

NATURAL ONGOING DESERTIFICATION IN THE ARID AND SEMI-ARID REGIONS OF THE MIDDLE EAST

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Introduction

In the arid and semiarid regions of the Middle East, gully incision erodes alluvial sediments and loess soils deposited during the Late Pleistocene along the valleys. This phenomenon becomes critical in the arid region of the Negev Highlands of southern Israel where the land carrying most of the natural biomass and which has agricultural value is limited to narrow valleys. These fields, cultivated during the Iron Age (3000 years BP) and the Roman-Byzantine Age (1800-1400 BP), were irrigated by runoff harvesting techniques. The semi-nomadic population in the region continues to cultivate parts of these fields even today.

Gully evolution and headcut migration

In most of the valleys in the region, headcuts, several meters deep are developed within the alluvial cover of the valleys (Fig 1). Downstream from the headcut, a narrow gully developed, whose base is 3-4 m below the valley floor. This phenomenon continues downstream almost without recovery.

The mechanism and rate of gully development and headcut migration has been studied in several locations in the Negev Highlands during the last 18 years. During flood events, the runoff penetrates the alluvial cover of the valleys, forming vertical headcuts, which gradually retreat up the valleys (Fig. 2). The deep and narrow gullies concentrate the runoff into narrow channels, preventing the irrigation of the whole width of the valleys. The annual migration of the headcuts in several monitoring sites within the study area ranges between less than 1 m up to 100 m. As a result, 10 to 440 m³/y of soil with agricultural value are eroded from each headcut (Fig. 3).

The sharp change in irrigation efficiency is reflected in a sharp drop in biomass. There is 80% less floral biomass below the gully headcuts than above them. This phenomenon continues downstream along the gullies, almost without recovery.

OSL dating and historical implications

OSL dating of alluvial units (Avni and Porat, 2002), as well as the position of archeological sites relative to the location of the headcuts and gullies within the valleys indicates that:

1. Loess sediments were deposited within the drainage basins during the last Late Pleistocene pluvial phase (aprox. 50– 20 KY BP).
2. Gully incisions initiated during the Late Pleistocene - Early Holocene (aprox. 16-7 KY BP), long before the initiation of the agriculture or herding activities.

3. During the last 3000 years, farmers built stone walls and dams to protect the fields from gully incision and soil erosion (Fig. 4). The dams caused the re-deposition of drifted sediments and contributed to land conservation.
4. After the abandonment, natural erosion processes were re-established. As a result, about 10% from the agriculture soil of some of the basins in the Negev Highlands was eroded during the last 1.5 KY.

Natural gully evolution and desertification

The ongoing stripping of the valleys floor in the Negev Highlands had severely reduced the natural biomass and the agricultural potential:

1. There is 80% less floral biomass in the lower valleys below the headcuts relative to the upper valleys (Fig. 1).
2. Large quantities of soil had drifted from the region since the initiation of the gullies (Fig. 3).

This natural phenomenon causes ongoing degradation of soil and biomass, leading toward increasing desertification of the region. As a result, throughout the history, farmers faced increasing difficulties in maintaining agriculture activities and nomads who adapted to the degraded conditions replaced them. As time passed, camels replace sheep in the most degraded regions.

Gully migration - negative and positive implications

The headcut migration up the valleys is damaging the modern infrastructures (roads, pipe lines, electricity power lines) located along them (Fig. 5). On the other hand, the positive feedback effect between soil erosion and runoff generation increases the runoff efficiency, floodwater volume and available water in arid regions.

Conclusions

1. Desertification, caused by gully incision and headcut migration, is a natural ongoing process, which has been active in the Negev Highlands since the termination of the Late Pleistocene pluvial phase.
2. This process is related to the long-term re-adjustment of the geomorphologic system to the Holocene climate. As a result, the Late Pleistocene loess sediments, formerly deposited within the drainage basins, are being eroded and removed during the Holocene.
3. The shift in climatic conditions is generating a long term dynamic change in the soil / rock ratio within the drainage basins through the Holocene. This natural process is leading toward ongoing degradation of the agriculture potential and to increasing desertification of the region.
4. The well-known land degradation processes caused by human activity (such as overgrazing and mismanagement of agricultural lands) is super-imposed on the natural desertification process.

5. The continuation of the present processes will turn the majority of the Negev Highlands to a rocky desert with reduced biomass and no agriculture potential.
6. Similar processes of natural gully incision and ongoing desertification are active in wide regions of the Middle East, as well as in other semiarid and arid regions worldwide, such as southern Africa, central Asia and northern China.

Avni, Y., and Porat, N., 2002. Environmental effects related to the degradation and erosion of Pleistocene sediments in the Negev Highlands. Isr. Geol. Surv., Rep. GSI/1/2002, 25 p. (In Hebrew).

Head cut in the Negev Highlands, Nahal Boqer



Backward migration of headcut during flood, Nahal Shekher





Soil erosion during flood, Nahal Shekher

Soil erosion in agriculture fields, Negev Highlands



Gully migration caused damage to modern infrastructures, Yeruham – Sede Boqer road, Negev

