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Frequency of Boulders Transport during Large Floods in Hyperarid Areas using Paleoflood Analysis – An Example from the Negev Desert, Israel

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Direct measurements of boulder entrainment in desert wadis are not available. The 2004 flood (peak discharge - 470 m^3 s^{-1}; recurrence interval - 120 years) in the hyperarid, ungauged Nahal Hatzera ephemeral stream (45 km^2), which drains the Small Erosional Crater (SEC; Makhetesh in Hebrew) in the Negev Desert Israel, transported and deposited 0.85-2.1 m concrete boulders and slabs detached from infrastructure upstream as well as natural boulders. EDM and drone air-photographic surveys documented the geometry of the study reach and the location of boulders. Analyses of flood slackwater deposits established a paleoflood record of 23 floods with peak discharges of 200-760 m^3 s^{-1}, during the last 600 years. 1-D HEC-RAS hydraulic analysis provided water surface profiles, discharges and hydraulics, along the study reach and velocity, shear stress and stream power for each boulder Xsection.. MAX program and Pearson 3 distribution were used for flood frequency analysis. Most of the concrete boulders were deposited in the sub-critical backwater of channel constrictions where velocities were 1.5-2.1 m s^{-1}. The largest boulders were deposited in super-critical flow where velocity was 8-9.2 m s^{-1}. The sandy alluvial channel enables to transport these concrete boulders, reflecting the unstable, active sandy layer of the channel bed over which the boulders moved. The maximum flood shear stress and stream power characterize medium-large floods with return period of 20-120 years rather than the largest floods, which produce larger extension of backwater ponding upstream of constrictions. The combination of the flood frequency analysis and the hydraulic parameters of the flood enables to reconstruct the frequency of the tractive forces that transported these boulders. Boulders <2.1 m and weighing <15 tonnes can be transported at least once in 120 years. The shear stress and stream power indicate that the moderate-large floods are the most geomorphically effective floods rather than the largest floods in Nahal Hatzera basin. Nevertheless, the 'geomorphic effectiveness' of the 2004 flood – a typical desert flash flood, was small based on the minor changes along the channel and banks indicating that their resistance thresholds were not exceeded and energy expenditure was mainly on boulders entrainment and transport.