

sea-water sulphates. In all deep-sea muds there is a certain amount of decaying animal and vegetable matter fallen from the hydrosphere, the proteids of which leave their sulphur, so far as it escapes oxidation, combined with the iron of the surrounding mud. But apart from this rather insignificant item, there are bacteria which, whilst living on sarcodic matter, seize on the dissolved sulphates of sea-water and reduce them to sulphides; the latter react with whatever ferruginous material is present, and produce the highly insoluble compound ferrous sulphide. Free sulphur, when found, is to be accounted for by the partial oxidation of sulphides, either by dissolved oxygen or at the expense of ferric iron. The retention of sulphur in bottom-deposits can only occur where there is plenty of decaying organic matter, where the bottom-waters are stagnant, or nearly so, and not well aerated, and where there is not a copious hail of calcareous tests; that is, mainly in the lower layers of muddy bottoms at shallow and medium depths. The sea-water imprisoned below the upper layer of mud becomes poorer in sulphate and richer in carbonic acid,¹ whilst the mud is darkened in colour by very finely-divided and easily oxidizable ferrous sulphide. Under suitable conditions the ferrous sulphide may, as in Black Sea muds,² combine with free sulphur and attain a condition of higher stability in the form of pyrites. The essential chemical factor which renders possible the retention of sulphur is the power of the colloidal ferric hydroxide in clay to react with sulphides. A small quantity of ammonium sulphide added, in the laboratory, to ordinary Red clay from the deep sea, at once goes into reaction: the clay is darkened to a tint resembling that of Blue mud; the original tawny colour is restored by atmospheric oxidation; the darkened clay evolves sulphuretted hydrogen with dilute acid. At the same time it is well to remember that many Blue muds owe their colour to quite other causes than the presence of sulphur.

The reduction of sulphates occurs only where there is a continuous deposition of detritus, and takes place, in the submarine muds, in the deeper layers. Consequently under normal conditions precipitated sulphur does not perform a cycle between bottom and sea, but remains irrevocably buried, accumulating as the deposit accumulates. No attempt seems hitherto to have been made to determine the ferrous sulphide in marine muds, but it is probably very minute in amount.

¹ Murray and Irvine, *Trans. Roy. Soc. Edin.*, vol. xxxvii. p. 481, 1893.

² Murray, *Scott. Geogr. Mag.*, vol. xvi. p. 673, 1900.