

whilst the carbonic acid owes its origin more or less indirectly to the atmosphere and to infra-oceanic respiration.

In considering by what agencies calcium carbonate may be precipitated from the sea, we can at once set aside two which are of importance in terrestrial geology, viz. removal of solvent by evaporation and change of temperature; neither are operative in adequate degree in the hydrosphere. Turning to chemical processes we note, in the first place, that the solubility of calcium carbonate in water is nearly proportional to the cube root of the CO_2 -tension,¹ i.e. the amount of free CO_2 present in solution. Calcium carbonate as such is scarcely soluble at all, but in presence of CO_2 the bicarbonate $\text{Ca}(\text{HCO}_3)_2$ is formed, and this is soluble to a considerable extent. Hence, if CO_2 be abstracted, calcium carbonate will tend to come out of solution. Here we have what seems to be the *modus operandi* of calcareous algæ. The plant absorbs CO_2 by way of nutrition, precipitates calcium carbonate, and thus builds its skeleton. That this process takes place in fresh water, where the bicarbonate is the chief salt of calcium present, may be considered as established. The mosses *Hypnum*, *Eucladium*, *Trichostoma* are cases in point, as also *Chara*. These plants deposit coral-like growths, known to mineralogists as tufa and travertine. Many occurrences have been noted in the Yellowstone Park and other American localities. In some instances the calcium carbonate is aragonitic, as at Carlsbad. The calcareous algæ, which are well represented at the surface and at the bottom of the warmer oceans (coccolithophoridæ), no doubt secrete their skeletons in the same way as the fresh-water algæ enumerated.

But there is another far more important agency at work. Calcium carbonate must separate out if the product of the concentrations of its ions Ca^{++} and CO_3^{--} happens to exceed a certain definite limit. Small increases in the concentration of Ca^{++} ions may be disregarded, since their concentration is already considerable; but small local accessions of CO_3^{--} ions, which, in the shape of alkaline carbonate, may and do occur, are more effective. Marine animals generate, as ultimate products of the metabolism of their proteid food, ammonia and carbon dioxide. These combine to form ammonium carbonate, which in aqueous solution is largely dissociated into NH_4^+ and CO_3^{--} ions; thus calcium carbonate is precipitated with liberation of ammonia, and a shell or coral growth may be formed. The reaction here described,

¹ Schloesing, *Comptes Rendus Acad. Sci. Paris*, vol. lxxv. p. 70, 1872; Bodländer, *Zeitschr. Phys. Chem.*, vol. xxxv. p. 23, 1900.