Complex interaction between Strombolian and phreatomagmatic eruptions in the Miocene monogenetic volcanism of the Harrat Shama Volcanic Field (SW of Sauda Arabia)

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The Harrat Shama volcanic Field (HSVF) is a well-exposed, intra-continental extensional basin during the opening of the Red Sea, containing 5 km of Miocene preserved and uplifted bimodal volcanics and interbedded volcaniclastic rocks. The HSVF comprises proximal wall deposits with a well defined crater wall unconformity and crater-fill deposits. The style of volcanic activity was mainly explosive and was reinforced by hydrovolcanic processes. The Shama deposits can be divided into two sequences depending on the field observations and the main depositional characteristics: lower sequence represents volcanic aggradational processes that constructed the crater, and is composed of hyaloclastites, zeolite-bearing bedded tuffs, and explosively fragmented accretionary bedded lapillituffs of wet surge facies and an upper sequence, made up of ash flow deposits and peperitic breccias that are capped by basaltic lava flows. The differences between the two sequences are reflected in both eruption dynamics and fragmentation mechanisms as well as the overall characteristics of the deposits. Fluvial erosion and deposition completed the evolution of the emerged marginal part of the basin.

The two complex volcanic successions that show evidence of several eruptive episodes, were built by magmatic and hydrovolcanic explosions of different styles (Strombolian, sub-Plinian and phreato-Strombolian) generated from a common source. They formed a dynamic closed intra-continental sedimentary system that experienced a successive subsidence. The initial eruptions are interpreted to have been dominated by discrete, highly efficient, phreatomagmatic fall deposits, which are attributed to an overall high eruption rate in a deep lacustrine setting (lower sequence), followed by a transition to dominantly subaerial ash-flow deposits and volcaniclastic sediments sited in the upper part of the basin. The Phreatomagmatism has contributed to the construction of more than a half of this volcanic edifice, frequently associated with the Strombolian activity but also independently, giving rise to a large variety of eruptive sequences. Dome growth occurred at the end of the eruption, but subsequent retrogressive explosions triggered by external water destroyed all trace of the original dome morphology. We find that the main cause of such complex eruptive behaviour resides in the stratigraphic, structural and hydrogeological characteristics of the substrate above which the volcanoes were emplaced, rather than on the compositional characteristics of the erupting magma, as they do not show significant variations among the different deposits studied.