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Tephra architecture, pyroclast texture and magma rheology of mafic, ash-dominated eruptions: the Violent Strombolian phase of the Pleistocene Croscat (NE Spain) eruption.

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A broad range of low- to mid-intensity explosive activity is dominated by the emission of ash-sized pyroclasts. Among this activity, Violent Strombolian phases characterize the climax of many mafic explosive eruptions. Such phases last months to years, and produce ash-charged plumes several kilometers in height, posing severe threats to inhabited areas.

To tackle the dominant processes leading to ash formation during Violent Strombolian eruptions, we investigated the magma rheology and the field and textural features of products from the 11 ka Croscat basaltic complex scoria cone in the Quaternary Garrotxa Volcanic Field (GVF).

Field, grain-size, chemical (XRF, FE-SEM and electron microprobe) and textural analyses of the Croscat pyroclastic succession outlined the following eruption evolution: activity at Croscat began with fissural, Hawaiian-type fountaining that rapidly shifted towards Strombolian style from a central vent. Later, a Violent Strombolian explosion included several stages, with different emitted volumes and deposit features indicative of differences within the same eruptive style: at first, quasi-sustained fire-fountaining with ash jet and plume produced a massive, reverse to normal graded, scoria deposit; later, a long lasting series of ash-explosions produced a laminated scoria deposit. The eruption ended with a lava flow breaching the western-side of the volcano.

Scoria clasts from the Croscat succession ubiquitously show micrometer- to centimeter-sized, microlite-rich domains (MRD) intermingled with volumetrically dominant, microlite-poor domains (MPD). MRD magmas resided longer in a relatively cooler, degassed zone lining the conduit walls, while MPD ones travelled faster along the central, hotter streamline, the two interminging along the interface between the two velocity zones. The preservation of two distinct domains in the short time-scale of the eruption was favoured by their rheological contrast related to the different microlite abundances.

The proportion of MPD and MRD, in agreement with bubble-number density (BND), in different tephra layers reflects the extent of the fast- and slow-flowing zones, thus reflecting the ascent velocity profile of magma during the different phases.

Recent works (Kueppers et al. 2006, "Explosive energy" during volcanic eruptions from fractal analysis of pyroclasts) indicate that fractal fragmentation theory may allow for quantifying fragmentation processes during explosive volcanic eruptions by calculating the fractal dimension (D) of the size distribution of pyroclasts.

At Croscat, BND and MPD/MRD volume ratio decreased during the violent Strombolian activity while D increased, suggesting that the decrease in the magma flow rate was accompanied by the increase in fragmentation efficiency, i.e. by the increase in the ash production capability. This trend may be tentatively attributed to an increased rheological stiffness of the magma progressively enhancing its brittle, more efficient fragmentation.