A corollary of some interest, not mentioned by the author, relates the history recorded by recessional moraines to that associated with Niagara gorge. From the beginning of the last ice retreat at Cincinnati Taylor counts seventeen moraines to Rochester, beyond which point new conditions enter, making the continuance of the analysis a matter of great difficulty. But just at the close of the term represented by these moraines the Niagara began its work, so that the moraine history is complemented by the river history. Together they represent all the time since the latest ice maximum, a period whose measurement in years is far more valuable to science than the determination of the age of the great cataract. Postulating the astronomic cycle of the precession of the equinoxes as the cause of the morainic cycle, the approximate time covered by the morainic history is computed (by the reviewer) at 315,000 years. This is so long a period in comparison with the most ample of modern estimates for the age of the Niagara that the uncertainty as to Niagara's age is of little moment in considering the sum of the two periods. Broadly stated, the hypothesis that the recessional moraines are functions of the precessional cycle estimates the time since the last maximum of glaciation at 300,000 to 400,000 years.

G. K. G.

The Influence of the Carbonic Acid in the Air upon the Temperature of the Ground. By PROFESSOR SVANTE ARRHENIUS. *Philosophical Magazine and Journal of Science*, Vol. XLI (Fifth Series) 1896, pp. 237–276. *La Revue Générale des Sciences*, Mai, 1899, pp. 1–22.

Professor Arrhenius was led to investigate this subject by the debates among the Swedish geologists upon the cause of the glacial and interglacial climates of the Pleistocene. The conclusion that none of the current hypotheses are satisfactory or at all competent to explain the observed phenomena led him to calculate the quantitative effect of any given variation in the amount of atmospheric carbon dioxide upon the temperature of the earth's surface. The fact that the carbon dioxide and water vapor are the chief agents in retaining the heat radiated from the earth's surface had long been known qualitatively and even the relative values of the selective absorption of radiant energy for the various atmospheric gases had been determined, but it remained for

Professor Arrhenius to show the exact effect of any given change in the carbon dioxide content of the atmosphere upon the surface temperature of the earth.

The essential work of the physicist and mathematician having now been done by him, it remains for the geologist to investigate the various sources of supply and depletion of carbon dioxide and to determine if possible if there have been any variations of such an order of magnitude as to produce the results observed.

Professor Arrhenius explains in his papers that the air retains heat (light and dark) in two different ways: (1) The heat suffers a selective diffusion as it passes through the air. This is greatest for the rays having short wave-lengths (ultra-violet) and insensible for those of long wave-lengths which form the chief part of the radiation of a body of the temperature of the earth, viz., 15° C. (2) The gases themselves have the power of absorbing selectively the light and heat of certain wave-lengths The carbon dioxide and the water vapor have this power of selective absorption to a far greater extent than the oxygen, nitrogen or argon, and this absorption is not distributed evenly throughout the spectrum but occurs in certain definite bands which are best developed in the ultra-red portion which represents the rays with long wave-lengths such as are given off by bodies with a low temperature.

There are two ways in which to measure the amount of the heat absorption by the carbon dioxide and the water vapor: (1) by measuring directly the amount of heat absorbed by such quantities of these gases as they appear in the atmosphere, and at a temperature of 15° C., and (2) by measuring the amounts of heat received from the full moon at different heights above the horizon. The amount of carbon dioxide through which the rays pass is evidently a function of altitude of the moon above the horizon, while that of the water vapor depends both upon the altitude and the humidity of the air.

Professor Arrhenius takes the second method and from Professor Langley's observations on the heat received from the full moon at various altitudes above the horizon he calculates the amount of heat absorbed by the two gases by an atmosphere having the present average amount of carbon dioxide and the average amount of water vapor, viz., ten grains per cubic meter at the earth's surface. The full moon has, however, a surface temperature of 100°, and he introduces the corrections necessary to apply the above to a body with the temperature of 15° C.

With these data it is not difficult to calculate the effect of any change in the amount of carbon dioxide upon the temperature of the surface of the earth. The temperature of the earth's surface is theoretically in equilibrium with that of the atmosphere. Now if by any increase in the amount of the carbon dioxide the atmosphere retains more heat than before, it will radiate more heat to the surface of the earth. The surface temperature then will rise until there is again an equilibrium between the two. This rise is governed by Stefan's law which states that the intensity of the radiation is proportionate to the fourth power of the e r

From these data Professor Arrhenius finds that if the carbon dioxide is increased 2.5 to 3 times its present value, the temperature in the arctic regions must rise 8° to 9° C. and produce a climate as mild as that of the Eocene period. A diminution to 0.62 to 0.55 of its present value must cause a fall of from 4° to 5° C. and give us a glacial period.

It is to be noted that in every case throughout the calculation Professor Arrhenius has preferred to slightly underestimate the effect of the carbon dioxide than to risk a possible overestimate. Also where he has been compelled to use interpolation the limit of error has been well within the degree of accuracy of the observations upon which they are founded.

The tremendous interest of these considerations, not only as a basis for the interpretation of the past history of the globe but also for the prophecy of its future, demands an investigation of the problem along the lines of direct experiment, as a supplement to the elegant calculations of Professor Arrhenius. CYRUS F. TOLMAN, JR.

Special Report on Gypsum and Gypsum Cement Plasters. By G. P. GRIMSLEY and E. H. S. BAILEY. University Geological Survey of Kansas, Vol. V. Pp. 183, 30 plates. Topeka, 1899.

Among the minor mineral industries of the country those connected with gypsum have been, so far as literature is concerned, heretofore neglected. The present report is accordingly particularly welcome. The papers so far accessible have been, in the main, devoted to the description of local deposits and the technology of the gypsum industries has not been described before in any adequate manner. The present volume includes not only a description of the Kansas gypsum beds