

while carbon-dioxide, sulphuretted hydrogen, and nitrogen occur at all the fumaroles, even where the temperature is not higher than that of the atmosphere.'

The following are the chief gases and acids evolved at volcanic fumaroles. Hydrochloric acid is abundant at Vesuvius, and probably at many other vents whence it has not been recorded. It is recognizable by its pungent, suffocating fumes, which make approach difficult to the clefts from which it issues. Sulphuretted hydrogen and sulphurous acid are distinguishable by their odors. The liability of the former gas to decomposition leads to the deposition of a yellow crust of sulphur; occasionally, also, the production of sulphuric acid is observed at active vents. From observations made at Vesuvius in May, 1878, Mr. Siemens concluded that vast quantities of free hydrogen or of combustible compounds of this gas exist dissolved in the magma of the earth's interior, and that these, rising and exploding in the funnels of volcanoes, give rise to the detonations and clouds of steam.⁷ At the eruption of Santorin in 1866, the same gases were also distinctly recognized by Fouqué, who for the first time established the existence of true volcanic flames. These were again studied spectroscopically in the following year by Janssen, who found them to arise essentially from the combustion of free hydrogen, but with traces of chlorine, soda, and copper. Fouqué determined by analysis that, immediately over the focus of eruption, free hydrogen formed thirty per cent of the gases emitted, but that the proportion of this gas rapidly diminished with distance from the active vents and hotter lavas, while at the same time the proportion of marsh-gas and carbon-dioxide rapidly increased. The gaseous emanations collected by him were found to contain abundant free oxygen as well as hydrogen. One analysis gave the following results: carbon-dioxide 0.22, oxygen 21.11, nitrogen 21.90, hydrogen 56.70, marsh-gas 0.07=100.00. This gaseous mixture, on coming in contact with a burning body, at once ignites with a sharp explosion. Fouqué infers that the water-vapor of volcanic vents may exist in a state of dissociation within the molten magma whence lavas rise.⁸ Carbon-dioxide rises

⁷ "Santorin et ses éruptions," Paris, 1879.

⁸ Monatsb. K. Preuss. Akad. 1878, p. 588.

⁹ Fouqué, "Santorin et ses éruptions," p. 225.