considerably in their estimates of that share. E. C. Andrews, of the Department of Mines, New South Wales, interpreted the Yosemite as being essentially a gorge created by the powerful erosive action of a plunging ice cascade, or ice fall, in the Yosemite Glacier, that receded gradually headward, just as the Niagara Gorge has been created by the erosive action of the slowly receding Niagara Falls. The cross cliff over which the Yosemite Glacier plunged he estimated to have been "at least 2,000 feet in height." [17]

Prof. Douglas W. Johnson, of Columbia University, following Gannett's idea out to its logical conclusion, undertook to deduce the depth of glacial excavation in the Yosemite chasm from the heights and gradients of its hanging side valleys. Reconciling as well as he could the discordant results which he obtained by this method, he arrived at a measure of "2,200 to 2,500 feet at least." [18]

Prof. Andrew C. Lawson, of the University of California, believed the Yosemite to have been elaborated by glaciation from "a profound erosional gorge." [19] From the insight into the preglacial history of canyon cutting in the Sierra Nevada previously gained through his studies in the Kern River Basin, it was manifest to him that the Yosemite, like the other great canyons of the Sierra, must have had great depth prior to the arrival of the glaciers. He believed it to have been further deepened and also widened by glacial action, but the work done by the ice, in his estimation, was "probably not great," as the morainal débris deposited below the Yosemite is of scant volume.

The wide discordance in these different estimates of the amount of excavational work accomplished by the glaciers and the preglacial streams, respectively, was due chiefly to the lack of reliable information as to the extent and magnitude of the ancient Yosemite Glacier and its tributaries, to the haziness of ideas that prevailed regarding the preglacial history of the Yosemite region, and to fundamental differences in conception as to the eroding capacity of glaciers and the precise manner in which glaciers do their erosional work. It will be readily understood, therefore, why in 1913 the United States Geological Survey at once responded to the popular demand, voiced by the Sierra Club, for further and more definite information regarding the geologic history of the Yosemite Valley and instituted a systematic and intensive investigation covering the entire Yosemite region and the neighboring parts of the High Sierra. There was additional warrant for such an investigation in the fact that since the end of the nineteenth century there had come to maturity a new branch of geologic science—geomorphology, or physiography, as it is also termed—which deals specifically with the origin and development of the surface features of the earth and within whose scope a problem such as that of the Yosemite Valley largely belongs. Furthermore, a new detailed topographic map of the valley that afforded an excellent base for the proposed studies had recently been completed.

The privilege of carrying out the new investigations fell to Frank C. Calkins and the author of this paper. Mr. Calkins's task was to study the characteristics, significance, and relationships of the different kinds of rock that occur in the Yosemite region, and the writer was charged with deciphering its glacial history and studying the evolution of its sculptural features. For several years the two investigators carried on their work conjointly throughout the Yosemite region and the adjoining areas in the High Sierra. Then each made supplementary reconnaissances, Mr. Calkins carrying a geologic section across the range from the mouth of the Merced Canyon up through the Yosemite region and the writer extending his glacial and geomorphologic studies northward to the regions drained by the Tuolumne and Stanislaus Rivers and southward over the drainage basins of the San Joaquin, Kings, and Kaweah Rivers.

As a result there is now at hand a considerable body of new and definitely correlated data, upon which, with more confidence than has been possible heretofore, the story of the origin and evolution of the Yosemite Valley may be built. In the first place, the farthest limits reached by the ancient Yosemite Glacier and all its tributaries and neighboring ice streams have now been traced out and definitely mapped. Much has been learned also of the sequence of advances and retreats of the ancient glaciers, and some perspective has been gained upon the spans of time involved in those fluctuations. Thus it is now established beyond reasonable doubt that the Yosemite region—indeed, the entire Sierra Nevada—was glaciated at least three times during the ice age, having gone through alternating glacial and interglacial stages, like the central parts of the continent. Further, three important chapters of the Yosemite's preglacial history now stand revealed, and the successive stages in the valley's development recorded in those chapters are definitely linked with successive epochs in the growth of the Sierra Nevada. The geologic age of the earliest of those epochs, moreover, has been tentatively determined from fossil remains found in other parts of the range. Again, the depth to which the Yosemite was excavated at each stage in its history has been ascertained within narrow limits, and so the crucial question as to how much of the work was done by the streams and how much by the glaciers can now be answered fairly definitely. Last of all, the reason for the distinctive form of the Yosemite Valley and for its exceptional wealth of sculptural features has been found in

[17] Andrews, E. C., An excursion to the Yosemite, California, or studies in the formation of alpine cirques, "steps," and valley "treads": Roy. Soc. New South Wales Jour. and Proc., vol. 44, p. 312, 1900.

[18] Johnson, D. W., Hanging valleys of the Yosemite: Am. Geog. Soc. Bull., vol. 43, p. 831, 1911.

[19] Lawson, A. C., Geology of Yosemite National Park, in Handbook of Yosemite National Park, compiled by Ansel E. Hall, p. 120, 1921.