

Factors influencing effusive and explosive eruptions of trachytic-phonolitic magmas, an example suite from Harrat Rahat, Saudi Arabia

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The 20,000 km² intraplate field of Harrat Rahat in Saudi Arabia hosts >1000 volcanic structures erupted between c.10 Ma to 1256AD. Alkali basaltic volcanism dominates, but in the central northern areas of the field (where the lava pile is thickest), more evolved magmas erupted, including benmoreitic, and trachytic compositions. These most evolved products exhibit a range of eruption styles that appear to represent a combination of controlling factors including: eruptive volume, compositional variation, mafic magma intrusion and dissolved gas content. The effusive volcanic suite ranges from simple cryptodome/dome formation, to larger-volume eruptions of large, complex multi-stage domes with temporal variations in magma composition. These produced flank-collapse pyroclastic flows up to 1 km from the flanks. In the parallel explosive sequence, small-volume magma intrusions encountered ground water at depths of 100-300 m and resulting phreatomagmatic explosions formed deep maar craters with minor rings of explosion breccias. In larger volume examples, initial explosions were followed by pyroclastic surges, with further larger volume events producing tephra columns and fountain-collapse pyroclastic flows, deposited up to 4 km from source. In the largest-volume cases, larger pyroclastic flows (>7 km runout), surges and falls were generated in complex eruption sequences that may have lasted several weeks. The most complex eruptive sequences show trends from early near-phonolitic compositions, to later more-primitive compositions. Some sequences were also apparently interrupted by eruption of hotter more mafic magmas. These mafic magmas may be the cause of instability of mid-crustal trachytic magmas, leading to their rise and eruption. Early erupted units are completely crystalline with trachytic textures and no residual glass. Later products contain glass between phenocrysts and vesicles with rounded, but highly deformed margins where they were restricted by the crystalline network. Latest stage eruptives show very small isolated vesicles also restricted by the crystalline mush. Hence, expansion was late-stage, indicating rapid unroofing of very crystal rich magma bodies.