Magma withdrawal below ground-water table as a trigger to form large maars over high magma discharge rate fissure-fed lava spatter/scoria cones: the Al Wahbah Crater (Harrat Kishb, Saudi Arabia)

Karoly Nemeth[1], Mohammed Rashad Moufti[2], Nabil El-Masry[2], Atef Qaddah[2]

[1]Institute of Agriculture and Environment, Massey University, Private Bag 11222, Palmerston North, New Zealand, [2]Faculty of Earth Sciences, King Abdulaziz University, P.O. Box 80200, Jeddah, 21589, Saudi Arabia

E-mail: k.nemeth@massey.ac.nz

Al Wahbah Crater is one of the largest and deepest Quaternary maar crater (NW-SE-elongated, appx.2.3-km wide and 250-m deep with an irregular near-perpendicular crater wall) not only in the Arabian Peninsula but also among other craters of volcanic fields on Earth. It is located in the SW edge of the bimodal (alkali olivine basalt/phonolite) Harrat Kishb (2Ma-Recent) that formed lava flows over 6000-km2. Al Wahbah Crater cuts deeply into the pre-eruptive surface exposing the Proterozoic diorite basement that is covered by at least two basanitic lava sheets and a lava spatter/scoria cone defining the crater as a maar. The half-sectioned pre-maar cone in the NW demonstrate that the maar collapse post-date the lava schield and cone formation. The lack of evidences to support significant time break between the pre-maar cone-building pyroclastic beds and the dune-bedded accidental lithic-rich pyroclastic beds that form the tuff ring suggests that the pre-maar cone (and its lava flow) and the tuff ring formation is in a time-continuum and they formed in the same eruptive episode. In this respect Al Wahbah's eruption is unique and differs from maar formation that implies initial magma-water interaction-driven explosions near surface followed by gradual explosion locus down-migration as a result of gradual exhaustion of ground-water sources (Lorenz's model). Al Wahbah seems to have been followed an opposite eruption path started with an initial lava shield and cone-building phase that have been intervened by phreatomagmatic explosive eruptions that have been culminated in a maar collapse and tuff ring formation. This scenario can be best explained by the drop of the magma discharge rate causing magma withdrawal below regional ground-water table. The drop in the magmatic pressure in the conduit due to the decrease in magma rise speed enhanced ground-water to enter to the top of the withdrawn magma column through cracks along the unsupported solidified mnargin of the conduit wall. As a result, effective thermohydraulic explosion took place initially in the time when the same volcanic system still emitted lava flows that rafted cone material and damping tuff breaccia on top of the still moving lava flows allowing protrusions of lava into the freshly deposited wet pyroclastic blanket. In the main phase of the maar-forming event the reduced magma discharge rate shifted the efficiency of the explosive phreatomagmatic magma fragmentation to its maximum to produce base surges that were travelled radially at least 2-km from their source leaving behind a quickly thinning blanket of dune-bedded pyroclastic deposit that covered, plastered and engulfed everything around the newly formed maar. It seems Al Wahbah represents a rare but potentially one of the most hazardous volcanic phenomena documented in the Harrat Kishb that is essential to understand to develop accurate volcanic hazard scenarios at the Harrat Kishb and elsewhere.