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Sediment source and mixing and the cycle of sediment transport: an example from NE Negev Desert, Israel

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Alluvial terraces represent the end product of sedimentary cycles; each includes sediment generation, transport, accumulation, and the ultimate incision that forms abandoned alluvial surfaces. We examine the middle Pleistocene to recent drainage system evolution in Makhtesh Hazera, Negev Desert, southern Israel and compare the characteristics of erosion and sediment transport in the present system with those expressed by the alluvial terraces. The Hazera drainage basin lies at the margins of the arid to hyper-arid Dead Sea rift (DSR). Makhtesh (crater) Hazera is a deeply incised erosional structure (5X7 km) that has been excavated since the early Pliocene into the crest of the Hazera asymmetric anticline. The Makhtesh floor is surrounded by cliffs rising more than 400 meters high. The cliffs are built of Upper Cretaceous hard carbonates caprocks overlying Lower Cretaceous friable quartz sandstones. Bedrock knickpoints isolate the drainage basin in the Makhtesh and above it from a direct influence of the terminal base level of the DSR. Thus, the accumulation of sediment and abandonment of terraces are controlled by climate and bedrock barriers located at the Makhtesh outlet. We use cosmogenic isotope concentrations to determine bedrock denudation rates, ages of alluvial terraces, and basin wide erosion rates in different channels throughout the basin. The use of cosmogenic isotopes enables us to determine sediment sources and reconstruct sedimentary cycles. OSL dating was used to determine the accumulation ages of alluvial sediment in alluvial terraces. These two methods enable quantitative evaluation of fluvial processes.

Bedrock erosion rates suggest a strong dependence of erosion on lithology. While the Lower Cretaceous sandstone erodes at >100 mm ky-1, the overlying hard carbonate caprock yielded cosmogenic isotope concentrations that correspond to erosion rates of 1-3 mm ky-1. This significant difference in erosion rates maintains the dramatic relief of the Hazera drainage basin. We find that the quartz sediment in the present fluvial system of Makhtesh Hazera originates from two predominant sources. One is the Lower Cretaceous sandstone that crops out along the base of the Makhtesh cliffs. The second source are un consolidated Miocene sands that fill the syncline which is located north west of the Makhtesh and is drained into it. 10Be concentrations in successive samples indicate that the Miocene sand is gradually diluted by Lower Cretaceous sand as it flows down stream and the mixing of sediment from both sources is good. Alluvial terraces and bedrock units exposed inside the Makhtesh do not contribute a significant amount of sediment to the present drainage system.

Three major alluvial terrace levels were identified. The highest terrace level (MKT0) was abandoned at 279±19 ky.This level probably covered most of the Makhtesh surface. The deposition of the two lower levels, MKT1 and MKT2 (which were abandoned at 160±6 and 47±9 ky, respectively), was confined to the present drainage system. Analysis of cosmogenic depth profiles from the terraces suggests significant recycling of sediment within the Mekhtesh. This is in contrast to the present system that lacks recycled sediment. We explain this difference by the fact that the terraces are the final product of a sedimentary cycle while the present drainage system presents a "snapshot" in time which does not represent the entire cycle only the present state of the system which is expressed by rapid incision and very little lateral migration.