Highly explosive basaltic eruptions: the case of the sunset crater (az, usa)

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Volcanic eruptions involving basaltic magma usually produce low explosivity events characterized by lava flow effusion, lava fountains and/or small Strombolian explosions. However, more explosive eruptions, ranging from violent Strombolian to sub-Plinian and Plinian events, are not uncommon and can represent a serious threat for to nearby populated areas. The study of highly explosive mafic eruptions thus provides an important test of our understanding of eruptive processes. The eruption of Sunset Crater volcano represents an interesting case in that it produced highly explosive eruptions, up to sub-Plinian in scale, that heavily affected the pre-historic communities in the area, and also produced intermittent episodes of lava effusion. Sunset Crater is a >300 m high scoria cone located ~25 km northeast of Flagstaff, AZ (USA), in the San Francisco Volcanic Field. The eruption produced three lava flows that cover ~8 km^2, a scoria-fall blanket up to 12 m thick covering an area of about 500 km^2, and minor spatter cones and ramparts that marked the onset of the eruption. The tephra sequence consists of at least eight fall units associated with major explosive phases, mainly dispersed to the east. The total volume of individual fall units varies between 0.02 and 0.08 km^3 DRE. The maximum is estimated for the Unit 3 deposit (0.08 km^3 DRE) and the total cumulative volume is ~0.3 km^3 DRE. This value is close to the volume calculated based on the total deposit isopach map from Ort et al. (2008, JVGR 176(3): 363-376) (~0.4 km^3 DRE). Associated column heights, calculated based on the maximum clast-size distribution of Amos (1986, ASU MS Thesis), are between 7 km (Unit 2) and 25 km (Unit 3). Sunset Crater scoria are characterized by a density of 1.2-1.9 x 10^3 kg m^{-3}, which corresponds to 35%-67% vesicularity. The chemical composition is nearly uniform (~47 wt.% SiO_2) for all eruptive units. Two textural endmembers, intimately intermingled at the mm-scale within a single clast, were identified: one endmember (sideromelane) is characterized by higher vesicularity, with large regular sub-spherical vesicles (modal diameter 0.6 mm), a glass-rich groundmass and evidence of post-fragmentation vesicle expansion; the second endmember texture (tachylite) is characterized by lower vesicularity, with small highly irregular vesicles (modal diameter 0.3 mm) that result in a higher vesicle number density than the sideromelane, and a groundmass rich in microcrysts, mainly Fe-oxides. Scoria compositions and textural characteristics suggest interaction between magmas stored at different depths. The crystalline tachylite texture is interpreted as shallower magma that mixed, in the upper conduit, with more rapidly cooled and decompressed magma (sideromelane) sourced from deeper crustal levels.