HUMAN INDUCED SOIL EROSION AND DELTA PROGRADATION IN THE GRAND MENDERES VALLEY (SW-TURKEY)

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Introduction

Intensive late Holocene delta progradation is fairly well known from some W-Anatolian rivers between Troy in the N (KRAFT et al. 1980, 1982; KAYAN 1996), and Kaunos in the S (RIEDEL 1994). The former „Latmian Gulf" in the lower course of the Grand Menderes valley is an area of extremely rapid coastal change during the late Holocene (SCHRÖDER & BAY 1996; BRÜCKNER 1997; BAY & SCHRÖDER 1998; BAY 1999b).

Low tidal influences on the growth of deltas and coastal plains helps to preserve about 80-90% of the suspended river load. In many cases around the Mediterranean progradation can be subdivided in separate stages classified by entire suspension yield over time and volume (BAY 1999b, BAY et al. 2001). The onset and intensities of delta and coastal plains progradation seems to be intimately connected with increasing and fluctuating human settlement.

The human impact on the landscape evolution in the lower course of the Grand Menderes valley can be traced and quantified by interdisciplinary field work and in intimate contact with archaeologists. Also the increasing growth of the the younger slope deposits as well as that of the alluvial fans can be traced and dated by ceramics (BAY 1999a, b).

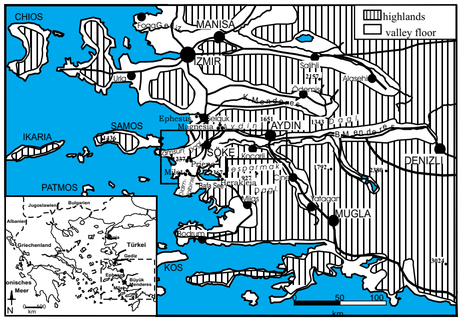

Fig. 1: View from SW-Anatolia. The study area is located in the lower course of the Grand Menderes River.

Delta progradation

The sediment distribution in the Grand Menderes valley has been reconstructed from over 200 boreholes. Marine sediments, found under the up to 30 m thick alluvial valley floor sediments, reach up to 60 km inland from the present day delta mouth, to south of the province capital Aydin and outline the former maximum extent of the Latmian Gulf (BAY 1999b). This is also supported by evidence from geoelectrical resistance measurements of the salt water content of the subsoil (ÜZER 1972) and from Chalcolithic and early Bronze Age settlement patterns (AKDENIZ 1996).

With the borehole and archaeological data, it has been possible to subdivide the delta progradation into six stages from the Chalcolithic era (5-6 Kyr BP) to the present day, and to classify the entire suspension yield over time and by volume. The calculated sedimentation rates (km^3 / 100 a) for the Grand Menderes delta increase from Archaic times until Roman times by fifteenfold. The maximum sedimentation rates coincide with the main settlement period, when the natural landscape was put over to agricultural use. At present it is four times higher than normal and equals rivers of very high relief of low latitudes. The time-averaged rate of mechanical erosion within the catchment area (25 000 km^2) is about 0.2-0.5 m during the last 5 kyr.

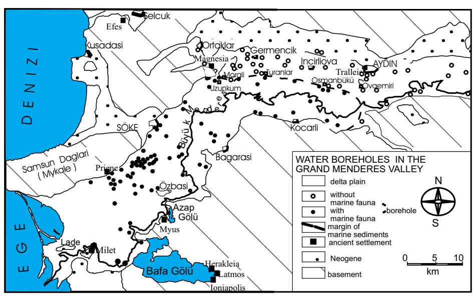

Fig. 2: Position of the recorded boreholes in the western part of the Grand Menderes valley. The marine fauna indicates the maximum extension of the former Latmian Gulf.

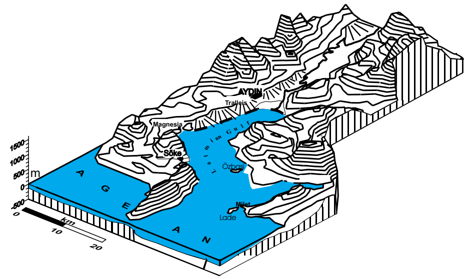

Fig. 3: 3-D view of the Latmian Gulf. The maximum extension was reached about 4000 BP.

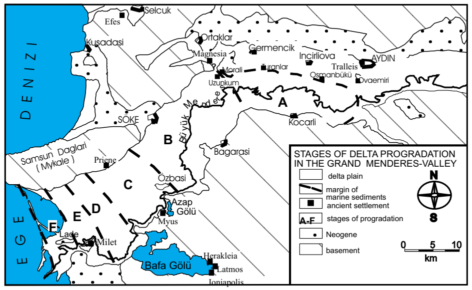

Fig. 4: Delta progradation stages (A-F) derived from historical data (comp. Fig. 5).

time period	stage of progradation	progradated area [km^2]	volume [km^3]	sedimentation rate [km^3/100a]
3500-1000 BC	A	160	6,4	0,26
1000-600 BC	B	198	12,9	3,2
600-250 BC	C	120	12,6	3,6
250 BC-100 AD	D	96	11,4	3,3
100-500 AD	E	52	7,6	1,9
500-1997	F	128	19,8	1,3

Fig. 5: Calculated sedimentation rates since the beginning of the delta progradation in the middle Holocene. Rapid increase of the sedimentation rates starts with human impact in the archaic period (1000 BC) by fifteenfold.

Late Holocene slope deposits and alluvial fans

Detailed geoarchaeological investigations of buried cultivated paleosols located near Miletos show evidence of human land-use and erosional history since the late Chalcolithic period (~ 5500 BP; BAY 1999a, b). A Holocene sequence of about 50 well-dig profiles with pottery-calibrated sediments in gently dipping alluvial fans at the toeslope/footslope region of the hillslope starts with a black, humic plough-pan horizon (up to 70 cm thickness preserved) with chalcolithic pottery at the bottom and archaic pottery at the top (BAY 1999a). This homogenous, compacted horizon contains abundant pottery sherds, yellowish-brown dusty clay, organic residues, coarse charcoal and fine mixed ash material due to human cultivation activities (COURTY et al. 1989). Intensive cultivation with manuring practices in the agriculturally highly developed archaic period (dung, ash material from hearths, organic waste with bones and pottery) led to an plough-horizon of up to 1 m (plaggen-soil).

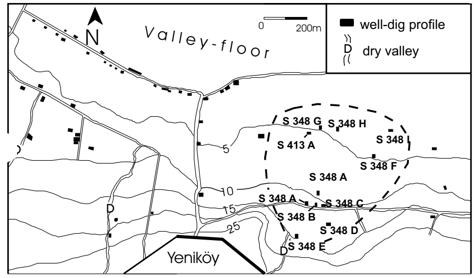

Fig. 6: Distribution of the well-dig profiles in the vicinity of Yeniköy.

Fig. 7: Detail view from the well-dig profile S 348 A. The dark layers represent cultivate paleosols (plough pan horizons). The Holocene sequence starts at the bottom of the lower dark layer with chalcholithic pottery sherds (~5500 BP).

Human induced soil erosion

Man's role in shaping the landscape started slowly during the late Neolithic period and eventually led to a first erosional maximum during the densely settled and cultivated Chalcolithic period. After depopulation and regeneration of the landcape in the early and middle Bronze Ages intensive cultivation was started again in the early Archaic period with deterioration of the soils and severe soil erosion. Gully erosion on the slopes can be recorded back to at least the late Archaic period. Increasing deforestation and overgrazing in Classical and Hellenistic periods caused sheet erosion with maximum erosion rates leading to the accumulation of thick colluvial layers (up to 2 m) in the footslope area until the early Roman period. The Roman time is characterized by slope stabilitity and soil forming processes probably due to rural depopulation. Above the colluvial layer a homogenous plough horizon indicates a second intensive cultivation period of the young soils in late Roman/ Byzantine times. Soil deterioration, decrease of organic matter, intensified surface crusting led to increasing run-off and started a second phase of soil erosion.

These results are supported by interdisciplinary data (mikro-palaeobotany – WILLE 1995; STIKA 1997, palaeozoology – PETERS & VAN DEN DRIESCH 1992), survey and historical data (LOHMANN 1997; MARCHESE 1986). The downslope increasing thickness of colluvial material and its accumulation since the Chalcolithic period may reach up to 6 m in the toeslope area of the gently dipping (1-2^0) fans.

A few data of sedimentation rates from alluvial cones of the steep Samsun Daglari show similar main erosion phases.

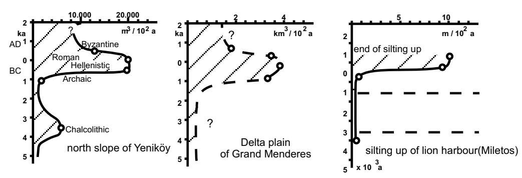

Fig. 8: Sedimentation rates derived from borehole and pottery data from the G. Menderes valley. The rapid increases in the sedimation rates are contemporary and coincide with the densely settled and intensively farmed periods from Archaic to Roman times.

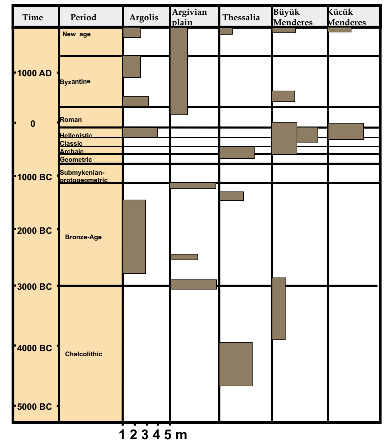

Fig. 9: Erosion/accumulation sequences from geoarchaologically well investigated areas in Greece compared with the Büyük and Kücük Menderes settlement areas. The local settlement patterns indicate heterochronous erosion phases with extreme different duration, intensity and spatial distribution. This indicates anthropogenic and not climatic causes for the holocene erosion phases.

Summary

Regionally effective, anthropogenically induced soil erosion probably caused a large increase in the suspension load of the Grand Menderes River leading to accelerated delta progradation within the Latmian Gulf. The sediment accumulation curve of the Grand Menderes delta, as well as the local curves derived from the slopes in the vicinity of Miletos and newly derived sedimentation rates from the alluvial cones of Samsun Daglari, point to main erosion phases that coincide with the densely settled and intensively farmed periods from Archaic to Roman times. The early stages of deforestation and destruction/erosion of soils in the area of Milet go back to the midth of the 4th millenium BC.. The most intensive human impact on the landscape started during the Archaic period and lasted till the early Byzantine period.

In a larger context, climatic factors can be largely excluded as a cause of "mediterraneanization", due to the strong links between the settlement patterns and increased erosion phases of the region.

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