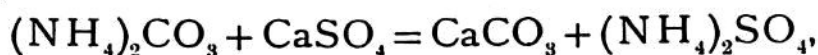


which, according to the older chemical notions, was expressed by the equation



seems to have been first suggested in this connection by Forchhammer, and was fully proved and worked out experimentally, with respect to marine organisms, by Murray and Irvine.<sup>1</sup> It accounts for the enormous amount of calcium carbonate at the bottom of the ocean, which once formed part of the tests or skeletons of living organisms. A limited amount of purely inorganic precipitation does, indeed, take place in coral reefs and some shallow-water deposits and in the Black Sea. In the Mediterranean, for instance, stone-like crusts are plentiful, consisting of clay cemented by calcium carbonate, which latter is produced by ammonium carbonate arising from the decay of organic matter in the mud below bottom-level meeting with fresh sea-water from above. We have further the lime-concretions of the Pourtales, Argus, and Seine banks, the "Challenger" casts of shells from the Great Barrier Reef,<sup>2</sup> and so on. But all these must be regarded as rarities. A great many of the reactions here referred to are believed to be ruled by enzymes and catalytic substances.

Whilst a great deal of calcium is thus being taken out of solution throughout the ocean, conversely the carbonate is continually being redissolved. Calcium and magnesium carbonates are held in solution mainly as bicarbonates; but since these compounds are incapable of existence in the solid state, questions of precipitation and dissolution, so far as they can be approached on theoretical grounds, must be decided by the solubilities of the normal carbonates. The solubility of  $\text{CaCO}_3$  in water (foreign salts being absent), and the equilibrium of the various molecules and ions concerned, have been fairly thoroughly elucidated.<sup>3</sup> When  $\text{MgCO}_3$  is also present and sea-water is the solvent, matters become so complicated that we cannot calculate, from first principles, how near sea-water is to saturation for calcium carbonate. There are, however, direct empirical data on this point. From the experiments of Anderson with natural, and of Cohen and Raken with artificial, sea-water, it would appear that with regard to  $\text{CaCO}_3$ , in the final stable modification of calcite, sea-water is saturated and incapable of taking up more, under conditions of stable equilibrium. Nevertheless the ocean does unquestionably dis-

<sup>1</sup> *Proc. Roy. Soc. Edin.*, vol. xvii. p. 79, 1889.

<sup>2</sup> Deep-Sea Deposits Chall. Exp., pp. 170, 172, 1891.

<sup>3</sup> Bodländer, *loc. cit.*