THE GREEN RIVER FORMATION

AMONG the continental formations of North America commonly described as lacustrine is the Green River (Eocene), which covers large areas of northwestern Colorado, southwestern Wyoming and northeastern Utah. Since the formation is one of the principal sources of oil shale in the western United States, geologists have studied various sections of it more or less intensively during the past decade and have obtained a large amount of information regarding the sedimentology and the fossil content. In a paper published under the above title, in the *Bulletin* of the American Association of Petroleum Geologists,[1] Professor Henderson has briefly reviewed this evidence to ascertain whether it accords with the view of the lacustrine origin of the formation, and, if so, whether the body or bodies of water in which the sediments were laid down were fresh or saline or alternately fresh and saline.

The formation, which is very generally considered a fresh-water lake deposit, is composed chiefly of fine-grained, even-bedded sediments, which, if not deposited in a lake, must have been laid down by streams meandering in broad valleys where shallow, temporary lakes were present. However, comparatively few strata showing cross-bedding, ripple-marks or mud-cracks, which would characterize this type of deposition, have been observed.

Fossils are numerous and are mainly of non-aquatic forms. Fresh-water fishes have been obtained principally from a single, thin stratum at two localities in Wyoming. The presence of so many skeletons in a thin layer of a lacustrine formation is difficult to explain, unless an arm of the lake were cut off and speedily desiccated. If the sediments are partly fluviatile, this accumulation could easily have taken place in isolated ox-bow lakes which were rapidly filled with sediments.

Well-preserved leaves of upland and lowland plants are abundant in the upper part of the formation far from any possible shore line. The aquatic plants are chiefly algae. The microscopic flora consists of conifer pollen, moss spores, annuli from fern sporangia and molds, all of which must have been carried from land; bacteria and blue-green algae, which can grow in both fresh and saline waters; Spirogyra and Protococcus, which are fresh-water types.

Insects are principally flying forms, whose wide distribution in the strata can be easily accounted for.

The most abundant and widespread fossils have been identified as the larvae of botflies or forms related to them. These larvae to-day infest land animals, and are not aquatic at any stage of their existence. The explanation of their distribution, if the Green River be lacustrine, is difficult.

It is evident from Professor Henderson's discussion that further intensive field work is necessary to determine the origin of certain parts of the formation. While probably most of the beds are fresh-water lake deposits, certain strata doubtless have been deposited by other agencies. The sedimentology of the formation should be thoroughly investigated, and more information secured regarding the paleontology. The identification of the botfly larvae needs confirmation. If these by chance should be some other form, the explanation of their distribution might be more easily made. In any event, it does not seem likely that these larvae had the habits of the modern types.

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[1] Vol. 8, pp. 662–668, 1924.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A METHOD OF MEASURING THE WATER TEMPERATURES OF LAKES AT DIFFERENT DEPTHS

THE measuring of the temperature of lake waters at various depths in connection with the study of the development of the thermocline, the percentage of saturation of oxygen and carbon dioxide and the distribution of life is a problem in which every limnologist is actively interested. The usual method of using the Negretti-Zambri reversing thermometer, while quite accurate after certain corrections have been made, is a rather slow and tedious procedure, even though several thermometers and lines are used at the same time. It is apparent that much time and labor would be eliminated by the use of some electrical indicating thermometer. The thermophone, described by Whipple, has not proven entirely satisfactory. The apparatus here to be described has been used successfully by the writer for three summers at the Iowa Lakeside Laboratory in taking daily temperature readings on Lake Okoboji with what seems to be accurate results. Feeling that other limnologists have felt the need for such apparatus the following brief description is given.

The indicator used is the Charles Engelhard type P–1 indicator provided with two centigrade scales of fifteen degrees each, divided into tenths of a degree. One scale reads from zero to fifteen degrees, the other from twelve to twenty-seven degrees centigrade, allowing an overlap on the two scales for checking purposes. While these scales are sufficient in range for ordinary work on the main lake, for ponds or shallow water which will give higher readings in mid-

summer, a third scale could be added. The markings on the scales are far enough apart so that much finer readings than tenths of a degree can be made. The indicator is of rugged construction so that it has given no serious trouble during the three summers used and seems to be in good condition for the coming summer as well.

This indicator is mounted in a double gimbel box to compensate for the rocking of the boat due to wave motion. Except on extremely rough days no difficulty has been experienced in reading the scales when the engine of the boat is not running. The gimbel box is placed in a larger box filled with loose excelsior to minimize the effects of the vibrations due to the running of the engine when going from one place to another.

The bridge box is of the Wheatstone type and is provided with a four-way switch. Switch point No. 1 is for the scale reading from 0–15, No. 2 for the scale 12–27, No. 3 is voltage proof for scale No. 1 and No. 4, the voltage proof for scale 2. It is possible, therefore, to check each scale before using. The resistance box is operated by two 1½ volt dry cells, which are easily replaced when worn out, usually not more than once during the summer. It would make for considerable compactness and ease in handling if the resistance box and the indicator were incorporated in one box, which could easily be done at the factory.

The thermometer, which is connected to the resistance box by a three-wire, 150 foot water-proofed lead, is the regular Engelhard 100 ohm platinum wire resistance thermometer. It is made up of a little spiral of highly resistant platinum wire wound upon a fused quartz tube which, in turn, is hermetically sealed into an outer quartz tube by fusion. This is then mounted in a perforated brass tube fitted with a moisture proof terminal head. The thermometer requires but little attention save to renew occasionally the rubber gaskets in the head so that the terminals may not get water soaked.

The advantages of this instrument are its reliability, the ease with which it may be used, the rapidity in making readings, the continuous line of readings from top to bottom and the possibility of checking up the readings as the thermometer is being raised. The thermometer responds very quickly to changes of temperature, one or two minutes are usually sufficient for the needle of the indicator to come to rest.

The following table gives a comparison of the readings as the thermometer is lowered from the surface to the bottom of the lake and again as it is raised.

The reading for August 16, 1922, was taken at 9 A. M. The sky was clear, there was very little breeze so that the lake was almost flat, although the day before was rough. This accounts for the evenness of the temperature in the epilimnion. For the same date in 1923 the reading is for 1:20 P. M., and the lake again was fairly smooth but somewhat rough in the morning. For August 16, 1924, the reading was taken at 8 A. M., with a northwest wind blowing at

	Aug. 16, '22. Air, 25.4° C.		Aug. 16, '23. Air, 26.5° C.		Aug. 16, '24. Air, 16° C.	Thermocline. Aug. 16, 1922.	
Meters.	Down.	Up.	Down.	Up.	Down.	Meters.	Centigrade.
0	22.80°	22.90°	22.30°	22.40°	18.70°		
1	22.75°	.....	22.20°	22.25°	18.80°	13	21.40
2	22.70°	.....	22.15°	22.15°	18.78°	13¼	21.30
3	22.70°	.....	22.10°	22.00°	18.68°	13½	21.09
4	22.70°	.....	22.00°	22.00°	18.60°	13⅝	20.89
5	22.70°	22.70°	21.90°	21.88°	18.60°	13¾	20.70
6	22.50°	22.50°	21.85°	.....	18.52°	13⅞	20.60
7	22.40°	22.40°	21.80°	21.80°	18.52°	14	20.50
8	22.30°	22.25°	21.80°	21.80°	18.50°	14⅛	20.30
9	22.00°	22.00°	21.80°	21.75°	18.50°	14¼	20.30
10	21.80°	21.80°	21.30°	21.20°	18.42°	14⅜	20.00
11	21.65°	21.60°	21.10°	21.10°	18.40°	14½	19.83
12	21.50°	21.50°	20.90°	21.00°	18.40°	14⅝	19.72
13	21.40°	21.35°	19.70°	20.00°	18.32°	14¾	19.60
14	20.80°	20.50°	17.20°	17.40°	18.25°	14⅞	19.50
15	19.50°	19.20°	15.00°	15.00°	16.20°	15	19.20
16	17.70°	17.60°	13.60°	13.50°	15.30°	15⅛	19.05
17	16.80°	16.50°	12.95°	12.90°	13.80°	15¼	18.90
18	16.10°	15.60°	12.50°	12.50°	13.00°	15⅜	18.82
19	15.00°	14.60°	12.20°	12.20°	12.00°	15½	18.60
20	14.10°	14.10°	11.80°	11.80°	11.30°	15⅝	18.30
21	13.70°	13.50°	11.70°	.....	11.05°	15¾	18.10
22	13.55°	13.50°	11.55°	.....	10.85°	15⅞	18.00
23	13.30°	13.25°	11.30°	.....	10.75°	16	17.95
24	13.10°	13.10°	11.15°	.....	10.60°	16⅛	17.80
25	12.80°	12.75°	11.05°	11.10°	10.50°	16¼	17.70
26	12.80°	.....	11.05°	.....	10.30°	16⅜	17.65
27	12.40°	.....	11.03°	.....	10.20°	16½	17.50
28	12.40°	12.35°	11.00°	.....	10.10°	16⅝	17.20
29	.....	.....	11.00°	.....	10.05°	16¾	17.10
30	.....	.....	10.95°	10.85°	9.90°	16⅞	16.99

the rate of 649 feet per minute. The summer of 1924 was a cold summer so that the surface temperature never reached as high as 22° C.

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SPECIAL ARTICLES

RETARDATION OF THE ACTION OF OXIDASES BY BACTERIA

IN a variety of plants and animals there are found substances which are capable of accelerating certain oxidations. These substances, in the majority of cases, resemble the hydrolyzing enzymes in the minute quantities in which they are effective and in their instability towards heat. The discovery of these oxidizing enzymes we owe to Schönbein, who employed guaiac as a means of detecting them. According to Bach and Chodat,[1] the oxidizing enzymes which occur in living tissues in reality consist of two parts: the one part, oxygenase, acting as the carrier of the oxygen; the other part, peroxidase, facilitating the transfer of the oxygen to the material undergoing oxidation. Onslow[2] believes that in plant tissues there are two separate enzymes acting as above.

It has long been known that milk would turn blue in the presence of guaiac, showing the presence of oxidases. The writers have found that stale milk would have no effect on a solution of guaiac. The staleness of milk is due to the growth of bacteria. This paper is an attempt to correlate the number of bacteria present in the milk with the destruction of the oxidases. It is an attempt to show that the presence of bacteria will hinder and finally stop all oxidations, through oxidizing enzymes.

In all the observations the following method was employed. Fresh Grade B milk was obtained at the store. Two hundred cc were put into a sterile bottle; corked with cotton and kept in an icebox at a temperature of 12° C. for further tests. From this stock supply there were daily drawn 5 cc of milk by means of a sterile pipette and tested as follows. To 2 cc in a sterile test tube was added 1 cc of a 1 per cent. solution of guaiac and the time determined for the blue color to disappear. The remaining 3 cc were treated in the following way in order to determine their bacterial count.

Four dilutions were made up: 1 to 100; 1 to 10,000; 1 to 1,000,000 and 1 to 100,000,000. One of each of the last three dilutions was plated out into a separate petri dish, and agar-agar added. The dish was rotated so as to form an emulsion between the milk and the agar. They were then kept at a temperature of 37.5° C. for a period of five days and then the colonies of bacteria counted. This was done daily at the same hour until the milk taken from the stock bottle failed to give a blue color with the guaiac solution. All apparatus used was sterilized in an autoclave, with live steam for two hours, and then allowed to cool before using.

The results are given in Tables 1 and 2. They show that at first the increase in bacteria accelerated the action of the oxidases as shown by the increasing length of time it takes for the blue color of the guaiac to disappear. But as the bacteria continue to increase the color of the guaiac disappears more and more quickly until finally there can be gotten no color with the guaiac. In the observations there is quite an agreement between the number of bacteria present and the time taken for the color of the guaiac to disappear.

TABLE I

SAMPLES OF 2 CC OF MILK PLUS 1 CC OF GUAIAC. TIME IN MINUTES IS GIVEN FOR THE BLUE COLOR TO DISAPPEAR

Sample of Milk	Number of Days 1	2	3	4	5	6	7	8	9	10
A	29	33.5	37.5	41	40	28	20	*	...	.....
B	51	55.0	59.0	40	21	19	17	15	...	.....
C	.....	48.0	45.0	40	20	18	*	.....	...	.....

* No blue color obtained.

TABLE II

BACTERIAL COUNT IS GIVEN IN MILLIONS OF BACTERIA PER CC OF EACH SAMPLE OF MILK USED

Sample of Milk	Number of Days 1	2	3	4	5	6	7	8
A	.06	.41	1.5	2.54	500	.....	600	1,100
B	.05	.25	2.5	18.6	400	1,100	22,000	37,000
C	.....	.60	7.0	12.0	900	.....	.....	.....

It will be seen that the three observations taken on the fourth day are practically equal in respect to time, although the bacterial count (Table 2) varies. Is this failure of the oxidases to change guaiac due to an accumulation of bacterial toxins? This phase of the problem will be determined in our next paper.

Summary: The staleness of the milk prevents the action of these oxidases to oxidize this solution of

[1] Bach and Chodat, Centr. f. Biochem, 1903, 1, pp. 417 and 457.

[2] Onslow, *Biochem. Jour.*, 1920, 14, pp. 535, 541.