to produce its characteristic red pigment. By allowing the organism to grow on the plate for a period of five days the greater portion of the colonies produced their pigment. If a transfer of a white colony is made to an agar slant the characteristic pigment is produced in twelve hours. In only one case was it necessary to make a second transfer in order to bring about the development of the pigment. The above is another example of the variation tendency of *Erythrobacillus prodigiosus.*

TABLE I
SUMMARY OF ANALYTICAL RESULTS

B. coli Data

Sample number	Time of irradiation in minutes	Total count per cc (24 hrs.–37° C.)	Remarks
1	0	70,000	
2	5	70,000	
3	15	17,000	Single colonies were picked from plate of sample number
4	30	9,000	6 and morphology and cultural characteristics were ex-
5	45	1,700	amined. All tests were characteristic of the original.
6	60	10	
7	90	0	

Erythrobacillus prodigiosus Data

Sample number	Time of irradiation in minutes	Observations of Glucose-Agar Plates			
		2nd day		3rd day	5th day
		Total count per cc 20° C.	Pigment	Pigment of colonies	Pigment of colonies
1	0	800,000	red	red	.....
2	5	600,000	red	red	.....
3	15	480,000	red	red	.....
4	30	400,000	red	red	.....
5	45	300,000	red	red	.....
6	60	45,000	80% white*	50% white	90% red
			20% red	50% red	10% white
7	90	400	100% white*	80% white	60% red, 40% white
8	120	0	.....	.....	.....

* All white colonies that were fished from the plates (12 in number) and streaked on agar slants produced luxuriant red pigmented growth at 20° C. in twenty-four hours with the exception of one colony fished from sample number 7 which failed to give red pigment until it was transferred to a second agar slant.

GEORGE L. CLARK,
C. S. BORUFF
UNIVERSITY OF ILLINOIS

MULTIPLE GLACIATION IN THE SIERRA NEVADA[1]

DEFINITE and conclusive proof of two stages of glaciation was found in the Sierra Nevada of California in 1913 independently by Knopf, on the east flank of the range, and by the writer, in the Yosemite region. The evidence consists primarily of two series, or bodies, of moraines, an older characterized by subdued, partly eroded forms and containing weathered, disintegrating boulders, and a younger characterized by well-preserved, sharp crests and containing mostly fresh, unweathered boulders. In addition both observers found erosional evidences of a roughly quantitative sort demonstrating that the interval between the deposition of the older and younger moraines was of the order of an interglacial stage.

The detailed mapping of the moraines of the Yosemite Glacier and its tributaries, however, soon enabled the writer to distinguish further subdivisions of the glacial record. Each of the two great bodies of moraines he found to be composite in its nature, so that together they embody a four-fold record—of two earlier and two later glacial advances. But

[1] Published by permission of the director of the U. S. Geological Survey.

whether each of these glacial advances represents a separate glaciation, or merely a major fluctuation of the glaciers, seemed at first uncertain. Comparative studies made in subsequent years on the morainal systems of the Tuolumne, San Joaquin, Kings and Kaweah glaciers, and revisits to the Yosemite region, however, have since tended to confirm the writer's opinion that the two later glacial advances occurred in relatively rapid succession and mark substages of a single—the last—stage of glaciation; whereas the two earlier advances were separated from each other by a long interval of time and mark two distinct stages of glaciation. Accordingly, there is on the west slope of the Sierra Nevada a definite record of three successive glaciations, of which the third and last had two climaxes. The general correctness of Willard D. Johnson's tentative recognition in 1905 of a triple glacial record in Bridgeport Valley, on the east side of the Sierra Nevada, is thereby borne out.

These proofs of multiple glaciation in the Sierra Nevada of course render desirable the finding of suitable names for the different stages. The last stage, to judge by the fresh appearance of its moraines and the excellent preservation of its glacier polish on rock surfaces, doubtless corresponds to the last glacial stage in the Rocky Mountains, and therefore is properly correlated with the Wisconsin stage of the continental ice. It scarcely needs a new name in the Sierra Nevada, and, therefore, in his reports on the Yosemite Valley and the San Joaquin basin the writer is referring to it as the Wisconsin stage. Its division into two substages would seem in harmony with the well-known division into distinct substages of the Wisconsin in the north-central parts of the continent. Still, the writer would not for the present dismiss altogether the possibility that what is here called the first substage of the Wisconsin in the Sierra Nevada may be the correlative of the Iowan.

The ice of the preceding, or second, glacial stage was much more extensive in the Sierra Nevada than the ice of the Wisconsin stage. Whereas the Yosemite Glacier of the Wisconsin stage terminated within the Yosemite Valley, as is attested by the frontal moraines above the Bridal Veil Meadow, the Yosemite Glacier of the second glacial stage reached ten miles farther down the Merced Canyon and terminated a short distance below El Portal, the entrance to the Yosemite National Park. Frontal moraines are lacking there, but the lateral moraines can readily be traced to the vicinity of El Portal, and beyond that place begin the remnants of a long valley train of outwash material that must have extended from the front of the glacier. The name El Portal stage therefore seems appropriate for this stage of glaciation (no more suitable name derived from a locality in any of the major glaciated canyons on the west flank of the range suggests itself).

The earliest of the three glaciations appears to be recorded in the Yosemite region only by erratic boulders occurring singly or in rows or groups, but without accompanying fine material, at levels one hundred to two hundred feet above the highest lateral moraines of the El Portal stage. They lie in places where there is every reason to believe that heavy, continuous moraines once were laid down. As the conditions there are on the whole favorable for the preservation of such moraines and as the boulders consist invariably of exceedingly resistant rocks, such as quartzite or highly siliceous granite, the conclusion seems inescapable that the boulders are the sole surviving remnants of moraines of a very early stage of glaciation that have wasted away almost completely. Such erratic boulders occur at a level about seven hundred feet above Glacier Point, extending in a row from the east base of Sentinel Dome to the north end of Illilouette Ridge. Others are scattered on the broad divide east of Mount Starr King. The extreme antiquity of the boulders above Glacier Point is attested also by the fact that, although they were carried by the ice only half a mile from their parent ledges, they have lost the angular forms of plucked blocks and have become rounded by long-continued exfoliation *in situ*. For this early stage of glaciation, accordingly, the name Glacier Point stage is proposed.

Correlation of the El Portal and Glacier Point stages with the generally accepted stages of the Pleistocene determined in the area of continental glaciation can scarcely be attempted at the present time. However, from the depth to which the granite on Moraine Dome, on the north side of the Little Yosemite, has disintegrated and wasted away since the El Portal glaciation—a minimum of seven feet, as is indicated by residual crags of resistant aplite—it may be judged that the time distance back to the El Portal stage is at least twenty times, and perhaps forty times, as long as the post-glacial interval and is to be reckoned in hundreds of thousands of years. The El Portal stage therefore probably corresponds to the Illinoian, and the Glacier Point stage, by inference, may correspond to the Kansan or even the Nebraskan.

Of particular interest in this connection is the recent discovery by Blackwelder at several points on the east front of the Sierra Nevada of what he regards as evidence of three, and possibly four, distinct glaciations. It is to be hoped that these may soon be definitely correlated with those recognized in the Yosemite region.

F. E. MATTHES

U. S. GEOLOGICAL SURVEY