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Ballistic analysis during multiscale explosive eruption at Vesuvius and hazard implications

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Ballistic Projectiles (BP) are rock-basement or magma fragments of variable size and density that are ejected from vents during explosive eruptions and follow almost parabolic trajectories that are influenced by gravity and drag forces before they reach their impact point on the surface.
During the past century, numerous observers have described the violent ejection of large blocks and bombs from volcanoes during volcanic explosions. Starting from '40 years of last century, several authors developed a mathematical expression relating initial velocity and trajectory angle of ejected blocks to the range, taking into account air drag and assuming a constant drag coefficient; but only in the last 30 years was developed the first mathematical algorithm for ballistic trajectories in the volcanological literature that considered variations in drag coefficient with Reynolds number. Finally, with 21st century computer power, ballistic computation should be available to anyone as a back-of-the-envelope indicator of explosive power by a user-friendly computer program.
At Mt. Vesuvius a series of explosion events accompanied eruptive mechanism stages during its history. In particular the explosive eruptive events at Vesuvius was affected by 3 types of energy activity: i) a normal strombolian activity that consists of rhythmic, mild to moderate explosions lasting a few seconds that eject scoriaceous lapilli and bombs, ash and lithic blocks; ii) a vulcanian or violent explosions characterized by short-lived events involving more than one vent, defined as strombolian paroxysms; iii) from sublinian to plinian activity, that have been the most powerful events observed at Mt. Vesuvius; on the other hand plinian was indicated as the energetic term to define the most famous eruption of 79 AD.
In this study, an eruptive model appropriate for exanimated eruptions, is used to estimate initial conditions (ejection height, take-off angle, velocity) for BP, assuming a broad range of gas concentration/overpressure in the vent. These initial conditions are then inserted into a ballistic model for the purpose of calculating the maximum range of BP for their different sizes (0.20-1.2 m), varying drag coefficient as a function of BP velocity and varying air density as a function takeoff point along eruptive column of the event examinated. Furthermore, the gas expansion in the column reduces the drag force on BP and assists their vertical-lateral transport. In agreement with previous studies a zone of reduced drag is also included in the ballistic calculations that is determined based on the size of vents that were active at Vesuvius during past eruptions.
Finally, the results for BP range (from 3 to 14 km) raise some significant implications regarding hazard zones for different future eruptive scenario.