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Living with the 'Big River': human-environment interactions along the Büyük Menderes (Big Meander) river, southwestern Turkey

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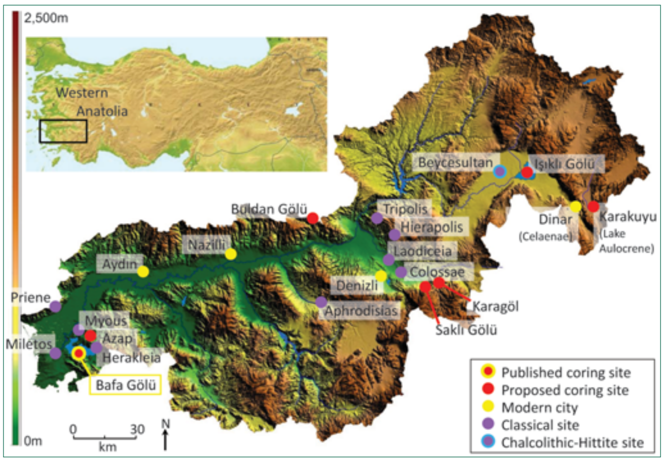
There has been long-standing debate in historical geomorphological studies about the relative importance of natural drivers of erosion, such as climate change, versus human-induced land-cover change (e.g. Grove, Rackham 2001). Some of the most widely studied field evidence for past changes in soil erosion and sediment flux comes from downstream records of alluviation and incision in Mediterranean river valleys (e.g. Vita-Finzi 1969). Dating and sedimentological analyses have enabled the reconstruction of regional alluvial chronologies, and this led to the recognition that significant geomorphological changes have taken place during historical times. Among them is the Younger Fill of Claudio Vita-Finzi (1969), found in many Mediterranean valleys and which formed during post-Roman times. While these studies highlight the widespread nature of historical slope destabilisation and soil loss, they have been less informative about their underlying causes. Vita-Finzi, for example, attributed his Younger Fill primarily to historic variations in climate (e.g. Medieval Climate Anomaly) rather than to post-Classical abandonment and subsequent lack of maintenance of agricultural terrace systems. In practice, alluvial records do not easily permit the kind of controlled field experimental conditions needed to establish clear causal relations. However, when reconstructed alluvial chronologies are analysed alongside lake-sediment data, then greater chronological precision and accuracy can be achieved (Vannière et al. 2013), and the analysis of lake-sediment data also offers the possibility of testing different causal mechanisms using a multi-proxy approach (Roberts et al. 2018).

Of the four main rivers that drain western Anatolia, it is the eponymous Büyük Menderes (Big Meander, typically referred to as the 'Meander', the ancient Maiandros) river that dominates and drains most of southwestern Turkey; it is also the largest river that drains into the Aegean Sea (see map). From its source near Dinar (ancient Celaenae) the Meander (~580km long, catchment of 25,000km^2) drains axially and passes through a series of tectonic basins and gorges eventually flowing for ~150km through the Meander graben. It is in this final reach (from Nazilli) that the Meander is especially characterised by the meander belts and cut-off (oxbow) lakes which have given their name to this meandering river channel pattern type.

Since mid- to late Holocene times, the Meander river has advanced its delta, silting-up a marine embayment that once reached inland for tens of kilometres (Brückner et al. 2017). The port city of Miletos, now 10km from the sea, was in Classical times located on the Latmian gulf; Bafa lake is the remnant of this once deep indentation of the sea (see map); other cities with coastal ports fared a similar fate (e.g. Myous, Priene, Herakleia). Various causes of this increased sedimentation and delta progradation have been advanced and include natural erosion, sea-level changes, tectonic activity and riverine sediment load, which is the main process effecting progradation. Helmut Brückner and colleagues (2017) hypothesise that human impact on the vegetation cover of the drainage basins is the main causal factor to account for increased erosion rates and increased sediment flux. However, there are very few data with which to test empirically the competing roles of natural forcing processes (e.g. climate change), on the one hand, and human agency on the other (Roberts et al. 2018). This is mainly because research carried out to date has either focused on a narrow strip of the coastal zone associated with the great Classical cities (e.g. Miletos, Priene, Ephesos) or on specific archaeological sites in the continental interior or montane zone (e.g. Sagalassos); essentially, previous research investigations have effectively divorced the floodplain from its interior and upland catchments. In order to understand the processes that have led to marked regional environmental and landscape changes over decadal, centennial and millennial timescales, and that have caused significant environmental and landscape change with concomitant impacts on local settlements in this part of southwestern Turkey, it is imperative that a regional landscape approach is adopted.



The Büyük Menderes (Big Meander) river.

Our project adopts a 'catchment-to-coast' (source-to-sink) approach in order to reconstruct past natural and human-induced environmental and landscape changes that have led to increased erosion rates along the course of the Meander. We will investigate the extent to which upland catchment processes via human agency (deforestation, burning, agriculture, grazing) may have caused vegetation change, increased run-off and mobilisation of catchment soils (Eastwood et al. 1998b; 1999; Roberts 2018). We will also investigate the extent to which regional climate change, for example to drier climatic conditions, may have caused decreased vegetation density and increased run-off and mobilisation of catchment soils. In order to test these hypotheses, we will reconstruct the pre-civilisation natural environment of the Meander catchment in order to establish baseline conditions and chart the *longue durée* of human occupance and landscape change.

The Meander flows through a series of cascading basins which act as intermediate, temporary sinks (e.g. Karakuyu, Işıklı, Denizli), so our fieldwork to date has concentrated on coring lakes in close proximity to these basins and archaeological sites (see map). Over the coming months, retrieved sediment cores will be subjected to a range of multi-proxy techniques (pollen, charcoal and coprophilous fungal analyses) to acquire data on vegetation change and local/regional burning, and to assess the magnitude of grazing and potential impacts on forest cover. Chronological control will be achieved using radiocarbon age dating on retrieved sediment sequences. Discovery of volcanic ash in trial sediment cores from Karagöl, most probably from the mid-second millennium BC Minoan eruption of Santorini (Thera), provides the opportunity to date some sediment sequences using tephrochronology (see photo to right; Eastwood et al. 1998a). Hydroclimate change will be reconstructed using stable isotope analysis of authigenic carbonates from large and small lakes (Dean et al. 2017). Enhanced hydro-geomorphic instability and palaeo-flood analysis will be reconstructed using core magnetic susceptibility, Itrax X-ray fluorescence (µXRF) core scanning and other geochemical techniques.

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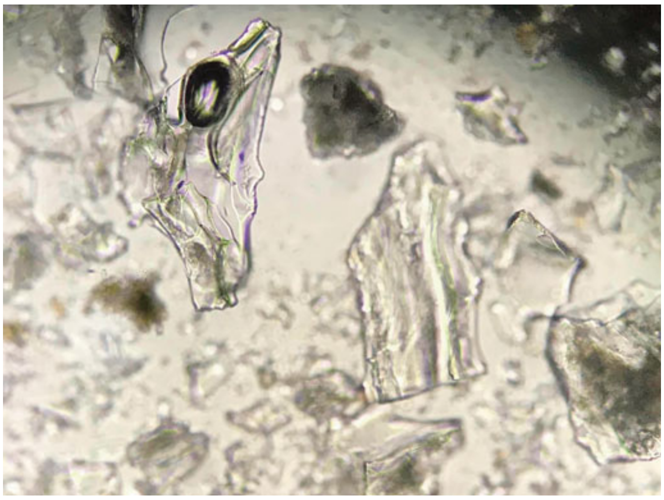

'Glassy' shards of volcanic ash recovered from a 5cm tephra layer at depth 695cm from Karagöl lake, southwestern Turkey. Geochemical determinations will indicate the provenance of this tephra unit, but its physical characteristics and depth in the sediment core suggest a Santorini origin.