Morphology of ash aggregates from a volcanic eruption (Zelve eruption) in Cappadocia-Central Anatolia, Turkey: An x-ray computed micro-tomography study

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Aims
Ash aggregates may convey information about the modes of eruption of volcanoes, transport and deposition of volcanic products. However, they were characterized on two-dimensional SEM micrographs or thin-sections to date. Here, the morphologies of ash aggregates from Zelve eruption in Cappadocia (Central Anatolia-Turkey) were obtained using X-ray computed micro-tomography (CMT), a non-destructive method providing three-dimensional data enabled the quantification of some properties which provide the estimation of the style of transportation and deposition of ash aggregates.

Method
Tomographic data were obtained using Skyscan (Belgium) 1174 compact micro-CT at Department of Anatomy in the Faculty of Medicine at Hacettepe University (Turkey). 50 kV X-ray source was used with a power of 40W. The ash aggregate samples were rotated at 1° steps over 360° rotation and their sinograms were acquired by a cooled 1,3 megapixel X-ray camera.

Results
All aggregates have coarse-grained cores surrounded by fine-grained rims (rim-type1) (Figure 1). The cores of aggregates are elongated or sub-spherical and can be easily distinguished from surrounding rims where they are separated from each other by bands and patches of vesicles. The size and abundance of vesicles vary through the contact planes between cores and rims. Some contact planes lack vesicles where the transition is indistinct. Different shaped vesicles (irregular, elongated, rounded to sub-rounded) are widely dispersed within the cores of ash aggregates. The ruptures have maximum lengths about the diameter of the core and apertures approximately 200 μm. The rims are internally graded with grain size decreasing progressively outward (graded rims1) and contain vesicles only at zones close to the cores. Three-dimensional models for rim-type ash aggregate are given in Figure 2. Average porosity for ash aggregate is about 24%. Porosity values were computed after segmentation of pores and by straight voxel counting on three-dimensional models. Minerals, glass and pores are distinguished in X-ray tomography on the basis of their linear attenuation coefficient, μ which depends on the electron density and the effective atomic number of the material, and the energy incoming X-ray beam. In this way, the phases in the aggregates can be identified based on variations in brightness in tomography images. EDS analyses were performed in order to determine the composition of phases. Most accreted particles consist of phenocrysts of plagioclase, quartz, biotite and scattered magnetite and
Ti-magnetite. Some aggregates have inclusions of pumiceous lapilli in the cores (Fig. 2B) and iron (hematite?) and apatite accumulations in the rims (Fig. 2C and 2D).

Figure 1: Orthogonal views of a rim-type ash aggregate. Patches of vesicles surrounding the core and different shaped vesicles in the core are illustrated.

Figure 2: 3D models of ash aggregates. A) Vesicles patches between core and rim and vesicles in the core were given in red color. B) A pumice inclusion in the core of an aggregate. C) Iron and apatite accumulations in the rim zone of aggregate. Watching the image with a pair of red/green stereo glasses produces an impression of depth (3D) D) The BSD SEM image of the accumulations (lighter-colored zones) in the aggregate. EDS analysis on accumulations give elemental peaks for Fe, Ca and P.

Conclusion
X-ray computed tomography (CT) is an established and rapidly evolving 3D imaging technology of proven value for geological investigations. Its area of usage is expanding and recent advances in X-ray tomography will enable it to be applied to open questions in geosciences. In this study, the morphologies of ash aggregates which convey information about the origin, transportation and deposition of pyroclastic deposits were presented in three-dimensions for the first time. Local iron (hematite?) and apatite accumulations in the rim zones of ash aggregates were displayed that may be missed after two-dimensional random sectioning. The adopted analysis can be improved by using an industrial CT with higher resolutions.

References: