temperature minima, and *vice*