

Challenger water analyses, had the satisfaction of finding that they had all given a small surplus of base, amounting on an average to 86 equivalents per 10,000 equivalents of acid present, corresponding (if we assume the excess of base to be present as normal carbonate) to about 0.11 gramme of carbonic acid, equivalent to 0.25 gramme of carbonate of lime per 1000 grammes of sea water analysed. While recognising the importance of this result, I was keenly alive to the possibility of its having been brought about by a constant positive error in my sum total of base determinations, and accordingly sought for an exact direct method for the determination of the surplus base in a given sea water."

That sea water has an alkaline reaction was observed early in the cruise by Mr. Buchanan. On the 29th September 1873 it was first remarked, and on that day the alkalinity in the cold of the surface water was repeatedly determined in samples of 500 c.c. each by means of tenth normal hydrochloric acid, using rosolic acid as an index. It was found that 3.5 c.c. 0.1HCl was required to neutralise 500 c.c. sea water, or that 1 litre of sea water is sufficiently alkaline to neutralise 7 c.c. of tenth normal acid, neutrality being indicated by rosolic acid. In other words, the alkalinity is equal to what would be produced by dissolving 28 mgrm. caustic soda (NaHO) in a litre of water. It was found that the water so neutralised recovered its alkaline reaction on standing, and that its alkalinity was increased by boiling.

Mr. Buchanan's observation of the alkalinity of sea water, though original, was not new. It had already been observed by v. Bibra. Its true significance was not seized until the discovery was again made independently by Tornøe on the Norwegian expedition. By working it out he showed that the whole of the carbonic acid in the sea waters experimented on by him must be taken as combined with base, and the average of his experiments gave for carbonic acid forming carbonates 52.78 mgrm. per litre and for carbonic acid forming bicarbonates 43.64 mgrm. per litre, that is, that in the average of the waters examined by him there were bicarbonates and neutral carbonates dissolved in the proportions of 43:9. It is evident that in these waters there was no carbonic acid which could be called "free," and the deficiency in the amount required to form bicarbonate goes to explain the alkaline reaction of freshly drawn sea water in the cold.

Professor Dittmar in his Report treats the subject of the alkalinity of sea water and its dependance on dissolved carbonates in an elaborate and exhaustive manner.

The average composition of ocean water salts, as the result of 77 complete analyses, has been given on p. 954. Commenting on these results, Professor Dittmar says :¹—
"As a general result of Forchhammer's and my own analyses, *the above numbers may be taken as holding approximately for any sample of ocean water.* Of the degree of approximation we can form an idea by comparing my numbers for the percentages of chlorine, sulphuric acid, magnesia, and potash, with the corresponding entries in the 77 reports tabulated on pages 23 to 25, and the numbers for the lime there with

¹ Phys. Chem. Chall. Exp., part i. p. 204, 1884.