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Dry? or Wet? Magma-Water Interaction during Minoan-Thera Eruption of Santorini depicted from 3D morphological analysis of Ashes

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Powerful and, catastrophic Minoan-Thera eruption of Santorini occurred at mid-second millennium BC (∼3300 BP) produced totally 30 km3 DRE of tephras (Sigurdsson et al., 1990; Pyle, 1990). Magnitude of Minoan-Thera of Santorini Late Bronze Age eruption was estimated as 6 (Colossal) to 7(super colossal) corresponding to Plinian/Ultraplinian style activity according to Volcanic Explosivity Index (McCoy&Heiken,2000). During this one of the largest eruptions in the human history, vent properties and eruption dynamics have changed from dry plinian phase (first phase) to wet phreatomagmatic surges and to pyroclastic flows, comprising of four distinct phases. Convective eruption cloud formed in the first phase was under influence of westerly winds, according to numerous published papers, extending toward east-northeast-southeast, toward Black Sea, Turkey, Mediterannean Sea.

We drilled Letoon Plain, southwestern coast of Turkey and cut 3 cm thick tephra deposit overlying an organic material-rich layer dated as 1612 BC (C14, AMS method), corresponding well to the age of Minoan-Thera eruption. The iron content of Minoan-Thera tephras ($\geq$ 2%) is higher than Turkish tephras (in general <2%). Grain size distribution of our Minoan-Thera tephra measured by Laser Sizer exhibits that drilled tephra is mostly fine-grained and 93 % of tephra is below 100 microns, meeting distal tephra characteristics.

We examined the surficial morphological features of distal, fine grained tephra and applied some quantitative statistical parameters for surface descriptors of volcanic ashes such as “Average roughness of profile (Ra), Surface Area (SA), Volume (V), Fractal Dimension of Roughness (DAS), Projected Area (PA)”. We compared quantitative morphological data acquired from Minoan-Thera eruption with that of well-known plinian style and phreatomagmatic eruptions derived from Central Turkey. Fragments of Minoan-Thera tephras either have tubular, spherical vesicles indicating magmatic fragmentation, or are sometimes blocky-equant, mosslike grains and curviplanar cut and shallow vesicles depicting typical phreatomagmatic fragmentation. We calculated True Surface Area (SA) and Plotted Area (PA) of ashes. SA/PA values of Santorini 63 μ deposits vary from 1.35 to 3.96, besides those of 125 μ range between 1.32-2.18. Comparing all SA/PA values, we can conclude that vesiculated ashes have SA/PA around 1.8 and over. Some are > 2 as polyhedron – multifractal unvesiculated glassy ashes. Meanwhile, blocky-equant ashes have SA/PA <1.6. On the correlative diagrams of surface descriptors, the intermediate character of Santorini tephras between Plinian deposits and Phreatomagmatic deposits is obvious. Ash surface morphology, surface descriptors, and the correlation with the known eruptions of distal tephras of Minoan-Thera indicate that the nature of the first phase of Minoan-Thera is not purely magmatic as it was classically claimed in most of the previous works.