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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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A long-standing debate in the field of historical geomorphology concerns the relative importance of natural drivers of erosion, such as climate change, *versus* human-induced land-cover change (for example 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 sedimentation and down-cutting in Mediterranean river valleys (for example Vita-Finzi 1969). Dating and sedimentological analyses have enabled regional alluvial chronologies to be reconstructed, which has led to the recognition that significant geomorphological changes have occurred during historical times. Claudio Vita-Finzi (1969) researched increased sedimentation found in many Mediterranean valleys, called it the 'Younger Fill' and further suggested that it had formed synchronously. However, we now know that it formed diachronously according to local landscape change trajectories. While the widespread nature of historical slope destabilisation and soil loss in arid regions has long been understood, there remains considerable uncertainty as to the underlying causes. Vita-Finzi, for example, attributed his 'Younger Fill' primarily to historic variations in climate such as the Medieval Climate Anomaly, although other possibilities, such as human impact on forests and post-classical collapse and abandonment and subsequent lack of maintenance of agricultural terrace systems, could equally be applicable. 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 continuously accumulating lake sediment data, greater chronological precision and accuracy can be achieved, and the analysis of lake sediment data offers unrivalled potential to test hypotheses concerning 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') that drains most of southwestern Turkey. Over the last ~6,000 years or so, the Meander has advanced its delta, silting up a marine embayment that once reached inland for ~50km. The principal port city, Miletos, was in classical times located on the Latmian gulf; Bafa is now a landlocked residual lake and Miletos is over 10km from the Aegean Sea. Other important classical cities and coastal ports also became landlocked, including Myous, Priene and Herakleia, and this significantly impacted regional trade and migration (Brückner et al. 2017). Various causes of increased sedimentation and delta advancement have been suggested, including natural erosion, sea-level change, tectonic activity and increased riverine sediment load. Helmut Brückner and colleagues (2017) hypothesise that change in catchment vegetation cover as a result of human activity is the main factor accountable for enhanced erosion rates and increased sediment flux. However, there is a lack of data with which to test empirically the competing roles of natural (climate) change and human agency. This is mainly because research undertaken to date has either focused on a narrow strip of the coastal zone associated with the great classical port cities (such as Miletos and Ephesos) or on individual archaeological research sites located in the continental interior (Aphrodisias for example). Thus, previous research has largely separated the floodplain from its upland catchments, and this represents an important research gap. Apart from its historical and prehistorical importance to civilisation, the Meander catchment is an ideal study region. The catchment extends into the montane, interior region of southwestern Turkey and contains a larger number of lakes than other river catchments in the region, allowing us to undertake multiproxy analyses on retrieved lake sediment cores. As reflected in its name, the river's floodplain is especially characterised by meander belts and numerous meander cut-off/oxbow lakes. These oxbow lakes offer unrivalled potential to apply innovative techniques to reconstruct high-resolution flood frequency and magnitude sequences directly from lake sediments. Although originally devised for temperate UK water bodies, we will test the feasibility of using these techniques on sediment sequences retrieved from the semi-arid environments of the Meander. Detailed geoarchaeological research on the coastal classical cities (such as Miletos), in addition to extensive archaeological and historical research on key classical cities located along the course of the Meander (Aphrodisias, Tripolis, Hierapolis), requires an interdisciplinary, regional, landscape approach to investigate human-environmental interactions over space and time. Our project adopts a novel 'catchment-to-coast' (source-to-sink) approach 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. We will also investigate the extent to which regional climate change (to drier climatic conditions, for example) 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 that act as intermediate, temporary sinks (for example Karakuyu, Çivril, Denizli), so our fieldwork to date has concentrated on coring lakes in close proximity to these basins and archaeological sites. Retrieved sediment cores will be subjected to a range of multi-proxy techniques (pollen, charcoal and coprophilous fungal analyses) to obtain data on vegetation change and local/regional burning, and to assess the magnitude of grazing and potential impacts on forest cover. Hydroclimate change will be reconstructed using stable isotope analysis of authigenic carbonates from large and small lakes. Enhanced hydro-geomorphic instability and palaeo-flood analyses will be conducted using core magnetic susceptibility, Itrax X-ray fluorescence (μXRF) core scanning and other geochemical techniques. Chronological control will be achieved using radiocarbon-age dating on retrieved sediment sequences in addition to tephrochonological techniques (analysis of volcanic ash layers preserved in sediment cores). Volcanic ash discovered in sediment cores most probably derives from the mid-second millennium BC 'Minoan' eruption of Santorini (Thera), but further work is needed to substantiate this.

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