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The transition from Strombolian to fire-fountain activity at active basaltic volcanoes: insight from the early 2000 Southeast Crater eruption on Mount Etna (Sicily)

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Persistently degassing basaltic volcanoes are characterized, besides 'typical' lava effusions, by explosive eruptive activity of variable intensity. At Mount Etna, explosive activity may span from mild to strong Strombolian explosions up to the transition to violent lava-fountain episodes consisting of vigorous, continuously sustained, jets of liquid magma and gas, frequently followed by a buoyant ash and lapilli column a few km high. Despite the frequency of occurrence, this type of activity has not been the focus of much work yet. Here, we use textural and compositional studies to investigate the 64 fire-fountain episode period that characterized Southeast Crater (SEC) from 26 January to 24 June 2000. Since each episode was immediately preceded by Strombolian activity, this eruptive sequence offers the unique opportunity to investigate the mechanisms driving the transition from one eruptive style to the other. We choose three episodes because they are well constrained by volcanological/chronological observations, and favourable circumstances allowed samples representative of both eruptive styles to be safely collected. Examination of samples from both Strombolian and fire-fountain activity points out that: 1) vesicularity is similar (ranging 0.50-0.60), but vesicle number density is lower in Strombolian scoria, vesicles are larger and show multiple steps of coalescence; 2) groundmass crystallinity does not discriminate between clasts from the two different regimes, as sideromelane (microlite-free glass) and tachylite (variably crystallized groundmass glass) occur in scoria from both Strombolian and lava fountain activity. Furthermore, tachylite and sideromelane frequently coexist and are heterogeneously distributed within the same sample. However, groundmass crystals are twice as thick in Strombolian scoria in comparison to lava

fountain; 3) sideromelane glass compositions measured in Strombolian scoria result slightly more evolved than in fire-fountain samples. Both compositions lie along the liquid line of descent from a common magma represented by the average bulk rock composition of 2000 activity. On the contrary, tachylite does not discriminate between scoria clasts from the two styles. Tachylite composition is overall more evolved than sideromelane, but measurements are strongly scattered also within the same sample, suggesting that the nature and high content of groundmass microlites strongly control liquid composition and its capability to homogenize. The overall dataset on textures and compositions of clasts from both eruptive styles indicate that magma initiating the Strombolian phase of each episode was resident long enough to exsolve, grow crystals, and develop permeability generating pathways of mildly esplosive gas separation. Instead, magma from the climactic fire-fountain phase of the episode has evidence of non-equilibrium fluid-dynamics, with syn-eruptive volatile exsolution, fast ascent, no time for growing microlites, and extremely explosive burst of gases out of the mixture. The onset of increasing eruptive activity thus appears to be driven by these two contrasting modes of magma degassing.