

characters to admit of even an approximate classification as to their origin. Among these are magnetite, black mica, apatite, epidote, zircon, delessite, and zeolites, such as analcim and chabasite. Some of these, as epidote and zircon, would not likely be found in any abundance among the debris of recent rocks; their presence, however, is possible. As to the secondary minerals and products of alteration, like glauconite, oxides of iron and manganese, zeolites, phosphates, and carbonate of lime casts, they will be considered in detail in the succeeding chapter.

Although it may be difficult to determine the relative abundance of the different kinds of mineral particles in each type of deep-sea deposit, still it may be stated generally that volcanic minerals, which bear distinctly the impress of their origin, are not only universally distributed throughout deep-sea deposits as a whole, but that they abound in the pelagic deposits properly so called, where they form essential constituents. In these pelagic regions the minerals are angular, generally of small dimensions, have a relatively fresh aspect, and are attached to vitreous particles or to rocks of volcanic origin. In certain cases these same volcanic minerals occur in the free state in Volcanic Muds and Sands close to the coasts, but then the dimensions and physical characters permit us to distinguish them from minerals of the same nature found in the deposits forming at depths beyond the mechanical action of the sea.

Some of the figures on the plates at the end of the volume represent the aspect of these volcanic minerals in the deposits of the littoral and shallow-water zones. Pl. XXVI. fig. 5 shows such particles from the littoral zone at the Sandwich Islands, where they are almost exclusively composed of broken crystals of olivine; this uniformity of the minerals proves that we are dealing with a deposit from a position in which the action of wind and water effects a separation according to specific gravity. A similar separation of minerals is never observed in deep-sea deposits, where the elements are much less voluminous, as may be seen by reference to figs. 1 to 4 on the same plate. Pl. XXVII. fig. 6 represents rounded grains of quartz, glauconite, tourmaline, and zircon, from Station 189, 28 fathoms, in the Arafura Sea. Pl. XXVI. fig. 6 represents the volcanic minerals of a shallow-water deposit off the Admiralty Islands. As in fig. 5 the grains are large; some are distinctly rolled, and among them are plagioclase, hornblende, augite, olivine, magnetite, fragments of volcanic glass, palagonite, rounded lapilli, and quartz. Pl. XI. fig. 2 shows the volcanic mineral particles in a deposit further removed from the coast, but not in pelagic conditions properly so called; these are from a Blue Mud, Station 237, 1875 fathoms, off Japan. Among the particles are plagioclase, sanidine surrounded and enclosed by a blackish opaque glass, hornblende, augite, little plates of black mica, magnetite, and fragments of volcanic glass more or less decomposed. In Pl. XXVII. figs. 1 to 3, and Pl. XXVI. figs. 2 to 4, the characters under which these volcanic minerals appear in pelagic deposits are represented, and may be compared with the figures above referred to.