of the Grande Grève limestone, which outcrops elsewhere on the peninsula and carries a similar Oriskany fauna of overgrown sand-loving invertebrates imprisoned in a calcareous matrix. As in New York, both the shallow and deep water facies of the Oriskany are present at Gaspé, but without the striking differences in faunal content. The Bonaventure conglomerate, in its lithology as well as in its structural relations to the underlying formations, bears testimony to the importance of the mid-Devonian orogeny in the northeastern Appalachian province. Dr. Clarke in another paper[12] in the same publication lays stress upon this diastrophy and couples with it the volcanic activity responsible for the Monteregian hills.

TRIASSIC FORMATIONS

Detailed descriptions of the Newark series, as exposed along the shores of Minas Basin and the Bay of Fundy, are given by Sidney Powers in an important contribution concerning the Acadian Triassic.[13] The area is the most northerly of the geo-synclinal basins developed in the Atlantic coastal province during the Triassic period and presents problems similar to those of the Connecticut Valley. Sedimentation was largely fluviatile, in the main resulting from the occasional floods of a hot dry climate. Fissure eruptions and volcanic ejections occurred at intervals during the accumulation of the sediments.

PLEISTOCENE (?) MAN IN BRITISH COLUMBIA

Fragments of a human skeleton were discovered in 1911 near Savona, B. C., in silt beds alleged to be of Pleistocene age. A claim of great antiquity for the skeleton was made before the Royal Society of Canada in May, 1915. The bones are those of an aged woman and display no characters that would distinguish them from those of a modern Shuswap Indian.[14] An investigation of the deposits from which the bones were obtained was undertaken by C. W. Drysdale. He reports[15] that the field evidence indicates the Recent age of the silts at the locality. There is, therefore, no basis for the belief that the Savona skeleton is a relic of Pleistocene man.

Kirtley F. Mather

Queen's University,
Kingston, Canada,
September 7, 1916

[12] N. Y. State Museum, Bull. 177, 1915, pp. 115–134.

[13] *Jour. Geol.*, Vol. 24, Nos. 1, 2 and 3, 1916.

[14] Knowles, F. H. S., Geol. Surv., Canada, Summary Report for 1915, 1916, pp. 281–283.

[15] "Human Skeleton from Silt Bed near Savona, B. C.," C. W. Drysdale, Geological Survey, Canada, Summary Report for 1915, 1916, pp. 91–92.

METHODS OF CRITICISM OF "SOIL BACTERIA AND PHOSPHATES"[1]

A circular letter, dated July 28, 1916, criticizing Bulletin 190 ("Soil Bacteria and Phosphates") of the University of Illinois Agricultural Experiment Station was sent to many editors of agricultural journals. This letter bears the signature of Dr. H. J. Wheeler, of the Agricultural Service Bureau of the American Agricultural Chemical Company.

The caption employed is as follows: "Confidential and Not For Publication." This will doubtless appear to those who welcome frank and open criticism as an entirely unwarranted and a highly undignified manner of criticism. No copy of this letter was received by us from Dr. Wheeler, but through the courtesy of the agricultural press the matter has reached us from many sources and from several different states.

The purpose of Dr. Wheeler's letter to the agricultural editors is evidently to belittle the importance of the discovery that the nitrifying bacteria have power to make rock phosphate soluble.

As space will not permit quoting in full the contents of this four-page letter, we quote only the statements under discussion. In the last paragraph of the first page, we read:

> The organic acids and the carbonic acid produced in the decomposition of vegetable matter or brought

[1] Science, p. 246, August 18, 1916, and Bulletin 190, University of Illinois Agricultural Experiment Station.

down in the rainfall, including also nitrous and nitric acid, produced as described above, tend to unite in the soil with the most readily attackable bases in the basic silicates and with the lime of the carbonate of lime before they can attack raw rock phosphate effectively.

That the acids attack the basic silicates is agreed, and this means that some of the potash minerals naturally contained in the soil are thus rendered soluble, and the potassium contained in them made available to higher plants. Potash minerals are important and abundant constituents of all normal soils. The idea conveyed by this part of the quoted statement is in agreement with the published results of the Illinois Experiment Station[2] and was sufficiently considered by the authors of Bulletin 190, as the following quotation indicates:

The nitrous acid produced may act upon compounds of iron, aluminum, potassium, sodium or magnesium which occur in soils or it may act upon tricalcium phosphate, calcium silicate or calcium carbonate, if present.

To intimate, as Wheeler does, that the acids will choose to unite first with these basic silicates before attacking effectively the raw rock phosphate, is not in accord with the scientific facts, nor does it appear to be sound chemical reasoning, and no mention is made by Wheeler of the acid silicates contained in the soil which may react with raw rock phosphate. To establish minute acid and alkaline areas in the soil is to approach the ideal for both the biological and chemical factors to work in unison in liberating insoluble materials. Ground limestone made up of various degrees of fineness actually provides alkaline areas, and fermentations of organic residues are always developing acid areas. As raw rock phosphate is dissolved by acids, whether produced by bacteria or by chemical means, and, as it is so placed that some of it must have contact with the fermenting areas, it is not difficult to understand why it becomes soluble and why it produces increased crop yields, even though at many other points in the soil centers of alkalinity exist.

The tricalcium phosphate used by us is commented upon by Dr. Wheeler as "an especially soluble artificial tricalcium phosphate." If tricalcium phosphate was a soluble material, which of course it is not, there would have been no logical reason for conducting the experiments.

The "high temperature" of the experiment is mentioned by Wheeler, and, although of minor importance, we note from the records that during the seventy-eight days from July 4 to September 18, 1916, there were sixty-one days on which the temperature of the air ranged above that of the experimental laboratory. At best, temperature could only influence the rate of biochemical action in this experiment.

In regard to the statements bearing on the extent of this solvent action of nitrite bacteria in soils, it is necessary to quote in part the last paragraph of Wheeler's letter.

In their hope of confining the solvent action of the nitrous acid as fully as possible to the raw rock phosphate, Hopkins has recommended that the phosphate be turned under in intimate contact with organic matter, yet when one realizes the even closer contact of the many soil particles with the organic matter at the same time, it will be obviously impossible for the nitrous acid to attack wholly or even chiefly the raw rock phosphate.

In the table below taken from Illinois Bulletin 190 are presented the amounts of phosphorus, calcium, and nitrogen required by standard crops, and the amounts of phosphorus and calcium which would be made soluble if all the nitrogen required for the crop should be oxidized to nitrate and should act upon pure rock phosphate.

The figures show that there is possible of solution from this biochemical process about 7 times as much phosphorus as corn, wheat, or oats require, and 9 times as much as timothy requires. Greater differences occur in the calcium figures, there being possible of solution 14 times that required for corn, 18 times that required for wheat, 12 times that required for oats, and 8 times that required for timothy.

Nowhere in Dr. Wheeler's letter has he pointed out that the nitrous acid furnishes

[2] Bulletin 182, "Potassium from the Soil."

from seven to nine times the necessary solvent power.

PHOSPHORUS, CALCIUM AND NITROGEN REQUIRED BY CROPS, COMPARED WITH THAT POSSIBLE OF SOLUTION WHEN NITRITE BACTERIA ACT UPON TRICALCIUM PHOSPHATE

(Expressed in pounds)

Crop	Nitrogen	Phosphorus		Calcium	
	Required	Required	Possible.	Required	Possible
Corn: Grain, 100 bu.. Stover, 3 tons. Cobs, ½ ton...	150	23	166	22	321
Wheat: Grain, 50 bu... Straw, 2½ tons.	96	16	107	11	206
Oats: Grain, 100 bu.. Straw, 2½ tons.	97	16	108	17	208
Timothy, 3 tons.	76	9	84	20	163

The authors desire to point out that the figures in the table were based upon the solvent action which only the nitrogen would exert when it is oxidized. The associated acid radicle as stated on page 402 of the bulletin may make equal amounts of phosphorus and calcium soluble, thus doubling that reported above. Thus, corn, wheat and oats only require one fourteenth of the phosphorus possible of solution when the acid formed by the nitrite bacteria and that which was combined with the oxidizable ammonia both act upon the raw rock phosphate. It may be that the phosphorus would be made available even if only converted to the dicalcium form, which would require only half as much acid.

The recent results of the New Jersey Station on the oxidation of sulfur and its solvent action on raw rock phosphate in soils support the statement that phosphorus is made soluble by biochemical oxidation in large amounts even in the near presence of other bases.[3]

Limited space is taken to include some field data from the large mass available, showing the advantage of rational systems of permanent soil enrichment in crop rotation, in which raw rock phosphate, limestone and "home-grown" organic matter are the only materials used.

WHEAT YIELDS PER ACRE: FOUR-YEAR AVERAGE UNIVERSITY OF ILLINOIS FARM

Soil Treatment	Bushels
Crop residues	27.6
Manure	28.8
Crop residues, phosphorus	42.0
Manure, phosphorus	45.6
Crop residues, phosphorus, limestone	46.8
Manure, phosphorus, limestone	48.9

These figures demonstrate sufficiently the advantage of mixing organic materials and raw rock phosphate as judged by increased crop yields, and they show that limestone, even when used with raw rock phosphate under field conditions, gives a further increase over that produced by the combination of organic materials and raw rock phosphate.

In his letter, Dr. Wheeler quotes from Director Thorne of the Ohio Agricultural Experiment Station as follows:

> Where we have used floats (raw rock phosphate) as a reenforcement of manure on this farm alongside of acid phosphate, the acid phosphate has given us a slightly larger net gain in the average of the 18 years' work, and a decidedly large gain during the last half of the period.

But Wheeler fails to point out that this statement is based upon only one of the two methods used by Director Thorne in computing the increase produced by the phosphates. He might have quoted from Director Thorne's writing as follows:[4]

> On Section *C*, Plots 1 and 11, which, it will be observed, are continuous, have regularly given yields so much larger than those of the other unmanured plots of this section as to suggest the possibility that the land covered by these plots may have been at one time occupied by a fence-row, the tract lying near a barn, and for this reason it has been deemed best to calculate the increase on the general average of all the unfertilized plots. By this method of calculation the average increase on Plots 2 and 3 combined (with raw phosphate) is found to be practically the same as on Plots 5 and 6 combined (with acid phosphate) but when the larger cost of the acid phosphate is deducted the net gain is a little greater on Plot 2 and 3.

[3] *Soil Science*, p. 533, June, 1916.

[4] P. 18, Ohio Experiment Station Circular 104.

On page 175 of Director Thorne's excellent book on "Farm Manures," he also shows that, when the increase is computed by the method which he states "has been deemed best," the net profit is greater per acre, and very much greater per dollar invested, from raw rock phosphate than from acid phosphate.

ACRE-YIELDS IN OHIO MANURE-PHOSPHATE EXPERIMENTS: AVERAGE OF 9 YEARS, 1906–1914

Phosphate	None	None	Rock	Rock	Acid	Acid
Manure	Yard	Stall	Yard	Stall	Yard	Stall
Corn, bushels	54.4	62.7	68.3	72.1	65.8	68.9
Wheat, bushels	24.3	25.5	27.2	28.2	29.8	29.4
Hay, tons	2.00	2.34	2.43	2.60	2.43	2.68
Value 3 crops	$57.20	$65.20	$68.52	$72.20	$69.60	$72.52
Phosphate gains	......	......	11.32	7.00	12.40	7.32
Phosphate cost	......	......	1.20	1.20	2.40	2.40
Phosphate profit	......	......	10.12	5.80	10.00	4.92
Profit per $1	......	......	8.43	4.83	4.17	2.05

The accompanying table gives the average of the actual yields secured in these Ohio experiments during the last half of the eighteen-year period.

If we value the corn at 40 cents a bushel, the wheat at 80 cents, and the hay at $8 a ton, and count the cost of rock phosphate at $7.50 per ton and acid phosphate at $15, we find, by this direct method of computation, that the rock phosphate was slightly more profitable per acre, and more than twice as profitable per dollar invested, as the acid phosphate.

In his letter to the agricultural editors, Dr. Wheeler quotes a personal letter from Professor Mooers expressing his opinion as to the conclusions which should be drawn from experimental data, in part unpublished, secured by the Tennessee Experiment Station. If this opinion is based upon a continuation of the experiments in which two crops (wheat followed by cowpeas) were grown every year on the same land, as reported in Tennessee Experiment Station Bulletin No. 90, in which on page 89 it is shown that for each dollar invested rock phosphate paid back $2.29, and steamed bone meal only $1.90, and in which the use of steamed bone meal is commended and the use of rock phosphate discouraged, we must await further publication by the Tennessee Station before accepting Wheeler's confidential report of Mooers' personal opinion.

For more complete data from the phosphate experiments conducted by many state experiment stations, the interested reader is referred to Illinois Experiment Station Circular 186, "Phosphates and Honesty."

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SPECIAL ARTICLES

THE LIGHT-PRODUCING SUBSTANCES, PHOTOGENIN AND PHOTOPHELEIN, OF LUMINOUS ANIMALS

In a previous issue of Science (N. S., XLIV., 208, 1916), I called attention to Dubois's discovery of substances called luciferin and luciferase in the West Indian "cucullo" *Pyrophorus noctilucans,* and the mollusc, *Pholas dactylus.* I also recorded the existence of similar bodies in the fire-flies, *Photinus* and *Photuris,* and of luciferin in luminous bacteria. Luciferase, according to Dubois, a thermolabile enzyme capable of accelerating the oxidation of luciferin, is prepared by allowing an extract of luminous cells to stand until the light disappears. The luciferin is thus completely oxidized and used up. The luciferin, according to Dubois, a thermostabile substance capable of oxidation with light production, is prepared by extracting the luminous cells with hot water which destroys the luciferase but not the luciferin. Light will appear if we mix the solutions of luciferin and luciferase in presence of oxygen. Each