

process of chemical pseudomorphism, either after or during the formation of the limestone. The vertical ramifying masses of flint in Chalk show that the calcareous ooze had to some extent accumulated before the segregation of these masses.¹³³

3. PHOSPHATIC.—A few invertebrata contain phosphate of lime. Among these may be mentioned the brachiopods *Lingula* and *Orbicula*,¹³⁴ also *Conularia*, *Serpulites*, and some recent and fossil crustacea. The shell of the recent *Lingula ovalis* was found by Hunt to contain, after calcination, 61 per cent of fixed residue, which consisted of 85.70 per cent of phosphate of lime; 11.75 carbonate of lime, and 2.80 magnesia. The bones of vertebrate animals likewise contain about 60 per cent of phosphate of lime, while their excrement sometimes abounds in the same substance. Hence deposits rich in phosphate of lime have resulted from the accumulation of animal remains from Silurian times up to the present day. Associated with the Bala limestone, in the Lower Silurian series of North Wales, is a band composed of concretions cemented in a black, graphitic, slightly phosphatic matrix, and containing usually 64 per cent of phosphate of lime (phosphorite).¹³⁵ The tests of the trilobites and other organisms among the Cambrian rocks of Wales also contain phosphate of lime, sometimes to the extent of 20 per cent.¹³⁶ Phosphatic, though certainly far inferior in extent and importance to calcareous, and even to siliceous, formations, are often of singular geological interest. The following examples may serve as illustrations.¹³⁷

Guano—a deposit consisting mainly of the droppings of sea-fowl, formed on islands in rainless tracts off the western coasts of South America and of Africa. It is a brown, light, powdery substance with a peculiar ammoniacal odor, and occurs in deposits sometimes more than 100 feet thick. Analyses of American guano give—combustible organic matter and acids, 11.3; ammonia (carbonate, urate, etc.), 31.7; fixed alkaline salts, sulphates, phosphates, chlorides, etc., 8.1; phosphates of lime and magnesia, 22.5; oxalate of lime, 2.6; sand and earthy matter, 1.6; water, 22.2. This

¹³³ On formation of chalk-flints, see Book III. Part II. Section iii. § 3.

¹³⁴ Sterry Hunt, Amer. Journ. Soc. xvii. (1854), p. 236. Logan's "Geology of Canada," 1863, p. 461.

¹³⁵ D. C. Davies, Q. J. Geol. Soc. xxxi. p. 357. ¹³⁶ Hicks, op. cit. p. 368.

¹³⁷ For an exhaustive account of deposits of phosphate of lime, see R. A. F. Penrose, Jr.; Bull. U. S. Geol. Surv. No. 46, 1888, also postea, Book III. Part II. Sect. iii. § 3.