Subaerial observations of subaqueous eruptions: useful inferences from an incomplete and unrepresentative dataset

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Volcanoes in eruption across continents and islands from ancient to recent times have given their names to styles of eruptions we recognize today, such as Strombolian, Vulcanian, and Hawai'ian. The bulk of the world's eruptions lack evocative names, however, because they occur underwater and unobserved; such eruptions produce most of the volcanic and volcaniclastic rocks extant.

The eruption forming the island of Surtsey gave name to a style of eruption also called "emergent", and represents well the observations that have been made of subaqueous eruptions. During the bulk of Surtsey's growth from the 130m-deep seafloor, no observations at all were made, but downwind residents recalled a sulfurous odor beginning 3 days before emergence, and there were weak seismic signals a week before emergence. Later, when the surface of the volcano grew to just below the sea's surface, discoloration and churning of the water were noted; steam began to form an ash-bearing atmospheric plume. Finally, the volcano began to form an island and a compelling suite of observations were obtained. In addition, other volcanoes grew to the surface as part of the 2 year eruption, providing additional glimpses of the process of emergence and some immediately preceding subaqueous activities. Such observations of eruption from shallowly submerged or flooded vents form the whole of our direct observational record of explosive submarine eruptions. Some of the observations are particularly useful in understanding the behavior of fully subaqueous eruptions. Both discrete and continuous explosivity occurred from individual vents from the earliest times observed. Turbulent discolored water, explosions, floating pumice, subaqueous incandescent flashes, and concentric waves were noted prior to emergence. There were multiple, ephemeral, often simultaneously active vents in a km-long line as Surtsey shoaled. Islands were repeated eroded away in one or a few days, even when emerged to more than 50 m in height; Syrtlingur island was destroyed entirely after emergence at least 3 separate times, and partly destroyed on many other occasions. Despite the lack of observations of explosivity from depths of more than a few meters, we know from geophysical observations and from ancient examples that Surtseyan volcanoes consist at all levels largely of clastic debris with little or no coherent lava. Surtsey may have grown subaqueously 130 m in one week. Many surtseyan depositional features can be interpreted in terms of primary depositional processes based on the observations from emergent eruptions, and record growth of the volcano edifice. The Surtsey eruption also illustrates the important role of syn-eruptive erosion, which produces reworked debris intercalated with beds formed directly from the eruption without intervening storage.