

ronian. The Canadian geologists have fallen into the custom of calling every thing Huronian that is schistose, and yet it is evident that much of the schists called by them Huronian are but dependencies of the older gneiss. I may say in this connection, that the 'Animikie group' of Thunder Bay, which Selwyn, following Logan, refers to the copper-bearing series, is, beyond question, the exact equivalent of the unfolded iron-bearing rocks of the Penokee region of Wisconsin, and these again of the folded iron-bearing schists of the Marquette and Menominee regions; and that there can be little doubt that all of these are the equivalents of the original Huronian of the north shore of Lake Huron. This reference of the Animikie rocks to the Huronian is, I know, a novel position, although Logan long since for a time held the same view; but I feel confident that it is a correct one. Indeed, I speak confidently as to all of the conclusions here mentioned, because I have had unusual opportunities for observation, having studied both the Cambrian sandstones and the copper-bearing rocks, as well as the Huronian from Keweenaw Point across Wisconsin, into Minnesota, and thence north-eastward to Thunder, Black, and Nipigon Bays. Having made this wide sweep, I can see quite well how others, examining only portions of the district, should be puzzled or reach different conclusions.

There is one other statement in Mr. Selwyn's letter that I cannot concur in; and that is as to the occurrence of tuffs, or volcanic detrital matter, among the copper-bearing rocks. I know such materials should be expected to occur in a series largely composed of volcanic flows; but after a careful search for them in the field, and the study of a large number of thin sections, I can find no fragmental rocks which are not either certainly ordinary sediments or at least much more probably so than of direct volcanic origin.

Madison, Wis., Feb. 16, 1883.

R. D. IRVING.

#### WHITNEY'S CLIMATIC CHANGES.

*The climatic changes of later geological times: a discussion based on observations made in the Cordilleras of North America.* By J. D. WHITNEY. Cambridge, 1882. 14+394 p. 4°.

##### I.

THIS volume is one of a series, by the same author, based on the work of the California geological survey, but published under the auspices of the Museum of comparative zoölogy. The preceding volume treated of the auriferous gravels of California, and this one is in some sense a sequel to it. Although the treatise is an outgrowth of the Californian work, its material includes observations by the author in eastern America and in Europe, as well as data gathered by others from all regions. It is of interest, not only by reason of its contribution of original matter, but because it develops at length a theory that has heretofore been stated but briefly, and which has been almost ignored by the advocates of its rivals. The book comprises four hundred quarto pages, but is without index,—an omission only imperfectly supplied by an analytic table of contents.

In the volume on the Auriferous gravels, our

author states that the Sierra Nevada has had substantially the same height and dimensions from cretaceous time. The streams which flowed down its western flank during the tertiary did not excavate gorges, but, on the contrary, spread great bodies of detritus. The modern rivers, following essentially the same courses, have cut deep V-shaped cañons, which were partially filled with ice during the glacial epoch. The tertiary climate was relatively moist, as is shown by the broad channels of the tertiary rivers, and by the fact that they filled their valleys with gravel instead of cutting cañons.

In the present volume, the idea of a diminution of precipitation from pliocene to present time is expanded into a theory of general, continuous, secular desiccation, and is developed at length. Evidence is adduced to show, that within historic time there has been a shrinking of lakes and rivers in South America, in the interior basin of Asia, and about the shores of the Mediterranean; and that, in late geological time, large areas in northeastern and northwestern Asia and northern Africa were covered with water, while the Great Basin of North America contained a system of fresh-water lakes. The ancient glaciers of the Sierra Nevada, and of the Cordilleras generally, are described; and their disappearance is referred to the same desiccation. An account is given of the tertiary lakes of western North America, and it is pointed out that their extent gradually diminished. The popular theory that modern desiccation is due to the destruction of forests, and the theory of some geologists that the great lakes and rivers of the immediate past were connected with the melting of the ice of the glacial epoch, are controverted; and it is argued that all the phenomena pertain to a general, secular diminution of precipitation.

To account for this diminution, the following considerations are adduced: The amount of moisture precipitated to the earth depends on evaporation. The amount of evaporation depends on temperature and on the extent of water-surface. If, therefore, it can be shown that the continents of the earth have gradually increased in area, while the oceans have gradually diminished, or if it can be shown that the temperature of the atmosphere has gradually lowered, then an explanation will be afforded of the change in precipitation. After a review of the facts, Professor Whitney concludes that an expansion of continents has actually taken place, but that it is inadequate to account for the observed recent desiccation. He therefore bases his theory chiefly upon a loss of heat,

adopting the doctrine of the dissipation of solar energy, and citing the paleontologic evidence of warm tertiary climates in arctic regions.

Search is made for proofs of recent changes of temperature corresponding to the recent changes in precipitation. The thermometric record is rejected, because the conditions of observation have not been constant; but certain circumstantial evidence is admitted. The northern limit of the grape and other cultivated plants is observed to be now farther south than formerly; and the northern limit of human habitation has been crowded somewhat southward. The people of Greenland and Iceland are emigrating, and icebergs are multiplying in arctic waters.

This theory of the continuous fall of general temperature is evidently inconsistent with the prevalent assumption that the glacial epoch was a period of exceptional cold, and a considerable share of the book is devoted to the setting-aside of that assumption. To this end the present glaciation of the earth is reviewed at some length, and the conditions of glacier formation are discussed. It is shown that mere cold, whether it pertain to high latitude or to high altitude, is not sufficient, but that an abundant precipitation must accompany it; and, since a lowering of general temperature tends to check precipitation by checking evaporation, it should not be predicated as the cause of the glacial epoch. A higher general temperature is quite as likely to be a favorable condition for producing the demonstrated effects.

For a series of decades there has been a general shortening of the glaciers of the Alps, the Caucasus, and the Pyrenees. In some localities the retrograde movement began about fifty years ago; in others, twenty-five; and the longer glaciers have receded several thousand feet. This is ascribed to a slight diminution of precipitation, caused by the general cooling of the atmosphere, and is correlated with the desiccation of the shores of the Mediterranean.

The phenomena of the glacial epoch are then reviewed; and it is stated that only in western Europe and north-eastern America was the glaciation so extensive as to demand the assumption of conditions considerably different from the present. The environments of individual glacier districts are discussed, and the prevalent ideas with reference to the magnitude of the phenomena of the glacial epoch are combated.

In particular are the phenomena of Greenland, Scandinavia, and the Ural contrasted.

Precipitation is now small in the district of the Ural, large in Scandinavia, and probably large in Greenland. This accounts for the extensive glaciation of Scandinavia and Greenland, and the absence of glaciers, both ancient and modern, from the Ural. The present conditions of Scandinavia and Greenland differ chiefly in that the latter is somewhat higher and more maritime; and to account for the ancient extreme glaciation of Scandinavia, it would be natural to suppose that it then resembled Greenland in these respects. According to the Swedish geologists, this was the case. Its altitude was greater, and during at least a portion of the glacial epoch the plain at its eastern margin was submerged.

The description of the glaciation of north-eastern America is somewhat meagre, and is chiefly characterized by a tendency to estimate lower than other geologists the magnitude of the phenomena. The existence of an ice-sheet is not denied; but the difficulties attending the glacial hypothesis are emphasized, and great importance is attached to the work of icebergs and rivers.

Incidentally the book is replete with illustrations of the independence of the author's opinions. He ascribes no erosive power whatever to glaciers, but refers the multitudinous rock basins of Canada and Finland to chemical decomposition and orographic displacement, and asserts that the tendency of streams is to deepen these basins rather than obliterate them. He has a theory of glacier-motion in which water plays an important part; and he ridicules the idea that different layers of a confluent ice-mass can move in different directions. The statement that most, if not all, of the detrital material of north-eastern North America is destitute of any true morainic character, will sound strange to the geologists who are now studying the moraines of that region.

In a succeeding number some of the author's more comprehensive conclusions will be discussed.

#### THE GOVERNMENT AGRICULTURAL REPORT.

*Report of the commissioner of agriculture for the years 1881 and 1882.* Washington, Government printing-office. 1882. 704 p., 84 pl. 8°.

INASMUCH as the present commissioner, when he entered upon his duties, "found the work for the season, both regular and special, elaborately laid out by my [his] successor," his report not unnaturally bears a strong resemblance to the reports of preceding years. It